INLAND WATERWAYS AUTHORITY OF INDIA (IWAI)

CONSULTANCY SERVICES FOR PREPARATION OF SECOND STAGE DETAILED PROJECT REPORT (DPR) OF CLUSTER 8 OF NATIONAL WATERWAYS

FINAL DETAILED PROJECT REPORT OF MAHI RIVER NATIONAL WATERWAY – 66 STRETCH - 0 Km TO 246.989 Km

VOLUME-I MAIN REPORT

WAPCOS Limited
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Acknowledgement

This Final Detailed Project Report is the outcome of detailed study of existing Hydrography, topography and traffic assessment along Mahi River. This vision is shared jointly by IWAI and WAPCOS Limited.

This report gives the present status of water-ways assets, topographic features, climatic variability, land use / land cover pattern, details of all cross structures along with socio-economic information of the waterway. Report also gives information Traffic and market assessment along the river for development of waterway. Report includes Preliminary Design, cost estimates and financial analysis of the project.

WAPCOS LTD. expresses their gratitude to **Mrs. Nutan Guha Biswas, IAS, Ex Chairperson** for sparing their valuable time and guidance for completing this Project. We would also like to thanks **Shri Pravir Pandey, Chairman (IA&AS); Shri Alok Ranjan, Member (Finance), Shri S.K.Gangwar, Member (Technical) and Shri Shashi Bhusan Shukla Member (Traffic)**

We also wish to express our gratitude to **Capt. Ashish Arya, Hydrographic Chief** for their guidance and inspiration for this project. We would also like to thank **Shri Rajiv Singhal, A.H.S.** for invaluable support and suggestions provided throughout the survey period. WAPCOS is pleased to place on record their sincere thanks to other staff and officers of IWAI for their excellent support and co-operation throughout the project period.

WAPCOS Team

Sector -18, Gurugram
Haryana- 122015

FINAL DETAILED PROJECT REPORT (DPR) OF NATIONAL WATERWAY NO. 66, RIVER: MAHI (247 KM) IN THE STATE OF GUJARAT

VOLUME-I: MAIN REPORT

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The tidal stretch of Mahi River is from 0 to 80 km chainage and the established chart datum value of 5.1 m below MSL at LNG Petronet terminal (approximately 50 km away from the CH 0 km) was considered for the entire tidal, sounding datum was transferred by simultaneous tidal observations at established & new gauges.

Non-Tidal Stretch

The non-tidal stretch of Mahi River is from Ch 80 km (U/S Umeta Check dam) to Ch 246.9 km (D/S Kadana Dam). The non- tidal stretches are sub-divided as downstream and upstream stretches of Wanakbori Dam and Tantroli Check Dam.

Downstream of Wanakbori Dam

This non-tidal stretch of Mahi River at downstream of Wanakbori Dam is from Ch 80.0 km to 172.6 km chainage. Narmada Canal is</td></tr>
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<tr><th>Sr. No.</th><th>Particulars</th><th colspan="6">Details</th></tr>
<tr><td></td><td></td><td colspan="6">passing through the Mahi River at Ch 158 km. The difference between water level and Sounding Datum at CWC Khanpur& LAD being co-related for deriving the Sounding Datum for this portion.

Upstream of Wanakbori Dam & Downstream Tantroli Check Dam

This non-tidal stretch of Mahi River at upstream of Wanakbori Dam is from Ch 172.6 km to Ch 232 km. Sounding Datum at CWC Wanakbori Gauge being established by the average minimum water level. Difference between water level and Sounding Datum & LAD in the river portion being taken into consideration for deriving the Sounding Datum for this stretch.

Upstream of Tantroli Check Dam

This non-tidal stretch is from upstream of Tantroli Check Dam to downstream of Kadana Dam (Ch 232 km to Ch 246.9 km). Sounding Datum being derived by the LAD and difference between water level & established SD.</td></tr>
<tr><td></td><td>Value</td><td colspan="6">Dahej -5.1

D/s of Wanakbori Dam (Khanpur CWC) +26.82

U/s of Wanakbori& D/s Tantroli Check Dam +76.5

U/s of Tantroli Check Dam +127.78</td></tr>
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<tr><td></td><td></td><td>Sub-stretch-7</td><td>Sub-stretch-8</td><td>Sub-stretch-9</td><td>Sub-stretch-10</td><td>Sub-stretch-11</td><td>Total</td></tr>
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Sr. No.	Particulars	Details					
	Length with LAD < 1.2 m	11.8	7.2	5.5	9.1	4.5	**115.65**
	With LAD from 1.2-1.4 m	2.5	2.8	2.6	2.7	1.2	**20.6**
	Length with LAD 1.5 – 1.7m	1.6	1.6	3.5	2.9	1.1	**20.7**
	With LAD from 1.8-2.0 m	0.8	1.3	2.2	2.7	0.9	**14.3**
	With LAD > 2.0 m	11.8	7.2	5.5	9.1	4.5	**75.65**
		Grand Total				**246.9**	
g)	Target Depth of Proposed Fairway (m)	2.0m					
h)	Conservancy Works Required	-					
	Type of Work						
	Dredging Required (M. Cum.)	12.8 Mm^3					
	Bandalling	No					
	Barrages & Locks	Lock at Sindhrot Check Dam					
	River Training/Bank Protection (Km.)	-					
i)	Existing Cross Structures						
	Name of Structure	**Type**	**Nos.**	**Range of Horizontal Clearance**	**Range of Vertical Clearance w.r.t. HFL/MHWS**		
	Dams/Barrages/Weirs/Aqueducts etc.	Wanakbori Dam and 2 Check Dams	3	NA	NA		
	Bridges	2 Rail & 17 Road Bridges	19	10.52 m to 46.20 m	-7.06 to 11.63 m		
	HT/Tele-communication lines	19HT Lines&7Electric lines	26	250 m to 750 m	10.5 m to 22 m		
	Pipelines, underwater cables, etc.	Aqueduct	1	NA	NA		
2.	***Traffic***						
a)	Present IWT Operations (type of services)	Bordi ferry Ghat at Ch.178.2 and Pattan ferry Ghat at Ch.201.30.					
b)	Major industries in the hinterland (i.e. within 25 km. on either side)	GIPCL, Gujarat Flurochemicals, ABB India, IOCL Gujarat Refinery, Wanakbori TPP, Jindal Stainless Steelway, GACL, Dhuvaran Gas CCPP, , Reliance Industries, Ultratech Cement, GSFC , Gulbrandsen Chemicals, Gayatri Chemical Industries, Apar Industries					
c)	Connectivity of major industries with Rail/Road network (Distances/Nearest Railway Stations etc.)	Within 5 km, Godhra, Kalol, Vadodara, Anand, Nadiad, Vasad, Borsad, sojitra and Khambhat are main railway stations located near industrial clusters along the proposed stretch of Mahi River. However all the industrial clusters are also well connected by road.Kheda, Nadiyad, Anand, Vasad and Vadodara are connected by national Highway.					
d)	Commodities	**In-bound**	**Out-bound**				
		Coal	-				
e)	Future Potential (MMT)						
	Name of Commodity(mnTonnes)	**5 years**	**10 years**	**15 years**	**20 years**	**25 years**	

Sr. No.	Particulars	Details				
	Cargo (Terminal 2)	2.6	3.3	4.0	4.6	5.6
3.	Terminals/Jetties					
a)	Terminal/Jetty - 1	Tourist Jetty at CH 80 Km				
	Location (Bank/city/district)	Sindhrot, Vadodara				
	Type/Services	Tourism				
	Facilities	Jetty, Buildings, STP, Amusement park, Water Supply, Bio-Toilets, Parking Areaand Amusement Park, reception & disposal facilities				
	Approach	-				
	Land Ownership	Govt. of Gujarat				
	Area (ha.)	**Govt.**		**Private**		
		2 Ha		NA		
b)	Terminal/Jetty – 2	Cargo Terminal at CH 150 Km				
	Location (Bank/city/district)	Wanakbori				
	Type/Services	Cargo				
	Facilities	Jetty, Buildings, Material handling equipments, Storage Area, Water Supply, Toilets, Parking Area				
	Approach	-				
	Land Ownership	Govt.				
	Area (ha.)	**Govt.**		**Private**		
		2 Ha		NA		
4.	***Design Vessel***					
a)	Type	Self-propelled vessel				
b)	No. & Size	70m X 12m				
c)	Loaded Draft	1.8 m				
d)	Capacity	1000 DWT				
5.	***Navigation Aids***					
a)	Type	-				
b)	Nos.	Marine Lantern/Buyos (50 nos.)				
b)	Communication Facilities	DGPS, VTMS and Marine Lantern/Buyos, , RIS Station				
C.	**FINANCIAL**					
1.	***Project Cost***					
a)	Capital Cost					
	Cost (Rs in Crores)	Total Cost				
		1194.42				
b)	O & M Cost					
	Cost (Rs in Crores)	56.00				
2.	***User Charges***					
a)	For IWAI	@ Rs. 1 per Tonne per Km for using channel				
3.	***Financial Internal Rate of Return (%)***					
a)	For IWAI	**FIRR: Channel usage @Rs 1 per tonne per Km: (-) value**				

Sr. No.	Particulars	Details
4.	***Economic Internal Rate of Return (%)***	**EIRR-13.74%**
5.	***Any other Important Feature***	**-**

EXECUTIVE SUMMARY

1.0 Project Background and Introduction

The Govt. of India desires to explore the commercial navigation potential on year round basis in inland waterways. Ministry of Shipping (MoS), Govt. of India had directed Inland Waterways Authority of India (IWAI) to identify the viable waterways in India for their phased development.

Accordingly, to make provisions for existing national waterways and to provide for the declaration of certain inland waterways to be national waterways and also to provide for the regulation and development of the said waterways for the purposes of shipping and navigation, National waterway act, 2016 has received the assent of the President on the25th March, 2016 declaring a total of 111 National Waterways. All the River stretches/Canals have been divided in different clusters for carrying out the study. Four Rivers in Gujarat & Maharashtra viz. Mahi, Narmada, Tapi and Sabarmati has been identified in Cluster-8 for development of waterways

M/s Inland Waterways Authority of India (IWAI) has entrusted WAPCOS with the responsibility for preparation of two stages DPR for 4 inland waterways (Sabarmati, Mahi, Narmada and Tapi) in the states of Gujarat & Maharashtra.

Accordingly, WAPCOS Ltd. has undertaken the feasibility studies for 4 national waterways (Mahi, Narmada, Sabarmati and Tapi River) in Gujarat & Maharashtra during stage-1. During the stage -1 following activities were carried out

A. Reconnaissance Survey
B. Collection and Review of available data
C. Feasibility studies

After the Stage-1 (feasibility studies) following stretch of the rivers were found feasible for further detailed studies.

Sl. No.	Waterway Details	Stretch Details
1.	**River Mahi (NW-66)**	**246.989 km from Lat 22°10'34.71"N, Long 72°30'36.31"E**
2.	River Narmada (NW-73)	226.343 km from Lat21°38'26.81"N, Long 72°33'28.24"E
3.	River Tapi (NW-100)	172.946 from Lat21°2'15.51"N, Long 72°39'29.63"E

2.0 Hydrographic Survey & Data Collection

The purpose of detailed hydrographic survey was to determine the hydraulic features and existing conditions of the Mahi River from confluence with the Arabian Sea at Gulf of Khambhat at Lat22°10'34.71"N, Lon 72°30'36.31"E to Kadana Dam of 247 km length.

Tidal Stretch is 0 to 80.0 Km and Non Tidal Stretch is 80.0 km to 246.989 km. Average tidal variation is 3.26 meter.

Water availability

The Waterway of Mahi River for 247 Km river stretch is divided into different stretches for LAD status. The details of the stretches are as follows:-

Table 1 – LAD status

	Sub-stretch-1	**Sub-stretch-2**	**Sub-stretch-3**	**Sub-stretch-4**	**Sub-stretch-5**	**Sub-stretch-6**
	0-25 km	**25-35**	**35-55 km**	**55-80 km**	**80-100 km**	**100-125 km**
(i) <1.2m	22.6	5.9	16.55	20.1	3.7	8.7
(ii) 1.2m to 1.4m	1.2	1.5	1.4	1.1	1.3	2.3
(iii) 1.5m to 1.7m	0.8	1.2	1.3	1.3	1.9	3.5
(iv) 1.8m to 2.0m	0	0.8	0.5	0.6	1.8	2.7
(v) > 2.0 m	0.4	0.6	0.25	1.9	11.3	7.8
Total	**25**	**10**	**20**	**25**	**20**	**25**

	Sub-stretch-7	**Sub-stretch-8**	**Sub-stretch-9**	**Sub-stretch-10**	**Sub-stretch-11**	**Total**
	125-150 km	**150- 172.6 km**	**172.6-203 km**	**203-232 km**	**232-246.9 km**	
(i) <1.2m	11.8	7.2	5.5	9.1	4.5	**115.65**
(ii) 1.2m to 1.4m	2.5	2.8	2.6	2.7	1.2	**20.6**
(iii) 1.5m to 1.7m	1.6	1.6	3.5	2.9	1.1	**20.7**
(iv) 1.8m to 2.0m	0.8	1.3	2.2	2.7	0.9	**14.3**
(v) > 2.0 m	8.3	9.7	16.6	11.6	7.2	**75.65**

	Sub-stretch-7	Sub-stretch-8	Sub-stretch-9	Sub-stretch-10	Sub-stretch-11	Total
	125-150 km	150- 172.6 km	172.6-203 km	203-232 km	232-246.9 km	
Total	25	22.6	30.4	29	14.9	246.9

Soil and Water samples were collected at different locations. Soil is mainly composed of silt and sand.

Dredging

Total dredging quantities of Mahi River for Class IV is given in Table-2.

Table 2 - Dredging Summary of Mahi River

Class	Stretch-1 (0-25km)	Stretch-2 (25-35km)	Stretch-3 (35-55km)	Stretch-4 (55-80km)	Stretch-5 ((80-100km)	Stretch-6 (100-125km)	Stretch-7 (125-152km)	Total
IV	3.58	1.37	2.45	2.48	0.05	1.15	1.78	12.8

Existing Cross Structures

i) Check Dam: 01 nos (Umeta/Sindhrot)

ii) Bridges –

Total 9 bridges are present upto 150 Km from the mouth of sea (Ch.0) including 1 Railway bridge and 2 under construction road bridges.

Clearance	Min (m)	Max (m)
Horizontal Clearance	10.52	46.20
Vertical Clearance (w.r.t HFL)	-7.066	11.630

3.0 Fairway Development

In India, the inland waterways are classified into seven categories for rivers as well as canals by the Inland Waterways Authority of India (IWAI) vide GOI Gazette Notification dated 26 January 2007 for safe passage of self-propelled vessels up to 2000 dead weight tonnage (DWT) and tug barge formation in push tow units of carrying capacity up to 8000 tonnes.

WAPCOS has studied the possibility of developing waterway as Class III, Class IV, and Class V. WAPCOS has recommend Class-IV type of waterway throughout the length of Mahi River from CH 0 to 150KM (Terminal-2).

One navigational lock is proposed at Sindhrot Check Dam as river training for navigation in the stretch. Demolition and reconstruction of bridges not having requisite clearance is proposed.

4.0 Traffic Studies

The districts that are located in the catchment area, i.e. within 25 km. of River Mahi are Anand, Kheda, Vadodara, Bharuch, Panchmahal and Mahisagar. These districts are studied in detail for finding opportunity for the proposed waterway. There exist several medium and large scale industries in the districts located in the catchment area of Mahi River. Majority of industries are located in Vadodara district.

Table 3 Major Industries in the Catchment Area of Mahi River

Name	Location	Dahej Port			Kandla Port		
		Road	Rail	River	Road	Rail	River
GIPCL	Vadodara	113	110	128	414	405	695
Gujarat Flurochemicals	Vadodara	113	110	128	414	405	695
ABB India	Vadodara	104	110	128	414	405	695
IOCL Gujarat Refinery	Vadodara	116	110	128	414	405	695
Wanakbori TPP	Balasinor	208	205	207	408	430	695
Jindal Stainless Steelway	Vadodara	131	110	143	414	405	695
GACL	Vadodara	127	156	146	390	329	695
Dhuvaran Gas CCPP	Khambhat	137	183	87	391	420	695
Reliance Industries	Vadodara	123	121	132	389	392	695
Ultratech Cement	Balasinor	199	205	198	406	422	695
GSFC	Vadodara	125	121	145	402	331	695
Gulbrandsen Chemicals	Vadodara	89	100	128	414	429	695
Gayatri Chemical Industries	Vadodara	112	110	128	414	405	695
Apar Industries	Vadodara	114	110	128	414	405	695

Table 4 Potential Commodities for River Mahi

Commodities	Source	Volume (mn T)	Reasoning
Coal	Wanakbori Thermal/ Captive Plant	1	Coal Consumption is around 5.2 Million Tonne. Domestic Coal is obtained from Chhatisgarh coalfields. Imported Coal can be transported from Waterways.
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	0.8	Based on reliable inputs, this critical power plant is likely to mostly use imported coal. This volume can be lightered to the plant using River Mahi

Commodities	Source	Volume (mn T)	Reasoning
Fly ash	Wanakbori TPS	1.2	Fly Ash from Wanakbori TPS is procured by UltraTech cement plant. A small volume is utilized at the plant, while the rest gets transported to its Surat Unit by road. The volume moved by road can be shifted using
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	1	This will be mostly surplus volume, suitable for distribution using the River Mahi waterway
Clinker	Ultratech Cement	2.0	A prospective cargo that can be moved via River Mahi from UltraTech's integrated clinker plant in Kuchh.
Black Trap	Produced in the Catchment area	0.9	This is total volume in the River Mahi catchment area, all of which is consumed locally.

The following table depicts the current origin-destination particulars for all the cargo that can be moved using River Mahi post required infrastructure development:

Table 5: O-D particulars for potential cargo on River Mahi

Name of companies	**Commodity**	**Volume (mn T)**	**Origin**	**Destination**
Wanakbori TPS	Coal	1	Hazira Port	Wanakbori TPS
	Fly Ash	1.2	Wanakbori TPS	Surat & Saurashtra
Wanakbori SCTPS (proposed)	Coal	0.8	Hazira Port & Chhatisgarh mines	Wanakbori SCTPS
	Fly ash	1	Wanakbori SCTPS	Surat & Saurashtra
UltraTech Cement	Clinker	2	Amreli	Wanakbori

The following table depicts growth in traffic once the proposed water park, amusement rides, and the floating restaurants open for business at Sindhrot Dam:

Table 6: Traffic projections at the proposed tourist attractions ('000 visitors)

	FY23	**FY25**	**FY30**	**FY35**	**FY40**	**FY45**
Amusement Park	9	22	99	107	108	108
FloatingRestaurant	35	88	397	428	468	513
Total	44	110	497	535	576	621

Source :Mantrana Maritime Advisory Pvt Ltd

Table 7: Commodity-wise traffic estimate for the proposed Terminal

Industries	Commodities	Traffic Estimates (MT)	Reasoning
Wanakbori TPS	Coal	1.6	Of the total 5.2 mn T of coal requirement, 30% has been targeted here. This volume is currently brought on rails, but has very good chances of shifting to the waterway, potentially resulting in net logistic savings.
	Fly ash	1.2	This target volume currently goes by road to Surat and even Saurashtra.The volume designated for Suratcan be distributed via River Mahi.
Wanakbori SCTPS	Coal	0.8	This potential traffic volume is 30% of the annual coal requirement for the upcoming plant, which could also be catered to by using River Mahi
	Fly ash	0.75	Similar to the rationale for distribution of existing fly ash volume, this potential traffic can also be moved via River Mahi.
UltraTech Cement	Clinker	1.5	This volume carries lower probability of being attracted for movement on River Mahi. However, with the proposed waterway, the likelihood for the switch should increase dramatically.

Source: Mantrana Maritime Advisory Pvt. Ltd.

The following table depicts projections for Terminal 2 along River Mahi:

Table 8: Traffic projections for the proposed Terminal

Cargo	Source/Destination	FY20	FY25	FY30	FY35	FY40	FY45
Coal	Wanakbori TPS	0.2	1.0	1.2	1.3	1.4	1.6
	Wanakbori SCTPS	0.1	0.3	0.4	0.6	0.7	0.8
	Coal Total	**0.3**	**1.3**	**1.6**	**1.9**	**2.1**	**2.4**
Fly Ash	Wanakbori TPS	0.1	0.4	0.5	0.6	0.7	0.9
	Wanakbori SCTPS	0.1	0.3	0.4	0.5	0.6	0.8
	Fly Ash Total	**0.2**	**0.7**	**0.9**	**1.1**	**1.3**	**1.7**
Clinker	UltraTech Cement	0.2	0.6	0.8	1.0	1.2	1.5
	Grand Total	**0.7**	**2.6**	**3.3**	**4.0**	**4.6**	**5.6**

5.0 Terminals

Following are the proposed terminals in the stretch of river Mahi on the basis of water availability, traffic requirements, land availability and environmental considerations:

Terminal 1: Sindhrot Tourist Jetty - (CH 80 km)
Terminal 2: Wanakbori Cargo Jetty - (CH 150 km)

6.0 Preliminary Engineering Design

The proposed jetty is required to handle Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m (Class-IV).

No bank protection is required in such a wide river.

A navigational lock of size 70m X 15.5m is proposed at Sindhrot Check Dam at CH 80 KM.

7.0 Vessel Design

The classification of vessels described by IWAI requires certain length and certain draft of vessel to be maintained for optimum use. Under this condition, there are other factors that will also influence the specific class of vessels that should be deployed on the River to handle traffic.

The following images depict typical Class IV vessels that are used for river cargo transportation. These are for illustrative purposes only:

Figure: Class IV vessels

8.0 Navigation & Communication System

Navigational system is considered as an important aid for any vessel movement in coastal and river channel. Navigational Safety in Port's Committee was formed in India known as NSPC to ensure navigational safety in waterways. DGPS, VTMS, Marine Lantern/Buyos (50 nos.) and RIS Station (3 Nos.) has been proposed to be installed for safe navigation of vessels and to have complete control on traffic handled at terminal.

9.0 Environmental and Social Aspects

The impact of project on potential environment is not much as it will not produce any harmful wastes.

The project will provide the employment to the local villagers nearby to the terminal area and barrages during construction as well as in operational phase this will improve the social and economic conditions of the nearby commuters. Also by shifting of traffic from distant ports or terminals, mode of operation like from road to waterway to these terminals will reduce the overall carbon emission. Therefore, it will bring a positive impact to the environment.

Other Major Clearances / Approvals / Permits Applicable to the Project

- Coastal Regulation Zone(CRZ) Govt. of Gujarat
- Environmental Clearance from MoEF & CC
- Forest Eco Sensitive Zone committee
- National Board on Wildlife (NBWL)
- Consent to Establish and operate from state pollution control board, Gujarat
- Gujarat Maritime Board

The Rapid EIA is suggested for the Project.

10.0 Institutional Requirements

The Authority envisaged is Navigational waterway maintenance, transportation enterprise dealing with passenger and cargo handling, transit and transfer as well as being an administrative unit and an organ of Government which implements Government policies.

River Mahi (NW-66) has been allocated to Deendayal Port trust (DPT) for development. In present case scenario, officer at level of assistant director and junior account officer at Head Office may be required to monitor various developments & monitoring of fund utilization.

11.0 Project Costing

The cost arrived at are based on the budgetary quotes and the in house data base available on cost estimates. The rates for various items of work have been prepared on the basis of current rates for various items of work prevailing in the region.

Gujarat Maritime Board Schedule of Rate, 2013-14 has been followed and escalated by 5% per annum to arrive at for year 2017-18 to arrive at the cost of the project.

The estimate of capital cost is made for the various items of civil, mechanical, electrical and utilities works for the development of terminals in the waterway stretch. Total capital cost estimate for the project worked out to Rs. 1194.42 Crore.

The annual operation and maintenance cost on different components of the project will be dependent on a number of variables such as the life of the component, repair and maintenance requirements, wages of crew of consumables etc. Approximate Operation & Maintenance cost estimate for the project worked out to Rs. 56.00 Crore. Based on the capital cost estimate and implementation schedule.

12.0 Implementation Schedule

At present, Mahi River is not feasible from navigation technically and financial point of view. *This report can be updated at a later stage when required, by considering the fresh cargo analysis, change in requirement of the Government or change in policy either of the state or Government of India.*

13.0 Economic & Financial Analysis

Considering life of project to be 30 years, the EIRR comes out to be 13.74%.

Considering life of project to be 30 years and charge for using the channel is Rs. 1/tonne, the FIRR comes out to be Negative.

14.0 Conclusions & Recommendations

WAPCOS has proposed two terminal locations at various places on the basis of traffic potential.

Also, in case of River Mahi, maximum length of river is in dry state. Hence, dredging of river from d/s of Terminal 2 to 2.0m depth contour of sea is a very challenging task. However, annuity model can be adopted for dredging exclusively.

Dredging of the river is a very challenging task. Dredging quantity calculated as approx. $13Mm^3$ which is exceptionally high. Cost of the dredging coming out to be Rs. 384 Crores which is highly uneconomical.

Mahi River is **not feasible** for navigation financially as well as economically due to the following reasons:

1) Traffic Constraint
2) Low water depths throughout the length which incurred substantial dredging of approx. 13 Mm^3. Also, maintenance dredging of river is very difficult.
3) Due to lack of vertical clearances, the 9 bridges situated on the proposed navigable stretch of waterway needs to be reconstructed and demolished which is highly uneconomical.

Recommendations:

Given below, there are 9 no. of bridges present across the river stretch which needs to be demolished and reconstructed due to lack of vertical clearances:

1) Gambhira Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

2) Umeta Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

3) Under Construction Bridge

Vertical clearance is available for all classes of waterway but horizontal clearance is not available even of Class-III of waterway. Hence it has to be demolished and reconstructed.

4) Vasad Rail Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

5) Vasad NH-8 Bridge

Horizontal clearance is available up to class-I of waterway and Vertical clearance is available up to class-II of waterway. Hence it has to be demolished and reconstructed.

6) Ahmedabad Vadodara Expressway Bridge (NE 1)

Horizontal clearance is available up to class-II of waterway and Vertical clearance is available up to class-III of waterway. Hence it has to be demolished and reconstructed.

7) Poicha Bridge

Horizontal clearance is available up to class-II of waterway and Vertical clearance is available up to class-III of waterway. Hence it has to be demolished and reconstructed.

8) Raniya UC Bridge

Horizontal clearance and Vertical clearance is available up to only class-I of waterway. Hence it has to be demolished and reconstructed.

9) Galteshwar Bridge

Neither of the horizontal clearance and vertical clearance is available for class-I of waterway. Hence it has to be demolished and reconstructed.

Following studies should be carried out prior to any development for broad view of implications:

i. Conduct a comprehensive geomorphic study and review and analyse sedimentation processes. The sedimentation study shall be aimed at developing an improved understanding of the significant sedimentation processes within the entire river basin. The major emphasis of this work shall be on analysing major channel morphology and the sedimentation phenomenon during the last 10 year period. As a minimum the sedimentation study shall:
   a. Document the variations in sediment transport (size and quantity);
   b. Identify and quantify all major sources of sediments (bed and banks, tributaries, etc.); and
   c. Locate degrading, aggrading, and stable reaches, and
   d. Establish the range of flows transporting the majority of sediments.
ii. Correlate the results of the sedimentation study with historical changes in the basin (channel improvements, land use, barrage and reservoir construction, etc.) enabling the development of a firm understanding of past and present sedimentation processes. This information shall be used to qualitatively analyse the effects of anticipated project features. This information shall be used to determine what may or may not work when designing navigation improvements. It shall include a determination of those reaches that are stable in depth and width and thus provide the basis for all subsequent preliminary design works. Included in

the analysis shall be a study of the bend-ways to determine the siltation and erosion process in the same and the minimum radius required for navigation of the reference vessels.

iii. Undertake various types of model studies to verify and / or enhance all design parameters. As a minimum this shall include a numerical model to produce detailed pictures of flow in the river system under current and future flow conditions and also the required flow/discharge to maintain 2.5 m LAD throughout the year with or without interventions like (barrages) in River.

iv. Non-destructive testing for bridges can be carried out.

LIST OF ABBREVIATIONS

CD	Chart Datum
BM	Benchmark/Local Reference Level
CH	Chainage
CRZ	Coastal Regulation Zone
CWC	Central Water Commission
DGPS	Differential Global Positioning Systems
ETS	Electronic Total Station
GPS	Global Positioning Systems
HC	Horizontal Control
HFL	Highest Flood Level
INT	International Hydrographic Organization
km	Kilometer
LAD	Least Available Depth
LBM	Local Bench Mark
m	Meter
MSL	Mean Sea Level
NTPC	National Thermal Power Corporation
RL	Reference Level
SBAS	Satellite-Based Augmentation System
SBES	Single Beam Echosounder
SD	Sounding Datum
TBC	Trimble Business Center
UTM	Universal Transverse Mercator
VC	Vertical Control
WGS	World Geodetic System

List of all Team Members (In-House & Empanelled Key Experts)

Sl. No.	Name of the Key Expert	Proposed Position
1.	Sh. D. N. Deshmukh	Team Leader
2.	Sh. Prakash Krishnaji Khare	Port Planning and Infrastructure Specialist
3.	Dr. Santosh K. Sati	GIS/Remote Sensing Expert
4.	Sh. R. N. Bansal	Floodplain Specialist
5.	Sh. Bidyadhyar Thakur	Hydrographic Expert
6.	Sh. Prasanta Kumar Kundu	Soil Engineer/Foundation Engineer
7.	Capt. Gary Vaz	Traffic Surveyor
8.	Sh. M Ganesan	Transport Economist

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CHAPTER – 1

INTRODUCTION

1.0 Introduction

1.1 Project Background and Summary of previous study

The Govt. of India desires to explore the commercial navigation potential on year round basis in inland waterways. Ministry of Shipping (MoS), Govt. of India had directed Inland Waterways Authority of India (IWAI) to identify the viable waterways in India for their phased development.

Accordingly, to make provisions for existing national waterways and to provide for the declaration of certain inland waterways to be national waterways and also to provide for the regulation and development of the said waterways for the purposes of shipping and navigation, National waterway act, 2016 has received the assent of the President on the 25th March, 2016 declaring a total of 111 National Waterways. All the River stretches/Canals have been divided in different clusters for carrying out the study. Four Rivers in Gujarat & Maharashtra viz. Mahi, Narmada, Tapi and Sabarmati has been identified in Cluster-8 for development of waterways

M/s Inland Waterways Authority of India (IWAI) has entrusted WAPCOS with the responsibility for preparation of two stages DPR for 4 inland waterways (Sabarmati, Mahi, Narmada and Tapi) in the states of Gujarat & Maharashtra. The lengths of all four river stretches under the feasibility studies (Stage-1) were as given below:

Sl. No.	Name of the River	Description of National Waterway	From:	Up to:
1.	Mahi River, Gujarat	248 km length of the river from Kadana Dam to confluence with Gulf of Khambhat near Kavi railway station **(National Waterway 66)**	23°18'22.35"N 73°49'37.45"E	22°10'34.71"N 72°30'36.31"E
2.	Narmada River, Gujarat & Maharashtra	227 km length of the river from Pandhariya to confluence of Narmada with Arabian Sea at Gulf of Khambhat **(National Waterway 73)**	21°57'10.37"N 74° 8'27.46"E	21°38'26.81"N, 72°33'28.24"E
3.	Sabarmati River, Gujarat	212 km length of the river from Barrage near Sadoliya to confluence with Gulf of Khambhat near Khambhat **(National Waterway 87)**	23°26'49.66"N 72°48'34.85"E	22°9'17.99"N 72°27'27.81"E

Sl. No.	Name of the River	Description of National Waterway	From:	Up to:
4.	Tapi River, Gujarat & Maharashtra	436 km length of the river from Hatnur Dam near Mangalwadi Long to confluence with Gulf of Khambhat (Arabian Sea) **(National Waterway 100)**	21°4'21.99"N 75°56'44.88"E	21°2'15.51"N, 72°39'29.63"E

Table 1.1: National Waterways in Gujarat & Maharashtra

The Google Map showing all river stretches is enclosed as **Figure 1.1**

Figure 1.1: Google Map showing four rivers in Gujarat & Maharashtra

Accordingly, WAPCOS Ltd. has undertaken the feasibility studies for 4 national waterways (Mahi, Narmada, Sabarmati and Tapi River) in Gujarat & Maharashtra during Stage-1. During the Stage -1 following activities were carried out

A. Reconnaissance Survey
B. Collection and Review of available data
C. Feasibility studies

After the Stage-1 (feasibility studies) following stretch of the rivers were found feasible for further detailed studies.

Sl. No.	Waterway Details	Stretch Details
1.	**River Mahi (NW-66)**	**246.989 km from Lat 22°10'34.71"N, Long 72°30'36.31"E**
2.	River Narmada (NW-73)	226.343 km from Lat 21°38'26.81"N, Long 72°33'28.24"E
3.	River Tapi (NW-100)	172.946 km from Lat 21°2'15.51"N, Long 72°39'29.63"E

1.2 Project Location / Details of Study Area

The total length of the river from Minda Village, in Dhar district to its outfall in the Gulf of Khambhat is 724 km. The length under consideration for present studies is detailed below:

246.989 km length of the river from Gulf of Khambhat (Arabian Sea) to Kadana Dam. (National Waterway 66)	**From: 22°10'34.71"N, 72°30'36.31"E**	**Up to: 246.989 km**

Present studies stretch passes through PanchMahal, Mahisagar, Anand and Vadodara district of Gujarat before falling into the Arabian Sea through the Gulf of Khambhat in Kheda district of Gujarat.

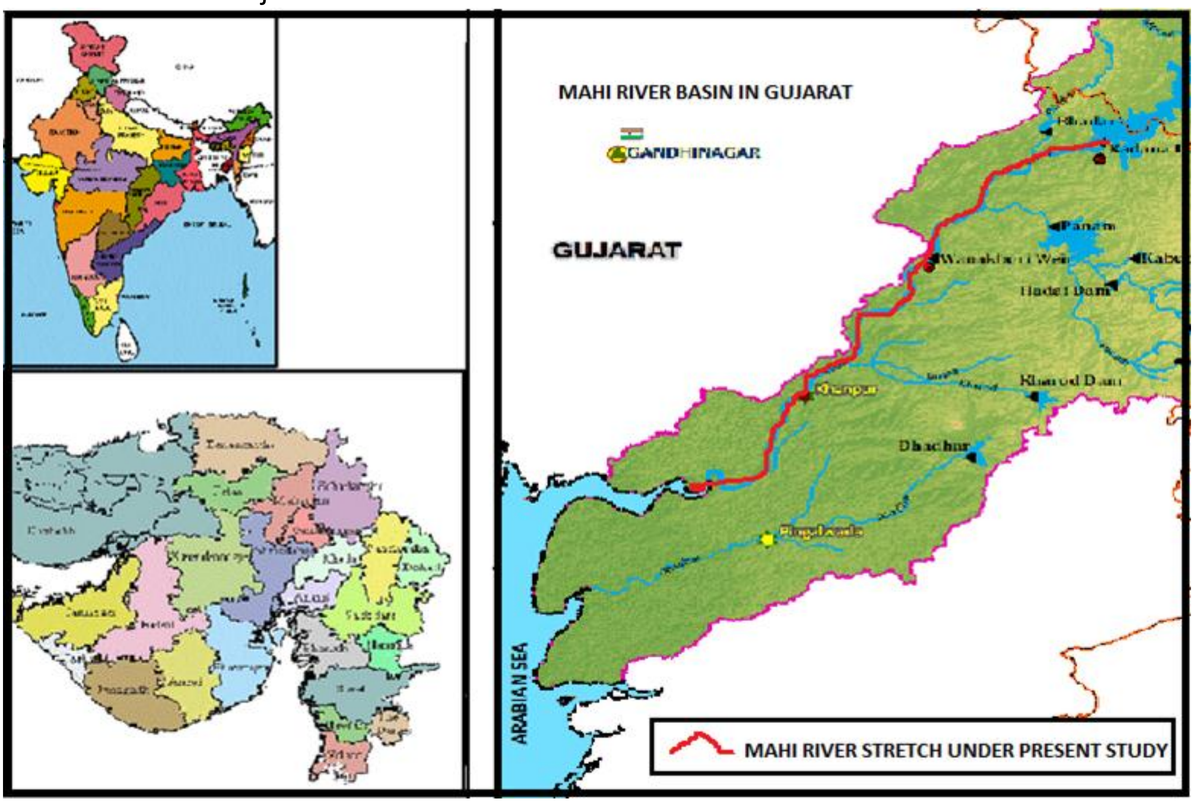


Figure 1.2: Project Location

1.3 Brief Scope of Work and Compliance statement

The brief scope of work is depicted as under:

A. Hydrographic Survey & Hydro-morphological survey
B. Traffic Survey & Techno economic feasibility
C. Geo-technical investigations
D. Preparation of Detailed Project Report

The Compliance statement is mentioned below:

A. Completed and given in Volume-III
B. Completed and mentioned in Volume-I Main Report
C. Geotechnical Investigations has been carried out at site and included in Volume-IV
D. DPR has been prepared after incorporating all studies mentioned in scope of work.

1.4 Brief Methodology & Approach

The detailed studies shall be carried out for all the feasible stretches.

The present studies consist of three inland waterways in rivers of Gujarat and Maharashtra having a total length of 646.278 kms:

1. Mahi River – 246.989 km
2. Narmada River – 226.343 km
3. Tapi River – 172.946 km

Stage -2 involves detailed surveys and studies; therefore it has been done in two tasks; First Field Surveys & Investigations and then Project Studies.

1. ***FIELD SURVEYS & INVESTIGATIONS:*** It comprises of the Data collection from site, Bathymetry, Topographic and Traffic Surveys, Measurements (Water level, gauge and current measurements), collection and analysis of water and soil samples, Benchmark construction.

2. ***PROJECT STUDIES:*** Project studies are carried out from the collected data, surveyed data and observed data to attain navigation and water transport facility in the potentially feasible stretches.

- STAGE -2 : Field Surveys & Investigations
  - Benchmark Establishment
  - Hydrographic survey & Topographical details
  - Water level (Gauge Measurements)
  - Current measurements
  - Water & soil samples
  - Traffic surveys
  - Geotechnical Surveys

- STAGE-2 : Project Studies
  - Analysis of Hydrographic survey data & Existing infrasturucture
  - Traffic Studies
  - Vessel analysis & dredging
  - Proposed location for terminals /Ports Loading and unloading terminals
  - Environmental Impact studies
  - Waterway crossings, Navigational Aids, Locks, communication facilities
  - River training, Shore /Bank protection measures
  - Locations requiring detailed geotech Investigations
  - Preliminary designs of proposed facilities & infrastructure , alternatives
  - Economic analysis & Financial Evaluation (EIRR, SWOT, CASH FLOWS, NPV)
  - Detailed Project Report , BOQ &Cost Estimates

CHAPTER – 2
WATERWAY/DETAILED HYDROGRAPHIC SURVEY

2.1 Hydrographic Survey

The detailed hydrographic and topographic survey task were undertaken from Gulf of Khambat Confluence (Lat 22°10'34.66"N, Long 72°30'36.13"E) to Kadana Dam, Kadana, Gujarat (Lat 23°18'21.09"N, Long 73°49'32.38"E) from 13 Dec 2016 to 25 Jan 2017.

2.1.1 Waterway in General and Hydro-morphological Characteristics

Mahi is the major inter-state west flowing river of India, rising from the northern slopes of Vindhyas in Madhya Pradesh at an elevation of about 500 m and draining into the Gulf of Khambhat. Initially the river flows northwards through Dhar and Jhabua districts of Madhya Pradesh and then turns left and passes through the Ratlam district of Madhya Pradesh, then turning to north-west, it enters the Banswara district of Rajasthan and flows in south-west directions and there after enters the PanchMahals district of Gujarat state. Then the river continuously flows in the same direction through Kheda district of Gujarat and finally falls into the Gulf of Khambhat in Arabian Sea. The Mahi river mouth is about 15 km wide at outfall.

The length under consideration for present studies is detailed below:

246.989 km length of the river from confluence of Mahiwith Arabian Sea at Gulf of Khambhat to Kadana Dam (National Waterway 66)	**From: 22°10'34.71"N72°30'36.31"E**	**Up to: 23°18'21.09"N 73°49'32.38"E**

2.1.2 Existing Hydrological / Topographical Reference levels

Trimble Spectra Precision GPS system was used in stand alone static observation mode for 24 hrs. at Lunawada for establishment of Horizontal Control in the survey area. Vertical Control was initially established from CWC Kadana to Lunawada Base by simultaneous GPS observation. Extension of the geodetic control was achieved by setting up new constructed BM pillars throughout the river stretches at every 10 km chainage approximately. Co-ordinates of such pillars were established by using DGPS in RTK mode. Details of these BM pillars along with station recovery descriptions are mentioned at Annexure 9. Values of CWC BM at Wanakbori & Khanpur were derived by RTK DGPS and the same was verified with the existing Benchmark value.

CWC Gauge at KadanaCh 246.9 km GPS Observation Baase at Lunawada

Kadana Dam TBM at Ch 246.9 km Kadana TBM 1 at Ch 244.2 km

Figure 2.1 : Trimble Spectra Precision GPS system

SR. NO	NAME OF BM	VALUE OF CWC BM (m)
01	KADANA CWC(Gauge Top Reading)	127.8
02	WANAKBORI CWC(Gauge Top Reading)	76.20
03	KHANPUR CWC MTBM	31.005

Table 2.1 : Trimble Spectra Precision GPS system

LEVELLING KADANA TBM TO CWC GAUGE, KADANA

LEVELLING BETWEEN KADANA CWC GAUGE TO KADANA TBM								
Leg No	Backsight Reading			Foresight Reading		Height of Instrument	Reduce Level	LOCATION
		Reading	Mean	Reading	Mean			
1	T	4.564		0.966			127.8	KADANA CWC GAUGE
	C	4.513	4.513	0.899	0.899	132.313	131.414	KADANA TBM
	B	4.462		0.832				

Table 2.2 : LEVELLING KADANA TBM TO CWC GAUGE, KADANA

2.1.3 Chart Datum / Sounding Datum

The datum for calculation of dredge volume needs to be adopted as per gradient of the river and the average water level observed for the river. The whole river stretch is having a tidal portion from Gulf of Khambat (Ch 0 km) to downstream of Umeta Check Dam (Ch 80 km) and non-tidal portion from upstream of Umeta Check Dam (Ch 80 km) to Kadana Dam (Ch 246.9 km). Sounding Datum of the tidal stretch was established from Dahej Port by simultaneous tidal observation. Sounding Datum for the non-tidal stretch was provided by IWAI.

Tidal Stretch

The tidal stretch of Mahi River is from 0 to 80 km chainage and the established chart datum value of 5.1 m below MSL at LNG Petronet terminal (approximately 50 km away from the CH 0 km) was considered for the entire tidal, sounding datum was transferred by simultaneous tidal observations at established & new gauges.

Non-Tidal Stretch

The non-tidal stretch of Mahi River is from Ch 80 km (U/S Umeta Check dam) to Ch 246.9 km (D/S Kadana Dam). The non-tidal stretches are sub-divided as downstream and upstream stretches of Wanakbori Dam and Tantroli Check Dam.

Downstream of Wanakbori Dam

This non-tidal stretch of Mahi River at downstream of Wanakbori Dam is from Ch 80.0 km to 172.6 km chainage. Narmada Canal is passing through the Mahi River at Ch 158 km. The difference between water level and Sounding Datum at CWC Khanpur & LAD being co-related for deriving the Sounding Datum for this portion.

Upstream of Wanakbori Dam & Downstream Tantroli Check Dam

This non-tidal stretch of Mahi River at upstream of Wanakbori Dam is from Ch 172.6 km to Ch 232 km. Sounding Datum at CWC Wanakbori Gauge being established by the average minimum water level. Difference between water level and Sounding Datum & LAD in the river portion being taken into consideration for deriving the Sounding Datum for this stretch.

Upstream of Tantroli Check Dam

This non-tidal stretch is from upstream of Tantroli Check Dam to downstream of Kadana Dam (Ch 232 km to Ch 246.9 km). Sounding Datum being derived by the LAD and difference between water level & established SD.

Dry/very shallow stretches

The topographic survey method was adopted and least MSL value on every kilometer (per-km Stretch) is accepted for establishing a sounding datum for dry/very shallow stretches of Mahi River.

Maximum and Minimum Water Level

Mahi River is having a primary source of water receiving from Kadana Dam. The CWC water level gauges present in the survey stretch of Mahi River are at Khanpur (Ch 109 km), Wanakbori (Ch 172.6 km) and Kadana (Ch 246.9 km). The Water Level data was provided by IWAI and the same being mentioned at Annexure 1. CD and MHWS/HFL/MWL value adopted at different gauges are as follows:-

Sl No	Water Level Gauge	Chainage (km)	CD/ SD Value	MHWS/HFL/ MWL
1	LNG Petronet Terminal, Dahej	-	-5.1	3.2
2	CWC Khanpur	109	8.76	26.82
3	CWC Wanakbori	172.6	63.16	75.89
4	CWC Kadana	246.9	115.32	127.78

Table 2.3 : Maximum and Minimum Water Level

Transfer of Sounding Datum.

Sounding Datum for tidal zone was transferred from the nearest port at Dahej. Simultaneous tidal observations were carried at Dahej Port, TP 1 (Ch 0 km), TP 2 (Ch 10 km), TP 3 (Ch 20 km) and TP 4 (Ch 30 km). Transfer of Sounding Datum for TP 5, TP 6, TP 7, TP 8 and TP 9 was done by single High Water & Low Water from Bhavnagar Port (Standard Port).

Attempts had been made for deployment during the full moon. But, the boat owners were not agreed to run their boats during the full/ new moon keeping the threat in mind and moreover, GMB was not agreed to give permission during that period. Hence, the transfer of Sounding Datum was carried out during the neap tide. Sounding datum transfer table for the tidal stretch being in the succeeding pages:-

Sl. No.	Tide Pole	Chainage (km)	Stretch	Zero of Tide Pole w.r.t MSL (m)	SD above Zero of TP (m)	SD w.r.t MSL (m)
1	TP-Mahi-01	0.1	0-5.15	-3.6	-2.1	-5.7
2	TP-Mahi-02	10.2	5.15-15.1	-1.7	-1.41	-3.11
3	TP-Mahi-03	20	15.1-26.3	-0.9	-1.05	-1.95
4	TP-Mahi-04	32.6	26.3-35.8	0.2	-1.29	-1.09
5	TP-Mahi-05	39	35.8-45.55	-0.06	0.31	-0.36
6	TP-Mahi-06	52.1	45.55-56.05	1.86	1.5	0.36
7	TP-Mahi-07	60	56.05-65.2	1.60	0.32	1.28
8	TP-Mahi-08	70.4	65.2-75.1	2.93	0.33	2.6
9	TP-Mahi-09	79.8	75.1-80.0	4.58	0.31	4.27

Table 2.4 : Transfer of Sounding Datum

TRANSFER OF SOUNDING DATUM AT TP 1 FROM DAHEJ PORT

TRANSFER OF SOUNDING DATUM **TP1** **H.533** **FROM DAHEJ PORT TO MAHI CH 0 KM**
(FOR SEMI DIURNAL TIDE)
Date and Time of 1st LW Observation at Established Gauge 20 JAN 2017 (Date)……1900 hrs(Time)

	Position Established Gauge	**Lat/ Long**	**21°41'0.54"N, 72°31'20.71"E**			**Position of New Gauge**	**Lat/ Long**	**22°11'0.94"N, 72°29'59.84"E**		
		Name	**Dahej Port**				**Name**	**TP 1**		
Sl No	**Height Above CD**			**Contribution For**		**Height Above Zero of Gauge**			**Contribution For**	
	HW	**LW**	**Factor**	**HWs**	**LWs**	**HW**	**LW**	**Factor**	**HWs**	**LWs**
a	-	2.24	1	-	2.24	-	0.324	1	-	0.324
b	7.38	-	1	7.38	-	5.28	-	1	5.28	-
c	-	3.66	3	-	10.98	-	1.572	3	-	4.716
d	6.56	-	2	13.12	-	4.102	-	2	8.204	-
e	-	2.68	3	-	8.04	-	0.28	3	-	0.84
f	7.31	-	1	7.31	-	5.12	-	1	5.12	-
g	-	3.63	1	-	3.63	-	1.483	1	-	1.483
Sum of Contribution				27.81	24.89		Sum of Contribution		18.604	7.363
Observed MHW				6.953			Observed MHW		4.651	
Observed MLW				3.111			Observed MLW		0.92038	
Observed Mean Range-(R)				3.841			Observed Mean Range-(r)		3.73063	
Observed Mean Level(M')				5.032			Observed Mean Level(m')		2.78569	

CALCULATION OF SOUNDING DATUM AT NEW GAUGE
Where The True Spring ML(M)' at Established Gauge is known
From Hydrographic Chart

MHWS =		**8.8**
MLWS =		**1.4**
True Spring ML (M) =		**5.1**

SD = m'-(M'-M)-M*(r/R)

SD = -2.099311483 Mtrs below zero of Gauge

RL of '0' of Gauge is (m) = -3.6

SD wrt MSL(mtrs)= -5.70

Where The True Spring ML(M)' at Established Gauge is not known

SD= m'-((M*r)/R)

SD= Mtrsabobe/ below zero of Gauge

Table 2.5 : TRANSFER OF SOUNDING DATUM AT TP 1 FROM DAHEJ PORT

Established Sounding Datum at TP 1 is -5.7 m wrt Mean Sea Level at Ch 0 km.

TRANSFER OF SOUNDING DATUM AT TP 2 FROM DAHEJ PORT

TRANSFER OF SOUNDING DATUM TP2 H.533 FROM DAHEJ PORT TO MAHI CH 10 KM

(FOR SEMI DIURNAL TIDE)

Date and Time of 1st LW Observation at Established Gauge... 20 JAN 2017 (Date) 1840 HRS..(Time)

	Position Established Gauge	Lat/ Long	21°41'0.54"N, 72°31'20.71"E			Position of New Gauge	Lat/ Long	22°13'45.72"N, 72°35'11.70"E		
		Name	Dahej Port				Name	TP 2		
	Height Above CD			Contribution For		Height Above Zero of Gauge			Contribution For	
Sl No	HW	LW	Factor	HWs	LWs	HW	LW	Factor	HWs	LWs
a	-	3.11	1	-	3.11	-	0.426	1	-	0.426
b	7.18	-	1	7.18	-	4.46	-	1	4.46	-
c	-	2.24	3	-	6.72	-	1.168	3	-	3.504
d	7.38	-	2	14.76	-	3.559	-	2	7.118	-
e	-	3.66	3	-	10.98	-	0.458	3	-	1.374
f	6.56	-	1	6.56	-	4.32	-	1	4.32	-
g	-	2.68	1	-	2.68	-	1.08	1	-	1.08
Sum of Contribution				28.5	23.49		Sum of Contribution		15.898	6.384
Observed MHW				7.125			Observed MHW		3.9745	
Observed MLW				2.936			Observed MLW		0.798	
Observed Mean Range-(R)				4.189			Observed Mean Range-(r)		3.1765	
Observed Mean Level(M')				5.031			Observed Mean Level(m')		2.38625	

CALCULATION OF SOUNDING DATUM AT NEW GAUGE

Where The True Spring ML(M)' at Established Gauge is known

From Hydrographic Chart

MHWS =		**8.8**
MLWS =		**1.4**
True Spring ML (M) =		**5.1**

SD = m'-(M'-M)-M*(r/R)

SD = -1.411913048 Mtrsbelow zero of Gauge

RL OF '0' OF GAUGE IS(m) = -1.7

SD wrt MSL(mtrs)= -3.11

Where The True Spring ML(M)' at Established Gauge is not known

SD= m'-((M*r)/R)

SD= Mtrsabobe/ below zero of Gauge

Table 2.6 : TRANSFER OF SOUNDING DATUM AT TP 2 FROM DAHEJ PORT

Established Sounding Datum at new gauge TP 2 is -3.11 m wrt Mean Sea Level

TRANSFER OF SOUNDING DATUM AT TP 3 FROM DAHEJ PORT

TRANSFER OF SOUNDING DATUM TP3 H.533 FROM DAHEJ PORT TO MAHI CH 20 KM

(FOR SEMI DIURNAL TIDE)

Date and Time of 1st LW Observation at Established Gauge...20 Jan 2017 (Date)...1730 hrs.(Time)

Sl No	Position Established Gauge	Lat/ Long	21°41'0.54"N, 72°31'20.71"E		Position of New Gauge	Lat/ Long	22°12'27.63"N, 72°40'24.18"E			
		Name	Dahej Port			Name	TP 3			
	Height Above CD			Contribution For		Height Above Zero of Gauge			Contribution For	
	HW	LW	Factor	HWs	LWs	HW	LW	Factor	HWs	LWs
a	-	3.11	1	-	3.11	-	0.34	1	-	0.34
b	7.18	-	1	7.18	-	3.96	-	1	3.96	-
c	-	2.24	3	-	6.72	-	1.25	3	-	3.75
d	7.38	-	2	14.76	-	3.099	-	2	6.198	-
e	-	3.66	3	-	10.98	-	0.42	3	-	1.26
f	6.56	-	1	6.56	-	3.826	-	1	3.826	-
g	-	2.68	1	-	2.68	-	1.142	1	-	1.142
Sum of Contribution				28.5	23.49		Sum of Contribution		13.984	6.492
Observed MHW				7.125			Observed MHW		3.496	
Observed MLW				2.936			Observed MLW		0.8115	
Observed Mean Range-(R)				4.189			Observed Mean Range-(r)		2.6845	
Observed Mean Level(M')				5.031			Observed Mean Level(m')		2.15375	

CALCULATION OF SOUNDING DATUM AT NEW GAUGE

Where The True Spring ML(M)' at Established Gauge is known

From Hydrographic Chart

MHWS =		**8.8**
MLWS =		**1.4**
True Spring ML (M) =		**5.1**

SD = m'-(M'-M)-M*(r/R)

SD = -1.045379924 Mtrsabovezero of Gauge

RL OF '0' OF GAUGE IS(m) = -0.9

SD wrt MSL(mtrs)= -1.95

Where The True Spring ML(M)' at Established Gauge is not known

SD= m'-((M*r)/R)

SD= Mtrsabobe/ below zero of Gauge

Table 2.7 : TRANSFER OF SOUNDING DATUM AT TP 3 FROM DAHEJ PORT

Established Sounding Datum at new gauge TP 3 is -1.95 m wrt Mean Sea Level

TRANSFER OF SOUNDING DATUM AT TP 4 FROM DAHEJ PORT

TRANSFER OF SOUNDING DATUM **P4** **H.533** **FROM DAHEJ PORT TO MAHI CH 32.6 KM**

(FOR SEMI DIURNAL TIDE)

Date and Time of 1st LW Observation at Established Gauge…20 Jan 2017 …(Date)…1750 hrs..(Time)

Sl No	Position Established Gauge	Lat/ Long	21°41'0.54"N, 72°31'20.71"E			Position of New Gauge	Lat/ Long	22°14'43.76"N, 72°47'11.95"E		
		Name	Dahej Port				Name	TP 4		
	Height Above CD			Contribution For		Height Above Zero of Gauge			Contribution For	
	HW	LW	Factor	HWs	LWs	HW	LW	Factor	HWs	LWs
a	-	3.11	1	-	3.11	-	0.075	1	-	0.075
b	7.18	-	1	7.18	-	2.079	-	1	2.079	-
c	-	2.24	3	-	6.72	-	0.086	3	-	0.258
d	7.38	-	2	14.76	-	2.055	-	2	4.11	-
e	-	3.66	3	-	10.98	-	0.114	3	-	0.342
f	6.56	-	1	6.56	-	2.328	-	1	2.328	-
g	-	2.68	1	-	2.68	-	0.113	1	-	0.113
Sum of Contribution				28.5	23.49		Sum of Contribution		8.517	0.788
Observed MHW				7.125			Observed MHW		2.12925	
Observed MLW				2.936			Observed MLW		0.0985	
Observed Mean Range-(R)				4.189			Observed Mean Range-(r)		2.03075	
Observed Mean Level(M')				5.031			Observed Mean Level(m')		1.11388	

CALCULATION OF SOUNDING DATUM AT NEW GAUGE

Where The True Spring ML(M)' at Established Gauge is known

From Hydrographic Chart

MHWS =		**8.8**
MLWS =		**1.4**
True Spring ML (M) =		**5.1**

SD = m'-(M'-M)-M*(r/R)

SD = -1.289283572 Mtrsabobe/ below zero of Gauge

RL OF '0' OF GAUGE IS(m) = 0.2

SD wrt MSL(mtrs)= -1.09

Where The True Spring ML(M)' at Established Gauge is not known

SD= m'-((M*r)/R)

SD= Mtrsabobe/ below zero of Gauge

Table 2.8 : TRANSFER OF SOUNDING DATUM AT TP 4 FROM DAHEJ PORT

Established Sounding Datum at new gauge TP 4 is -1.09 m wrt Mean Sea Level

Sounding Datum transfer at TP 5 to TP 9 was established from Bhavnagar Port (Standard Port) with single High & Low Water.

TRANSFER OF SOUNDING DATUM AT TP 5 FROM BHAVNAGAR PORT

OBSERVED HIGH WATER(A)	3.11
OBSERVED LOW WATER(B)	0.45
MTL, M =(A+B)/2	1.78
OBSERVED TIDE RANGE AT NEW GAUGE R= (A-B)	2.67
PREDICTED HIGH WATER AT STANDARD PORT (C)	11.24
PREDICTED LOW WATER AT STANDARD PORT (D)	1.17
PREDICTED TIDE RANGE AT STANDARD PORT R'= (C-D)	10.07
RANGE RATIO r0 = R/R'	0.27
PREDICTED RANGE AT STANDARD PORT WHEN TIDE FALL NEAR TO CD (R")	11.10
EQUIVALET RANGE AT TIDE POLE EqR=(r0 X R")	2.94
EQUIVALENT HALF RANGE (EqR/2)	1.47
DATUM AT NEW GAUGE = (M-EqR/2)	0.31

Table 2.9 : TRANSFER OF SOUNDING DATUM AT TP 5 FROM DAHEJ PORT

Sounding Datum is 0.31m above the 0 of the tide pole.
Zero of the Tide Pole was kept at -0.056 m wrt MSL.
Sounding Datum for TP 5 will be (-0.056-0.31)m or -0.36 m wrt Mean Sea Level.

TRANSFER OF SOUNDING DATUM AT TP 6 FROM BHAVNAGAR PORT

OBSERVED HIGH WATER(A)	4.25
OBSERVED LOW WATER(B)	1.60
MTL, M =(A+B)/2	2.92
OBSERVED TIDE RANGE AT NEW GAUGE R= (A-B)	2.65
PREDICTED HIGH WATER AT STANDARD PORT (C)	11.60
PREDICTED LOW WATER AT STANDARD PORT (D)	1.30
PREDICTED TIDE RANGE AT STANDARD PORT R'= (C-D)	10.30
RANGE RATIO r0 = R/R'	0.26
PREDICTED RANGE AT STANDARD PORT WHEN TIDE FALL NEAR TO CD (R")	11.10
EQUIVALET RANGE AT TIDE POLE EqR=(r0 X R")	2.85
EQUIVALENT HALF RANGE (EqR/2)	1.43
DATUM AT NEW GAUGE = (M-EqR/2)	1.50

Table 2.10 : TRANSFER OF SOUNDING DATUM AT TP 6FROM BHAVNAGAR PORT

Sounding Datum is 1.5m above the 0 of the tide pole.
Zero of the Tide Pole was kept at 1.855 m wrt MSL.
Sounding Datum for TP 5 will be (1.855-1.50)m or -0.36 m wrt Mean Sea Level.

TRANSFER OF SOUNDING DATUM AT TP 7 FROM BHAVNAGAR PORT

OBSERVED HIGH WATER(A)	3.45
OBSERVED LOW WATER(B)	0.85
MTL, M =(A+B)/2	2.15
OBSERVED TIDE RANGE AT NEW GAUGE R= (A-B)	2.60
PREDICTED HIGH WATER AT STANDARD PORT (C)	9.42
PREDICTED LOW WATER AT STANDARD PORT (D)	1.56
PREDICTED TIDE RANGE AT STANDARD PORT R'= (C-D)	7.86
RANGE RATIO r0 = R/R'	0.33
PREDICTED RANGE AT STANDARD PORT WHEN TIDE FALL NEAR TO CD (R")	11.10
EQUIVALET RANGE AT TIDE POLE EqR=(r0 X R")	3.66
EQUIVALENT HALF RANGE (EqR/2)	1.83
DATUM AT NEW GAUGE = (M-EqR/2)	0.32

Table 2.11 : TRANSFER OF SOUNDING DATUM AT TP 7FROM BHAVNAGAR PORT

Sounding Datum is 0.32 m above the 0 of the tide pole.
Zero of the Tide Pole was kept at 1.6 m wrt MSL.
Sounding Datum for TP 5 will be (1.6-0.32) m or 1.28 m wrt Mean Sea Level.

TRANSFER OF SOUNDING DATUM AT TP 8 FROM BHAVNAGAR PORT

OBSERVED HIGH WATER(A)	3.23
OBSERVED LOW WATER(B)	0.54
MTL, M =(A+B)/2	1.89
OBSERVED TIDE RANGE AT NEW GAUGE R= (A-B)	2.69
PREDICTED HIGH WATER AT STANDARD PORT (C)	11.16
PREDICTED LOW WATER AT STANDARD PORT (D)	1.56
PREDICTED TIDE RANGE AT STANDARD PORT R'= (C-D)	9.60
RANGE RATIO r0 = R/R'	0.28
PREDICTED RANGE AT STANDARD PORT WHEN TIDE FALL NEAR TO CD (R")	11.10
EQUIVALET RANGE AT TIDE POLE EqR=(r0 X R")	3.11
EQUIVALENT HALF RANGE (EqR/2)	1.55
DATUM AT NEW GAUGE = (M-EqR/2)	0.33

Table 2.12 : TRANSFER OF SOUNDING DATUM AT TP 8 FROM BHAVNAGAR PORT

Sounding Datum is 0.33 m above the 0 of the tide pole.
Zero of the Tide Pole was kept at 2.93 m wrt MSL.
Sounding Datum for TP 5 will be (2.93-0.33) m or 2.60 m wrt Mean Sea Level.

TRANSFER OF SOUNDING DATUM AT TP 9 FROM BHAVNAGAR PORT

OBSERVED HIGH WATER(A)	3.24
OBSERVED LOW WATER(B)	0.46
MTL, M =(A+B)/2	1.85
OBSERVED TIDE RANGE AT NEW GAUGE R= (A-B)	2.78
PREDICTED HIGH WATER AT STANDARD PORT (C)	11.30
PREDICTED LOW WATER AT STANDARD PORT (D)	1.29
PREDICTED TIDE RANGE AT STANDARD PORT R'= (C-D)	10.01
RANGE RATIO r0 = R/R'	0.28
PREDICTED RANGE AT STANDARD PORT WHEN TIDE FALL NEAR TO CD (R")	11.10
EQUIVALET RANGE AT TIDE POLE EqR=(r0 X R")	3.08
EQUIVALENT HALF RANGE (EqR/2)	1.54
DATUM AT NEW GAUGE = (M-EqR/2)	0.31

Table 2.13 : TRANSFER OF SOUNDING DATUM AT TP 9FROM BHAVNAGAR PORT

Sounding Datum is 0.31 m above the 0 of the tide pole.
Zero of the Tide Pole was kept at 4.58 m wrt MSL.
Sounding Datum for TP 5 will be (4.58-0.31) m or 4.27 m wrt Mean Sea Level.

2.2 Existing Cross Structures

2.2.1 Bridges

There are 19 in no’s bridges present across the river. Details are tabulated below:-

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL/MHWS
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Gambhira Bridge	69.3	22°16'4.32"N 72°59'46.09"E	22°15'38.10"N 72°59'58.20"E	293520.065 2463845.24	293856.197 2463034.451	872.6	10.29	23	38.11	11.630
Umeta Bridge	81.37	22°20'29.98"N 73° 3'3.17"E	22°20'36.20"N 73° 3'25.59"E	299268.974 2471943.882	299912.383 2472126.77	669.13	10.26	19	35.64	-2.950
Under Construction Bridge	86.15	22°22'56.90"N 73° 3'32.65"E	22°22'42.24"N 73° 3'45.54"E	300169.83 2476451.56	300532.86 2475995.68	588.29	-	13	44.62	-
Vasad Rail Bridge	92.86	22°26'21.38"N 73° 4'14.19"E	22°26'9.45"N 73° 4'28.00"E	301439.218 2482726.912	301829.364 2482354.12	548.57	31.41	16	30.9	3.491
Vasad NH-8 Bridge	93.1	22°26'28.96"N 73° 4'19.96"E	22°26'15.09"N 73° 4'34.42"E	301607.667 2482957.175	302015.633 2482525.21	594	60.12	16	35	4.279
Ahmedabad Vadodara Expressway Bridge (NE1)	98.58	2°28'54.54"N 73° 5'14.58"E	22°28'56.53"N 73° 5'34.99"E	303226.094 2487415.236	303810.942 2487469.396	587.287	27.84	14	41.68	8.849
Poicha Bridge	116.71	22°36'12.12"N 73°10'48.04"E	22°35'57.02"N 73°10'54.96"E	312922.54 2500756.337	313114.573 2500289.941	504.33	7.36	8	45.83	11.341
Raniya UC Bridge	128.65	22°40'8.15"N 73°15'56.12"E	22°40'4.56"N 73°16'12.52"E	321805.72 2507911.19	322272.92 2507795.21	520.00	-	14	40.00	1.57
Galteshwar Bridge (SH-63)	142.62	2°46'58.88"N 3°16'33.50"E	22°46'42.45"N 73°16'35.18"E	323019.542 2520532.104	323061.754 2520026.2	504.42	6.9	34	14.84	-7.066
Sevaliya Rail Bridge	153	22°48'34.00"N 3°21'27.81"E	22°48'29.28"N 73°21'55.94"E	331445.58 2523362.21	332246.75 2523208.37	831.59	18.26	18	46.20	1.389
Sevaliya Broken Bridge	153.2	22°48'43.70" 73°21'32.34"	22°48'33.32" 73°21'53.12"	331578.13 2523659.04	332167.06 2523333.29	675.31	6.48	66	10.52	NA
Sevaliya Bridge	153.23	22°48'46.03"N 73°21'31.33"E	22°48'33.91"N 73°21'55.67"E	331550.26 2523731.15	332239.98 2523350.64	792.97	12.18	20	38.95	2.32
Shanipur Bridge(NH47)	155.04	22°49'33.86"N 73°22'7.51"E	22°49'20.30"N 73°22'29.20"E	332598.06 2525192.88	333211.78 2524766.95	748.13	22	25	30	1.51
Narmada Canal	158	22°51'0.07"N 73°22'47.58"E	22°50'52.10"N 73°23'6.46"E	333769.52 2527829.91	334305.63 2527579.77	601	76.55	23	25.09	2.779
Thana Savli Bridge	188.1	23° 3'16.22"N 73°28'19.44"E	23° 3'2.08"N 73°28'24.03"E	343465.53 2550371.23	343591.15 2549934.75	430.95	6.82	10	44.16	5.929
Hadod Bridge	203.6	23° 9'6.46"N 73°32'52.99"E	23° 9'1.74"N 73°33'3.90"E	351358.69 2561064.059	351667.286 2560916.53	342.05	6.79	20	16.87	-3.602
Limbrodra Bridge	212.25	3°12'34.80"N 73°35'59.67"E	23°12'21.87"N 73°36'4.65"E	356729.53 2567420.344	356867.729 2567021.198	432.55	24.18	10	41.82	11.619
Tantroli Bridge	231.22	3°15'42.99"N 3°43'30.67"E	23°15'34.67"N 73°43'35.25"E	369601.28 2573090.216	369729.896 2572833.881	286.79	8.01	17	16.94	-4.391
Kadana Bridge	244.6	23°17'10.12"N 3°49'45.74"E	23°17'8.32"N 73°49'56.60"E	380281.923 2575680.97	380589.983 2575622.594	313.42	6.26	15	20.04	-6.271

Table 2.14 : Bridges

2.2.2 Electric Lines / Communication Lines

Details of HT lines and electric pole are tabulated below:-

Sl No.	Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
			GLOBAL		UTM				
			Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
1	HT LINE	50.87	22°15'48.2808"N	72°55'14.5648"E	285739	2463457	-	314	Under Construction
2	HT LINE	51.83	22°16'16.2360"N	72°55'03.1400"E	285424	2464322	17	350	Complete
3	HT LINE	68.93	22°15'49.2468"N	72°59'39.2821"E	293318	2463384	16.5	350	Complete
4	HT LINE	69.42	22°15'55.9022"N	72°59'54.4274"E	293898	2463581	19.1	650	Complete
5	HT LINE	73.71	22°17'25.1478"N	73°01'44.1580"E	296932	2466287	21.2	650	Complete
6	HT LINE	98.87	22°29'02.7729"N	73°05'21.5974"E	303429	2487665	19.6	650	Complete
7	HT LINE	99	22°29'08.1626"N	73°05'20.4727"E	303400	2487832	18.5	591	Complete
8	HT LINE	99.25	22°29'14.9177"N	73°05'18.5722"E	303348	2488041	18.6	350	Complete
9	HT LINE	104.59	22°31'04.0490"N	73°07'09.0990"E	306549	2491357	20.6	538	Complete
10	HT LINE	108.46	22°32'29.3546"N	73°08'43.2458"E	309272	2493948	19.7	300	Complete
11	HT LINE	138.77	22°45'20.1195"N	73°15'25.4080"E	321041	2517517	20.1	734	Complete
12	HT LINE	140.45	22°46'14.4106"N	73°15'28.9758"E	321163	2519186	19.6	645	Complete
13	HT LINE	157.58	22°50'47.0583"N	73°22'42.7773"E	333628	2527431	18.9	523	Complete
14	ELECTRIC LINE	188.04	23°03'12.8338"N	73°28'18.5395"E	343438	2550267	12.5	300	Complete
15	ELECTRIC LINE	188.14	23°03'13.4896"N	73°28'22.2358"E	343543	2550285	10.8	300	Complete
16	HT LINE	188.2	23°03'13.9966"N	73°28'24.2065"E	343600	2550301	18.7	750	Complete
17	HT LINE	188.37	23°03'15.5222"N	73°28'29.6845"E	343756	2550346	20.1	675	Complete
18	HT LINE	189.75	23°03'30.9227"N	73°29'17.0932"E	345111	2550806	22.5	550	Complete
19	ELECTRIC LINE	199.65	23°06'55.6900"N	73°32'47.0821"E	351150	2557044	12.6	230	Complete
20	HT LINE	203.81	23°09'11.0655"N	73°33'03.3393"E	351654	2561202	17.9	650	Complete
21	ELECTRIC LINE	212.18	23°12'24.5471"N	73°36'02.9876"E	356820	2567104	13.2	250	Complete
22	HT LINE	214.22	23°12'18.4364"N	73°37'07.5810"E	358655	2566898	19.2	600	Complete
23	HT LINE	224.95	23°15'08.2955"N	73°40'39.9762"E	364741	2572066	20.5	700	Complete
24	ELECTRIC LINE	231.1	23°15'36.8893"N	73°43'30.3257"E	369590	2572902	10.5	350	Complete
25	ELECTRIC LINE	231.15	23°15'37.7271"N	73°43'31.7890"E	369631	2572928	12.5	350	Complete
26	ELECTRIC LINE	231.32	23°15'40.6710"N	73°43'36.6148"E	369770	2573018	11.3	350	Complete

Table 2.15 : High Tension Lines Details

2.2.3 Pipe Lines / Cables

There is no pipeline/cable in the present study stretch of Mahi River.

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

There are two Check Dam viz. Umeta and Tantroli Check dam at Ch 80 km and Ch 232 km respectively. Two dams are also relevant in this waterway and they are Kadana Dam at Ch 246.9 km and Wanakbori Dam at Ch 172.6 km.

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	HT wrt MSL	Present Condition
		Lt Bank	Rt Bank	Lt Bank	Rt Bank				
Kadana Dam	246.9	23°18'12.90"N 73°49'21.16"E	23°18'41.02"N 73°50'1.32"E	379598.26 2577616.43	380746.00 2578472.00	1551	10.54	131.414	Completed
Tantroli Check Dam	232	23°15'57.20"N 73°43'54.85"E	23°15'47.76"N 73°44'1.41"E	370292.67 2573521.46	370476.96 2573229.20	350	77.49	84.8	Completed
Wanakbori Dam	172.6	22°56'59.60"N 73°25'30.60"E	22°56'44.84"N 73°25'53.52"E	338535.41 2538838.71	339183.52 2538377.23	795.52	16.52	66.77	Completed
Umeta Check Dam	80	22°19'49.28"N 73° 3'14.22"E	22°19'50.94"N 73° 3'33.83"E	299568.80 2470687.25	300130.13 2470731.86	571	12.58	8.034	Completed

Table 2.16 : Dam, Weir and Barrages

Figure 2.2 : Umeta Check Dam CH 80 km

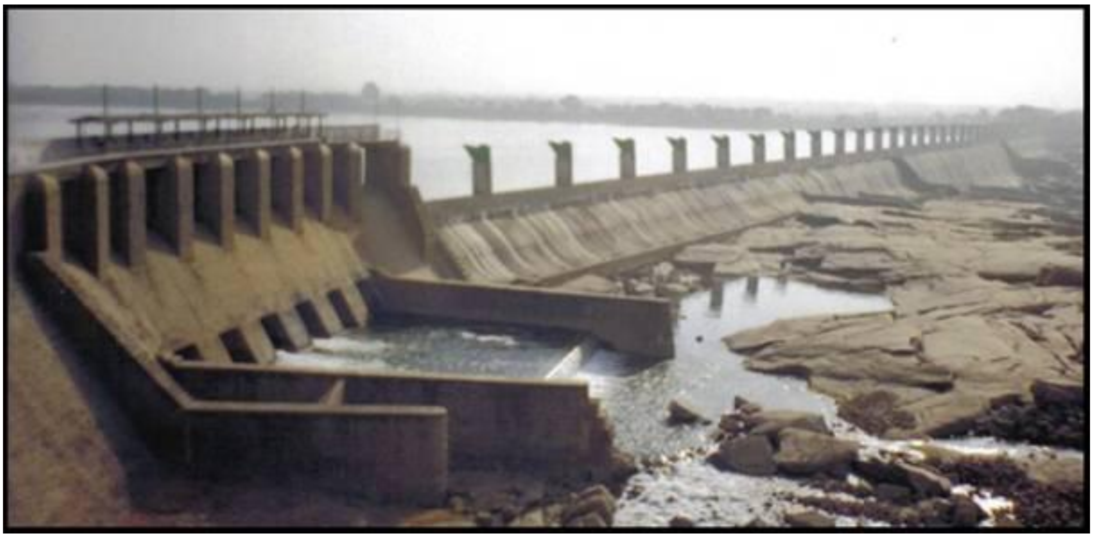


Figure 2.3 : Wanakbori Dam at Ch. 172.6 km

Figure 2.4 : Tantroli Check Dam at Ch. 232 km

Figure 2.5 : Kadana Dam CH 246.9 km

Details of Locks

There are no Locks present in the entire survey stretch of Mahi River.

Details of Aqueducts

There is only one aqueduct i.e. Mahi Aqueduct which is passing across the Mahi River. Details being tabulated below:-

Salient Features of Mahi Aqueduct			
Purpose	Irrigation		
Location		Chainage	158 km
Length of Aqueduct	602.50 m	Width of canal at approaches	64.40 m
Height of Aqueduct	34.50 m	Flow per Second	1008 m3
Largest river bed level	EL 42.98 m	Depth of flow	6.10 m
Lowest foundation level of piers	EL 39.69 m	Top of Aqueduct	EL 77.48 m
Sill level of duct - Downstream	EL 67.49 m	Sill level of duct - Upstream	EL 68.34 m

Table 2.17 : Salient Features of Mahi Aqueduct

Details of Other Cross Structures.

There are total 19 water-intake in the river corridor. Details are being tabulated below:-

SL No.	Structure Name	Ch (km)	Position (Lat, Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
			Start	End	Start	End					
1	Water Intake	91.6	22°25'38.6219N"	22°25'39.2601N"	301292.679	301227.74	63	10	3	40	4
			073°04'9.6663 E"	073°04'7.3866 E"	2481412.398	2481432.87					
2	Water Intake	92.6	22°26'08.8410N"	22°26'3.26120N"	301511.12	301708.68	260	12	5	45	3.2
			073°04'16.8871 E"	073°04'23.8729 E"	2482339.29	2482165.09					
3	Water Intake	93.7	22°26'37.0968N"	22°26'30.1800N"	302138.22	302378.9	330	12	7	50	2.9
			073°04'38.4276 E"	073°04'46.94 E"	2483200.54	2482984.66					
4	Water Intake	94.5	22°26'56.9379N"	22°26'48.7710N"	302680.63	302928.46	360	10	8	45	4.2
			073°04'57.1242 E"	073°05'5.904 E"	2483804.01	2483549.59					
5	Water Intake	95.03	22°27'11.2787N"	22°26'59.7912N"	303044.42	303429.18	517	12	11	50	1.8
			073°05'9.6505 E"	073°05'23.2649 E"	2484240.56	2483882.24					
6	Water Intake	96.1	22°27'34.5178N"	22°27'36.1086N"	303628.2	303946.6	340	10	7	45	2.9
			073°05'29.75 E"	073°05'40.8648 E"	2484948.07	2484992.96					
7	Water Intake	96.2	22°27'38.3977N"	22°27'38.2586N"	303890.31	303984.716	100	8	1	45	-
			073°05'38.8647 E"	073°05'42.1688 E"	2485064.1	2485058.618					
8	Water Intake	96.9	22°28'00.2439N"	22°28'01.0851N"	303535.03	303882.29	350	6	8	45	3.1
			073°05'26.1387 E"	073°05'38.2738 E"	2485740.72	2485762.18					
9	Water Intake	98.3	22°28'44.3348N"	22°28'45.6285N"	303551.4	303747.82	220	10	4	40	1.8
			073°05'26.1067 E"	073°05'32.9601 E"	2487096.97	2487134.27					
10	Water Intake	99.6	22°29'27.4633N"	22°29'27.0000N"	303509.43	303677.51	170	8	3	40	-
			073°05'24.0467 E"	073°05'29.9331 E"	2488424.36	2488408.22					
11	Water Intake	101.2	22°30'18.8865N"	22°30'16.4507N"	303755.76	303886.99	125	6	2	40	-
			073°05'31.9591 E"	073°05'36.584 E"	2490003.26	2489926.65					
12	Water Intake	102.2	22°30'49.8184N"	22°30'31.2342N"	304101.51	304332.87	635	10	12	45	2.5
			073°05'43.6325 E"	073°05'51.9822 E"	2490950.48	2490375.79					
13	Water Intake	104.07	22°30'53.4976N"	22°30'55.6170N"	306119.122	306090.124	65	8	0	60	-
			073°06'54.1799 E"	073°06'53.1364 E"	2491038.113	2491103.684					
14	Water Intake	116.63	22°35'58.9820N"	22°35'57.1911N"	313016.61	313039.085	45	6	0	45	-
			073°10'51.5272 E"	073°10'52.3378 E"	2500350.59	2500295.215					
15	Water Intake	153.04	22°48'36.6665N"	22°48'36.7332N"	331500.59	331466.476	33	6	0	33	-
			073°21'29.7073 E"	073°21'28.5103 E"	2523443.63	2523446.061					
16	Water Intake	162.6	22°52'59.8375N"	22°52'59.2266N"	332576.61	332541.343	45	6	0	45	-
			073°22'4.3021 E"	073°22'3.0718 E"	2531527.34	2531508.942					
17	Water Intake	168.15	22°55'27.8056N"	22°55'27.4702N"	335198.513	335209.567	35	8	0	35	-
			073°23'34.5565 E"	073°23'34.9486 E"	2536050.273	2536039.829					
18	Water Intake	207.3	23°10'51.3145N"	23°10'51.3746N"	353297.39	353308.472	30	6	0	30	-
			073°34'0.0603 E"	073°34'0.4494 E"	2564270.27	2564272.014					
19	Water Intake	223.85	23°15'06.3644N"	23°15'07.2482N"	363851.9	363845.978	30.2	8.34	0	NA	-
			073°40'8.7171 E"	073°40'8.5 E"	2572015.16	2572042.401					

Table 2.18 : Details of Other Cross Structures

2.3 Bends

There are around 54 nos. of bends noticed in river Mahi in a length of 246.989 km.

2.3.1 Radius of Curvatures

The bends along with radius of curvature are tabulated below:

Sr. No.	Chainage (in Km)	Radius of Curvature(in m)
1	4.8	400
2	5.4	1050
3	14.1	820
4	23.2	980
5	36.1	750
6	39.8	1550
7	49	1020
8	54	1200
9	57.5	1150
10	64.7	1050
11	78.2	1350
12	83.	2020
13	88.5	2100
14	91.6	1950
15	95.6	1490
16	101.8	870
17	113.6	850
18	117.7	700
19	121.2	300
20	124	750
21	124.8	580
22	128.9	2200
23	139.6	1100
24	141.5	680
25	146.7	650
26	147.7	620
27	152	380
28	153.95	510
29	154.4	650
30	156.4	630
31	160.8	640
32	163	1200
33	176.6	900
34	186	1100
35	190.6	790
36	193.9	980

Sr. No.	Chainage (in Km)	Radius of Curvature(in m)
37	197	1180
38	200	1190
39	203.4	950
40	205.7	350
41	206	250
42	206.3	380
43	208	410
44	213	1200
45	215.5	1050
46	219.4	800
47	222.8	1200
48	225.5	695
49	228	940
50	230.5	780
51	236.2	910
52	237.6	800
53	240.2	950
54	242.6	780

Table 2.19 : Radius of curvatures

2.4 Velocity and Discharge Details

Current meter observations and discharge calculations were undertaken at every 10 km interval approximately. Details of the same are tabulated below:-

Stretch No	Chainage	Position				Observed Depth (m)	Velocity	Average Velocity	X-Sectional Area	Discharge
						(D)	(m/sec.)	(m/sec.)	(sq. m)	M³/Sec
	(Km)	Latitude	Longitude	Easting	Nortning		0.5D			
MAHI 1	0	22°10'35.22"N	72°30'36.28"E	243249.02	2454464.38	4.2	1.21	1.21	2373.05	2833.94
MAHI 2	10.8	22°14'4.64"N	72°34'58.99"E	250879.93	2460785.79	3.7	1.12	1.12	2172.40	2404.08
MAHI 3	22	22°12'35.67"N	72°40'21.98"E	260089.32	2457903.54	4.5	1.05	1.05	1571.03	1649.59
MAHI 4	42.8	22°13'30.07"N	72°51'54.84"E	279960.33	2459284.95	1.8	0.58	0.58	509.67	295.61
MAHI 5	50	22°14'46.77"N	72°55'15.29"E	285733.74	2461564.39	2.8	0.52	0.52	696.75	354.38
MAHI 6	60	22°55'15.29"E	72°56'38.01"E	288184.64	2467560.59	2.8	0.59	0.59	935.27	551.81
MAHI 7	70	22°15'40.48"N	72°59'46.41"E	293519.29	2463111.73	3.3	0.62	0.62	1351.15	829.19
MAHI 8	80	22°19'20.53"N	73° 3'41.45"E	300335.94	2469792.68	2.3	0.98	0.98	474.47	464.98
MAHI 9	90	22°24'10.59"N	73° 4'17.87"E	301492.51	2478701.4	6.4	0.22	0.22	1551.80	338.40
MAHI 10	100	22°29'1.77"N	73° 5'20.67"E	303402.83	2487635.19	4.8	0.39	0.39	773.13	296.69
MAHI 11	110	22°32'42.71"N	73° 8'41.51"E	309228.16	2494359.21	3.7	0.47	0.47	939.60	441.61

Stretch No	Chainage	Position				Observed Depth (m)	Velocity	Average Velocity	X-Sectional Area	Discharge
						(D)	(m/sec.)	(m/sec.)	(sq. m)	M³/Sec
	(Km)	Latitude	Longitude	Easting	Nortning		0.5D			
MAHI 12	120	22°36'45.53"N	73°11'49.01"E	314675.57	2501762.56	3.4	0.18	0.18	397.28	68.77
MAHI 13	130	22°40'10.98"N	73°16'7.57"E	322133.1	2507994.29	1.3	0.49	0.49	117.73	52.25
MAHI 14	140	22°45'21.76"N	73°15'20.21"E	320893.42	2517569.21	6.4	0.58	0.58	1041.93	604.32
MAHI 15	150	22°47'5.36"N	73°20'11.53"E	329239.65	2520660.02	2.3	0.79	0.79	400.10	307.23
MAHI 16	160	22°51'19.89"N	73°23'1.87"E	334183.58	2528435.18	2.9	0.12	0.12	485.62	56.72
MAHI 17	170	22°55'36.55"N	73°23'55.40"E	335795.25	2536312.76	2.7	0.23	0.23	82.13	18.89
MAHI 18	180	22°59'31.41"N	73°26'15.65"E	339867.81	2543493.49	6.9	0.37	0.37	2005.27	741.95
MAHI 19	190	23° 3'15.08"N	73°28'45.38"E	344203	2550328.24	14.8	0.52	0.52	2410.48	1204.44
MAHI 20	200	23° 6'13.88"N	73°33'11.84"E	351841.53	2555750.74	6.6	0.22	0.22	1543.15	334.09
MAHI 21	209.4	23°11'46.12"N	73°34'34.54"E	354294.31	2565946.42	5.3	0.18	0.18	134.07	24.13
MAHI 22	220	23°12'35.95"N	73°39'10.06"E	362141.95	2567404.33	3.2	0.36	0.36	467.57	168.32
MAHI 23	230	23°15'46.35"N	73°42'21.47"E	367635.71	2573211	2.2	0.55	0.55	184.68	95.33
MAHI 24	240	23°16'41.19"N	73°47'43.34"E	376795.91	2574818.81	6.3	0.58	0.58	897.67	520.65
MAHI 25	246	23°17'57.11"N	73°49'49.93"E	380410.68	2577001.22	5.4	0.69	0.69	434.95	264.41

Table 2.20 : Current meter and discharge Detail

Note: Sounding spacing is 10m. Calculation is based on Simson's Method.

2.5 Waterway description

2.5.1 Sub-Stretch 1: From Ch 0 km to Ch 25 km.

This stretch of the surveyed river is having length of 25 km. Only Bathymetric survey was conducted as the width of the river from Ch 0 km to Ch 25 km is having a range from 7.5 km to 15 km. Current meter observation and discharge measurement were carried out at Ch 0 km, Ch 10.8 km and Ch 22 km. BM pillar Mahi 1, Mahi 2 and Mahi 3 are falling in this section at Vainaj, Lunej and Ralej village respectively. Shree Stambheshwar Mahadev Temple is located at Kavi on the right bank. Khambat is located in the left bank in this section. This river portion is falling in the daily tidal zone. Simultaneous tidal observations were carried out wrtDahej port for deriving the Sounding Datum at three gauge stations. In this river portion, scanty fishing activity was observed. Agricultural activity is not viable along the river due to salty water.

Figure 2.6: Sub-Stretch-01 from CH 0 to CH 25 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	0	25	-	-	-	-	-0.3	1.4	25000	2889701.5
Class-IV	0	25	-	-	-	-	-0.3	1.4	25000	3581739.9
Class-V	0	25	-	-	-	-	-0.3	1.4	25000	5337479.5

Table 2.21 : Stretch-1 Dredging Quantity

This portion of the river stretch is completely tidal in nature. Hence, length of shoal, volume being considered only for reduced data w.r.t Sounding Datum.

(a) Bathymetry Survey & Topographic Survey.

SUB-STRETCH-1 (0-25 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	0-25	The full stretch is covered by bathymetric survey only.
Topographic Survey	Nil	No topographic survey was carried in this stretch.

(b) Reduced Depth Profile of the Stretch: Only reduced depth profile being depicted below as this portion is tidal in nature.

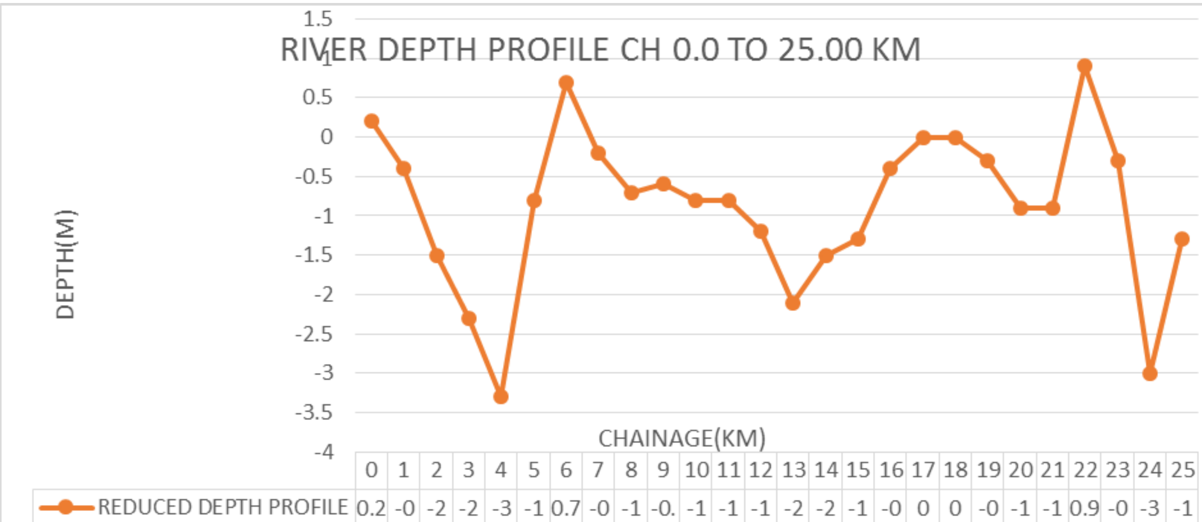


Figure 2.7: River Depth Profile CH 0.0 TO 25.00 KM

CHAINAGE (KM)	REDUCED DEPTH (M)
0	0.2
1	-0.4
2	-1.5
3	-2.3
4	-3.3
5	-0.8
6	0.7
7	-0.2
8	-0.7
9	-0.6
10	-0.8
11	-0.8
12	-1.2
13	-2.1
14	-1.5
15	-1.3
16	-0.4
17	0
18	0
19	-0.3
20	-0.9
21	-0.9
22	0.9
23	-0.3
24	-3
25	-1.3

(c) **Prominent Dam/ Barrage**: There is neither any dam nor any barrage exists in this stretch.

(d) **Tidal Stretch**: This 25 km of river stretch is having tidal effect.

(e) **Bank**: Only bathymetric survey was conducted in this stretch as the river width at Ch 25 km is 7.5 km approximately. Hence, bank protection is not viable in this portion.

(f) **Hindrances**: Shallow stretches during the low tide being the hindrance in this section.

(g) **Encroachment**: No encroachment was observed in this stretch.

(h) **Protected Area**: There is no wildlife, Defence, Atomic power plant and any other protected area present in this river stretch.

(i) **NH/ SH**: SH 89 & 16 are falling in this corridor within 10 km.

(j) **Railway Station**: Khambat Raiway Station is located 4.5 km towards north eastern side from the river.

(k) **Land Use Pattern**: Land on either banks of the river being utilised for either residential or commercial purpose.

(l) **Crops**: No crop is harvested in this section due to salty water.

(m) **Bulk Construction Material**: There is no bulk construction material available in the river stretch.

(n) **Existing Industry**: No major industry was noticed in this stretch.

(o) **Existing Ghats, Jetties and Terminals**: There is no ghat, jetty and terminal was seen in this portion.

(p) **Cargo Movement**: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) **Prominent City/ town or Place of Worship:** Prominent town in this section is Khambat. Shree Stambheshwar Mahadev temple is located at Kavi.

(r) **Ferry**: No ferry ghat was observed in this section.

(s) **Water Sports Recreational Facilities**: There is no facility for water sports in this section.

(t) **Fishing Activity:** Scanty fishing activity was observed in this river portion.

(u) **Sand Mining**: No sand mining activity was found in this stretch.

(v) **Tributaries:**There is no tributary of the river present in this portion.

(w) **Details of Irrigational Canals:** There is no irrigational canal present in this section.

(x) **Details of Nalas:** No nalla is present in this section.

(y) **Usage of Water:** Water in this portion is neither utilised for drinking not cultivation due to its hardness.

(z) **Details of Cross-Structures**: No bridge/cross-structured was noticed in this section.

2.5.2 Sub-Stretch 2: From Ch 25 km to Ch 35 km.

This stretch of the surveyed river is having length of 10 km from Ch 25 km to Ch 35 km with width from 7 km. Daily tidal effect was noticed in this stretch. Hence, this portion of the river is completely tidal in nature. BM control pillars Mahi 4 is located in this section. One in no water and soil sample were also collected in this section. Sparse fishing activity by fishing folks was observed in this portion. Famous temples in this portion are Dhumeshwar Mahadev Temple and Shree Harsiddhi Mata Temple at Dhuvran. Gujrat State power production plant GBCCPP is located at Dhuvran.

Figure 2.8 : Sub- Stretch-02 from CH 25 to CH 35 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	25	35	-	-	-	-	-0.3	-0.3	10000	1102752.8
Class-IV	25	35	-	-	-	-	-0.3	-0.3	10000	1373169.96
Class-V	25	35	-	-	-	-	-0.3	-0.3	10000.0	2056137.7

Table 2.22- Stretch-2 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-2 (25-35 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	Nil	No Bathymetric Survey was conducted due to shallow depth
Topographic Survey	25-35	Topographic survey was carried out for the entire 10 km river stretch.

(b) **Reduced Depth Profile of the Stretch**: Reduced depth profile of the stretch being mentioned below:-

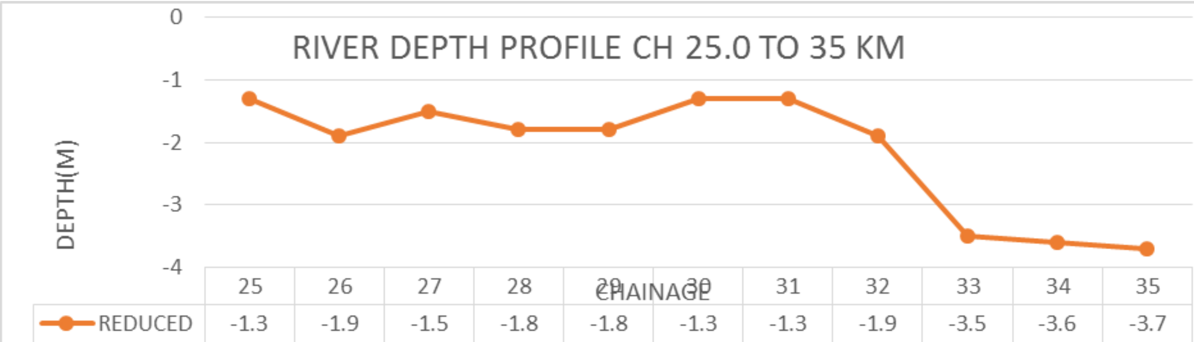


Figure 2.9 :River Depth Profile CH 25.00 TO 35.00 KM

CHAINAGE (KM)	REDUCED DEPTH (M)
25	-1.3
26	-1.9
27	-1.5
28	-1.8
29	-1.8
30	-1.3
31	-1.3
32	-1.9
33	-3.5
34	-3.6
35	-3.7

(c) **Prominent Dam/ Barrage**: There is neither any dam nor any barrage exists in this stretch.

(d) **Tidal Stretch**: This 10 km of the river stretch is tidal in nature.

(e) **Hindrances**: No relevant navigational hazard was observed in this portion other than shallow patch.

(f) **Encroachment:** No encroachment was observed in this stretch.

(g) **Protected Area:**There is no wildlife, Defence, Atomic power plant and any other protected area present in this river stretch.

(h) **NH/ SH**: SH 89 and SH 140 are located towards northern side from the waterway.

(i) **Railway Station**: Kathana Railway station is located 300m towards northern side from the river bank.

(j) **Land Use Pattern:** Land on either banks of the river being utilised for either agricultural or residential purpose.

(k) **Crops:** Both banks of the river are quite fertile and agricultural activity is prominent throughout the waterway. Primary crops are tobacco, mustard, cucumber, gourd, etc.

(l) **Bulk Construction Material:** There is no bulk construction material available in the river stretch.

(m) **Existing Industry**: Thermal plant at Dhuvran and Sterling SEZ & Infrastructure Ltd at Sarod are the two major existing industries along the waterway.

(n) **Existing Ghats, Jetties and Terminals**: There is no jetty, ghat and terminal was observed in this portion.

(o) **Cargo Movement**: There is no cargo movement observed in this portion of the water way during the course of survey.

(p) **Prominent City/ town or Place of Worship:** Dhumeshwar Mahadev Temple & Shree Harsiddhi Mata Temple are the places for worship at Dhuvran. No city/ town exist in this stretch.

(q) **Ferry:** No ferry ghat exist in this section.

(r) **Water Sports Recreational Facilities:** There is no facility for water sports in this section.

- **(s) Fishing Activity**: Small wooden boats were seen engaging fishing activity in this river portion.
- **(t) Sand Mining:** No sand mining activity was found in this stretch.
- **(u) Tributaries:** There is no tributary of Mahi River present in this portion.
- **(v) Details of Irrigational Canals:** There is no irrigational canal present in this section.
- **(w) Details of Nalas:** One nala was noticed at Ch 33.2 km on the left bank.
- **(x) Usage of Water**: Water in this portion is being utilised for irrigation and industrial purpose.
- **(y) Details of Cross-Structures:**No cross structure/ bridge exists in this section of the waterway.

2.5.3 Sub-Stretch 3: From Ch 35 km to Ch 55 km.

This stretch of the surveyed river is having length of 20 km from Ch 35 km to Ch 55 km with width from 2 km to 5 km. This portion of the river stretch only having the effect of spring tide. This stretch is tidal in nature. BM control pillars Mahi P5 & Mahi P6 are located in this section. Current meter observations were carriedout at Ch 40.6 km & Ch 50 km. 02 in Nos. Water and soil samples were also collected in this section. Farce fishing activity by fishing folks was observed in this portion. Primary crops are tobacco, wheat, Mustard, gourd, cucumber, etc.

Figure 2.10 :Sub-Stretch 3: From Ch 35 km to Ch 55 km.

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	35	55	-	-	-	-	-0.3	2.1	20000	2003626.8
Class-IV	35	55	-	-	-	-	-0.3	2.1	20000	2447161.9
Class-V	35	55	-	-	-	-	-0.3	2.1	20000	3674757.7

Table 2.23 : Stretch-3 Dredging Quantity

(a) Bathymetry Survey& Topographic Survey.

SUB-STRETCH-3 (35-55 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	42.4-55	Bathymetric survey was conducted from Ch 42.5 km to Ch 55 km.
Topographic Survey	35-42.4	Topographic survey was carried out from Ch 35 km to Ch 42.4 km.
	35-55	River banks, drying heights & shallow patches.

(b) Reduced Depth Profile of the Stretch. Reduced depth profile of the stretch is mentioned below:-

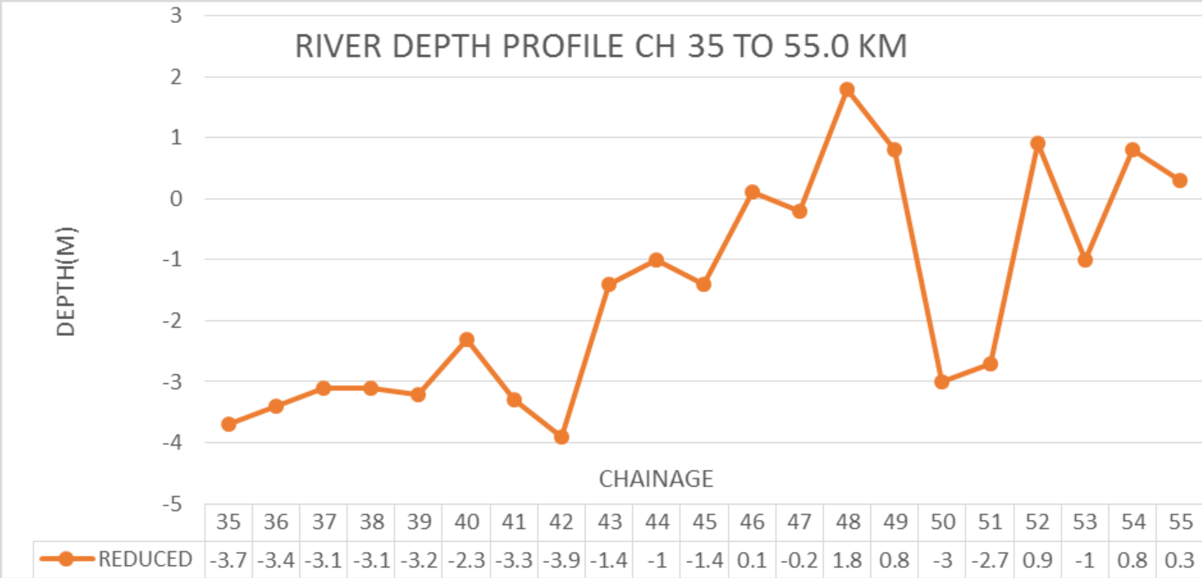


Figure 2.11 :River Depth Proifle CH 35 to 55.0 Km

CHAINAGE (KM)	REDUCED DEPTH (M)
35	-3.7
36	-3.4
37	-3.1
38	-3.1
39	-3.2
40	-2.3
41	-3.3
42	-3.9
43	-1.4
44	-1
45	-1.4
46	0.1
47	-0.2
48	1.8
49	0.8
50	-3
51	-2.7
52	0.9
53	-1
54	0.8
55	0.3

(c) **Prominent Dam/ Barrage:** There is neither any dam nor any barrage exists in this stretch.

(d) **Tidal Stretch:** Daily tidal effect exists at Ch 25 km to Ch 35 km. Only spring tide effects were noticed at Ch 35 km to Ch 55 km. Hence, 15 km length in this river stretch (from Ch 35 km to Ch 55 km) is considered to be non-tidal.

(e) **Bank:** Details of bank protection is tabulated below:-

FROM CH (KM)	TO CH (KM)	LENGTH(M)	LEFT/ RIGHT BANK
52.9	52.95	50	LEFT
53.2	53.22	20	LEFT
53.8	53.82	20	RIGHT
54.5	54.8	300	RIGHT

Table 2.24 :Details of bank protection

(f) **Hindrances:** No relevant navigational hazard was observed in this portion other than shallow patch.

(g) **Encroachment:** No encroachment was observed in this stretch.

(h) **Protected Area:** There is no wildlife, Defence, Atomic power plant and any other protected area present in this river stretch.

(i) **NH/ SH:** SH 89 and SH 140 are located towards northern side from the waterway.

(j) **Railway Station.** Kathana Railway station is located 300m towards northern side from the river bank.

(k) **Land Use Pattern.** Land on either banks of the river being utilized for either agricultural or residential purpose.

(l) **Crops.** Both banks of the river are quite fertile and agricultural activity is prominent throughout the waterway. Primary crops are tobaco, mustard, cucumber, gourd, etc.

(m) **Bulk Construction Material:** There is no bulk construction material available in the river stretch.

(n) **Existing Industry:** Thermal plant at Dhuvran and Sterling SEZ & Infrastructure Ltd at Sarod are the two major existing industries along the waterway**.**

(o) **Existing Ghats, Jetties and Terminals:** There is no jetty, ghat and terminal was observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey**.**

(q) Prominent City/ town or Place of Worship: Dhumeshwar Mahadev Temple & Shree Harsiddhi Mata Temple are the places for worship at Dhuvran. No city/ town exist in this stretch.

(r) Ferry: No ferry ghat exist in this section.

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Small wooden boats were seen engaging fishing activity in this river portion.

(u) Sand Mining: No sand mining activity was found in this stretch.

(v) Tributaries: There is no tributary of Mahi River present in this portion.

(w) Details of Irrigational Canals: There is no irrigational canal present in this section.

(x) Details of Nalas: One nala was noticed at Ch 33.2 km on the left bank.

(y) Usage of Water: Water in this portion is being utilised for irrigation and industrial purpose.

(z) Details of Cross-Structures: No cross structure/ bridge exists in this section of the waterway. However, HT Line across the river is prominent and the same being tabulated below:-

<u>Details of HT Lines/ Electric Pole</u>

Sl No.	Cross-Structure Type	Chainage (km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
			GLOBAL		UTM				
			Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
1	HT LINE	50.87	22°15'48.2808"N	72°55'14.5648"E	285739	2463457	-	314	Under Construction
2	HT LINE	51.83	22°16'16.2360"N	72°55'03.1400"E	285424	2464322	17	350	Complete

Table 2.25 : Details of HT Lines/ Electric Pole

2.5.4 Sub-Stretch 4: From Ch 55 km to Ch 80 km.

This stretch of the river is having length of 25 km from Ch 55 km to Ch 80 km. Current meter observation and discharge measurement were carried out at Ch 60 km, Ch 70.06 km and Ch 80 km. This section is having only one bridge viz. Gambhira Bridge at Ch 70.3 km. BM control pillars Mahi 6, 7 , 8 & 9 are located in this section. Kotiya Khad a small town falls on the left bank in this section. Umeta Check Dam is located at Ch 80 km. Khadol and Sindhot are two small villages in this section, which are located on the left bank and right bank of the river respectively. This stretch is tidal in nature and tidal effect exists uptodown stream of Umeta Check dam.

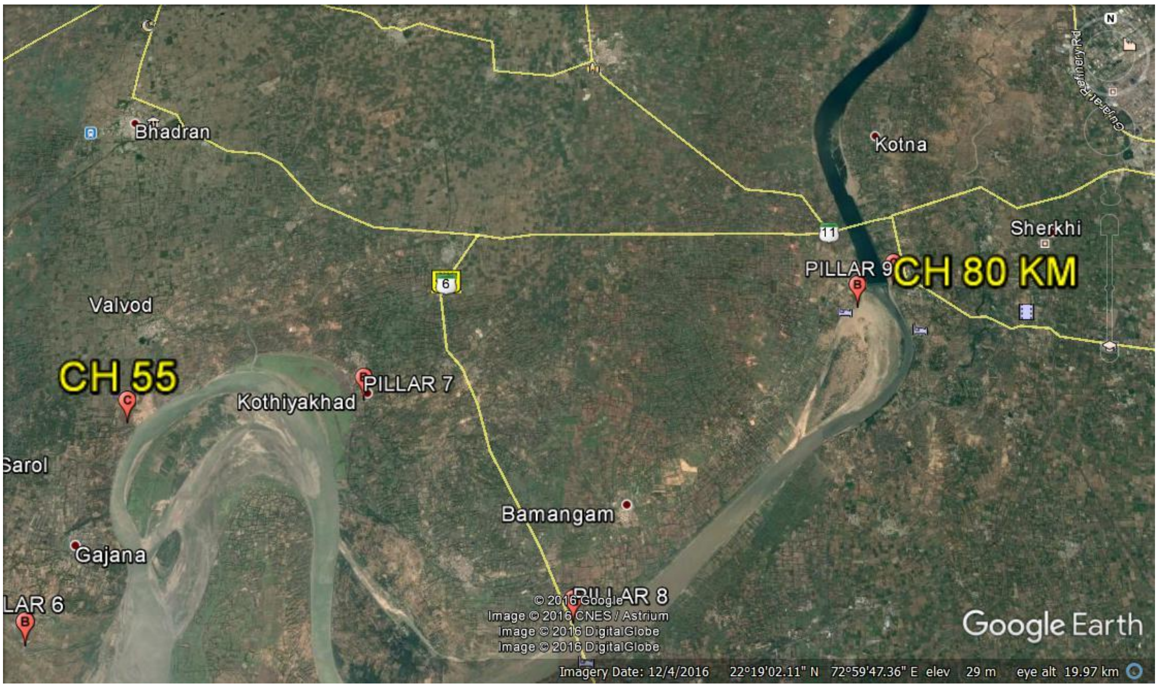


Figure 2.12 :Sub-Stretch-04 from CH 55 km to CH 80 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	**From**	**To**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**
Class-III	55	80	-	-	-	-	-0.3	3.1	25000	1950305.62
Class-IV	55	80	-	-	-	-	-0.3	3.1	25000	2482771.86
Class-V	55	80	-	-	-	-	-0.3	3.1	25000	3814779.98

Table 2.26 : Stretch-4 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-4 (55-80 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	55-80	Covered by bathymetric survey
Topographic Survey	55-80	River banks, drying heights, topographic features.

(b) **Reduced Depth Profile of the Stretch.** Only reduced depth profile of the stretch is mentioned below as the stretch is tidal in nature:-

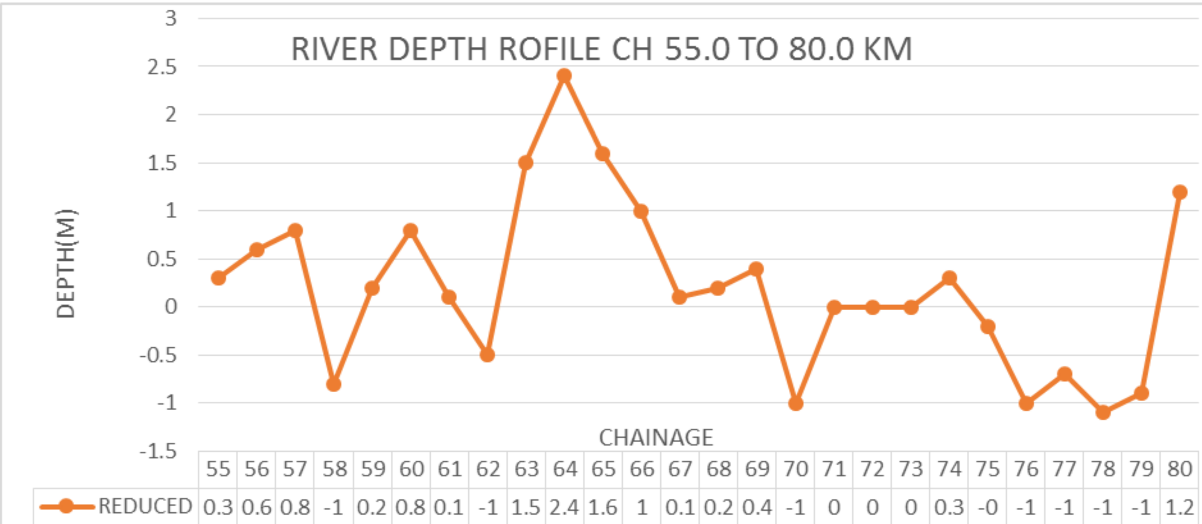


Figure 2.13 : River Depth Profile CH 55.0 to 80.0 KM

CHAINAGE (KM)	REDUCED DEPTH (M)
55	0.3
56	0.6
57	0.8
58	-0.8
59	0.2
60	0.8
61	0.1
62	-0.5
63	1.5
64	2.4
65	1.6
66	1

CHAINAGE (KM)	REDUCED DEPTH (M)
67	0.1
68	0.2
69	0.4
70	-1
71	0
72	0
73	0
74	0.3
75	-0.2
76	-1
77	-0.7
78	-1.1
79	-0.9
80	1.2

(c) **Prominent Dam/ Barrage**: There is neither any dam nor any barrage exists in this stretch.

(d) **Tidal Stretch**: This 26 km of river stretch is non-tidal.

(e) **Bank:** Details of bank protection is tabulated below:-

FROM CH (KM)	TO CH (KM)	LENGTH(M)	LEFT/ RIGHT
55.4	55.43	25	RIGHT
56.1	56.2	100	LEFT
56.4	56.6	200	LEFT
75.6	75.8	200	Left
79	79.085	85	Right

Table 2.27 : Details of bank protection

(f) **Encroachment:** No encroachment was observed in this stretch.

(g) **Protected Area:** There is no wildlife, Defence, Atomic power plant and any other protected area present in this river stretch.

(h) **NH/ SH:** SH 6 is passing across the river at Ch 70.3 km.

(i) **Railway Station**: Bhadran Railway station is located 6.5 km towards north western side from the river.

(j) **Land Use Pattern**: Land on either banks of the river being utilised for either agricultural or residential purpose. Few cottage was found on the banks of the river at the stretch of the river.

(k) Crops: Both banks of the river are quite fertile and agricultural activity is prominent throughout the waterway. Primary crops are tobaco, cauliflower and wheat, etc.

(l) Bulk Construction Material: There is no bulk construction material available in the river stretch.

(m) Existing Industry: There is no major or minor industry exists along the waterway.

(n) Existing Ghats, Jetties and Terminals: No ghat, jetty and terminal was observed in this portion.

(o) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(p) Prominent City/ town or Place of Worship: The only town Borsad is located 14 km towards north western side from the river.

(q) Ferry: No ferry ghat is located in this section

(r) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(s) Fishing Activity: No fishing activity was observed in this section.

(t) Sand Mining: No sand mining activity was found in this stretch.

(u) Tributaries: No tributary exists in this section.

(v) Details of Irrigational Canals: There is no irrigational canal present in this section.

(w) Details of Nalas: Only nala is present in this river portion at Ch 78.6 km.

(x) Usage of Water: Water in this portion primarily used for irrigation purpose.

(y) Details of Cross-Structures: Details Bridges/ Cross structures and HT lines are appended below:-

Details of Bridges/ Cross Structure

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Gambhira Bridge	69.3	22°16'4.32"N	22°15'38.10"N		293520.065	293856.197	872.6	10.29	23	38.11
		72°59'46.09"E	72°59'58.20"E		2463845.24	2463034.451				

Table 2.28 : Details of Bridges/ Cross Structure

Details of HT Lines/ Electric Pole

Sl No.	Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
			GLOBAL		UTM				
			Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
HT LINE	68.93	22°15'49.2468"N	72°59'39.2821"E	293318	2463384	16.5	350	Complete	HT LINE
HT LINE	69.42	22°15'55.9022"N	72°59'54.4274"E	293898	2463581	19.1	650	Complete	HT LINE
HT LINE	73.71	22°17'25.1478"N	73°01'44.1580"E	296932	2466287	21.2	650	Complete	HT LINE

Table 2.29 : Details of HT Lines/ Electric Pole

2.5.5 Sub-Stretch 5: From Ch 80 km to Ch 100 km:

This stretch of the river is having length of 20 km from Ch 80 km to Ch 100 km and is completely non-tidal. Current meter observation and discharge measurement were carried out at Ch 90 km and Ch 100 km. Umeta Check Dam is located at Ch 81 km. Manjusar city and Vasad town are located at right and left bank respectively in this section. BM Control pillar 10 is located in this portion of the river stretch. Asodar and Anklav are two small towns in this section, which are located on the left bank of the river. Primary crops are tobacco, wheat and mustards, etc.

Figure 2.14 : Sub-Stretch-05 from CH 80 km to CH 100 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	80	100	1	9.5	2200	3118.4	-0.3	9.33	3400	19272.28
Class-IV	80	100	1	9.5	2600	9953.42	-0.3	9.33	4200	45116.63
Class-V	80	100	0.6	9.5	3600	29037.5	-0.3	9.33	4600	89837.29

Table 2.30 : Stretch-5 Dredging Quantity

(a) Bathymetry Survey & Topographic Survey.

SUB-STRETCH-5 (80-100 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	80-100	Covered by bathymetric survey
Topographic Survey	80-100	River banks, drying heights, topographic features.

(b) Observed & Reduced Depth Profile of the Stretch: Reduced & observed depth profile of the stretch is mentioned below:-

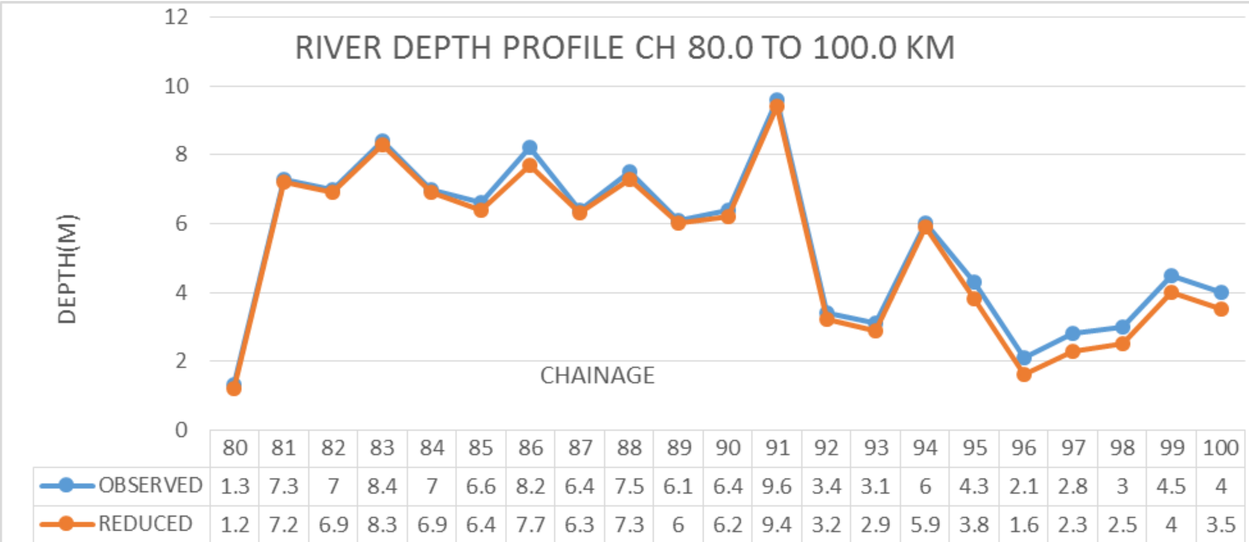


Figure 2.15 : River Depth Profile CH 80.0 to 100. 0 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
80	1.2	1.3
81	7.2	7.3
82	6.9	7
83	8.3	8.4
84	6.9	7
85	6.4	6.6
86	7.7	8.2
87	6.3	6.4
88	7.3	7.5
89	6	6.1
90	6.2	6.4
91	9.4	9.6

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
92	3.2	3.4
93	2.9	3.1
94	5.9	6
95	3.8	4.3
96	1.6	2.1
97	2.3	2.8
98	2.5	3
99	4	4.5
100	3.5	4

(c) **Prominent Dam/ Barrage**: Umeta Check Dam is located at Ch 81 km.

(d) **Tidal Stretch**: The river from Ch 81 km to Ch 100 km is completely non tidal.

(e) **Bank**: Bank protection details being tabulated below:-

From Ch(km)	To Ch(km)	Length(m)	Left/ Right Bank
81	81.08	80	Right
81.55	81.6	50	Right
86.7	87	300	Left
98.2	98.25	50	Right
98.4	98.45	50	Left
99.7	99.8	100	Left

Table 2.31 : Bank protection details

(f) **Hindrances:** No navigational hindrances was observed from Ch 81-100 km.

(g) **Encroachment:** No encroachment was observed in this stretch.

(h) **Protected Area**: There is no wildlife, Defence, Atomic power plant and any other protected areas in this stretch.

(i) **NH/ SH**: NH 8, NH 1 and SH 11 are passing across the river at Ch 94.3 km, Ch 99.8 km and Ch 82.4 km respectively.

(j) **Railway Station:** Nandesari Railway Station and Vasad Jn are located 3 km towards south eastern side and 2 km towards north western side from the river stretch respectively.

(k) **Land Use Pattern**: Land on either banks of the river is very fertile and utilised for agricultural purpose.

(l) **Crops**: Agricultural activity was monitored in this section. Primary crops are tobacco, wheat and mustards, etc.

(m) **Bulk Construction Material:** Grable mining is prominent in this section.

(n) **Existing Industry**: Dhanora Petro Chemicals is located 4 km towards eastern side from the river bank.

(o) **Existing Ghats, Jetties and Terminals:** There is no jetty, terminal and ghat observed in this portion.

(p) **Cargo Movement**: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) **Prominent City/ town or Place of Worship:** Manjusa & Vasad town are located approximately 10 km & 3 away towards eastern side & western side from the river bank.

(r) **Ferry**: No ferry ghat exists in this section.

(s) **Water Sports Recreational Facilities:** There is no facility for water sports in this section.

(t) **Fishing Activity**: Scanty fishing activity was observed in this stretch.

(u) **Sand Mining**: No sand mining activity was found in this stretch.

(v) **Tributaries**: There is no tributary present in this section.

(w) **Details of Irrigational Canals**: There is no irrigational canal present in this section.

(x) **Details of Nalas**: No nala is located in the river stretch.

(y) **Usage of Water:** Water in this portion primarily utilised for irrigational and industrial purpose.

(z) **Details of Cross-Structures:** Details of cross-structures, Water Intake and HT lines are being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Umeta Bridge	81.37	22°20'29.98"N 73° 3'3.17"E	22°20'36.20"N 73° 3'25.59"E	299268.974 2471943.882	299912.383 2472126.77	669.13	10.26	19	35.64	-2.95
Under Construction Bridge	86.15	22°22'56.90"N 73° 3'32.65"E	22°22'42.24"N 73° 3'45.54"E	300169.83 2476451.56	300532.86 2475995.68	588.29	-	13	44.62	-
Vasad Rail Bridge	92.86	22°26'21.38"N 73° 4'14.19"E	22°26'9.45"N 73° 4'28.00"E	301439.218 2482726.912	301829.364 2482354.12	548.57	31.41	16	30.9	3.491
Vasad NH-8 Bridge	93.1	22°26'28.96"N 73° 4'19.96"E	22°26'15.09"N 73° 4'34.42"E	301607.667 2482957.175	302015.633 2482525.21	594	60.12	16	35	4.279
Ahmedabad Vadodara Expressway Bridge (NE1)	98.58	2°28'54.54"N 73° 5'14.58"E	22°28'56.53"N 73° 5'34.99"E	303226.094 2487415.236	303810.942 2487469.396	587.287	27.84	14	41.68	8.849

Table 2.32 : Details of Bridges & Crossings

Details of Water Intake

SL No.	Structure Name	Ch (km)			Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
			Start	End	Start	End					
1	Water Intake	91.6	22°25'38.6219N" 073°04'9.6663 E"	22°25'39.2601N" 073°04'7.3866 E"	301292.679 2481412.398	301227.74 2481432.87	63	10	3	40	4
2	Water Intake	92.6	22°26'08.8410N" 073°04'16.8871 E"	22°26'3.26120N" 073°04'23.8729 E"	301511.12 2482339.29	301708.68 2482165.09	260	12	5	45	3.2
3	Water Intake	93.7	22°26'37.0968N" 073°04'38.4276 E"	22°26'30.1800N" 073°04'46.94 E"	302138.22 2483200.54	302378.9 2482984.66	330	12	7	50	2.9
4	Water Intake	94.5	22°26'56.9379N" 073°04'57.1242 E"	22°26'48.7710N" 073°05'5.904 E"	302680.63 2483804.01	302928.46 2483549.59	360	10	8	45	4.2
5	Water Intake	95.03	22°27'11.2787N" 073°05'9.6505 E"	22°26'59.7912N" 073°05'23.2649 E"	303044.42 2484240.56	303429.18 2483882.24	517	12	11	50	1.8
6	Water Intake	96.1	22°27'34.5178N" 073°05'29.75 E"	22°27'36.1086N" 073°05'40.8648 E"	303628.2 2484948.07	303946.6 2484992.96	340	10	7	45	2.9
7	Water Intake	96.2	22°27'38.3977N" 073°05'38.8647 E"	22°27'38.2586N" 073°05'42.1688 E"	303890.31 2485064.1	303984.716 2485058.618	100	8	1	45	-
8	Water Intake	96.9	22°28'00.2439N" 073°05'26.1387 E"	22°28'01.0851N" 073°05'38.2738 E"	303535.03 2485740.72	303882.29 2485762.18	350	6	8	45	3.1
9	Water Intake	98.3	22°28'44.3348N" 073°05'26.1067 E"	22°28'45.6285N" 073°05'32.9601 E"	303551.4 2487096.97	303747.82 2487134.27	220	10	4	40	1.8

SL No.	Structure Name	Ch (km)	Position (UTM)				Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
			Start	End	Start	End					
10	Water Intake	99.6	22°29'27.4633N"	22°29'27.0000N"	303509.43	303677.51	170	8	3	40	-
			073°05'24.0467 E"	073°05'29.9331 E"	2488424.36	2488408.22					

Table 2.33 : Details of Water Intake

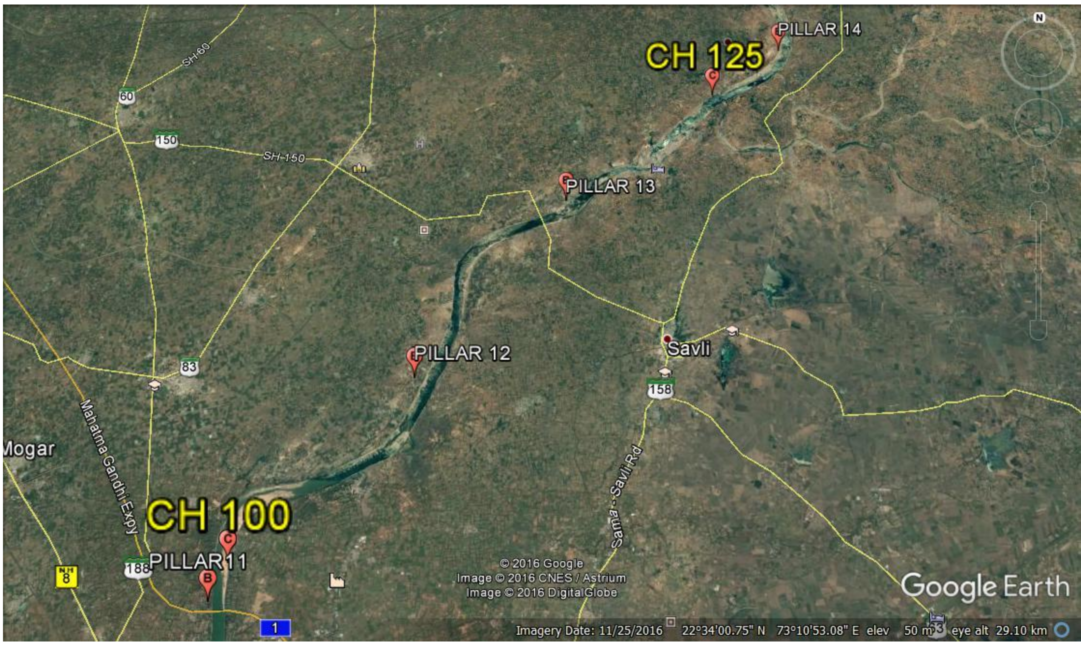
Details of HT Line/ Electric Pole

Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
		GLOBAL		UTM				
		Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
HT LINE	98.87	22°29'02.7729"N	73°05'21.5974"E	303429	2487665	19.6	650	Complete
HT LINE	99	22°29'08.1626"N	73°05'20.4727"E	303400	2487832	18.5	591	Complete
HT LINE	99.25	22°29'14.9177"N	73°05'18.5722"E	303348	2488041	18.6	350	Complete

Table 2.34 : Details of HT Line/ Electric Pole

2.5.6 Sub-Stretch 6: From Ch 100 km to Ch 125 km.

This stretch of the river is having length of 25 km from Ch 100 km to Ch 125 km. Current meter observation and discharge measurement were carried out at Ch 110 km and Ch 120 km. The surveyed river length is having shallow patches from Ch 118-119 km and from Ch 122-125 km. BM Cultivated control pillars Mahi 11, 12 & 13 are located in this section. CWC Khanpur is situated at Ch 108.6 km. Sand mining activity is prominent in this section. Cultivated crops are tobacco, mustard, wheat, cabbage, cucumber, carrot, etc.



Sub-

Figure 2.16 : Stretch-06 from CH 100 km to CH 125 km

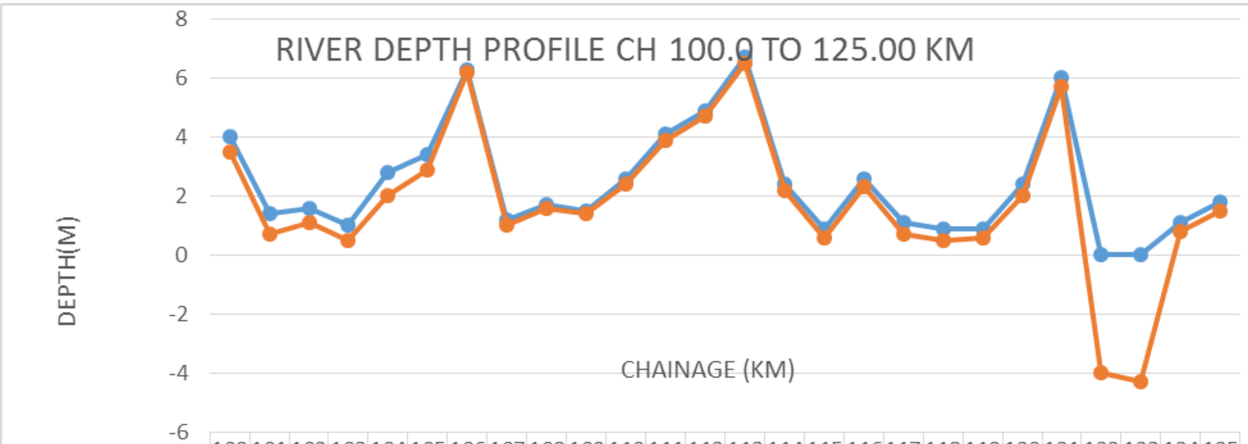
	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	**From**	**To**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**
Class-III	100	125	0	7.2	17600	618009.2	-0.3	7.05	18800	885591.38
Class-IV	100	125	0	7.2	18200	875518.4	-0.3	7.05	19400	1144852.8
Class-V	100	125	0	7.2	19200	1430098	-0.3	7.05	20800	1874496.07

Table 2.35 : Stretch-6 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-6 (100-125 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	100-106.2 107.6-114 115-117.2 118-121 123.2-125	Covered by bathymetric survey
Topographic Survey	106.2-107.6	Being very shallow/ dry, covered by Topographic Survey
	114-115	
	117.2-118	
	121-123.2	
	100-125	River banks, drying heights, topographic features.

(b) **Observed & Reduced Depth Profile of the Stretch:** Reduced & observed depth profile of the stretch is mentioned below:-



	100	101	102	103	104	105	106	107	108	109	110	111	112
OBSERVED	4	1.4	1.6	1	2.8	3.4	6.3	1.2	1.7	1.5	2.6	4.1	4.9
REDUCED	3.5	0.7	1.1	0.5	2	2.9	6.2	1	1.6	1.4	2.4	3.9	4.7

	113	114	115	116	117	118	119	120	121	122	123	124	125
OBSERVED	6.7	2.4	0.9	2.6	1.1	0.9	0.9	2.4	6	0	0	1.1	1.8
REDUCED	6.5	2.2	0.6	2.3	0.7	0.5	0.6	2	5.7	-4	-4	0.8	1.5

Figure 2.17 : River Depth Profile CH 100.0 to 125.00 KM

(c) Prominent Dam/ Barrage: No dam/ barrage exists in this section.

(d) Tidal Stretch: This 25 km river stretch is completely non-tidal.

(e) Bank: This river portion is having unprocted bank.

(f) Hindrances: Navigational hindrances being perceived at Ch 118-119 km and Ch 122-125 km due to shallow depth and steep terrain. Rest portion of the river seems to be navigable throughout the year.

(g) Encroachment: No encroachment was observed in this stretch.

(h) Protected Area: There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) NH/ SH: SH 150 is passing across the river at Ch 117.8 km. SH 83, SH 158 and SH 63 are located 7 km towards western side, 7 km towards eastern side and 4.5 km towards south eastern side from the river stretch.

(j) Railway Station: Anand Jn is located 14 km towards western side from the river stretch.

(k) Land Use Pattern: Land on either banks of the river is very fertile and utilised for agricultural purpose.

(l) Crops: Primary crops are tobacco, wheat and mustards, etc.

(m) Bulk Construction Material: High quality sand and black stone are available in this section.

(n) Existing Industry: Sand mining industry, Quarry factory and dairy industry of Anand are the major industry in this section.

(o) Existing Ghats, Jetties and Terminals: There is no jetty, terminal and ghat observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) Prominent City/ town or Place of Worship: Savli, Anand and Ode are the three towns in this section, which are located 6 km towards south eastern side, 14 km towards western side and 5 km towards north western side from the river corridor.

(r) Ferry: No ferry ghat is located in this section.

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Fishing folks were seen engaged in fishing activity by small wooden boats.

(u) Sand Mining: Sand mining activity is very much prominent in this stretch.

(v) Tributaries: There is no tributary present in this section.

(w) Details of Irrigational Canals: There is no irrigational canal present in this section.

(x) Details of Nalas: Details of nala being appended below:-

Ch (km)	Bank
102.2	LT
114.5	LT

Table 2.36 : Details of nala

(y) Usage of Water: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) Details of Cross-Structures: Details of cross-structures, Water Intake and HT lines being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Poicha Bridge	116.71	22°36'12.12"N 73°10'48.04"E	22°35'57.02"N 73°10'54.96"E	312922.54 2500756.337	313114.573 2500289.941	504.33	7.36	8	45.83	11.341

Table 2.37 :Details of Bridges & Crossings

Details of Water Intake

SL No.	Structure Name	Ch (km)			Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
			Start	End	Start	End					
1	Water Intake	101.2	22°30'18.8865N" 073°05'31.9591 E"	22°30'16.4507N" 073°05'36.584 E"	303755.76 2490003.26	303886.99 2489926.65	125	6	2	40	-
2	Water Intake	102.2	22°30'49.8184N" 073°05'43.6325 E"	22°30'31.2342N" 073°05'51.9822 E"	304101.51 2490950.48	304332.87 2490375.79	635	10	12	45	2.5
3	Water Intake	104.07	22°30'53.4976N" 073°06'54.1799 E"	22°30'55.6170N" 073°06'53.1364 E"	306119.122 2491038.113	306090.124 2491103.684	65	8	0	60	-
4	Water	116.63	22°35'58.9820N"	22°35'57.1911N"	313016.61	313039.085	45	6	0	45	-

SL No.	Structure Name	Ch (km)			Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
			Start	End	Start	End					
	Intake		073°10'51.5272 E"	073°10'52.3378 E"	2500350.59	2500295.215					

Table 2.38 :Details of Water Intake

High Tension Lines / Electric Lines

Cross Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
		GLOBAL		UTM				
		Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
HT LINE	104.59	22°31'04.0490"N	73°07'09.0990"E	306549	2491357	20.6	538	Complete
HT LINE	108.46	22°32'29.3546"N	73°08'43.2458"E	309272	2493948	19.7	300	Complete

Table 2.39: High Tension Lines / Electric Lines

2.5.7 Sub-Stretch 7: From Ch 125 km to Ch 150 km.

This stretch of the river is having length of 25 km from Ch 125 km to Ch 150 km. Current meter observation and discharge measurement were carried out at Ch 128.75 km, Ch 139.30 km and Ch 149.24 km. Shallow stretches, irrigation water pump and fishing activity are prominent in this section. Cultivated crops are mustard, wheat, gourd, ridge gourd, cucumber, etc.

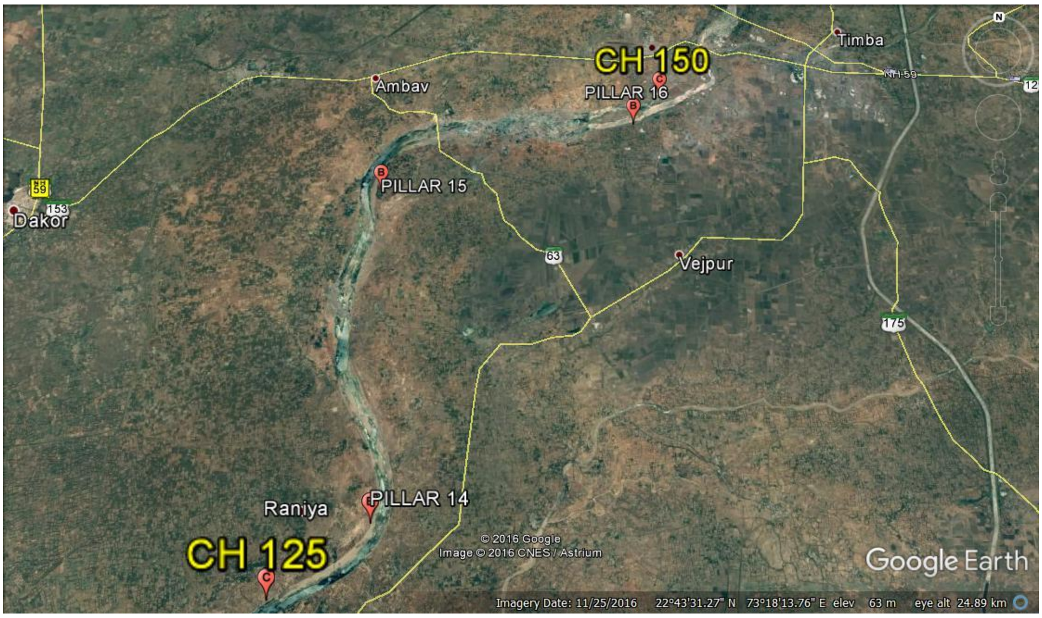


Figure 2.18: Sub-Stretch-07 from CH 125 km to CH 150 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	125	150	0	8.2	17600	972791.3	-0.3	8.02	20800	1407523.2
Class-IV	125	150	0	8.2	18400	1268519	-0.3	8.02	21800	1767314.04
Class-V	125	150	0	8.2	20000	1959663	-0.3	8.02	23400	2709134.45

Table 2.40 :Stretch-7 Dredging Quantity

(a) Bathymetry Survey & Topographic Survey.

SUB-STRETCH-7 (125-150 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	125-128 128.8-130 138-141.8 146.6-150	Covered by bathymetric survey
Topographic Survey	128-128.8	Being very shallow/ dry, covered by Topographic Survey
	130-138	
	141.8-146.6	
	125-150	River banks, drying heights, topographic features.

(b) Observed & Reduced Depth Profile of the Stretch: Reduced & observed depth profile of the stretch is mentioned below:-

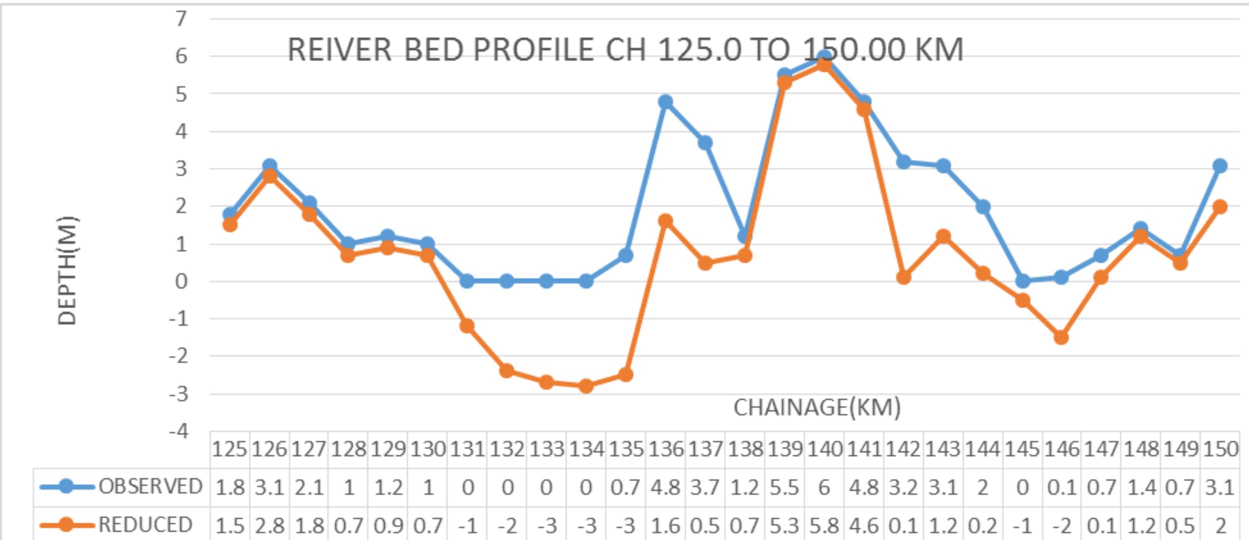


Figure 2.19: River Bed Profile CH 125.0 to 150.00 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
125	1.5	1.8
126	2.8	3.1
127	1.8	2.1
128	0.7	1
129	0.9	1.2
130	0.7	1
131	-1.2	0
132	-2.4	0
133	-2.7	0
134	-2.8	0
135	-2.5	0.7
136	1.6	4.8
137	0.5	3.7
138	0.7	1.2
139	5.3	5.5
140	5.8	6
141	4.6	4.8
142	0.1	3.2
143	1.2	3.1
144	0.2	2
145	-0.5	0
146	-1.5	0.1
147	0.1	0.7
148	1.2	1.4
149	0.5	0.7
150	2	3.1

(c) **Prominent Dam/ Barrage**: No dam/ barrage exists in this section.

(d) **Tidal Stretch**: This 25 km river stretch is completely non-tidal.

(e) **Bank**: This river portion is having unprocted bank.

(f) **Hindrances:** Navigational hindrances being perceived at Ch 131-139 km and Ch 139-148 km due to shallow depth and steep terrain. In these areas, quarry mining is also predominant. Vessels can be operated in the rest portion of the river with due safety and pracaution.

(g) **Encroachment**: No encroachment was observed in this stretch.

(h) **Protected Area:** There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) NH/ SH: SH 63 is passing accross the river at Ch 143.8 km. SH 153 is located 7 km towards north western side from the river stretch.

(j) Railway Station: Dakor Railway Station is located 10 km towards western side from the river stretch.

(k) Land Use Pattern: This portion of the river is having rocky terrain and being utilised for quarry mining. Land in this stretch is used for residential and industrial purpose.

(l) Crops: Due to presence of hard rocky terrain, this portion of the river cannot be utilised in agricultural activity.

(m) Bulk Construction Material: Quarry mining is very predominant here.

(n) Existing Industry: Sand mining industry and dairy industry of Anand are the major industry in this section.

(o) Existing Ghats, Jetties and Terminals: There is no jetty, terminal and ghat observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) Prominent City/ town or Place of Worship: Dakor town is located 10 km towards western side from the river corridor. GalteswarMahadev Temple is located at Ch 143.8 km.

(r) Ferry: No ferry ghat is located in this section.

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Fishing folks were seen engaging in fishing activity by small wooden boats.

(u) Sand Mining: Quarry mining activity is very much prominent in this stretch.

(v) Tributaries: There is no tributary present in this section.

(w) Details of Irrigational Canals: There is no irrigational canal present in this section.
(x) Details of Nalas: Details of nala being appended below:-

Ch (km)	Bank
128.8	RT
140.9	RT

Table 2.41: Details of Nala

(y) Usage of Water: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) Details of Cross-Structures: Details of cross-structures, Water Intake and HT lines are being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Raniya UC Bridge	128.65	22°40'8.15"N 73°15'56.12"E	22°40'4.56"N 73°16'12.52"E	321805.72 2507911.19	322272.92 2507795.21	520	-	14	40	1.57
Galteshwar Bridge (SH-63)	142.62	2°46'58.88"N 3°16'33.50"E	22°46'42.45"N 73°16'35.18"E	323019.542 2520532.104	323061.754 2520026.2	504.42	6.9	34	14.84	-7.066

Table 2.42: Details of Bridges & Crossings

High Tension Lines / Electric Lines

Sl No.	Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
			GLOBAL		UTM				
			Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
11	HT LINE	138.77	22°45'20.1195"N	73°15'25.4080"E	321041	2517517	20.1	734	Complete
12	HT LINE	140.45	22°46'14.4106"N	73°15'28.9758"E	321163	2519186	19.6	645	Complete

Table 2.43: High Tension Lines / Electric Lines

2.5.8 Sub-Stretch 8: From Ch 150 km to Ch 172.6 km.

This stretch of the river is having length of 22.6 km from Ch 150 km to Ch 172.6 km. Current meter observation and discharge measurement were carried out at Ch 159.03 km and Ch 169.80 km. There is no forest zone or restricted zone in this section. Cultivated crops are mustard, wheat, gourd, ridge gourd, cucumber, etc.

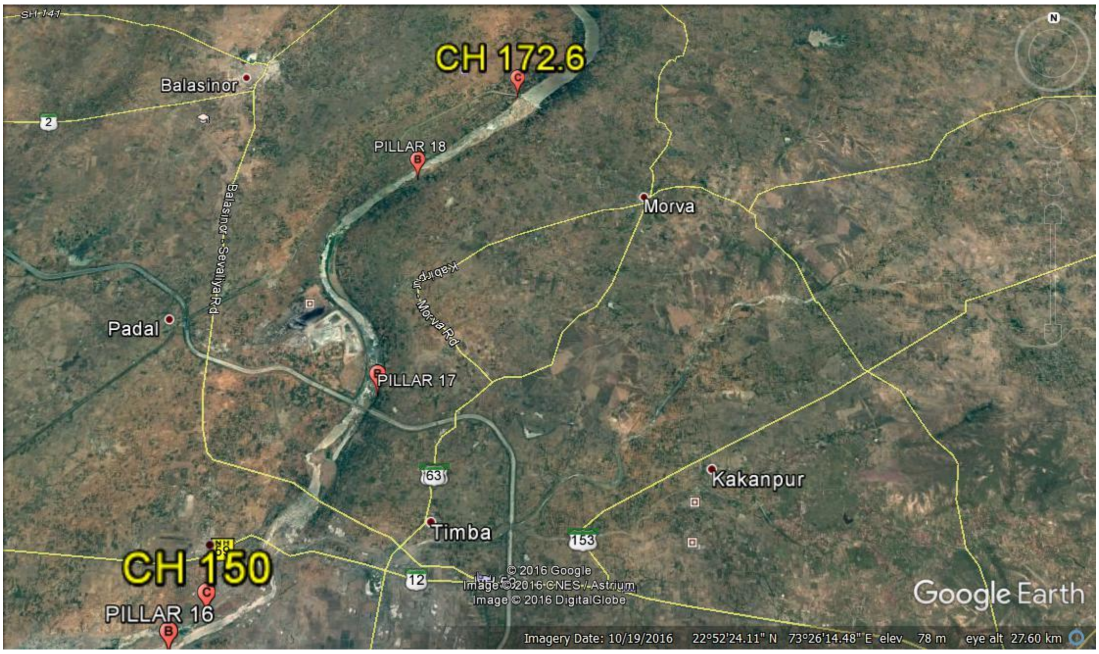


Figure 2.20: Sub-Stretch-08 from CH 150 km to CH 172.6 km

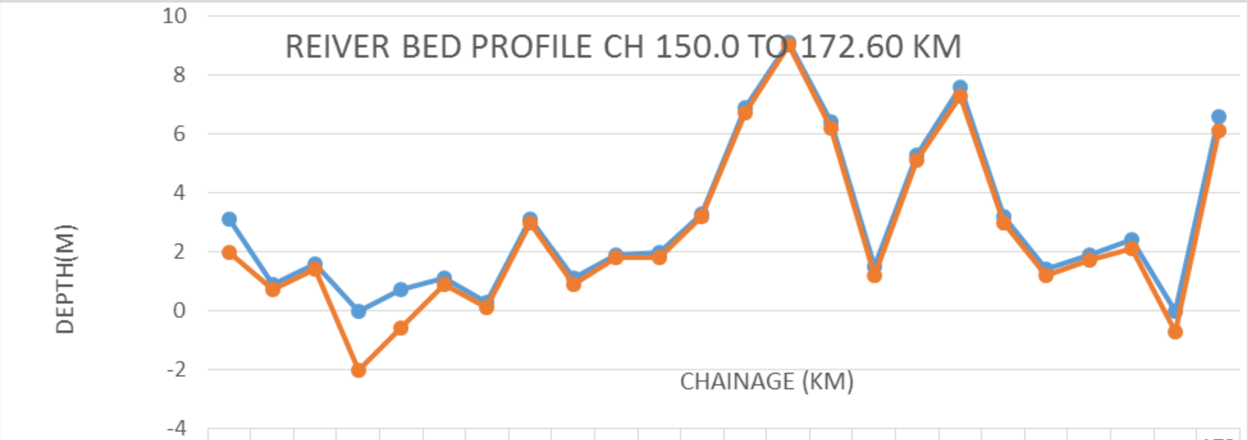
	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	**From**	**To**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**
Class-III	150	172.6	0	12.5	12400	414640.9	-0.2	12.33	13400	543349.83
Class-IV	150	172.6	0	12.5	13600	558765.9	-0.2	12.33	13600	705437.31
Class-V	150	172.6	0	12.5	16000	1005471	-0.2	12.33	16800	1233633.39

Table 2.44: Stretch-8 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-8 (150-172.6 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	150-152.4 154.6-156 156.4-159.4 159.6-171	Covered by bathymetric survey
Topographic Survey	152.4-154.6	Being very shallow/ dry, covered by Topographic Survey
	156-156.4	
	159.4-159.6	
	171-172.6	
	150-172.6	River banks, drying heights, topographic features.

(b) **Observed & Reduced Depth Profile of the Stretch:** Reduced & observed depth profile of the stretch is mentioned below:-



	150	151	152	153	154	155	156	157	158	159	160	161
OBSERVED	3.1	0.9	1.6	0	0.7	1.1	0.3	3.1	1.1	1.9	2	3.3
REDUCED	2	0.7	1.4	-2	-0.6	0.9	0.1	3	0.9	1.8	1.8	3.2

	162	163	164	165	166	167	168	169	170	171	172	172.6
OBSERVED	6.9	9.1	6.4	1.5	5.3	7.6	3.2	1.4	1.9	2.4	0	6.6
REDUCED	6.7	9	6.2	1.2	5.1	7.3	3	1.2	1.7	2.1	-0.7	6.1

Figure 2.21: River Bed Profile CH 150.0 to 172.60 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
150	2	3.1
151	0.7	0.9
152	1.4	1.6
153	-2	0
154	-0.6	0.7
155	0.9	1.1
156	0.1	0.3
157	3	3.1
158	0.9	1.1
159	1.8	1.9
160	1.8	2
161	3.2	3.3
162	6.7	6.9
163	9	9.1
164	6.2	6.4
165	1.2	1.5
166	5.1	5.3
167	7.3	7.6
168	3	3.2
169	1.2	1.4
170	1.7	1.9
171	2.1	2.4
172	-0.7	0
172.6	6.1	6.6

(c) Prominent Dam/ Barrage: Wanakbori dam is located at Ch 173.9 km. Maximum height above the river bed level is 22.60m and length of the dam is 795.52m.

(d) Tidal Stretch: This 25 km of river stretch is completely non-tidal.

(e) Bank: Details of bank protection being tabulated below:-

From Ch(km)	To Ch(km)	Length(m)	Left/ Right Bank
169.3	169.385	55	Left
172.6	173.4	800	Right
173.7	173.75	50	Left

Table 2.45 :Details of bank protection

(f) Hindrances: This portion of the river is having shallow stretch and rocky botton in most of the places. Plying of vessel can only be possible with due precaution.

(g) Encroachment: No encroachment was observed in this stretch.

(h) Protected Area: There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) NH/ SH: SH 63 and SH 175 are located 2.5 km towards south eastern side and 1.7 km towards north eastern side from the river corridor respectively. SH 47 and NH 59 are crossing the river at Ch 156.2 km and Ch154.5 km respectively.

(j) Railway Station: Sevaliya Railway Station is located 1 km towards western side from the river stretch.

(k) Land Use Pattern: Land on either banks of the river being utilised for residential and commercial purpose.

(l) Crops: Primary crops are tobacco, wheat, mustard, corn, etc.

(m) Bulk Construction Material: Excavation of quarry is predominant in this section.

(n) Existing Industry: Thermal plant at Sangol and Hydel Plant at Wanakbori are located at Ch 162 km and Ch 173.9 km respectively.

(o) Existing Ghats, Jetties and Terminals: There is no jetty, terminal and ghat observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) Prominent City/ town or Place of Worship: Balasinor and Sevaliya are located 6 km towards north western side and 1 km towards western side from the river corridor.

(r) Ferry: No ferry service is available in this stretch.

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Fishing folks were seen engaging in fishing activity.

(u) Sand Mining: Quarry mining activity was found in this stretch.

(v) Tributaries: There is no tributary of MahiRiver in this section.

(w) Details of Irrigational Canals: Narmada Irrigation Canal is passing across the river at Ch 159.2 km. Wanakbori Irrigation Canal is located at Ch 173.9 km.

(x) Details of Nalas: Details of nala being appended below:-

Ch (km)	Bank
160.3	RT
166	LT
173.9	RT
160.3	RT
166	LT
172.6	RT

Table 2.46 :Details of Nala

(y) Usage of Water: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) Details of Cross-Structures: Details of cross-structures and HT lines being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL/MHWS
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
(SH-63)		3°16'33.50"E	73°16'35.18"E	2520532.104	2520026.2					
Sevaliya Rail Bridge	153	22°48'34.00"N	22°48'29.28"N	331445.58	332246.75	831.59	18.26	18	46.2	1.389
		3°21'27.81"E	73°21'55.94"E	2523362.21	2523208.37					
Sevaliya Broken Bridge	153.2	22°48'43.70"	22°48'33.32"	331578.13	332167.06	675.31	6.48	66	10.52	NA
		73°21'32.34"	73°21'53.12"	2523659.04	2523333.29					
Sevaliya Bridge	153.23	22°48'46.03"N	22°48'33.91"N	331550.26	332239.98	792.97	12.18	20	38.95	2.32
		73°21'31.33"E	73°21'55.67"E	2523731.15	2523350.64					
Shanipur Bridge(NH47)	155.04	22°49'33.86"N	22°49'20.30"N	332598.06	333211.78	748.13	22	25	30	1.51
		73°22'7.51"E	73°22'29.20"E	2525192.88	2524766.95					
Narmada Canal	158	22°51'0.07"N	22°50'52.10"N	333769.52	334305.63	601	76.55	23	25.09	2.779
		73°22'47.58"E	73°23'6.46"E	2527829.91	2527579.77					
		3°49'45.74"E	73°49'56.60"E	2575680.97	2575622.594					

Table 2.47 :Details of Bridges & Crossings

Details of Water Intake

Structure Name	Ch (km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Start	End	Start	End					
Water Intake	153.04	22°48'36.6665N"	22°48'36.7332N"	331500.59	331466.476	33	6	0	33	-
		073°21'29.7073 E"	073°21'28.5103 E"	2523443.63	2523446.061					
Water Intake	162.6	22°52'59.8375N"	22°52'59.2266N"	332576.61	332541.343	45	6	0	45	-
		073°22'4.3021 E"	073°22'3.0718 E"	2531527.34	2531508.942					
Water Intake	168.15	22°55'27.8056N"	22°55'27.4702N"	335198.513	335209.567	35	8	0	35	-
		073°23'34.5565 E"	073°23'34.9486 E"	2536050.273	2536039.829					

Table 2.48 :Details of Water Intake

High Tension Lines / Electric Lines

Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
		GLOBAL		UTM				
		Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
HT LINE	157.58	22°50'47.0583"N	73°22'42.7773"E	333628	2527431	18.9	523	Complete

Table 2.49 :High Tension Lines / Electric Lines

2.5.9 Sub-Stretch 9: From Ch 172.6 km to Ch 203 km.

This stretch of the river is having length of 30.4 km from Ch 172.6 km to Ch 203 km. Current meter observation and discharge measurement were carried out at Ch 180 km , Ch 190 km and Ch 200 km. BM control pillars Mahi 19, 20 & 21 are located in this section. Panam River which is the tributary of Mahi is located at Ch 199 km. There is no forest zone or restricted zone in this section. Cultivated crops are tobacco, mustard, wheat, etc.

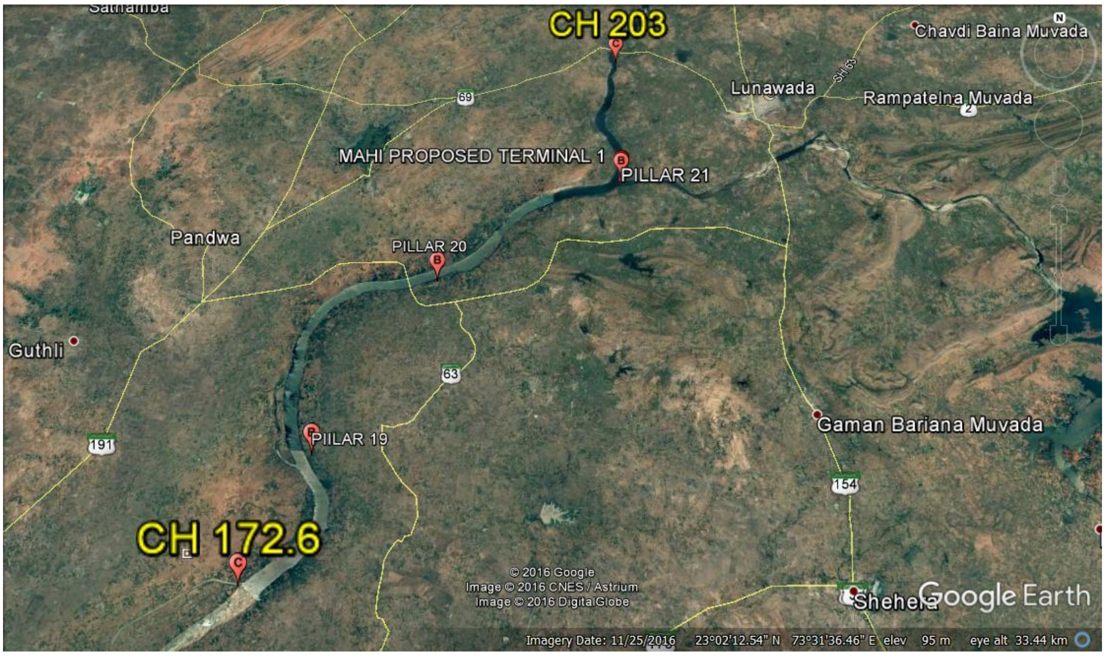


Figure 2.22 : Sub-Stretch-09 from CH 172.3 km to CH 203 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	**From**	**To**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**
Class-III	172.6	203	1.4	14.5	400	366.33	1.4	14.23	400	291.63
Class-IV	172.6	203	1.4	14.5	1800	2374.13	1.4	14.23	1400	1837.52
Class-V	172.6	203	0.5	14.5	2200	9049.54	0.3	14.23	2200	8274.37

Table 2.50 : Stretch-9 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-9 (172.6-203 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	172.6-203	Covered by bathymetric survey
Topographic Survey	172.6-203	River banks, drying heights, topographic features.

(b) **Observed & Reduced Depth Profile of the Stretch:** Reduced & observed depth profile of the stretch is mentioned below:-

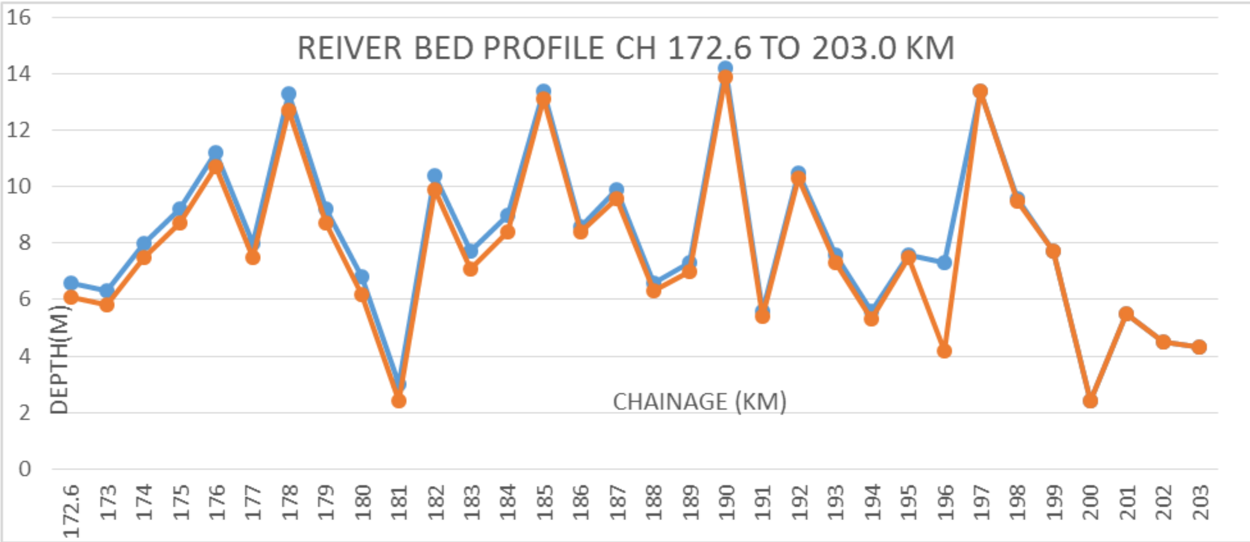


Figure2.23 :River Bed Profile CH 172.6 to 203.0 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
172.6	6.1	6.6
173	5.8	6.3
174	7.5	8
175	8.7	9.2
176	10.7	11.2
177	7.5	8
178	12.7	13.3
179	8.7	9.2
180	6.2	6.8
181	2.4	3
182	9.9	10.4

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
183	7.1	7.7
184	8.4	9
185	13.1	13.4
186	8.4	8.6
187	9.6	9.9
188	6.3	6.6
189	7	7.3
190	13.9	14.2
191	5.4	5.6
192	10.3	10.5
193	7.3	7.6
194	5.3	5.6
195	7.5	7.6
196	4.2	7.3
197	13.4	13.4
198	9.5	9.6
199	7.7	7.7
200	2.4	2.4
201	5.5	5.5
202	4.5	4.5
203	4.3	4.3

(c) Prominent Dam/ Barrage: No dam/ barrage exists in this section after wanakbori.

(d) Tidal Stretch: This 29.1 km of river stretch is completely non-tidal.

(e) Bank: Details of bank protection being tabulated below:-

From Ch(km)	To Ch(km)	Length(m)	Left/ Right Bank
189.3	189.35	50	Left
199.2	199.3	100	Right

Table 2.51 :Details of bank protection

(f) Hindrances: This portion of the river is having sufficient depth for plying vessels throughout the year. No navigational hindrances being perceived in ths portion.

(g) Encroachment: No encroachment was observed in this stretch.

(h) Protected Area: There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) NH/ SH: SH 2 and SH 69 are located 5.5 km towards north western side from the river corridor and SH 63 crosses the river at Ch 189.3 km.

(j) Railway Station: No railway network was observed in this strech.

(k) Land Use Pattern: Land on either banks of the river being utilised for residential and commercial purpose.

(l) Crops: Agricultural activity is prominent in this section. Primary crops are tobacco, wheat and mustard, etc.

(m) Bulk Construction Material: No bulk construction material is available in this section.

(n) Existing Industry: No major industry was observed in this section.

(o) Existing Ghats, Jetties and Terminals: There is no jetty, terminal and ghat observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) Prominent City/ town or Place of Worship: Thana Savli town is located approximately 5 km away towards eastern side from the river bank. However Lunawada is the most populated city falling in the depicted river stretch.

(r) Ferry: Bordi ferry ghat is located at Ch 178.2 km. Pattan ferry ghat is located at Ch 201.3 km.

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Fishing folks were seen engaging in fishing activity.

(u) Sand Mining: No sand mining activity was found in this stretch.

(v) Tributaries: Panam River is the only tributary present in this section.

(w) Details of Irrigational Canals: There is no irrigational canal present in this section.

(x) Details of Nalas: Details of nala being appended below:-

Ch (km)	Bank
176.2	RT
177	RT
182.5	LT
190.4	LT
192	RT
192.3	RT
198	RT
176.2	RT

Ch (km)	Bank
177	RT
201.85	LT

Table 2.52 :Details of Nala

(y) Usage of Water: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) Details of Cross-Structures.: Details of cross-structures and HT lines are being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Thana Savli Bridge	188.1	23° 3'16.22"N 73°28'19.44"E	23° 3'2.08"N 73°28'24.03"E	343465.53 2550371.23	343591.15 2549934.75	430.95	6.82	10	44.16	5.929

Table 2.53 :Details of Bridges & Crossings

High Tension Lines / Electric Lines

Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
		GLOBAL		UTM				
		Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
ELECTRIC LINE	188.04	23°03'12.8338"N	73°28'18.5395"E	343438	2550267	12.5	300	Complete
ELECTRIC LINE	188.14	23°03'13.4896"N	73°28'22.2358"E	343543	2550285	10.8	300	Complete
HT LINE	188.2	23°03'13.9966"N	73°28'24.2065"E	343600	2550301	18.7	750	Complete
HT LINE	188.37	23°03'15.5222"N	73°28'29.6845"E	343756	2550346	20.1	675	Complete
HT LINE	189.75	23°03'30.9227"N	73°29'17.0932"E	345111	2550806	22.5	550	Complete
ELECTRIC LINE	199.65	23°06'55.6900"N	73°32'47.0821"E	351150	2557044	12.6	230	Complete

Table 2.54 :High Tension Lines / Electric Lines

2.5.10 Sub-Stretch 10: From Ch 203 km to Ch 232 km

This stretch of the river is having length of 29 km from Ch 203 km to Ch 232 km. BM Control pillars 22 , 23 & 24 are falling in this section. Current meter observation and discharge measurement were carried out at Ch 210 km, Ch 220 km and Ch 230 km. Lunawada town is located in the right bank of this stretch. Tantroli Check dam is located at Ch 232 km. Agricultural activity is not much prominent along the waterway due to steep terrain. Gravel mining is very much prominent in this section. There is no forest zone or restricted zone in this section. Cultivated crops are tobacco, mustard, wheat, cauliflower, cabbage and carrot, etc.

Figure 2.24 : Sub-Stretch 10: From Ch 203 km to Ch 232 km

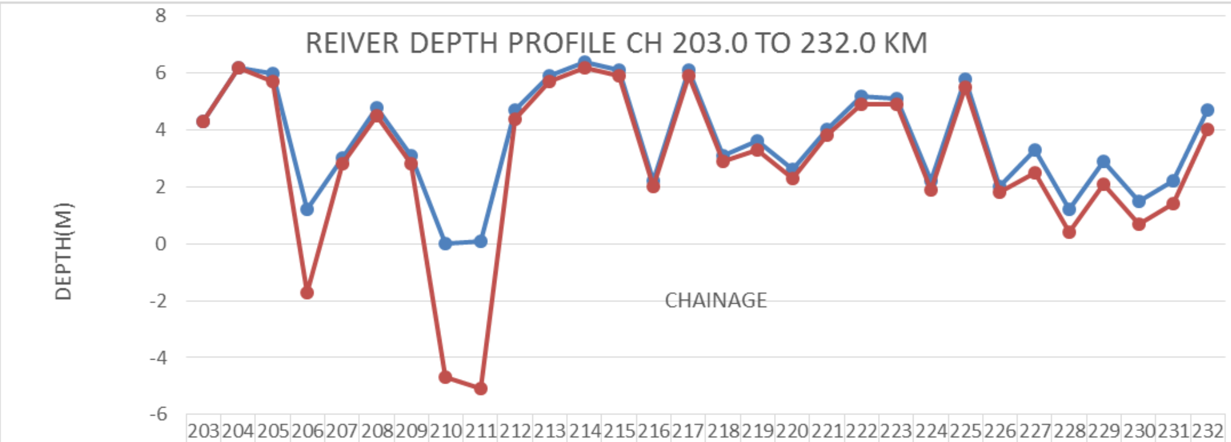
	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	From	To	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)	Min Depth (m)	Max Depth (m)	Length of Shoal (m)	Dredging Qty (cu.m)
Class-III	203	232	0	8.5	14200	296575.2	-0.3	8.27	16800	479737.95
Class-IV	203	232	0	8.5	17200	448788.4	-0.3	8.27	19600	663167.49
Class-V	203	232	0	8.5	19800	746446.9	-0.3	8.27	22600	1120938.85

Table 2.55 : Stretch-10 Dredging Quantity

(a) Bathymetry Survey & Topographic Survey.

SUB-STRETCH-10 (203-232 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	203-205.6	Covered by bathymetric survey
	206.2-209	
	211.2-231.8	
Topographic Survey	205.6-206.2	Due to dry/ shallow patches, Topographic Survey carried out.
	209-211.2	
	231.8-232	
	203-232	River banks, drying heights, topographic features.

(b) Observed & Reduced Depth Profile of the Stretch: Reduced & observed depth profile of the stretch is mentioned below:-



	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232
OBSERVED	4.3	6.2	6	1.2	3	4.8	3.1	0	0.1	4.7	5.9	6.4	6.1	2.2	6.1	3.1	3.6	2.6	4	5.2	5.1	2.2	5.8	2	3.3	1.2	2.9	1.5	2.2	4.7
REDUCED	4.3	6.2	5.7	-2	2.8	4.5	2.8	-5	-5	4.4	5.7	6.2	5.9	2	5.9	2.9	3.3	2.3	3.8	4.9	4.9	1.9	5.5	1.8	2.5	0.4	2.1	0.7	1.4	4

Figure 2.25 : River Bed Proifle CH 203 to 232 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
203	4.3	4.3
204	6.2	6.2
205	5.7	6
206	-1.7	1.2
207	2.8	3
208	4.5	4.8
209	2.8	3.1
210	-4.7	0
211	-5.1	0.1
212	4.4	4.7
213	5.7	5.9
214	6.2	6.4
215	5.9	6.1
216	2	2.2
217	5.9	6.1
218	2.9	3.1
219	3.3	3.6
220	2.3	2.6
221	3.8	4
222	4.9	5.2
223	4.9	5.1
224	1.9	2.2
225	5.5	5.8
226	1.8	2
227	2.5	3.3
228	0.4	1.2
229	2.1	2.9
230	0.7	1.5
231	1.4	2.2
232	4	4.7

(c) **Prominent Dam/ Barrage**: Tantroli Dam is located at Ch 233 km.

(d) **Tidal Stretch**: This 29 km of river stretch is completely non-tidal.

(e) **Bank**: This river portion is having unprocted bank.

(f) **Hindrances**: This portion of the river is having sufficient depth for plying small vessels throughout the year. No navigational hindrances being perceived in ths portion. Tantroli Check Dam at Ch 233 km will create due hindrance for navigational activities.

(g) **Encroachment**: No encroachment was observed in this stretch.

(h) **Protected Area**: There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) **NH/ SH**: SH 191 and SH 63 are located 3 km towards northern side and 3.5 km towards southern side from the river corridor respectively.

(j) **Railway Station**: No railway network was observed in this strech.

(k) **Land Use Pattern**: Land on either banks of the river being utilised for residential and commercial purpose.

(l) **Crops**: No agricultural activity was monitored in this section.

(m) **Bulk Construction Material**: Gravel mining is prominent in this section.

(n) **Existing Industry**: No major industry was observed in this section. However under construction Hydel plant at Tantroli will be a prominent commerce in future, gravel industries are the prominent industries in this river stretch.

(o) **Existing Ghats, Jetties and Terminals**: There is no jetty, terminal and ghat observed in this portion.

(p) **Cargo Movement**: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) **Prominent City/ town or Place of Worship:** Lunawada town is located approximately 6 km away towards south eastern side from the river bank.

(r) **Ferry**: There is no ferry ghat observed in the depicted stretch of the river.

(s) **Water Sports Recreational Facilities**: There is no facility for water sports in this section.

(t) **Fishing Activity**: Farce fishing activity was observed in this stretch.

(u) **Sand Mining**: No sand mining activity was found in this stretch, but remarkable gravel mining activity was observed during the course of survey.

(v) **Tributaries**: There is no tributary present in this section.

(w) **Details of Irrigational Canals:** There is no irrigational canal present in this section.

(x) **Details of Nalas**: Details of nala being appended below:-

Ch (km)	Bank
203.5	RIGHT BANK
204.7	RIGHT BANK
206.2	LEFT BANK
208.1	RIGHT BANK
210.5	LEFT BANK
214.6	LEFT BANK
219.6	RIGHT BANK
221.7	RIGHT BANK
225.5	LEFT BANK
227.2	RIGHT BANK
228.9	LEFT BANK

Table 2.56 :Details of Nala

(y) **Usage of Water**: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) **Details of Cross-Structures**: Details of cross-structures, Water Intake and HT lines being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Hadod Bridge	203.6	23° 9'6.46"N 73°32'52.99"E	23° 9'1.74"N 73°33'3.90"E	351358.69 2561064.059	351667.286 2560916.53	342.05	6.79	20	16.87	-3.602
Limbrodra Bridge	212.25	3°12'34.80"N 73°35'59.67"E	23°12'21.87"N 73°36'4.65"E	356729.53 2567420.344	356867.729 2567021.198	432.55	24.18	10	41.82	11.619
Tantroli Bridge	231.22	3°15'42.99"N 3°43'30.67"E	23°15'34.67"N 73°43'35.25"E	369601.28 2573090.216	369729.896 2572833.881	286.79	8.01	17	16.94	-4.391

Table 2.57 :Details of Bridges & Crossings

Details of Water Intake

Structure Name	Ch (km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Start	End	Start	End					
Water Intake	207.3	23°10'51.3145N"	23°10'51.3746N"	353297.39	353308.472	30	6	0	30	-
		073°34'0.0603 E"	073°34'0.4494 E"	2564270.27	2564272.014					
Water Intake	223.85	23°15'06.3644N"	23°15'07.2482N"	363851.9	363845.978	30.2	8.34	0	NA	-
		073°40'8.7171 E"	073°40'8.5 E"	2572015.16	2572042.401					

Table 2.58 :Details of Water Intake

High Tension Lines / Electric Lines

I No.	Cross-Structure Type	Chainage(km)	Position				Vertical clearance above H.F.L.(m)	Horizontal Clearance (m)	Remarks (Complete/ Under - construction)
			GLOBAL		UTM				
			Latitude(N)	Longitude(E)	Easting(m)	Northing(m)			
1	HT LINE	203.81	23°09'11.0655"N	73°33'03.3393"E	351654	2561202	17.9	650	Complete
2	ELECTRIC LINE	212.18	23°12'24.5471"N	73°36'02.9876"E	356820	2567104	13.2	250	Complete
3	HT LINE	214.22	23°12'18.4364"N	73°37'07.5810"E	358655	2566898	19.2	600	Complete
4	HT LINE	224.95	23°15'08.2955"N	73°40'39.9762"E	364741	2572066	20.5	700	Complete
5	ELECTRIC LINE	231.1	23°15'36.8893"N	73°43'30.3257"E	369590	2572902	10.5	350	Complete
6	ELECTRIC LINE	231.15	23°15'37.7271"N	73°43'31.7890"E	369631	2572928	12.5	350	Complete
7	ELECTRIC LINE	231.32	23°15'40.6710"N	73°43'36.6148"E	369770	2573018	11.3	350	Complete

Table 2.59 : High Tension Lines / Electric Lines

2.5.11 Sub-Stretch 11: From Ch 232 km to Ch 246.9 km

This stretch of the river is having length of 14.9 km from Ch 232 km to Ch 246.9 km. Current meter observations and discharge measurements were carried out at Ch 240 km and Ch 246.8 km. BM Control pillars Mahi 25 & 26 are located in this section. Tantroli Check dam is located at Ch 232 km. Kadana Dam is the end point of river corridor and located at Ch 246.9 km. Kadana Hydroelectric Power Station is situated in this section. Agricultural activity is not prominent along the waterway due to steep terrain. Grabel mining is very much prominent in this section.

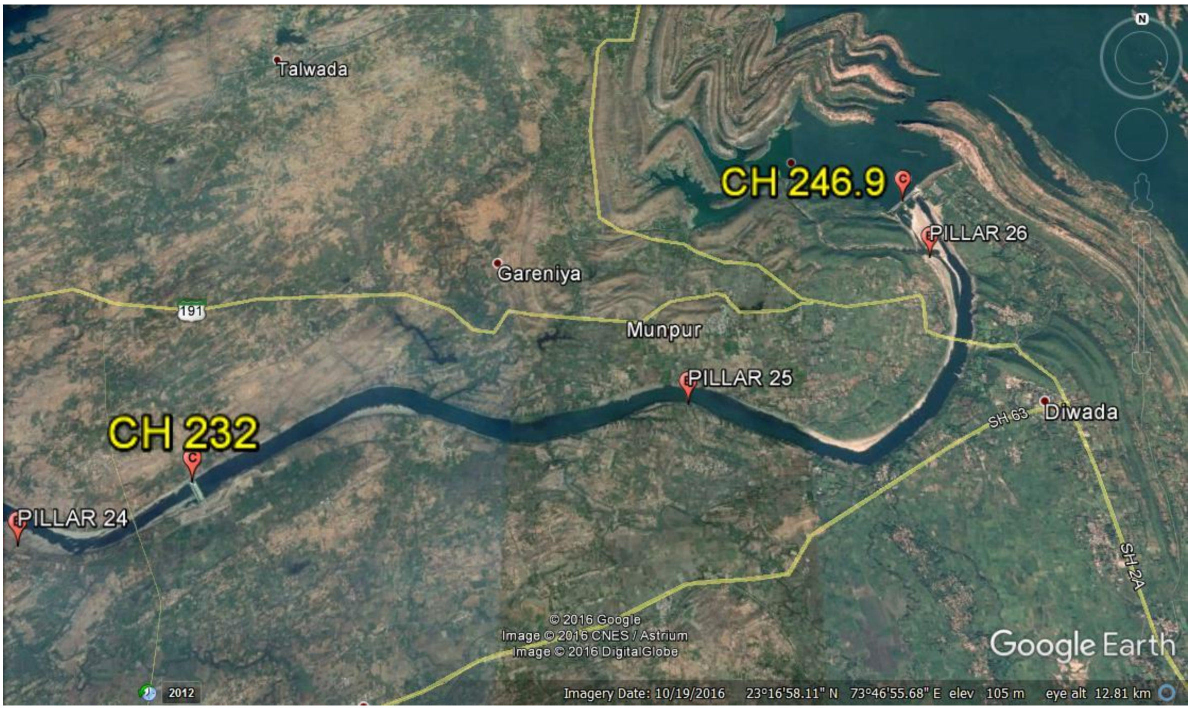


Figure 2.26 : Sub-Stretch 11: From Ch 232 km to Ch 246.9 km

	Chainage (km)		Observed				Reduced wrt Sounding Datum			
Type	**From**	**To**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**	**Min Depth (m)**	**Max Depth (m)**	**Length of Shoal (m)**	**Dredging Qty (cu.m)**
Class-III	232	246.9	0.7	10.3	1400	15576.1	0.3	9.93	2000	22402.57
Class-IV	232	246.9	0.7	10.3	1800	21743.63	0.3	9.93	2600	38035.57
Class-V	232	246.9	0	10.3	3600	49943.01	-0.3	9.93	4800	84282.14

Table 2.60 : Stretch-11 Dredging Quantity

(a) **Bathymetry Survey & Topographic Survey**.

SUB-STRETCH-11 (232-246.9 KM)		
Type of Survey	**Chainage (km)**	**Remarks**
Bathymetry Survey	232-246.9	Covered by bathymetric survey
	232-246.9	River banks, drying heights, topographic features.

(b) **Observed & Reduced Depth Profile of the Stretch:** Reduced & observed depth profile of the stretch is mentioned below:-

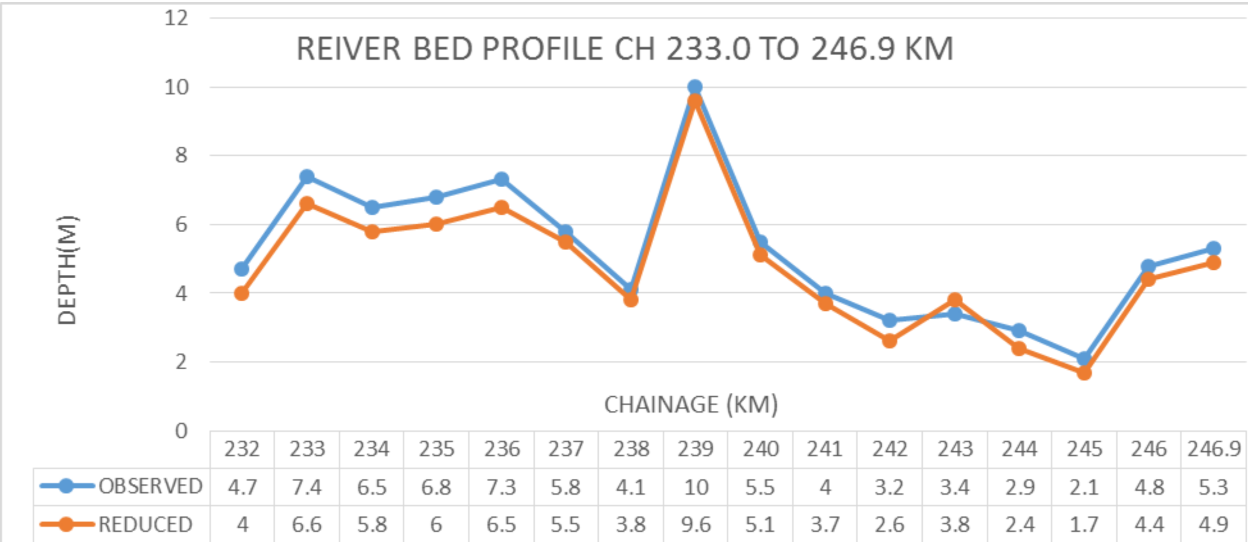


Figure 2.27 : River Bed Profile CH 232.0 to 246.9 KM

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
232	4	4.7
233	6.6	7.4
234	5.8	6.5
235	6	6.8
236	6.5	7.3
237	5.5	5.8

CHAINAGE (KM)	REDUCED DEPTH (M)	OBSERVED DEPTH (M)
238	3.8	4.1
239	9.6	10
240	5.1	5.5
241	3.7	4
242	2.6	3.2
243	3.8	3.4
244	2.4	2.9
245	1.7	2.1
246	4.4	4.8
246.9	4.9	5.3

(c) **Prominent Dam/ Barrage**: Kadana Dam is located at Ch 246.9 km and details of which being depicted later.

(d) **Tidal Stretch**: This 13.9 km of river stretch is completely non-tidal.

(e) **Bank**: This river portion is having unproocted bank.

(f) **Hindrances**: Shallow patches are the prominent hindrances for navigation in this section.

(g) **Encroachment**: No encroachment was observed in this stretch.

(h) **Protected Area**: There is no wildlife, Defence, Atomic power plant and any other procted areas in this stretch.

(i) **NH/ SH**: SH 191 and SH 63 are located 3 km towards northern side and 3.5 km towards southern side from the river corridor respectively

(j) **Railway Station**: No railway network was observed in this strech.

(k) **Land Use Pattern**: Land on either banks of the river being utilised for residential and commercial purpose.

(l) **Crops:** No agricultural activity was monitored in this section.

(m) Bulk Construction Material: Gravel mining is prominent in this section.

(n) Existing Industry: Kadana Hydro Electric Plant is only existing industrial structure located in the stretch.

(o) Existing Ghats, Jetties and Terminals: There is no jetty, terminal and ghat observed in this portion.

(p) Cargo Movement: There is no cargo movement observed in this portion of the water way during the course of survey.

(q) Prominent City/ town or Place of Worship: No prominent town/ city or place of worship is located in this section.

(r) Ferry. No ferry is located in this stretch:

(s) Water Sports Recreational Facilities: There is no facility for water sports in this section.

(t) Fishing Activity: Farce fishing activity was observed in this stretch.

(u) Sand Mining: No sand mining activity was found in this stretch. But remarkable gravel mining activity was observed during the course of survey.

(v) Tributaries: There is no tributary present in this section.

(w) Details of Irrigational Canals: There is no irrigational canal present in this section.

(x) Details of Nala: Details of nala being appended below:-

Ch (km)	Bank(RT/Lt)
234.7	RT
236.2	LT
236.4	LT
237.9	RT
238.2	RT
239	RT
240.4	LT

Table 2.61 :: Details of Nala

(y) Usage of Water: Water in this portion primarily utilised for irrigational and industrial purpose.

(z) Details of Cross-Structures: Details of cross-structures and HT lines being appended below:-

Details of Bridges & Crossings

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	No of Piers	Horizontal clearance (Distance Between piers) (m)	Vertical clearance (m) wrt HFL
		Lt Bank	Rt Bank	Lt Bank	Rt Bank					
Kadana Bridge	244.6	23°17'10.12"N 3°49'45.74"E	23°17'8.32"N 73°49'56.60"E	380281.923 2575680.97	380589.983 2575622.594	313.42	6.26	15	20.04	-6.271

Table 2.62: Details of Bridges & Crossings

2.6 Water and Soil Samples analysis and Results

The soil and water samples were collected near the BM/ Tide Gauge established during theHydrographic survey. The Soil and water samples at sampling location number 18 could not be obtained due to unavailability if sufficient water level.

2.6.1 Water Sample Analysis and Results

Water samples were collected at following 26 locations:-

S.No	Chainage (Km)	Easting	Northing	Latitude	Longitude	Depth (m)	Mid-Depth (0.5d) (m)
MAHI 1	0	243249.02	2454464.38	22°10'35.22"N	72°30'36.28"E	4.4	2.2
MAHI 2	10.8	250879.93	2460785.79	22°14'4.64"N	72°34'58.99"E	4.2	2.1
MAHI 3	22	260089.32	2457903.54	22°12'35.67"N	72°40'21.98"E	2.4	1.2
MAHI 4	32.6	269921.19	2459906.88	22°13'45.58"N	72°46'4.09"E	0.6	0.3
MAHI 5	40.6	276917.97	2460507.54	22°14'8.41"N	72°50'8.03"E	0.5	0.25
MAHI 6	50	285733.74	2461564.39	22°14'46.77"N	72°55'15.29"E	3.5	1.75
MAHI 7	60	288184.64	2467560.59	72°55'15.29"E	72°56'38.01"E	2.7	1.35
MAHI 8	70	293519.29	2463111.73	22°15'40.48"N	72°59'46.41"E	4	2
MAHI 9	80	300335.94	2469792.68	22°19'20.53"N	73° 3'41.45"E	1.2	0.6
MAHI 10	90	301492.51	2478701.4	22°24'10.59"N	73° 4'17.87"E	6.3	3.15
MAHI 11	100	303402.83	2487635.19	22°29'1.77"N	73° 5'20.67"E	4.2	2.1
MAHI 12	110	309228.16	2494359.21	2°32'42.71"N	73° 8'41.51"E	3.6	1.8
MAHI 13	120	314675.57	2501762.56	22°36'45.53"N	73°11'49.01"E	2.8	1.4
MAHI 14	130	322133.1	2507994.29	2°40'10.98"N	73°16'7.57"E	1.4	0.7
MAHI 15	140	320893.42	2517569.21	22°45'21.76"N	73°15'20.21"E	7	3.5
MAHI 16	150	329239.65	2520660.02	22°47'5.36"N	73°20'11.53"E	4.7	2.35

S.No	Chainage (Km)	Easting	Northing	Latitude	Longitude	Depth (m)	Mid-Depth (0.5d) (m)
MAHI 17	160	334183.58	2528435.18	22°51'19.89"N	73°23'1.87"E	2.7	1.35
MAHI 18	170	335795.25	2536312.76	22°55'36.55"N	73°23'55.40"E	4.5	2.25
MAHI 19	180	339867.81	2543493.49	2°59'31.41"N	73°26'15.65"E	10	5
MAHI 20	190	344203	2550328.24	23° 3'15.08"N	73°28'45.38"E	6.8	3.4
MAHI 21	200	351841.53	2555750.74	23° 6'13.88"N	73°33'11.84"E	8.9	4.45
MAHI 22	210	353150.59	2565030.59	23°11'15.98"N	73°33'54.63"E	5.3	2.65
MAHI 23	220	362141.95	2567404.33	23°12'35.95"N	73°39'10.06"E	4.8	2.4
MAHI 24	230	367635.71	2573211	23°15'46.35"N	73°42'21.47"E	5	2.5
MAHI 25	240	376795.91	2574818.81	23°16'41.19"N	73°47'43.34"E	5.4	2.7
MAHI 26	246.8	380163.27	2577770.88	23°18'18.07"N	73°49'41.01"E	2.8	1.4

Table 2.63- Water sampling locations

INFINITY SOLUTIONS LABORATORIES

(ISO 9001:2008 Certified)

Certificate of Analysis

NAME AND ADDRESS OF ~~MANUFACTURER~~ / SENDER		Report Number	ISLRD16028
STARBAG INDIA PVT LTD. 4TH FLOOR, 402. SUNRISE CO.OP. SOCIETY LTD, 247 WATER FIELD ROAD, BANDRA, BANDRA WEST,400050		Date of Receipt	30/01/2017
		Date of Report	04/02/2017
		Barcode Number	NM
SAMPLE NOT DRAWN BY INFINITY SOLUTIONS LABORATORIES			
Name of Sample	WATER (MAHI RIVER) SAMPLE	BatchNumber	MAHI P1 TO P26
Analysis Required	Description, pH,Sediment Concentration	Mfg. Date	NM
		Exp. Date	NM
Quantity Received	Approx.1 lit	Batch size	NM

14	MAHI P14	8.1	0.06
15	MAHI P15	8.04	0.04
16	MAHI P16	8.08	0.05
17	MAHI P17	7.74	0.05
18	MAHI P18	8.01	0.05
19	MAHI P19	7.78	0.03
20	MAHI P20	7.98	0.05
21	MAHI P21	7.87	0.05
22	MAHI P22	7.94	0.04
23	MAHI P23	8.17	0.05
24	MAHI P24	7.82	0.06
25	MAHI P25	7.7	0.06
26	MAHI P26	8	0.06

Remark: Sample analysed as per party's specification for above mention test parameter.

c. Report in part or full shall not be published for advertisement / legal purpose unless permission in writing is obtained from General Manager of Infinity Solutions Laboratories. Balance sample if any shall be discard after two weeks of the date on certificate unless specified otherwise.

b. Subject to the Thane Jurisdiction.

Analysed By: Approved By:

Date: Date 04/02/2017

INFINITY SOLUTIONS LABORATORIES NAVI MUMBAI

C-01, CIDCO Commercial Complex, Plot No.-2, Sector-2, Nerul, Navi Mumbai.
Tel: 022-27727818,

2.6.2 Soil Sample Analysis and Results

River bed soil samples were collected during survey period, the details of sample locations are as below:-

S.No	Chainage (Km)	Easting	Northing	Latitude	Longitude	Depth (m)
MAHI 1	0	243249.02	2454464.38	22°10'35.22"N	72°30'36.28"E	4.4
MAHI 2	10.8	250879.93	2460785.79	22°14'4.64"N	72°34'58.99"E	4.2
MAHI 3	22	260089.32	2457903.54	22°12'35.67"N	72°40'21.98"E	2.4
MAHI 4	32.6	269921.19	2459906.88	22°13'45.58"N	72°46'4.09"E	0.6
MAHI 5	40.6	276917.97	2460507.54	22°14'8.41"N	72°50'8.03"E	0.5
MAHI 6	50	285733.74	2461564.39	22°14'46.77"N	72°55'15.29"E	3.5
MAHI 7	60	288184.64	2467560.59	72°55'15.29"E	72°56'38.01"E	2.7
MAHI 8	70	293519.29	2463111.73	22°15'40.48"N	72°59'46.41"E	4
MAHI 9	80	300335.94	2469792.68	22°19'20.53"N	73° 3'41.45"E	1.2
MAHI 10	90	301492.51	2478701.4	22°24'10.59"N	73° 4'17.87"E	6.3
MAHI 11	100	303402.83	2487635.19	22°29'1.77"N	73° 5'20.67"E	4.2
MAHI 12	110	309228.16	2494359.21	22°32'42.71"N	73° 8'41.51"E	3.6
MAHI 13	120	314675.57	2501762.56	2°36'45.53"N	73°11'49.01"E	2.8
MAHI 14	130	322133.1	2507994.29	22°40'10.98"N	73°16'7.57"E	1.4
MAHI 15	140	320893.42	2517569.21	22°45'21.76"N	73°15'20.21"E	7
MAHI 16	150	329239.65	2520660.02	22°47'5.36"N	73°20'11.53"E	4.7
MAHI 17	160	334183.58	2528435.18	22°51'19.89"N	73°23'1.87"E	2.7
MAHI 18	170	335795.25	2536312.76	2°55'36.55"N	73°23'55.40"E	4.5
MAHI 19	180	339867.81	2543493.49	22°59'31.41"N	3°26'15.65"E	10
MAHI 20	190	344203	2550328.24	23° 3'15.08"N	73°28'45.38"E	6.8
MAHI 21	200	351841.53	2555750.74	23° 6'13.88"N	73°33'11.84"E	8.9
MAHI 22	210	353150.59	2565030.59	23°11'15.98"N	73°33'54.63"E	5.3
MAHI 23	220	362141.95	2567404.33	23°12'35.95"N	73°39'10.06"E	4.8
MAHI 24	230	367635.71	2573211	3°15'46.35"N	3°42'21.47"E	5
MAHI 25	240	376795.91	2574818.81	23°16'41.19"N	73°47'43.34"E	5.4
MAHI 26	246.8	380163.27	2577770.88	3°18'18.07"N	3°49'41.01"E	2.8

Table 2.64- Soil sampling locations

RESULTS: Soil sample test results show that river bed material is mainly composed of silt and sand Test Report is given below:

SOIL SAMPLE REPORT

INFINITY SOLUTIONS LABORATORIES

(ISO 9001:2008 Certified)

Certificate of Analysis

NAME AND ADDRESS OF ~~MANUFACTURER~~ / SENDER	Report Number	ISLRD16029
STARBAG INDIA PVT LTD.	Date of Receipt	30/01/2017
4TH FLOOR, 402. SUNRISE CO.OP. SOCIETY LTD, 247	Date of Report	09/02/2017
WATER FIELD ROAD, BANDRA, BANDRA WEST, 400050	Barcode Number	NM

SAMPLE NOT DRAWN BY INFINITY SOLUTIONS LABORATORIES

Name of Sample	SOIL SAMPLE (MAHI RIVER)	Batch Number	MAHI P1 TO P26
Analysis Required	Description, grain size, specific gravity,Cu, Cc , clay silt%	Mfg. Date	NM
		Exp. Date	NM
Quantity Received	Approx.1 kg	Batch size	NM

S.No	Sample No	Sample Description	Grain Size Analysis						Specific Gravity
			Garvel %	Sand %	Slit %	Clay %	Cu	Cc	
1	MAHI P1	Sandy silt (CL)	0	42	56	2	17.70	1.41	2.69
2	MAHI P2	Sandy silt (CL)	1	39	58	2	12.00	3.26	2.68
3	MAHI P3	Sandy silt (CL)	0	38	60	2	18.60	1.94	2.66
4	MAHI P4	Sandy silt (CL)	0	40	59	1	19.00	1.09	2.65
5	MAHI P5	Sandy silt (CL)	0	42	55	3	18.00	1.13	2.67
6	MAHI P6	Sandy silt with garvel	1	39	58	2	12.14	2.69	2.69
7	MAHI P7	Sandy silt (CL)	0	41	56	3	18.00	1.28	2.68
8	MAHI P8	Sandy silt (CL)	0	42	55	3	16.50	1.52	2.67
9	MAHI P9	Sandy silt (CL)	1	39	58	2	12.00	3.26	2.68
10	MAHI P10	Sandy silt (CL)	0	42	54	4	18.00	1.85	2.68

Remark: Sample analysed as per party's specification for above mention test parameter.

a. Report in part or full shall not be published for advertisement / legal purpose unless permission in writing is obtained from General Manager of Infinity Solutions Laboratories. Balance sample if any shall be discard after two weeks of the date on certificate unless specified otherwise.

b. Subject to the Thane Jurisdiction.

Analysed By:
Date: 09/02/2017

INFINITY SOLUTIONS LABORATORIES NAVI MUMBAI

Approved By:
Date: 09/02/2017

C-01, CIDCO Commercial Complex, Plot No.-2, Sector-2, Nerul, Navi Mumbai.
Tel: 022-27727818,

INFINITY SOLUTIONS LABORATORIES

(ISO 9001:2008 Certified)

Certificate of Analysis

NAME AND ADDRESS OF ~~MANUFACTURER~~ / SENDER		Report Number	ISLRD16029
STARBAG INDIA PVT LTD. 4TH FLOOR, 402. SUNRISE CO.OP. SOCIETY LTD, 247 WATER FIELD ROAD, BANDRA, BANDRA WEST, 400050		Date of Receipt	30/01/2017
		Date of Report	09/02/2017
		Barcode Number	NM
SAMPLE NOT DRAWN BY INFINITY SOLUTIONS LABORATORIES			
Name of Sample	SOIL SAMPLE (MAHI RIVER)	Batch Number	MAHI P1 TO P26
Analysis Required	Description, grain size, specific gravity,Cu, Cc , clay silt%	Mfg. Date	NM
		Exp. Date	NM
Quantity Received	Approx.1 kg	Batch size	NM

S.No	Sample No	Sample Description	Grain Size Analysis						Specific Gravity
			Garvel %	Sand %	Slit %	Clay %	Cu	Cc	
1	MAHI P11	Sandy slit	1	39	57	3	20.63	2.39	2.66
2	MAHI P12	Sandy silt with traces of garvel (CL)	1	40	54	5	18.89	1.77	2.67
3	MAHI P13	Sandy silt with traces of garvel (CL	2	35	58	5	18.67	1.96	2.69
4	MAHI P14	Sandy silt with traces of garvel (CL	2	46	50	2	17.80	1.70	2.69
5	MAHI P15	Sandy silt with traces of garvel (CL	3	38	55	4	16.67	2.63	2.68
6	MAHI P16	Sandy silt with traces of garvel (CL	2	40	53	5	12.75	3.31	2.67
7	MAHI P 17	Sandy silt with traces of garvel (CL	1	32	62	5	11.00	2.27	2.65
8	MAHI P 18	Sandy silt with traces of garvel (CL	2	33	60	5	13.33	3.33	2.69
9	MAHI P 19	Sandy silt with traces of garvel (CL	1	45	50	4	16.70	1.88	2.68
10	MAHI P 20	Sandy silt with traces of garvel (CL	2	46	50	2	20.63	2.05	2.69

Remark: Sample analysed as per party's specification for above mention test parameter.

c. Report in part or full shall not be published for advertisement / legal purpose unless permission in writing is obtained from General Manager of Infinity Solutions Laboratories. Balance sample if any shall be discard after two weeks of the date on certificate unless specified otherwise.

d. Subject to the Thane Jurisdiction.

Analysed By:
Date: 09/02/2017

INFINITY SOLUTIONS LABORATORIES NAVI MUMBAI

Approved By:
Date: 09/02/2017

C-01, CIDCO Commercial Complex, Plot No.-2, Sector-2, Nerul, Navi Mumbai.
Tel: 022-27727818,

INFINITY SOLUTIONS LABORATORIES

(ISO 9001:2008 Certified)

Certificate of Analysis

NAME AND ADDRESS OF ~~MANUFACTURER~~ / SENDER	Report Number	ISLRD16029
STARBAG INDIA PVT LTD.	Date of Receipt	30/01/2017
4TH FLOOR, 402. SUNRISE CO.OP. SOCIETY LTD, 247	Date of Report	09/02/2017
WATER FIELD ROAD, BANDRA, BANDRA WEST, 400050	Barcode Number	NM

SAMPLE NOT DRAWN BY INFINITY SOLUTIONS LABORATORIES

Name of Sample	SOIL SAMPLE (MAHI RIVER)	Batch Number	MAHI P1 TO P26
Analysis Required	Description, grain size, specific Gravity,Cu, Cc , clay, silt%	Mfg. Date	NM
		Exp. Date	NM
Quantity Received	Approx.1 kg	Batch size	NM

S.No	Sample No	Sample Description	Grain Size Analysis						Specific Gravity
			Garvel %	Sand %	Slit %	Clay %	Cu	Cc	
1	MAHI P21	Sandy silt	0	41	57	2	22.13	2.54	2.67
2	MAHI P22	Sandy silt with garvel	10	36	52	2	8.89	3.47	2.66
3	MAHI P23	Sandy silt with garvel	10	36	52	2	8,89	3.47	2.66
4	MAHI P24	Sandy silt with garvel	11	45	43	1	28.00	0.39	2.66
5	MAHI P25	Sandy silt with gravel	13	42	43	2	17.70	1.84	2.66
6	MAHI P26	Sandy silt with garvel	14	41	43	2	17.70	1.84	2.67

Remark: Sample analysed as per party's specification for above mention test parameter.

e. Report in part or full shall not be published for advertisement / legal purpose unless permission in writing is obtained from General Manager of Infinity Solutions Laboratories. Balance sample if any shall be discard after two weeks of the date on certificate unless specified otherwise.

f. Subject to the Thane Jurisdiction.

Analysed By:

Date: 09/02/2017

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Approved By:

Date: 09/02/2017

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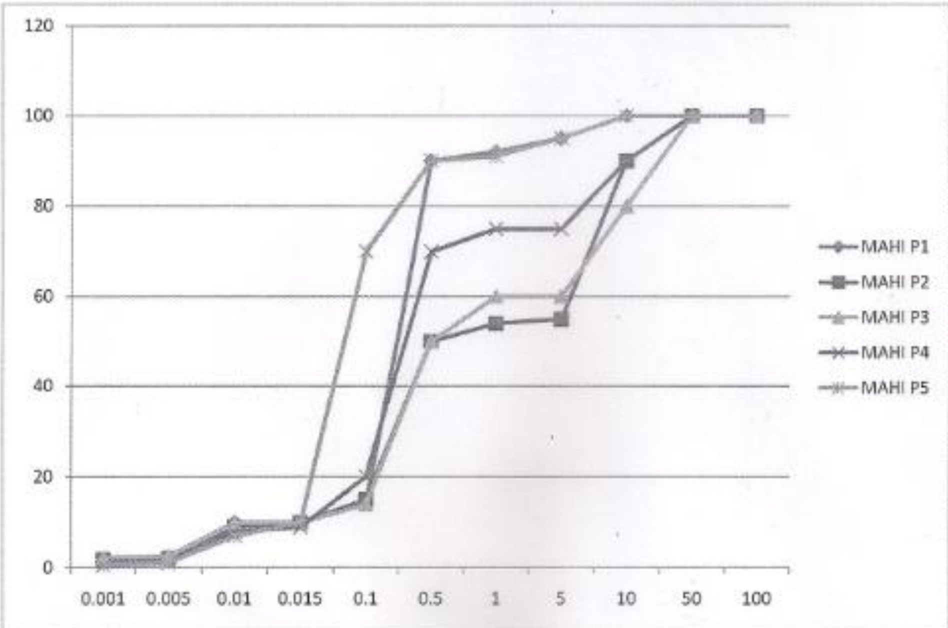
S.No	Sample No	Sample Description	Test Result								
			Garvel %	Sand %	Slit %	Clay %	D60	D30	D10	Cu	Cc
1	MAHI P1	Sandy silt (CL)	0	42	56	2	0.177	0.05	0.01	17.70	1.41
2	MAHI P2	Sandy silt (CL)	1	39	58	2	0.096	0.05	0.008	12.00	3.26
3	MAHI P3	Sandy silt (CL)	0	38	60	2	0.093	0.03	0.005	18.60	1.94
4	MAHI P4	Sandy silt (CL)	0	40	59	1	0.209	0.05	0.011	19.00	1.09
5	MAHI P5	Sandy silt (CL)	0	42	55	3	0.18	0.045	0.01	18.00	1.13

Hydrometer analysis ⟷ Sieves Analysis ⟷

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Grain Size Distribution curve (Mahi River)

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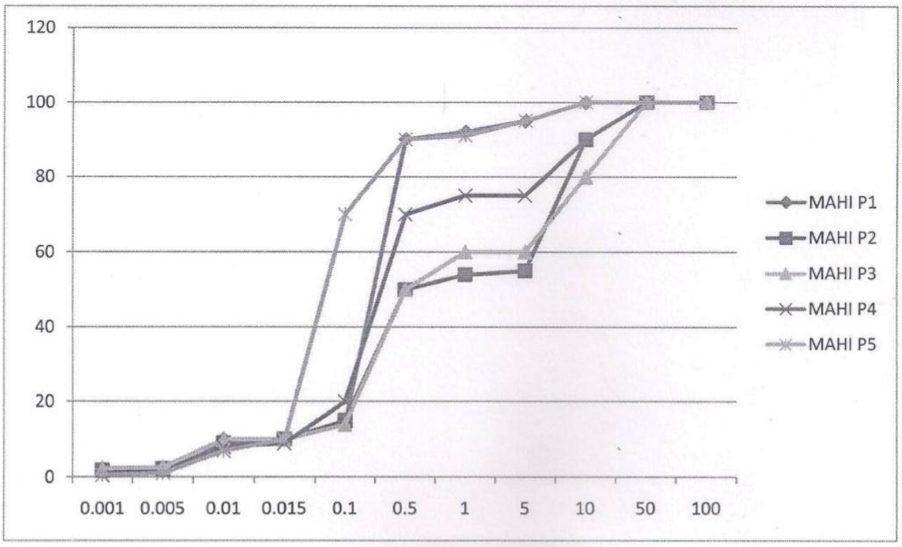
S.No	Sample No	Sample Description	Test Result								
			Garvel %	Sand %	Slit %	Clay %	D60	D30	D10	Cu	Cc
1	MAHI P6	Sandy silt with garvel	1	39	58	2	0.085	0.04	0.007	12.14	2.69
2	MAHI P7	Sandy silt (CL)	0	41	56	3	0.18	0.048	0.01	18.00	1.28
3	MAHI P8	Sandy silt (CL)	0	42	55	3	0.165	0.05	0.01	16.50	1.52
4	MAHI P9	Sandy silt (CL)	1	39	58	2	0.185	0.13	0.03	12.00	3.26
5	MAHI P10	Sandy silt (CL)	0	42	54	4	0.162	0.052	0.009	18.00	1.85

Hydrometer Analysis		Sieves Analysis				
Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Particle Size mm

Grain Size Distribution curve (Mahi River)

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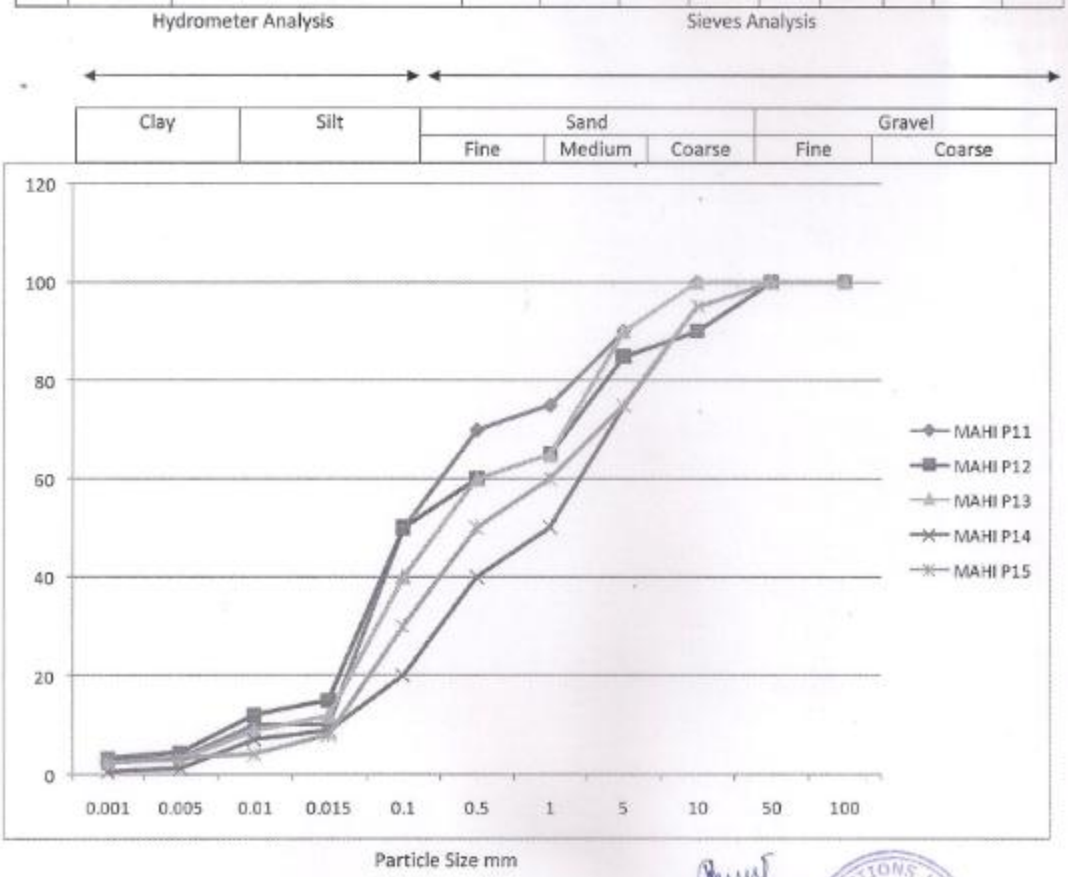
S.No	Sample No	Sample Description	Grain Size Analysis								
			Garvel %	Sand %	Slit %	Clay %	D60	D30	D10	Cu	Cc
1	MAHI P11	Sandy slit	1	39	57	3	0.165	0.15	0.008	20.63	2.39
2	MAHI P12	Sandy silt with traces of garvel (CL)	1	40	54	5	0.17	0.052	0.009	18.89	1.77
3	MAHI P13	Sandy silt with traces of garvel (CL	2	35	58	5	0.168	0.14	0.009	18.67	1.96
4	MAHI P14	Sandy silt with traces of garvel (CL	2	46	50	2	0.178	0.055	0.01	17.80	1.70
5	MAHI P15	Sandy silt with traces of garvel (CL	3	38	55	4	0.15	0.06	0.009	16.67	2.63



Grain Size Distribution curve (Mahi River)

09/02/2017

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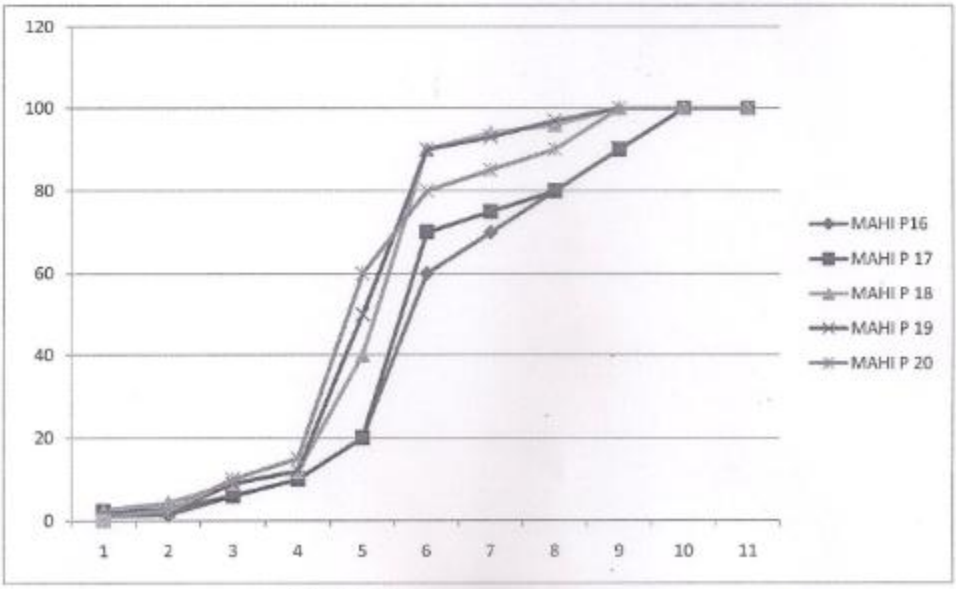
S.No	Sample No	Sample Description	Test Result								
			Garvel %	Sand %	Silt %	Clay %	D60	D30	D10	Cu	Cc
6	MAHI P16	Sandy silt with traces of garvel (CL	2	40	53	5	0.255	0.13	0.02	12.75	3.31
7	MAHI P 17	Sandy silt with traces of garvel (CL	1	32	62	5	0.088	0.04	0.008	11.00	2.27
8	MAHI P 18	Sandy silt with traces of garvel (CL	2	33	60	5	0.12	0.06	0.009	13.33	3.33
9	MAHI P 19	Sandy silt with traces of garvel (CL	1	45	50	4	0.167	0.056	0.01	16.70	1.88
10	MAHI P 20	Sandy silt with traces of garvel (CL	2	46	50	2	0.165	0.52	0.008	20.63	2.05

Hydrometer Analysis ⟷ Sieves Analysis

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Particle Size mm

Grain Size Distribution curve (Mahi River)

09/02/2017

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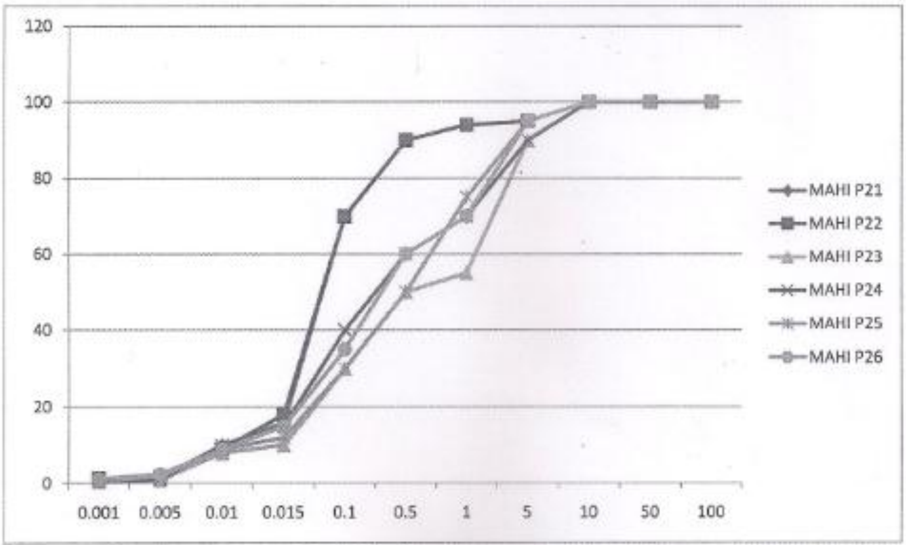
S.No	Sample No	Sample Description	Test Result								
			Garvel %	Sand %	Slit %	Clay %	D60	D30	D10	Cu	Cc
1	MAHI P21	Sandy silt	0	41	57	2	0.177	0.06	0.008	22.13	2.54
2	MAHI P22	Sandy silt with garvel	10	36	52	2	0,088	0.06	0.003	8.89	3.47
3	MAHI P23	Sandy silt with garvel	10	36	52	2	0.08	0.05	0.009	8,89	3.47
4	MAHI P24	Sandy silt with garvel	11	45	43	1	0.177	0,062	0.009	28.00	0.39
5	MAHI P25	Sandy silt with gravel	13	42	43	2	0.177	0.059	0.01	17.70	1.84
6	MAHI P26	Sandy silt with garvel	14	41	43	2	0.177	0.057	0.01	17.70	1.84

Hydrometer Analysis		Sieve Analysis				
Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Particle Size in mm

Grain Size Distribution Curve (River Mahi)

09/02/2017

INFINITY SOLUTIONS LABORATORIES NAVI MUMBAI

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CHAPTER – 3

FAIRWAY DEVELOPMENT

3.1 Proposed Class / Type of Waterway

In India, the inland waterways are classified into seven categories for rivers as well as canals by the Inland Waterways Authority of India (IWAI) vide GOI Gazette Notification dated 26 January 2007 & 07 November 2016 including amendments for safe passage of self-propelled vessels up to 2000 dead weight tonnage (DWT) and tug barge formation in push tow units of carrying capacity up to 8000 tonnes.

The classification of waterways is discussed below.

A. Classification of Inland waterways for Rivers

Table 3.1: Inland Waterway classification for Rivers

Class of Waterway	Rivers				
	Minimum Depth	Bottom Width	Bend Radius	Vertical Clearance	Horizontal Clearance
I.	1.2 m	30 m	300 m	4 m	30 m
II.	1.4 m	40 m	500 m	5 m	40 m
III.	1.7 m	50 m	700 m	6 m	50 m
IV.	2.0 m	50 m	800 m	8 m	50 m
V.	2.0 m	80 m	800 m	8 m	80 m
VI.	2.75 m	80 m	900 m	10 m	80 m
VII.	2.75 m	100 m	900 m	10 m	100 m

B. *Classification of Inland waterways for Canals*

Table 3.2: Inland Waterway classification for Canals

Class of Waterway	Canals				
	Minimum Depth	Bottom Width	Bend Radius	Vertical Clearance	Horizontal Clearance
I.	1.5 m	20 m	300 m	4 m	20 m
II.	1.8 m	30 m	500 m	5 m	30 m
III.	2.2 m	40 m	700 m	6 m	40 m
IV.	2.5 m	50 m	800 m	8 m	50 m
V.	-	-	-	-	-
VI.	3.50 m	60 m	900 m	10 m	60 m
VII.	-	-	-	-	-

The above classification for Rivers and Canals shall be effective if:

- Minimum depth of channel should be available for about 330 days in a year (about 90% days in a year).
- Vertical clearance at cross structures over the waterway should be available at least in central 75% portion of each of the spans in entire width of the waterway.

C. *Vertical Clearance for Power Cables / Telephone Lines for all Classes*

- Telephone lines and Low Voltage lines 16.5 m
- High Voltage Transmission lines not exceeding 110 KV – 19 m
- High Voltage Transmission lines exceeding 110 KV – 19 m + 1 cm per each KV. In case of underground pipe / power lines and other cables norms to be decided as per conditions and navigational requirement

D. *Reference level for vertical clearance for different types of channels*

- For rivers – over navigational HFL which is highest flood level at frequency of 5% in any year over a period of last 20 years
- HTL for tidal channels
- For channels design FSL

E. *Type of vessels to be used in different class waterways*

Table 3.3: Type of vessels to be used in different class of waterways

Class	Self-propelled vessel	Tug with barges
I.	Self-propelled, carrying capacity 100 DWT, Size (32m X 5m), Loaded draft 1m	1 Tug + 2 barges – 200 DWT, length 80m X breadth 5m , loaded draft 1m
II.	Self-propelled, carrying capacity 300 DWT, Size (45m X 8m), Loaded draft 1.2m	1 Tug + 2 barges – 600 DWT, length 110m X breadth 8m , loaded draft 1.2m
III.	Self-propelled, carrying capacity 500 DWT, Size (58m X 9m), Loaded draft 1.5m	1 Tug + 2 barges – 1000 DWT, length 141m X breadth 9m , loaded draft 1.5m
IV.	Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m	1 Tug + 2 barges – 2000 DWT, length 170m X breadth 12m , loaded draft 1.8m
V.	Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m	1 Tug + 2 barges – 2000 DWT, length 170m X breadth 24m , loaded draft 1.8m (moulded with 24 m)
VI.	Self-propelled, carrying capacity 2000 DWT, Size (86m X 14m), Loaded draft 2.5m	1 Tug + 2 barges – 4000 DWT, length 210m X breadth 14m , loaded draft 2.5m
VII.	Self-propelled, carrying capacity 4000 DWT, Size (86m X 14m), Loaded draft 2.9m	1 Tug + 4 barges – 8000 DWT, length 210m X breadth 28m , loaded draft 2.5m

All structures to be constructed across waterway classified should conform to respective requirement of vertical clearance and horizontal clearance. Before construction of any structure across the national waterway

As per office memorandum IWAI/NW-5/64/Nav. Clearance/2017 dtd. 08/12/17, River Mahi is classified as under: -

1) Class-IV from sea (Ch. 0.0) to Umeta Check Dam (Ch-80.0 km)
2) Class-III from Umeta Check Dam (Ch. 80.0 Km) to Kadana Dam (Ch. 247 Km)

Proposed class of waterway: WAPCOS has studied the possibility of developing waterway. WAPCOS recommend Class-IV waterway from CH 0 to 150KM in Mahi River.

However, Class-IV waterway from CH 0 to 150KM in Mahi River is based on current traffic studies. Waterways sector are in developing state, keeping that in view, NW-66 can be matured further as mentioned in the notification IWAI/NW-5/64/Nav. Clearance/2017 dtd. 08/12/17.

3.2 Details of Shoals (Length, Width and proposed development works)

During hydrographic survey of the river stretch it was found that there are number of shoals in Mahi River. Details of the shoals are as follows:

Table 3.4: Details of Shoals

Chainage		**Length(km)**	**Proposed Development Works**
From	To		Dredging is required as per proposed class of waterway
0	25	25	
25	35	10	
35	55	20	
55	80	25	
80	100	4.2	
100	125	19.4	
125	152	21.8	

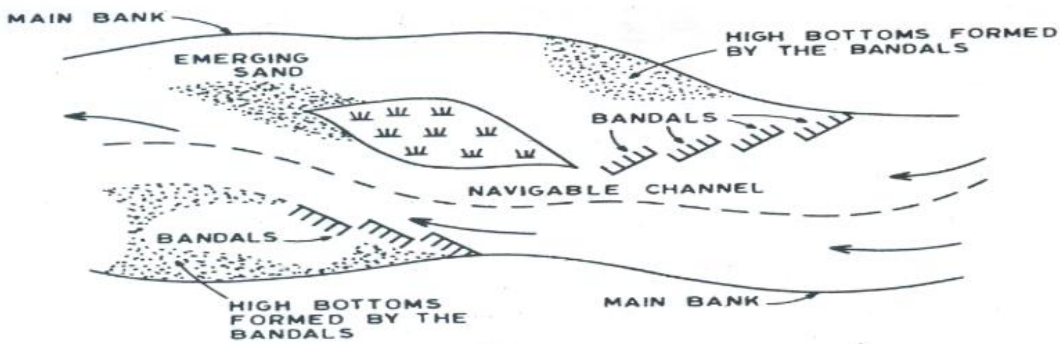
3.3 General Conservancy Activities

3.3.1 Low Cost structures

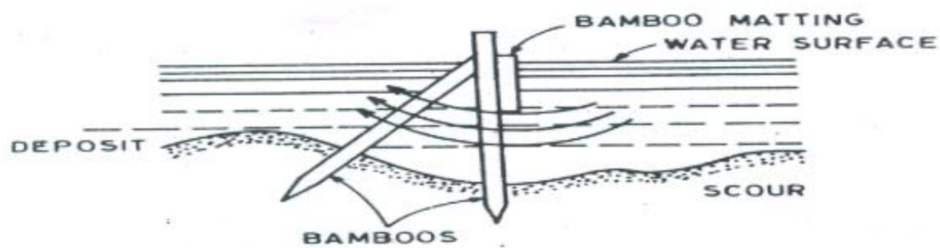
a) Bandalling

Bandals are commonly used low cost structures for improvement of navigation depth in rivers. Bandals are designed to confine the low water flow in a single channel for maintaining required navigation depth. A bandal consist of framework of bamboos driven in to the river bed, set 6m apart by means of horizontal ties and supported by struts at every 1.2 m. Bamboo matting are tied with coir ropes at water levels to the bamboo framework. The bamboo used on the framework are generally 3 to 6m in length and the matting is 0.9m wide strengthened at the edges bye strips of split bamboo as shown in fig 3.1

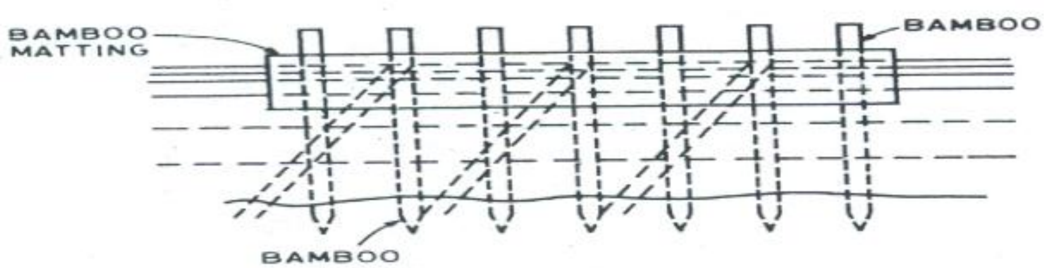
Bandals are placed at an angle of 30⁰ to 40⁰ inclined downstream. They check the flow and cause sand to be deposited parallel to and behind the bandals. Thus a channel confined between bandals is formed with sand banks on either side and the whole discharge of the river is directed through this channel.



LAYOUT PLAN OF BANDALS



SIDE VIEW OF A BANDAL



ELEVATION OF A BANDAL

b) Sub-merged vanes

Submerged vanes are frequently used as vortex generating for maintaining depth in navigation channel. The vanes are small flow-training structures designed and installed on the riverbed to modify the near-bed flow pattern and redistribute flow and sediment transport within the channel cross section. The structures are laid out so they create and maintain a flow and bed topography that is consistent with that of a stable channel creating optimum conditions for managing the river.

Significant changes in depth can be achieved without causing significant changes in cross-sectional area, energy slope, roughness and downstream sediment transport. As per literature, number, size and layout of the vanes depend on the channel morphology, velocity and depth at a meander bend. Vanes stabilize a channel reach without inducing changes upstream or downstream of that reach. Vanes may not be visible in time as they become buried by depositing sediment and aid the stream in doing the work by redistributing the flow energy to produce a more uniform cross-section without an appreciable increase in the energy loss through the reach.

The structures are installed at an angle of attack of typically 10^{o} to 20^{o} with the flow and their initial height is 0.1 to 0.4 times the local water depth at design stage. Typically, vanes are installed in arrays along one side or both sides of a river channel long enough to create a desired flow and bed redistribution. The advantage over traditional training structures, such as dikes and groins is that they can produce a given redistribution of flow at less resistance to the flow and less cost.

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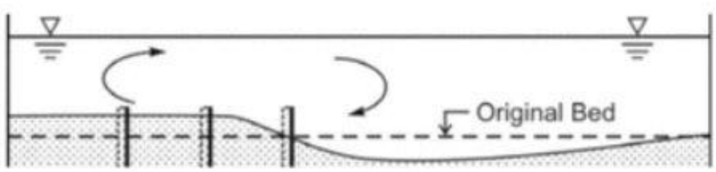


Figure 3.1 Schematic showing changes in bed profile induced by an array of three vanes

3.3.2 Dredging

Among the methods of regulation of rivers for navigation and removal of natural obstructions, dredging is a common remedy. With all training measures it becomes necessary, sometimes to keep the channel open for navigation by resorting to dredging. Natural scour is useful in its own way, but it may not be able maintain depths throughout the year, mainly because the condition in rivers change from season to season. Dredging is a useful auxiliary method, and there are few ports and navigational channels which are maintained without the aid of systematic dredging.

Dredging Plan:

For Dredging, Self-propelled Cutter Section Dredger (CSD) is recommended. Below milestone is subjected to the condition that contractor should mobilize all the dredgers, allied vessels, equipments and manpower within 45 days from award.

Dredging Work Milestone for Mahi River

Milestones	Milestone Quantity (m^3)	Cumulative Quantity (m^3)	Milestone Month	Cumulative Month
Oct-Dec 18 (1st Quarterly)	1200000	1200000	3	3
Jan-mar19 (2nd Quarterly)	1200000	2400000	3	6
Apr-jun19 (3rd Quarterly)	1200000	3600000	3	9
Jul-Sep 19 (4thQuarterly)	-	-	3	12
Oct-Dec 19 (5th Quarterly)	1200000	4800000	3	15
Jan-mar 20 (6th Quarterly)	1200000	6000000	3	18
Apr-jun20 (7thQuarterly)	1200000	7200000	3	21
Jul-Sep 20 (8thQuarterly)	-	-	3	24
Oct-Dec 20 (9th Quarterly)	1200000	8400000	3	27
Jan-mar 21 (10th Quarterly)	1200000	9600000	3	30
Apr-jun21 (11thQuarterly)	1200000	10800000	3	33
Jul-Sep 21 (12thQuarterly)	-	-	3	36
Oct-Dec 21 (13th Quarterly)	1200000	12000000	3	39

Parameters for Dredger, Allied Vessels &Equipment

Sr. No.	**Equipment type and characteristics**			**Minimum number Period**
	Equipment	**Minimum Capacity**	**Max. Age (Years)**	
1	Cutter Suction Dredger	250 m^3/hr of solids	15 years	2.0
2	Work Boats/Tugs	For towing dredging unit/anchor shifting etc.	15 years	2.0
3	Accommodation Boats (if required)	To accommodate crew and supervisory staff separately (if required)	15 years	2.0
4	Any other vessel	As required	15 years	As required
5	Vessel and equipment for survey works	As required	15 years	As required

Approximate Principal dimension and other particulars

The principal dimensions & other particulars as mentioned below are purely indicative

Length overall	:	27 m
Breadth	:	12 m
Depth	:	2.5 m
Maximum draught	:	1.5 m loaded draft with full Bunkers
Trial speed (deep water)	:	8.5 knots (calm water)
Dredge Pump capacity	:	Mixture capacity of 1250 cub. mt/hr at 20% concentration of solid by volume and mixture density of 1.3 t/cub mt and capable of discharging at 500 m distance using floating pipelines and throw of about 80m with side cast facility on either side (5% variation allowed). Discharge coupling at the aft for pumping to be provided.
Fuel Oil Bunker Capacity	:	15 days of operation of the dredger of which 10 days of dredging for 12 hours and 5 days of steaming for 10 hours
Endurance	:	15days
Accommodation	:	For eight persons in 3 cabins, galley, mess cum recreation room, two bio bathrooms cum toilet to be provided. Deviation allowed from specified dimensions (length, breadth and depth) in principal particulars shall be+5% &-5%. No deviations allowed for maximum draught and minimum trial speed.

Material to be dredged

As per geotechnical investigation, soft rocky strata along with poorly graded gravels and boulders have been observed.

Disposal of dredged material:

A total of 128 lakhs m^3 of material has been calculated as described above. In principle, dredged material is being dumped in 3 ways:

(i) Into the river
(ii) Outside the river
(iii) On the bank of the river

From economical consideration the dredged material is proposed to be dumped in the bank with the provision of dowel/ Parapet wall so that dredged material may not slipped back into the river. Clearance would be taken from the competent authorities before dumping the dredged material.

3.3.3 River Training

River training works are used for bank protection and river regulation for improvement of channel. Training structures generally used for river regulation are mentioned below:

a) Spur and Longitudinal training walls

Spurs are structures constructed transverse to the river flow and extend from the bank in to the river. These structures are known by several names, the most popular being spurs, spur dikes, groynes and transverse dikes and constitute probably the most widely used training works.

The spurs may be either of piles, stones, rock-fill or sand and may be either submersible or non-submersible. Spurs are very helpful in constricting a wide river channel for the improvement of depth for navigation

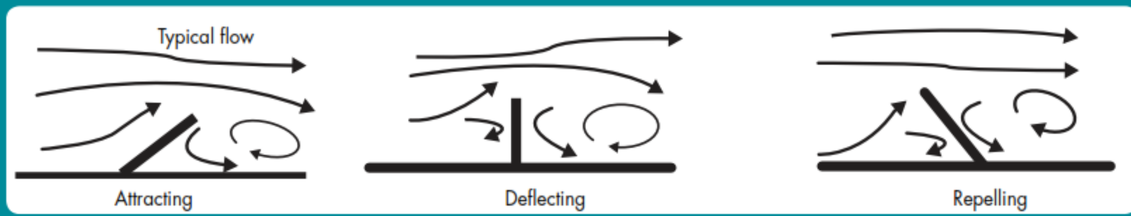
Type of spurs

Attracting spur: These are the spurs which attract flow towards the bank and are aligned in a direction pointing downstream. In a river where there is a heavy attack on one bank, it may be desirable to construct the attracting spurs on the opposite bank in conjunction with a repelling spur on the affected bank

Repelling spur: A spur pointing upstream has the property of repelling the river flow away from it and hence it is termed as repelling spur.

Deflecting spur: Where the spur, usually of short length changes only the direction of flow without repelling it, is known as a deflecting spur and gives only local protection.

Figure 47: Different orientation of spurs



Experience of rivers in many countries shows similarly that groynes facing downstream cause trouble. These groynes endanger adjacent banks, since silting between successive groynes is absent and hence are not recommended. Repelling groynes are usually successful in achieving desired results if they are properly located with due regard to their position in relation to meander length. It is recommended to test them in hydraulic models before adopting them in practice.

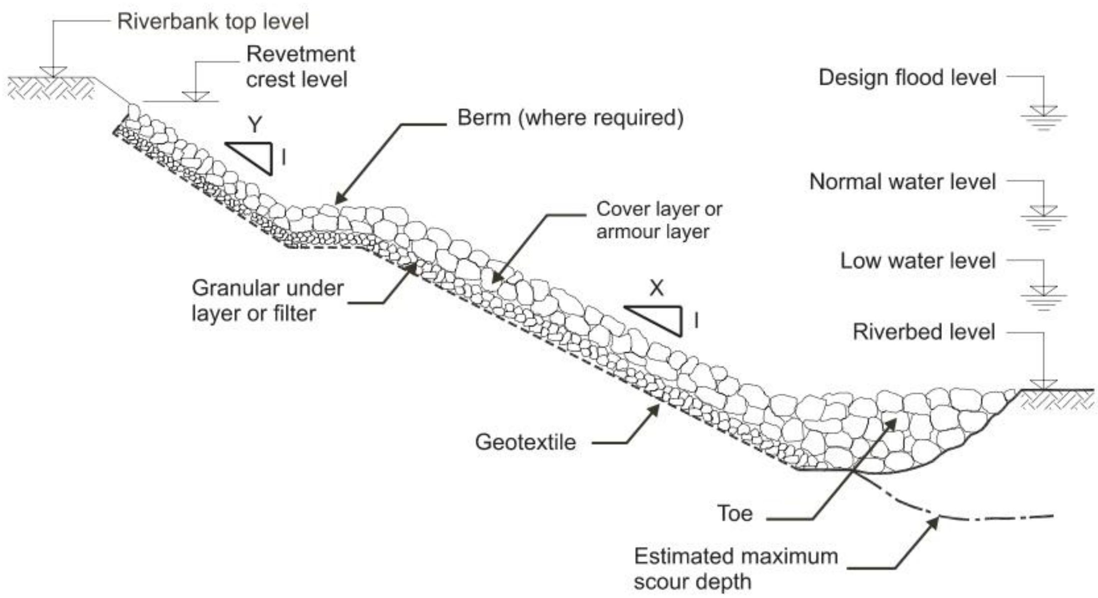
b) Bottom Panels

A new technique improving river channel has been investigated by the Chatou Research and Test Centre of France. Bottom panels are vertical screens wholly immersed and set on the river bed at falling stage when the depth in the channel is about three times the height of panels. They form angle of 100 to 45 with the current diverting the bottom currents out of the navigational channel. The panel are about 25m long and spaced by about two and half times their own length these are left in the river even during floods.

c) Revetment

The most common form of river training structure is the revetment or bank protection. It is composed of a layer of erosion-resistant material that covers the erodible material of the river banks, and sometimes also the bed of the river. Various materials may be used for this purpose, including grouts and geotextiles. The choice of the most suitable material should be made at an early stage in the project. Armour stone can be directly placed onto the bank or bed to be protected.

However, it is generally good practice to place it on an under layer that provides a transition between the coarse armour stone of the cover layer and the fine erodible material of the foundation. The underlayer may be made of crushed rock or gravel that prevents subsoil from being eroded through the voids of the protection. Geo-textiles may be used as a part of the filtering system, either with or instead of the granular filter. The under layer reduces both the risk of the foundation material being washed through the armour layer and of the cover layer punching into the subsoil.



d) Retards

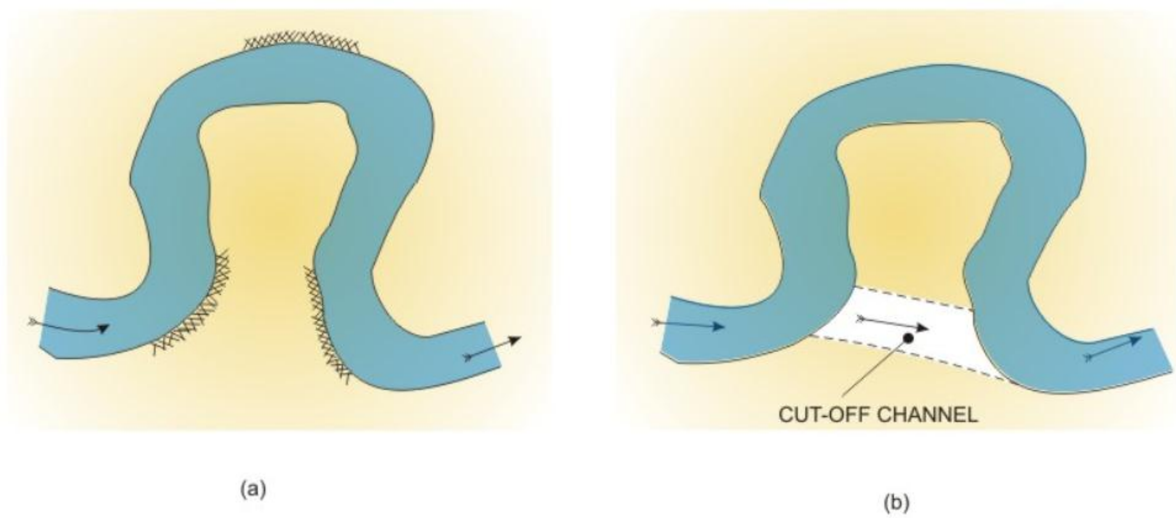
These are the structures constructed spanning a river section. They are used principally to protect eroding concave banks and are constructed by sinking old barges weighted with stones by putting woven wire fence supported on wooden parts or by putting bundles of poles across the river cross section. The structures may be maintained by wires tied to anchors placed upstream. Retarders are lower in cost than spurs and revetment, but are not equally definite in operation. Care in placement and understanding of river behaviour is required for their use.

e) Cut-offs

Cut offs have also been extensively used for improvement of navigation. A cut off is developed by river meandering to acute condition in the form of hair-pin bends. Under favourable condition these bends become large loops with narrow necks. The narrowing of the neck reaches a limit when, a breakthrough occurs and chute channel known as cut-off forms across the neck.

Cut off results in violent changes in river regime. As the river totuosity is decreased the river slope upstream of the cut off steepens and flood levels are lowered. The cut-offs are not enough by themselves. While they correct the instability and in efficiency at sharp bends and loops, where much head is lost by excessive river length, they do little to correct conditions in the reaches between these bends. It becomes necessary therefore to do extensive work between cut offs to improve the alignment width and depth of the channel by supplementary training works. Such works involves two procedures viz., directing the flow and closing of pockets found at unduly wide points of the channel by training groynes of dredged sand fill. Revetment at places, where erosion is likely to take place, should also be provided. The objective is the creation of a uniform river width and establishment where feasible of a central river channel, deep enough to maintain itself by normal scour action.

A typical instance of cut off is shown in fig. below



(a) Meandering river with possible threat of bank erosion (marked as xxxxx)
(b) An engineered cut-off channel

Proposed river training works (stretch wise): River banks are already established in Mahi River hence no river training works are required for river banks. One navigational lock is proposed as river training for navigation in the stretch.

3.4 Bank Protection / Embankment Strengthening

3.4.1 General consideration:

Current measurements during the survey period reveal that the velocities in the non-tidal reach of channel are considerably less with an average current of the order of 0.1 m/sec to 0.6 m/sec. In tidal reach current varies from 0.6 m/sec to 1.21m/sec.

Geotechnical characteristics of the river bed shows that the soil is composed of mostly silt. The average grain size of the material is about 0.07mm to 0.1 mm. Therefore, it appears that the banks are not much susceptible to erosion by natural surface current it may also be mentioned here that while carrying out the hydrographic survey along river stretch under consideration, the banks seen to be fairly stable free of erosion or cut gullies. However once navigation by mechanised vessel is introduced, bank erosion is likely to occur due to fast movement of mechanised vessels in the narrow stretches/navigation channel flows near the bank. Moving vessels generate waves and turbulence of different magnitude depending upon the speed of vessel, its hull form, type and spacing of propellers, draft and river bed form. The effect of these waves and turbulence on the channel cross section including the stability of the sides depends upon the width of the channel and the relative cross-section of the vessel and channel. Further when a vessel moves in a confined channel, the return flow of water is caused by the water displaced water displaced along the vessel side. The extent of return flow depends upon the velocity of the craft and can cause intensive suction effect on the banks eroding the side slopes of the soil. The channel bed gets disturbed by the impact of propeller jet.

3.4.2 Identification of stretches for bank protection works

During Hydrographic survey no embankment was found damaged. Hence no strengthening of embankment is required on Mahi River. Wherever the waterway is wide and movement of vessels will not affect the bank, no protection is proposed. Wherever the waterway is very narrow and width is just enough for two-way navigation, and flowing near the river bank stone pitching is proposed. The exact requirement however should be established at the time of construction. The banks in vulnerable region should be inspected after introduction of mechanised vessels and any damaged section should immediately be protected as part of regular maintenance.

3.4.3 Existing Protection works

Table 3.5: Existing Protection works

Stretch No.	Start Chainage	Dist. in Meters	River Bank	Start		Condition
				Latitude	Longitude	
1	53.8	20	Right	22 16 16.8908 N	072 55 1.5316 E	Concrete

Stretch No.	Start Chainage	Dist. in Meters	River Bank	Start		Condition
				Latitude	Longitude	
2	54.5	300	Right	22 17 4.9721 N	072 54 36.4031 E	Concrete
3	56.1	500	Left	22 17 55.767 N	072 54 35.2632 E	Concrete
4	75.6	200	Left	--	--	--
5	80	85	Right	22 19 21.7916 N	073 03 45.4185 E	Concrete
6	81	80	Right	22 19 49.2529 N	073 03 33.7524 E	Concrete
7	81.55	50	Right	22 20 6.9374 N	073 03 28.2659 E	Concrete
8	86.7	300	Left	22 22 42.1123 N	073 03 26.0788 E	Concrete
9	98.2	50	Right	--	--	--
10	98.4	50	Left	22 28 8.019 N	073 05 20.3294 E	Concrete
11	99.7	100	Left	22 28 53.3327 N	073 05 17.1888 E	Concrete
12	169.3	55	Left	22 55 25.8698 N	073 23 33.6839 E	Concrete
13	172.6	800	Right	22 56 20.1592 N	073 25 23.3367 E	Concrete
14	173.7	50	Left	22 56 54.2001 N	073 25 26.6986 E	Concrete
15	189.3	50	Left	23 03 15.2398 N	073 28 19.0278 E	Concrete
16	199.2	100	Right	23 05 46.2997 N	073 33 9.7619 E	Concrete

3.4.4 Proposed bank protection

On the basis of topographic and hydrographic survey of Mahi River no bank protection is required in such a big river.

3.5 Navigation Marking/ Navigation Aids

The terms Aids to Navigation, Nav-aids and Navigational aids used interchangeably, are all meant to convey marks, including floating marks, such as buoys and beacons, transit and clearing marks as well as signalling systems, radio aids and communications, electronic systems, radar etc. which are installed on land or in water for guidance to all ships for safe and regulated navigation in the channels, anchorages, berths, docks etc. It is envisaged that navigation will be carried out throughout the year, by day and night except during times of high wind speeds and low visibility. For day navigation, channel is demarcated by conventional bamboo marks but when frequency of IWT mode increases it becomes essential to provide night navigation facilities.

Marine Lantern @ 2km C/C is provided along the river Mahi has been provided on the basis of light intensity, soil condition and wind direction and velocity

General assembly of proposed buoy is shown in Fig. 6.1 (A) & 6.1(B)

RIS (River Information System):

LIST OF EQUIPMENTS:

Sensor System

a. AIS Base Station

b. RADAR

c. VHF System

d. Meteor Sensor

e. Automatic Tank Gauge

Tracking

a. RIS Hardware (Servers & Computers)

b. RIS Software

Power Supply

a. UPS

b. DG Set

Civil Deliverables

a. Trestle Tower for installation RADAR

b. Building for installing RIS equipment / Porta cabin

3.6 Modification Requirement in existing Bridges / Cables / Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

There are total 19 bridges on the Mahi River under present study stretch. For the proposed class of waterway and design vessel the minimum vertical clearance requirement is 6m to 8m. No road bridge (except one Under-construction Bridge) is having vertical clearance.26 nos. of HT lines passes through the river stretch under present studies. Vertical clearance ranges from 20m to 31 m above HFL. As there is sufficient vertical clearance available, there is no need of modification in HT line structures. Provision of navigational lock is suggested at the weir situated at Sindhrot (CH 80).

Gambhira Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

Umeta Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

Under Construction Bridge

Vertical clearance is available for all classes of waterway but horizontal clearance is not available even of Class-III of waterway. Hence it has to be demolished and reconstructed.

Vasad Rail Bridge

Horizontal clearance is available up to class-I of waterway but Vertical clearance is not available even of Class-I of waterway. Hence it has to be demolished and reconstructed.

Vasad NH-8 Bridge

Horizontal clearance is available up to class-I of waterway and Vertical clearance is available up to class-II of waterway. Hence it has to be demolished and reconstructed.

Ahmedabad Vadodara Expressway Bridge (NE 1)

Horizontal clearance is available up to class-II of waterway and Vertical clearance is available up to class-III of waterway. Hence it has to be demolished and reconstructed.

Poicha Bridge

Horizontal clearance is available up to class-II of waterway and Vertical clearance is available up to class-III of waterway. Hence it has to be demolished and reconstructed.

Raniya UC Bridge

Horizontal clearance and Vertical clearance are available up to only class-I of waterway. Hence it has to be demolished and reconstructed.

Galteshwar Bridge

Neither of the horizontal clearance and vertical clearance is available for class-I of waterway. Hence it has to be demolished and reconstructed.

3.7 Proposed Dams / Barrages / Locks / Weirs to improve depth

Provision of a navigational lock is suggested at the weir situated at Sindhrot (CH 80).

3.8 Land Acquisition

Land acquisition is not required for development in River Mahi.

3.9 Fairway Costing

3.9.1 Fairway Development Cost

Cost estimates for fairway development components viz. Dredging, Demolition & Reconstruction of bridges, Aids to Navigation, etc. has been worked out based on prevailing rates in the adjoining area and placed in table 3.6.

Table 3.6 Capital Cost

Capital Cost	In Crores
(I) Civil Cost	
Navigation Locks	45.56
Demolition & Reconstruction of bridges	559.51
Total	605.07
3% Contingencies and 7% Supervision charges on Base cost	60.51
Total civil Cost	**665.58**
(II) Navigation & Communication Cost	
DGPS	1.00
VTMS	1.00
Marine Lantern/Buyos (50 nos.)	1.00
RIS	14.30
Total Cost(II)	17.30
3% Contingencies and 7% Supervision charges on Base cost	1.73
Total Navigation & Communication Cost	**19.03**
(III) Dredging	
Dredging **(12.8 Mm3)**	**384.00**
Total Fairway Development Cost	**1068.61**

3.9.2 O&M Cost

The total operating cost for development of waterway has been worked out based on prevailing rates in the state/country. The total operating cost (Fairway Development) includes maintenance of dredging, port craft, aids to navigation etc.

Table 3.7 Operation & Maintenance Cost

	O & M Cost	In Crores
(i)	Dredging @ 10%	38.40
(ii)	Civil works @ 1%	7.09
(iii)	Ports Crafts/Nav. Aids @ 5%	0.95
	Total	**46.34**

CHAPTER – 4
TRAFFIC STUDY

4.1 General

Located on the western coast of India, Gujarat has the longest coastline of 1,600 km. The Arabian Sea borders the state, both to the west and the southwest. Mahi River originates from Minda Village, which is situated in Dhar district of Madhya Pradesh. The river rises in the western Vindhya Range, just south of Sardarpur, and flows northward through Madhya Pradesh state. After flowing through the Vagad region of Rajasthan, it enters Gujarat and flows into the Arabian Sea by a wide estuary past Khambhat after about a 580 km course. The silt brought down by Mahi River has contributed to the shallowing of the Gulf of Khambhat and the abandonment of its once prosperous ports. The riverbed lies considerably lower than the land level and is of little use for irrigation. It is one of three rivers, along with Tapi and Narmada River, to flow from East to West in India. There exist many temples and places of worship along the bank of Mahi River. It is also known as Mahi sagar, due to the vastness of the river. The industrial area in Gujarat is located nearby to the ports. Many of the companies own captive jetties taking the advantage of the coastal movement of the raw materials for cost effective logistics. The port nearest to the Mahi River proposed stretch is Dahej Port. For the analysis, the primary catchment area is considered, which is 25km, to the north and south along the length of the river within Gujarat.

Figure 4-1 Mahi Overview Map

4.2 Influence area / Hinterland (within 25km on either side of the waterway)

Mahi River originates from Vindhyachal Hills, Madhya Pradesh and meets in Bay of Khambhat in Gujarat. Its total length is 580 km. and catchment area is 34,842 sq.km. Mahi River has two tributaries, Bhadar is right bank tributary and Panam, Kun and Goma are left bank tributaries of Mahi River. Its catchment area is 25,520 sq.km. On Mahi River, Wanakbori weir is built which is located in Kheda district.

The districts that are located in the catchment area, i.e. within 25 km. of Mahi River are Anand, Kheda, Vadodara, Bharuch, Panchmahal and Mahisagar. These districts are studied in detail in following sections for finding opportunity for the proposed waterway. Profile of each district is shown in below section.

Vadodara is the largest district with an area of 7.52 lakh hectares and Bharuch is the second largest district with an area of 5.24 lakh hectares. Vadodara is the most industrialized district in Gujarat, followed by Panchmahal district having 5.13 lakhs hectares of area. Panchmahal is a densely forested district. People here are predominantly occupied in agriculture. Kheda district has least unutilized agriculture land and least forest cover. Non-agricultural land in this district is almost 75 thousand hectares, which explains total Geographical industrial area. Mahisagar district formed after census 2011

District	Total Geographical area	Non-Agricultural Land	Pasture-Grazing land/ forest cover	Cultivable land but not cultivated
Anand	2,94,759	46,395	14,327	10,469
Kheda	3,94,388	4,242	9,807	958
Vadodara	7,52,776	74,908	77,788	7,729
Bharuch	5,24,683	72,455	24,506	19,825
Panchmahal	5,13,800	63,500	1,16,800	27,300
Mahisagar	2,26,064	NA	NA	NA

Source: Planning Commission, Dec 2014

Table 4-1 Land Utilization Pattern of selected Districts (Ha.)

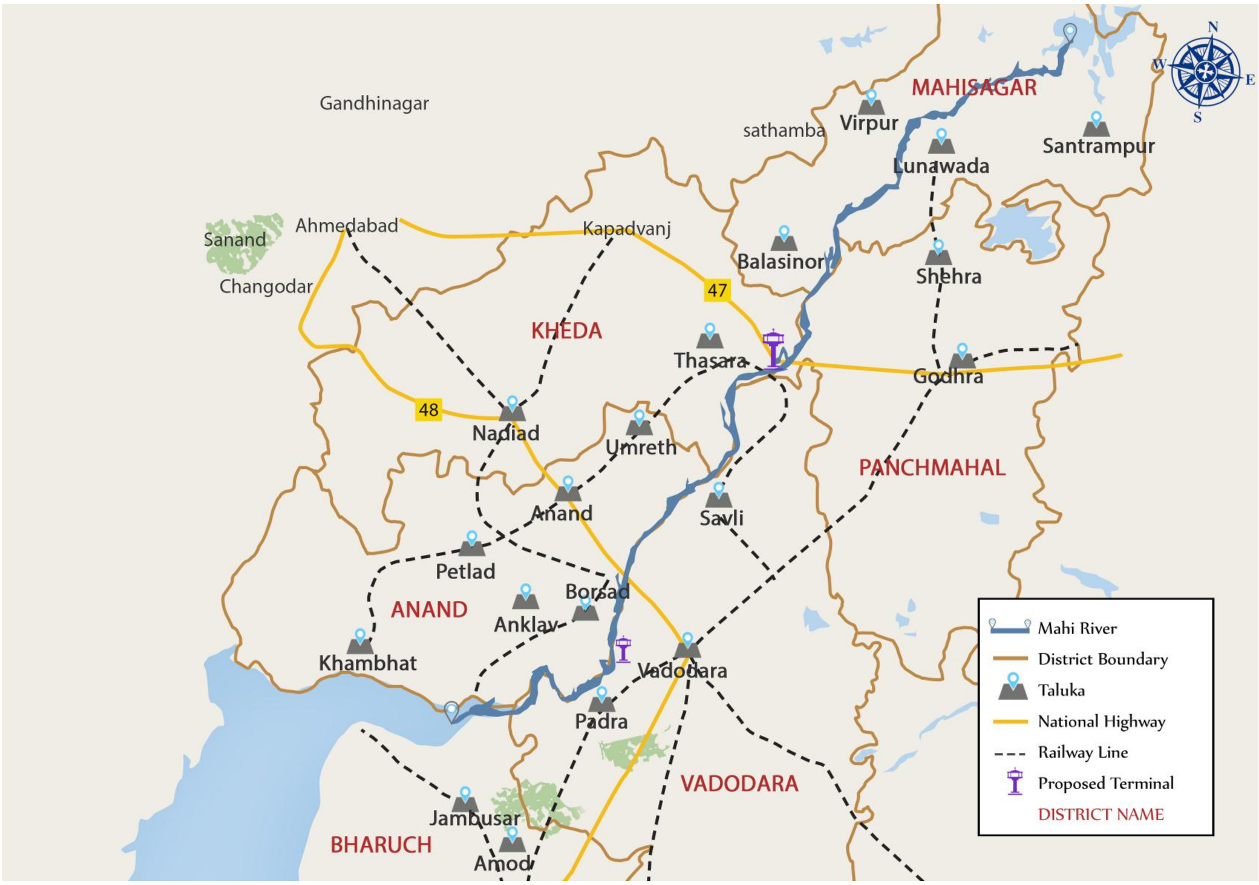


Figure 4 2 River Mahi and the Districts in the Catchment Area

Bharuch

Bharuch city is the administrative head quarter. It is considered the Chemical Capital of India as major chemical companies operate here. As River Narmada flows through the centre of the district, there is no lack of water. Regular water supply has flourished the agriculture and industries sector here. Cotton and Groundnuts of Bharuch are famous.

Anand

Anand district is situated in the Central part of Gujarat. Geographical area of Anand district is 2951.10 sq. km., which accounts for 1.50 percent of total geographical area of the state. Anand is divided in 8 talukas viz. Anand, Umreth, Borsad, Petlad, Sojtra, Khambhat, Tarapur and Anklav. Sojtra and Tarapur are far from the catchment area of Mahi River, hence they would not be included in the study. Headquarter of the district is Anand taluka. This district has 12 towns and 11 Nagar Palikas.

Kheda

Kheda district is situated on Southern part of Gujarat, having an area of 3959 sq. km., which amounts to 2.02 percent of the total geographical area of the State. It has 8 talukas namely Kheda, Thasra, Nadiad, Kapadwanj, Mehmedabad, Kathal, Matar and Mahudha. Except Thasra and Nadiad, other talukas of Kheda district are located far from the catchment area of Mahi River, hence they would not be included in the study. Nadiad is one of the main district headquarters. As Kheda district is a major producer of tobacco in Gujarat, it is famous by the name "Golden Leaf".

Vadodara

Vadodara is a cosmopolitan city, which is located at the South East of Ahmedabad on Vishwamitri River's bank. The district has 12 tehsils, 15 towns and 1,548 villages, of which the major towns are Vadodara (District Headquarter), Savli, Waghodiya, Padra, Dabhoi, Karjan and Sankheda. Only Vadodara, Savli, and Padra fall in the catchment area of Mahi River.

Bharuch

Bharuch is located in the southern part of Gujarat, near Gulf of Khambhat in Arabian Sea. Total area of this district is 5253 sq. km. Bharuch has 8 talukas viz. Bharuch, Vagara, Ankleshwar, Jambusar, Amod, Hansot, Jhagadia, Valia. Except Jambusar and Amod, other talukas of Kheda district are located far from the catchment area of Mahi River, hence they would not be included in the study. Dahej Port operated by Gujarat Maritime Board (GMB), has made significant contribution to facilitate industrial growth in this district.

Panchmahal

Panchmahal has 7 talukas namely Godhra, Shehra, Halol, Kalol, Ghogamba (Morva), Hadaf, Jambughoda. Only Godhra and Shehra talukas fall in the catchment of Mahi River. Godhra taluka is the Headquarter of the district. This district is undeveloped compared to other districts of the state. Panchmahal is rich in respect of forest resources with forest area of 117 sq. km.

Mahisagar

District of Mahisagar has been carved out of two districts, Panchmahal and Mahisagar. Lunawada is the district headquarters of Mahisagar. Total area of the district is 2260.64 sq. km. There are 6 Talukas in Mahisagar district namely Balasinor, Kadana, Khanpur, Lunawada, Santranpur and Virpur. All these talukas are near Mahi River, hence would be included in the study. The economy of the district is mainly based on Agro & Food Processing, Oil industries and Tourism. Agriculture and Animal husbandry is the predominant economic activities of the district. Dairy is the main activity in the Animal Husbandry.

4.2.1 Population of Hinterland

According to Census 2011, the total population of Gujarat is 6,04,39,692. The population of Gujarat forms 4.99 percent of India in 2011. Out of this, the male population is 31,491,260 and the female population is 28,948,432. The sex ratio of Gujarat is 919, which is quite less than the national average of 940.

District	Taluka	Population
Anand	Khambhat	2,85,679
	Borsad	3,69,812
	Anklav	1,47,108
	Anand	6,09,307
	Umreth	1,88,029
	Petlad	2,87,924
Kheda	Nadiad	5,50,330
	Thasra	3,42,145
Vadodara	Savli	2,55,009
	Vadodara	20,09,434
	Padra	2,65,901
Bharuch	Jambusar	1,53,694
	Amod	93,819
Panchmahal	Godhra	4,62,516
	Shehra	2,77,559
Mahisagar	Lunawada	2,57,229
	Balasinor	1,45,823
	Kadana	1,29,545
	Virpur	1,00,293
	Khanpur	96,041
	Santrampur	2,64,327

Source: Census 2011

Table 4-2: Population of nearby Talukas as per Census 2011

According to census 2011, Vadodara is the biggest and most populated city in the catchment area of Mahi River with a total population of 41,65,626. It contributes 6.89% of the state population. Most of the companies are situated in this district; hence people from different parts of the state migrate here for employment.

The district of Anand contributes 3.46% to the population of Gujarat. Bharuch forms 2.56 % of the state population. The population of males is 8,05,707 and 7,45,312 of females. Kheda forms 3.8% of the population of Gujarat. The Panchamahal district has 3.95% of the state's population.

The least populated talukas are Amod and Khanpur. Though Amod is a part of Bharuch, one of the most industrialized districts in India, it is underdeveloped. Khanpur is a secluded area in the recently formed Mahisagar district near Rajasthan.

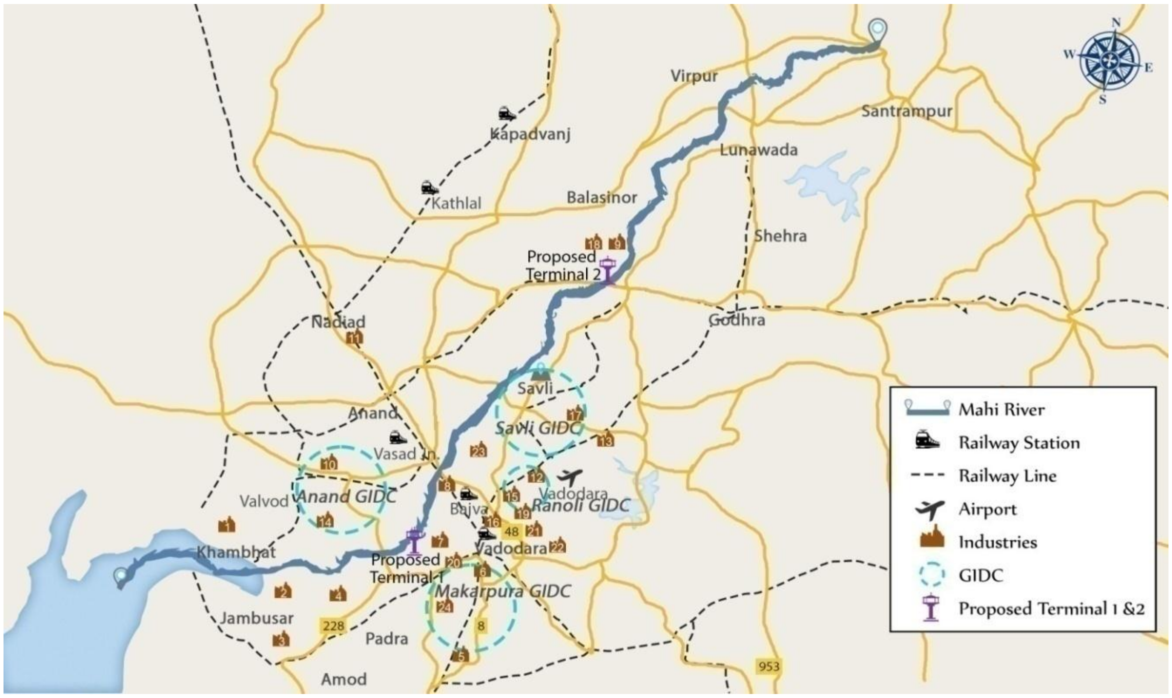
4.2.2 Existing and proposed Industries

Existing Industries

There exist several medium and large-scale industries in the districts located in the catchment area of Mahi River. Majority of industries are located in Vadodara district.

Gujarat contributes nearly 16% to country's industrial production. Its industrial growth has averaged to about 15% in the last couple of years. The state has the highest industrial production share in Soda Ash, Salt, Castor Seeds, POL, and Drugs & Pharmaceuticals. Gujarat has a manufacturing share of over 50% in POL, 31% in chemical and 45% in pharmaceuticals. On the back of such large-scale production in a wide range of industrial segment, Gujarat has been able to contribute almost 19% to India's total exports of merchandised goods and services.

There exist several medium and large-scale industries in the districts located in the catchment area of Mahi River. The table below presents a list of industries located n these districts.



The table below presents a list of industries in the districts, located in the catchment area of Mahi River.

Figure 4-3: Connectivity around Industries via Mahi River

Name	Location	Dahej Port			Kandla Port		
		Road	Rail	River	Road	Rail	River
GIPCL	Vadodara	113	110	128	414	405	695
Gujarat Flurochemicals	Vadodara	113	110	128	414	405	695
ABB India	Vadodara	104	110	128	414	405	695
IOCL Gujarat Refinery	Vadodara	116	110	128	414	405	695
Wanakbori TPP	Balasinor	208	205	207	408	430	695
Jindal Stainless Steelway	Vadodara	131	110	143	414	405	695
GACL	Vadodara	127	156	146	390	329	695
Dhuvaran Gas CCPP	Khambhat	137	183	87	391	420	695
Reliance Industries	Vadodara	123	121	132	389	392	695
Ultratech Cement	Balasinor	199	205	198	406	422	695
GSFC	Vadodara	125	121	145	402	331	695
Gulbrandsen Chemicals	Vadodara	89	100	128	414	429	695
Gayatri Chemical Industries	Vadodara	112	110	128	414	405	695
Apar Industries	Vadodara	114	110	128	414	405	695

Table 4-3 Existing and proposed Industries

Gujarat State Fertilizer Corporation

The smaller version of plant is located in Ranoli GIDC area in Vadodara. Its main and large plant is situated at Dahej. The plant produces Ammonia, Melamine, Phosphoric acid, Sulphuric acid, Urea, Methanol etc. The total plant capacity is 26,72,680 MTPA. Further expansion is under execution, which will increase the capacity by 75,000 MTPA. The products are supplied all over India.

Gujarat Flourochemicals Ltd

It is located in Vadodara. It manufactures Refrigerant & Anhydrous Hydrogen chloride. The manufacturing plant also has its own captive co-generation plant operating at high fuel efficiency to produce electricity and process steam. The capacity of Refrigerant plant is 25000 TPA and that of Anhydrous Hydrogen Chloride is 6000TPA.

Gujarat Alkali & Chemicals Ltd (GACL)

Gujarat Alkalies and Chemicals Limited offers Caustic Soda Lye and Caustic Soda Flakes. Major products are Caustic Soda, Chlorine, Hydrochloric Acid, Hydrogen, Chloromethanes, Potassium Hydroxide, Potassium Carbonate, Sodium Cyanide, Sodium Ferro Cyanide, Hydrogen Peroxide, Sodium Chlorate, Stable Bleaching Powder, Poly Aluminum Chloride, Anhydrous Aluminum Chloride, Toluene-based chemicals and Chlorinated Paraffin Wax. It is mainly used in various industries, such as textiles, pulp and paper, soaps and detergents, alumina, water, treatment, petroleum, plastics, fertilizers, pharmaceuticals, agrochemicals, plant protection, dyes and dyes intermediates, refrigeration gases and epoxy. It exports products, such as Potassium Hydroxide Flakes and Liquid Chlorine to Europe and West Asia. Production capacity of Caustic Soda is 429,050 MT. Export from Vadodara plant is around 9600-12000 Tonnes to Hazira whereas export from Dahej plant is around 84,000 Tonnes

Gujarat Refinery

Indian Oil Corporation Ltd owns Gujarat refinery. It is located at Vadodara. The current capacity is 14.7 MMTPA. There are plans for expansion up to 18 MMTPA. 40 units are operating in this refinery. The Refinery processes indigenous and imported crudes into LPG, petrol, diesel, ATF and other value-added petroleum products. It holds second largest market share of Linear Alkyl Benzene and exports it to almost 20 countries around the world.

Dhuvaran Gas based Power Plant

It is located in Khambhat, Anand. It is a Combined Cycle Power Project. It uses both natural gas and steam to produce almost 50% more power. It is operating in three phases. The first plant has a capacity of 106.67 MW. The second plant has a capacity of 112.45 MW and that of third plant is 376 MW.

GIPCL (Gujarat Industries Power Company Ltd)

The power plant is situated in Vadodara. It has 2 gas based power generating units. The capacity of the first unit is 145 MW and that of the second unit is 165MW. For both units, LNG is supplied by GAIL and R-LNG is supplied by GAIL and GSPC. It supplies the power to Gujarat Urja Vikas Nigam Ltd.

Wanakbori Thermal Power Plant

The Wanakbori Thermal Power Station is located near Wanakbori Dam on the bank of Mahi River in Mahisagar Disrict. It is a Coal Based Power Station. There are seven units of 210 MW each with a total installed capacity of 1470 MW. The 8th unit is under construction and will have a capacity of 800 MW, which is Supercritical Thermal Power Station (SCTPS). The present mode of transport is through rail route is Vadodara-Godhra-Sevalia station to power plant. This route runs parallel to the identified Mahi-River stretch. Hence it could be a potential cargo to move between Vadodara and Wanakbori in Kheda. The distance between Wanakbori and Vadodara along the river stretch is approximately 80 km.

ABB India Ltd

There are 2 manufacturing units in Savli, Vadodara in 2013. The new manufacturing units produce high-voltage switchgear and distribution transformers. ABB is looking forward to make India its export hub for power transmission systems and micro grids.

Apar Industries

It has a registered office in Vadodara. It manufactures Power Transmission Conductors, Petroleum Specialties and Power & Telecom Cables. However, manufacturing units do not fall in the catchment area of any of the rivers.

Ultratech Cement

The plant has been acquired from Jaypee Cements Ltd. in 2014. The plant is located at Wanakbori in Kheda district. The production capacity of the plant is 2.4 MMTPA.

Proposed Industries

Gujarat Infrastructure Development Board (GIDB) has undertaken the construction of two industrial parks in this river stretch. One is in Akalbara, Padra and the other is in Khambhat, Anand. The park will span over 500 hectares of area. It will consist of 3 estates- Chemical, Engineering and General. The engineering estate will consume around 55% of total area, chemical estate will use 32% of land and the remaining 13% of land will be the general estate. Around Rs. 200 crores will be invested in this project. A pipeline will be drawn from GACL (Gujarat Alkalies and Chemicals Limited) for water supply.

Another industrial park is going to come up in Khambhat taluka of Anand district. The park is being developed in 800 hectares of land. The park will consist of engineering and chemical estates. Rs. 320 crores is being invested in this project.

The Govt. of Gujarat has projected Kheda, Vadodara and Bharuch as a hub for defence manufacturing in the Vibrant Gujarat 2017 Global Summit

4.3 Commodity Composition / Categorization

The major industries along River Mahi are power plants, petrochemicals refinery, cement, and fertilizer industries. The raw materials consumed by these industries are studied in detail. Commodities like coal, fly ash, black trap, and chemicals, which are raw materials for the above mentioned industries are considered for the study.

Commodities	Source	Volume (M T)	Reasoning
Coal	Wanakbori Thermal/ Captive Plant	1	Coal Consumption is around 5.2 Million Tonne. Domestic Coal is obtained from Chhatisgarh coalfields. Imported Coal can be transported from Waterways.
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	0.8	Based on reliable inputs, this critical power plant is likely to mostly use imported coal. This volume can be lightered to the plant using River Mahi
Fly ash	Wanakbori TPS	1.2	Fly Ash from Wanakbori TPS is procured by UltraTech cement plant. A small volume is utilized at the plant, while the rest gets transported to its Surat Unit by road. The volume moved by road can be shifted using
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	1	This will be mostly surplus volume, suitable for distribution using the River Mahi waterway
Clinker	Ultratech Cement	2.0	A prospective cargo that can be moved via River Mahi from UltraTech's integrated clinker plant in Kutchh.
Black Trap	Produced in the Catchment area	0.9	This is total volume in the River Mahi catchment area, all of which is consumed locally.

Table 4-4 Potential Commodities for River Mahi

4.3.1 Coal

Gujarat has very low reserve of lignite. Coal is mainly used for power generation. There are many power plants in Gujarat, which use coal and lignite for generating power. Wanakbori Thermal Power Plant is a coal based power plant in Gujarat with total capacity of 1470 MW. The plant consumes 5.19 Million T coal. 20% of the total requirement of coal, i.e. 1 Million T is imported. Rest is procured from Chhattisgarh. Coal from Chhattisgarh is transported through railways to the power plant. This volume is unlikely to shift to the proposed waterway, as it entails multi-modal transportation, incurring additional handling charges. This makes the shift economically unviable.

However, the import share that the plant acquires from Hazira Port can be moved using the River Mahi stretch. The Government of India has issued a guideline to all the thermal power plants to minimize, or even abandon, import coal in favour of domestic coal. As a result, the plant has ceased its import operations for an indefinite period. In the event it does, the import volume can be shipped using barges from Hazira to the plant using River Mahi.

Another 800 MW plant has been proposed at Wanakbori. This upcoming SCTPS would would mostly rely on imported coal. Once the plant achieves operational status, it will procure import variety of coal from Hazira Port. This, too, can be moved using River Mahi. There are other captive coal based power plants on this River's stretch, procuring majority of its coal requirements from neighbouring states.

4.3.2 Fly Ash

The main source of fly ash is the coal based power plants. Fly ash is a fine powder, which is a by-product from burning pulverized coal in power generation power plants. The fly ash is an important raw material in producing cement, tiles, and blocks. It can also be used for paving of roads and can be blended in concrete. UltraTech cement has a plant near Wanakbori Power Plant. The Wanakbori TPS consumes 5.19 MMTA of coal and this generates 1.8 MMTA of fly ash. Out of this, UltraTech cement uses approx 0.6 MMTA of fly ash for manufacturing cement and the remaining 1.2 Million T gets transported to its Surat unit. There is potential for moving this 1.2 Million T of fly ash using the envisaged River Mahi waterway. The same route can be utilized for distribution of fly ash that will be generated by the proposed 800 MW TPS in Wanakbori.

4.3.3 Black Trap

Black trap is a minor mineral, which has huge reserves in Gujarat. The total annual production of black trap on this stretch is 0.95 MMTPA. Black trap has a huge market, as it has diverse uses. It is used in making construction materials for roads and railways. Further demand for black trap will be fuelled by a tremendous growth in infrastructure activities in the region. Therefore, black trap has good market prospects in Gujarat as well as other states. Mines are located on one side of the river. Black Trap produced in the region is locally consumed, using road transportation. This leaves no scope for movement of the commodity using the River Mahi waterway. Cost advantage is with the current logistics employed by the producers and consumers of black trap. Moving it using the proposed River Mahi waterway will result in double handling charges, at the loading and unloading point. Furthermore, local consumers of black trap located inland would require last-mile connectivity using roadways, further adding to the overall logistics cost. Being low value low volume cargo, and intended for inland customers, River Mahi is neither a financially viable nor logistically sound choice for transportation of the said commodity.

4.3.4 Clinker

UltraTech Cement has an integrated plant in Gulf of Kutchh, which is used to source clinker for the company's cement plants throughout the state. The company operates a jetty at its Amreli grinding unit, and owns 2,500 DWT barges, exclusively, for clinker and coal movement. This will serve as an origin-point infrastructure for the company, if it were to move clinker for its Wanakbori plant from Amreli. Erstwhile, owned by Jaypee Cements, the Wanakbori grinding plant was acquired by UltraTech Cement. So, a suitable handling facility on River Mahi near Wanakbori can serve UltraTech's annual clinker requirement of an estimated 2 Million T.

4.3.5 Chemicals & Fertilisers

Every manufacturing company uses chemicals in different forms for producing their finished goods. These chemicals are used by rubber, plastic, paint, textile, petroleum refinery, pulp and paper industries. Therefore chemicals are always in high demand and have a good export value. There are many chemical industries in the catchment area of River Mahi, mainly in the petrochemical complex in Vadodara. The complex is a base for many prominent chemicals & fertilizer companies, and PSU refiners. Companies like Reliance Vadodara Manufacturing Division (Reliance VMD), GSFC, GACL, GFL, IOCL, etc. operate their units from this location. Some of these companies have major plants in Dahej, next to Dahej Port. This is a logistic advantage for the companies, facilitating prompt delivery of import requirements and evacuation of export volume. Based on inputs from companies like GSFC, GACL, and GFL, these companies operate smaller units in the petrochemical complex. Import requirements for such plants are low, with even lower export volume. Last mile connectivity, to and from Dahej Port, for these units' low-volume import and export operations are carried out using rail. Piecemeal, moving these volumes on the proposed waterway will not be commercially viable. Double handling at the terminal on River Mahi induced by switch from waterway to road mode will add to the logistics cost. This can prove to be a counterproductive move for the companies operating in the complex. Therefore, there exists no opportunity for the River Mahi waterway to attract cargo traffic to and from the petrochemical complex.

4.4 Originating / Terminating Commodities

The following table depicts the current origin-destination particulars for all the cargo that can be moved using River Mahi post required infrastructure development:

Name of companies	Commodity	Volume (M T)	Origin	Destination
Wanakbori TPS	Coal	1	Hazira Port	Wanakbori TPS
	Fly Ash	1.2	Wanakbori TPS	Surat & Saurashtra
Wanakbori SCTPS (proposed)	Coal	0.8	Hazira Port & Chhatisgarh mines	Wanakbori SCTPS
	Fly ash	1	Wanakbori SCTPS	Surat & Saurashtra
UltraTech Cement	Clinker	2	Amreli	Wanakbori

Table 4-5 O-D particulars for potential cargo on River Mahi

A large share of existing coal requirement for the Wanakbori TPS is sourced from domestic mines, delivered using rail. The import share, which comes to 1 Million T, is delivered via road from Hazira Port. Due to close distance between the plant and River Mahi, this volume can be shifted to the proposed waterway. A similar requirement and logistics arrangement is sought for the future 800 MW SCTPS, purported to start operation in FY19 or FY20.

Fly ash from both the existing Wanakbori TPS and the planned SCTPS can be transported from plant to Surat using the proposed waterway. At present, UltraTech Cement gets fly ash from the Wanakbori TPS, but is able to utilize only 0.6 Million T of the total generated 1.8 Million T of fly ash. This leftover volume is transported via road to Surat. Following the same model, fly ash that will be generated at the proposed SCTPS can also be moved using River Mahi.

In order for clinker traffic to be handled on River Mahi, UltraTech Cement needs to switch to procuring this raw material from its Amreli units for its Wanakbori plant. Overall, this shift may even be economical in comparison to its current modality of transporting it from Kutchh unit using road.

4.5 Passenger Traffic

Passenger traffic consists of Ro-Ro traffic and people visiting famous locations. Visitors to Gujarat travel by road, railway, waterway, or by using multimodal mode. From the standpoint of passengers in and around the River Mahi catchment, there is adequate road and rail connectivity at their disposal. An additional transportation mode such as waterway is unlikely to influence these passengers into switching. This leaves little scope for developing a terminal on River Mahi to cater to existing passenger traffic.

4.6 Tourism Traffic

The table below shows the tourism traffic of Gujarat state between FY09 and FY14.

Origin	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Within Gujarat	12,285	13,077	15,062	17,176	19,536	22,161
Other Indian states	3,227	3,624	4,355	4,728	5,356	6,061
NRI	181	203	257	285	316	338
Foreign	114	107	139	175	201	228
Total	15,808	17,011	19,812	22,364	25,409	28,788

Source: Ministry of Tourism, Gujarat

Table 4-6 Tourism Traffic in Gujarat ('000 units)

The table above depicts the growth in tourism traffic in Gujarat since 2008-09. Influx of tourists has almost doubled, driven mostly by domestic tourists. There has also been a constant uptick in the visits by travellers from outside the state and from foreign visitors.

The table below gives a yearly distribution of tourist inflow in districts relevant to River Mahi. Hence, tourist traffic for certain years has been estimated based on the trend between FY09 and FY14.

District	2008-2009	2009-10	2010-11	2011-12	2012-13	2013-14
Anand	75,404	86,157	1,09,071	1,36,093	1,67,134	2,29,076
Vadodara	6,21,640	6,41,053	8,38,849	10,08,320	11,44,479	13,59,437

Table 4-7 Tourism Traffic in Catchment Area

The table above shows that Vadodara district has high potential to attract tourists than other districts located in the catchment area of River Mahi. The district has, consistently, been accommodating nearly 40% of the total tourist traffic in the state. However, these tourists rely on the existing, and adequate, network of road and rail connectivity.

District	Tourist Place	Distance (Km)
Vadodara	Laxmi Vilas palace	18
	Sayajibaug	17
	EME temple	16
	Sursagar lake	18
	Baroda Museum & Picture Gallery	17
	Tapovan temple	10

District	Tourist Place	Distance (Km)
	Kirti Mandir	16
	Nandalay Mandir	12
	Haridham Shree Akshar puroshaottam Mandir	12
	Nyay Mandir	18
	Gujarat Fun World	22
	Sagar Aquarium	16
	Shiva Mahal palace	14
	Riparian Resort	0
	Crocodile Pond	16
Kheda	Galteshwar Temple	0

Table 4-8 Tourist places in River Mahi catchment

Tourist hubs in Vadodara districts are closer to River Mahi compared to other districts, viz. Bharuch and Anand. Therefore, tourists visiting these locations in Vadodara are more likely to also visit River Mahi. However, lack of any attraction in the catchment area dilutes this possibility.

Galteshwar Temple

The temple is located on the bank of Mahi River, in Thasra, Kheda district. It is rich in art and architecture; and has a unique eight-sided hall. The walls have carved figures of Gods, gandharvas, humans, rishis, horse riders, elephant riders, chariots, doli (palanquins) and the chronology of human life, from birth to death. Major cities and towns nearby are Anand and Vadodara.

Riparian Resort

Riparian Resort is located on the banks of river Mahi at Lachhanpura near Rasulpur, Savli. The place organizes various activities like zip line, high rope, rappelling, river crossing, river rafting, riverside camping, bird watching, etc. Some of the upcoming activities are paintball fights and mountain biking. Tourists opting for Riparian Resort can use waterway because the resort is in close proximity located to River Mahi, while enjoying the scenic beauty of the river and around it.

Sayaji Baug

It is a huge park located at the centre of Vadodara, just 19 km. from the river. It was built by Maharaja Sayajirao III in 1879. It is also known as Kamati Baug. It includes a 45 hectares garden, with 2 museums, a zoo, a planetarium, a flower clock, and an operational toy train. The astronomy park here exhibits astronomical instruments of ancient India. This place would not provide much opportunity for the waterway, because there is good road connectivity to this place, and tourists would prefer roadways to waterways.

Laxmi Villa Palace

This palace is located 22 km. away from the river. This palace is used for shooting Bollywood productions. Built from red sandstone in Rajput style, with a central dome, Bengal domes on the sides, bastions on the corner, and colored glass windows overall. The balcony at the top provides a vantage point for a superb view of the surrounding area, and the King's tomb can also be seen from here. Even this palace would not provide any tourist traffic to the proposed waterway, because it is far from River Mahi while providing good road connectivity.

EME Temple

EME temple is also known as The Dakshina murthy Temple, built by Electrical & Mechanical (EME) Corps. The temple is run by The Indian Army Authorities. It houses holy symbols of every religion. Built from aluminum, the temple carries army architecture, and has a garden housing 106 ancient statues ranging from 6th to 16thcentury. The temple garden is lush green, offering serene vistas to its visitors.

Sursagar Lake

Sursagar Lake was formerly known as Chandan Talao. The lake is walled around the ring, allowing visitors to sit and take in the view of the lake in its moonlight beauty. There is 120 ft Sarveshwar Mahadev statue in the middle of the lake, which is decorated during the festivals like Shivratri, Maha Shivratri and Ganesh Chaturthi. There are boating rides available on the lake. During the festival of Ganesh Chaturhti, the Lake is also used for immersion of idols.

Baroda Museum & Picture Gallery

The Baroda Museum and Art Gallery was built in the Indo-Sarcenic style by King Sayajirao Gaekwad. The museum houses rich collections like Mughal miniatures, gallery of Tibetan Art, objects from Japan and Nepal, and coins from all over the world. The ethnography section has exhibits of Gujarat’s tribes. There is also a Sayajirao gallery inside the museum that houses paintings of Sayajirao himself. The museum also has a bronze statue room and European paintings from 16th, 18th, and 19th century.

Kirti Mandir

Kirti Mandir is a temple complex dedicated to Lord Shiva. It is a cenotaph built by King Sayajirao Gaekwad in the memory of his ancestors. The highlight of the temple is the tall shikara that houses idols of gods and goddess; and also the sun, moon, and earth; along with undivided map of India in bronze. The inside of the temple is decorated with eloquent murals. It also has paintings by Raja Ravi Verma, and items used by the Royal family.

Nyay Mandir

Nyay Mandir is called Temple of Justice, and was built by King Sayajirao Gaekwad in memory of his Chimnabhai. The Nyay Mandir holds a statue of Chimnabhai. Now,the place functions as a district sessions court.

Gujarat Fun World

Gujarat Fun world was set up in 1990, and was the first of its kind in Gujarat. There are more than 25 amusement rides inside the park. The park is spread over 5 acres of land. The park attracts 1.2 million tourists every year.

Shiv Mahal Palace

Shiv Mahal Palace was built for the 3rd son of Shivajirao. It was the home of Prince Uday Singh and Princess Sharda of Gaekwad Dynasty. The palace has now been converted into a hotel, and is rented out for marriages and functions.

Potential Tourist Attraction – Sindhrot Dam

Most of the above-discussed attractions are few and far between, when considering River Mahi as a mode to traverse these locations. Riparaian Resort and Galteshwar Temple are two of the attractions that are located on the bank of River Mahi. However, the chainage between these two locations is over 30 km, with nothing tourism related in between to appeal to the tourists. Building a standalone infrastructure on the basis of these two spots is not recommended, nor is it likely to be commercially viable.

Dearth of tourism activity right alongside River Mahi can be overcome by developing certain infrastructure that could, potentially, attract tourists. One such remote prospect could be explored at Sindhrot Dam. The location is just 7 km beyond the outskirts of the city of Vadodara. This proximity will serve as an advantage to any tourist attraction that could be developed near the Dam. Couple of recommended infrastructure that can be erected at the said location is an amusement park, inclusive of water-sports facilities and amusement rides for kids. In addition, a floating restaurant alongside the park will further help drive traffic. A precedent is already established in Singanapore, near Weir-cum-Causeway on the bank of River Tapi. A floating restaurant and a water sports facility is already in operation, run by a company called Blue Adventure. A similar development strategy could be applied for the proposed tourist attraction at Sindhrot Dam.

The following figure depicts the location for the proposed amusement park and floating restaurant near Sindhrot Dam:

Sindhrot Dam

Current makeshift establishment at the Dam

Figure 4-4 Proposed infrastructure (ground level)

Figure 4-5 Proposed location, connectivity, and adjoining tourist attractions (Aerial)

At present, Sindhrot Dam is popular among the local young demographic, mostly as a picnic spot or just to hang out. During site visit, about 200 visitors could be accounted for, which was on a weekday. On weekends, this figure is likely to be significantly more. Influx of such crowd can be tapped into and exploited by providing them more quality reasons to keep visiting this place. A combination of recreation and leisure activities at a single location can facilitate in creating such tourist attractions. These reasons underlie the suggestion of an amusement park and a floating restaurant near the Dam.

The proposed park could provide, but not limited to, the following facilities and activities on its premise. Amusement rides will help increase its popularity among kids, too.

- Jet-skiing
- Kayaking
- Speed-boating, Leisure boat rides, Pedal-boat rides, Banana boat rides, etc.

- Aquarium
- Various water rides
- Various joy rides

Back in 2015, India’s amusement-park industry was pegged to grow at a 5-year CAGR of 20%, with annual footfalls to increase at a 10% - 15% CAGR for the next couple of years. India’s urban population was expected to increase from 31% in 2010 to 35% of the total population by 2020. As per 2015 reports, India had about 150 parks for its total population of 1.2 billion, while USA had 400 parks for its population of 319 million. This suggests that there’s tremendous scope for growth in this segment.

Most parks in India are small scale, with an annual capacity of 0.3 million visitors or less. Such parks are primarily located in and around small towns, and on the outskirts of metro cities. Vadodara, being one of the bustling and economically forward districts, a small-scale recreational facility will be a gross mismatch. Appropriately, a medium-scale amusement park should be built to cater to such a potential crowd. Traditionally, such an infrastructure is built on the outskirts of metros and tier-1 cities, and can accommodate about 0.5 million visitors every year. Total capital expenditure (capex) for such a development could be anywhere between INR 300 million and INR 400 million, occupying a total area of 10 acres to 40 acres. However, such a vast expanse of land is not available at the proposed spot near Sindhrot Dam. Due to land scarcity, it’s therefore suitable to develop a small-scale amusement park, spanning anywhere between 3 acres and 5 acres. The floating restaurant would complement the proposed park well. With reference to the floating restaurant at Dumas Beach along River Tapi, a similar facility can be set up alongside the park. The restaurant at Dumas Beach is 30 meters by 12 meters, and can seat 200 people at a given time. The estimated capex for the floating restaurant was around INR 80 million.

There is a couple of existing tourist attractions in the vicinity of Sindhrot Dam. Such facilities could further enhance the appeal of the location once the parks and the restaurants are in business.

Erdas Speedway Go Kart Racing

The Erdas Speedway Go Kart Racing is about 650 m from Sindhrot Dam. Built on an area ofabout1.5 acres, this circuit is used for organizing Go-kart racing, which sees anywhere between 300 – 500 visitors. The facility also sees daily visitors, but the numbers are likely to be around 300, if not less.

Nature Education Park

Popularly known as “Prakruti Udyan”, the park is part of state’s conservation program. Built on an area of 35 acres, the park is situated in the ravines of River Mahi, roughly 1 km away from Sindhrot Dam. The park has diverse facilities suitable for activities like guided walks, watch towers, bird watching, planetarium, astronomical observatory, meteorological observatory, energy park, waterfalls, splash pool, and library. As per last estimates, the park has about 84 species of birds. The park organizes seminars and events focused on raising awareness in regard to conservation issues in the state of Gujarat.

In future, provided adequate land could be acquired, more tourism-related development could be undertaken to transform the place into a moderate-scale tourism hub. The aforesaid existing attractions would add to the diversity of the location’s overall appeal.

4.7 Ro-Ro Traffic

There are no ferry services available on the stretch at present. The district of Vadodara, exclusively, attracts large number of tourists on a yearly basis. These locations are within 10 km – 25 km from River Mahi, but they are currently better accessible via road and rail mode. There is the National Highway 8, and multiple state highways connecting the two districts that flank River Mahi. Hence, water connectivity to these locations via River Mahi will not be a feasible and practical alternative. Visitors from districts like Anand and Kheda would require a multimodal arrangement for last mile connectivity. This would make a Vadodara-tourism-oriented ferry service redundant and more expensive. A similar inference can be drawn for visitors moving from Vadodara to Anand, or other districts up north.

4.8 Growth Trend

River Mahi has high potential of catering to cargo traffic, than tourist traffic. Growth trend along this river is broadly divided into cargo growth and passenger growth.

Cargo Growth

Wanakbori Thermal power station is located in the primary catchment area, and is in close proximity to the proposed Terminal 2. This TPP requires 5.2 million tons of coal per annum. At present the plant brings in coal using its own rail siding. There exists a possibility of diverting a share of this rail-bound coal traffic using River Mahi, provided the latter mode of transport is logistically economical, which is an unlikely proposition. The only possibility is with the 20% import share of coal that the plant acquires from Hazira Port. As part of its expansion, an 800 MW SCTPS at Wanakbori will be added by

FY19 or FY20, at the latest. This plant will have a coal requirement of an estimated 2.8 MMTA. The boiler units in this plant is designed so that it can operate on 100% imported coal or 100% indigenous coal. However, with the Government of India's efforts to reduce its thermal coal import dependency, coal-based power plants are being urged to lower their imported coal share. Regardless, indigenous coal has a quality trade off vis-à-vis the imported varieties. Being a critical power plant, the reliance is likely to be on imported coal. Like almost all the plants in the region, this plant, too, is likely to procure coal from Hazira Port. This will present yet another opportunity to move coal for the plant via River Mahi.

The leftover fly ash volume of nearly 1.2 Million T from Wanakbori TPS is transported to Surat using road transportation. This is supplied to UltraTech's unit in Surat, which is based alongside Magdalla Port. In comparison to transporting via road, waterway movement should result in lower per-ton logistics cost. Future growth in this traffic will come from the soon-to-be-set-up SCTPS at Wanakbori. An estimated 1 Million T of fly ash will be generated, which will be surplus in nature. Hence, this volume, too, has the potential of being moved using River Mahi.

At present, UltraTech Cement's 2.4 MMTA grinding unit in Wanakbori acquires clinker from its integrated plant in Kutchh. The total annual requirement is an estimated 2 Million T. The company also has cement plants in Jaffrabad and Rajula, both of which are in Amreli district, and proximal to Jaffrabad Port and Pipavav Port. If the Wanakbori plant were to use these Amreli units for clinker instead of the Kutchh unit, then River Mahi can provide direct and most suitable connectivity. Also, no certain expansion plans are on the anvil for the Wanakbori unit.

Tourism Growth

At present, growth in the tourism industry around River Mahi catchment may not translate into a viable opportunity for ferry services. It's recommended that a different strategy be adopted to develop River Mahi for tourism potential. Growth can be induced by developing appropriate infrastructure at a suitable location along the river stretch.
Opportunity exists for transforming location near Sindhrot Dam into a tourism hub. At present, the place attracts an overall crowd of 1,000 – 1,500 every week. A go-kart racing facility nearby, by the name Erdas Speedway Go Kart Racing, also handles decent crowd at a given time, considering the scale of its operation. In addition and in contrast, Nature Education Park near Sindhrot village provides means for leisure activities. Considering in totality, the proposed facilities of water-cum-amusement-park and floating restaurant near Sindhrot Dam would be diverse and attractive additions to the region from tourism standpoint.

Comparison between FSR and DPR Traffic

The following table gives a brief comparison between the potential cargo for River Mahi waterway, as judged by the FSR and DPR:

Commodity	Source	Considered in FSR	Potential	Reasoning
Coal	Imported Coal from Hazira	✓	✓	A high potential cargo for the existing plant, as well as for the upcoming SCTPS at the same location.
Fly Ash	Wanakbori TPS & SCTPS	✓	✓	Same as above
Clinker	UltraTech Cement	✓	✓	This potential traffic rests on the possibility of UltratTech Cement's grinding plant in Wanakbori sourcing its clinker requirement from Amreli, instead of their existing integrated plant in Kuchh
Black Trap	Mines in the catchment area	✓	▯	Total produced volume of this commodity, around 0.9 Million T gets distributed locally via road for end consumption.
Rock Phosphate	Fertilizer companies	✓	▯	Scattered distribution of total Rock Phosphate landing at Dahej Port, with very low volumes being utilized by the fertilizer plants located in the region, mostly Vadodara and Dahej.
Tourism Potential				
Tourism	Sindhrot Dam	▯	✓	New tourism opportunities could be created by developing certain infrastructure that can take advantage of Vadodara's tourism industry as well its direct connectivity to Sindhrot Dam

Table 4-9 Comparative Analysis of FSR with DPR

There are agreements between FSR and DPR for the cargo of coal, fly ash, and clinker. Prima facie, there is a healthy opportunity for handling these cargo on the River Mahi waterway. Also, due to future addition of 800 MW SCTPS at Wanakbori, there are growth opportunities for both coal and fly ash.

Black Trap is not a viable cargo to target for River Mahi. Local consumption of this commodity, and distribution via road makes handling black trap on River Mahi a, relatively, expensive proposition. Similarly, overall logistic involved in shifting rock phosphate to waterway from the current transport mode will prove to be a disadvantage. This raw material is consumed by fertilizer companies spread across the region, and in low volume. Such disparate distribution using River Mahi will result in overhead for these companies.

In contrast to FSR's focus on attracting some share from existing tourist traffic in the region, DPR advocates for creating such a potential. The location near Sindhrot Dam seems suitable for tourism development. The location is accessible from the city of Vadodara via a 2-lane State Highway 11. The immediate region near Sindhrot dam has Erdas Speedway Go-Kart Racing and Nature Education Park, which attracts some visitors on a regular basis. Furthermore, the Sindhrot Dam also gets visitors on a regular basis, which can be as high as 1,500 per week. Looking at the moderate-to-low incoming visitor traffic in the region, new tourist-oriented facilities will only drive the numbers higher. Assuming such a potential can be harnessed, a combination of facilities like a water park, amusement rides, and floating restaurant has been proposed.

4.9 Forecasting & Potential IWT Assumption

An overview of the rationale behind the traffic study adopted, and the driving factors for the projections made herein are depicted in the flowchart in the following figure:

- Business opportunities in primary hinterland (distance under 25 kms from River Mahi) and secondary Hinterland (distance beyond 25 kms from River Mahi) were researched and analyzed.

- With respect to tourist and passenger traffic potential, preliminary analysis suggested potential in the former, but nothing for the latter.

- Despite the presence of several tourist spots spread across districts like Vadodara, Anand, and Kheda, traffic potential from existing prospects is non-existent. This is, primarily, because of good connectivity between and within these districts, making an additional transport mode redundant.

- New prospects can be explored and necessary infrastructure developed to continue to attract current visitors in the region, as well as the urban population from the nearest cities like Vadodara.

- Potential in handling cargo traffic on River Mahi was distinguished between requirements for industries spread throughout the region (industrial cargo) and for retail businesses (retail cargo).

- Retail cargo is distributed in smaller parcel sizes, and to fragmented end merchants. Waterway transportation is suitable for large volume cargo, and, typically, for long-distance shipment.

- Opportunities for industrial cargo could emerge from traffic currently using road or rail mode of transportation. Second source of opportunities could come from the companies that can benefit from the proposed waterway for moving their cargo in future. Both these possibilities were evaluated.

- Estimations were calculated for the cargo volume that currently uses other modes of transportation, and the logistics cost entailed between the designated origin and destination nodes. Potential parties that could use the proposed waterway were identified, and the volume likely to be shifted was determined.

- Similar assessment was undertaken for future potential based on companies that are either expanding their operations or setting up new units. Driven by the rationale of net savings in logistics, the likelihood of using River Mahi for their exim operations was determined.

- The cumulative rationale that drive the traffic potentials, as discussed above, is used to propose setup of terminal(s) on the River Mahi stretch.

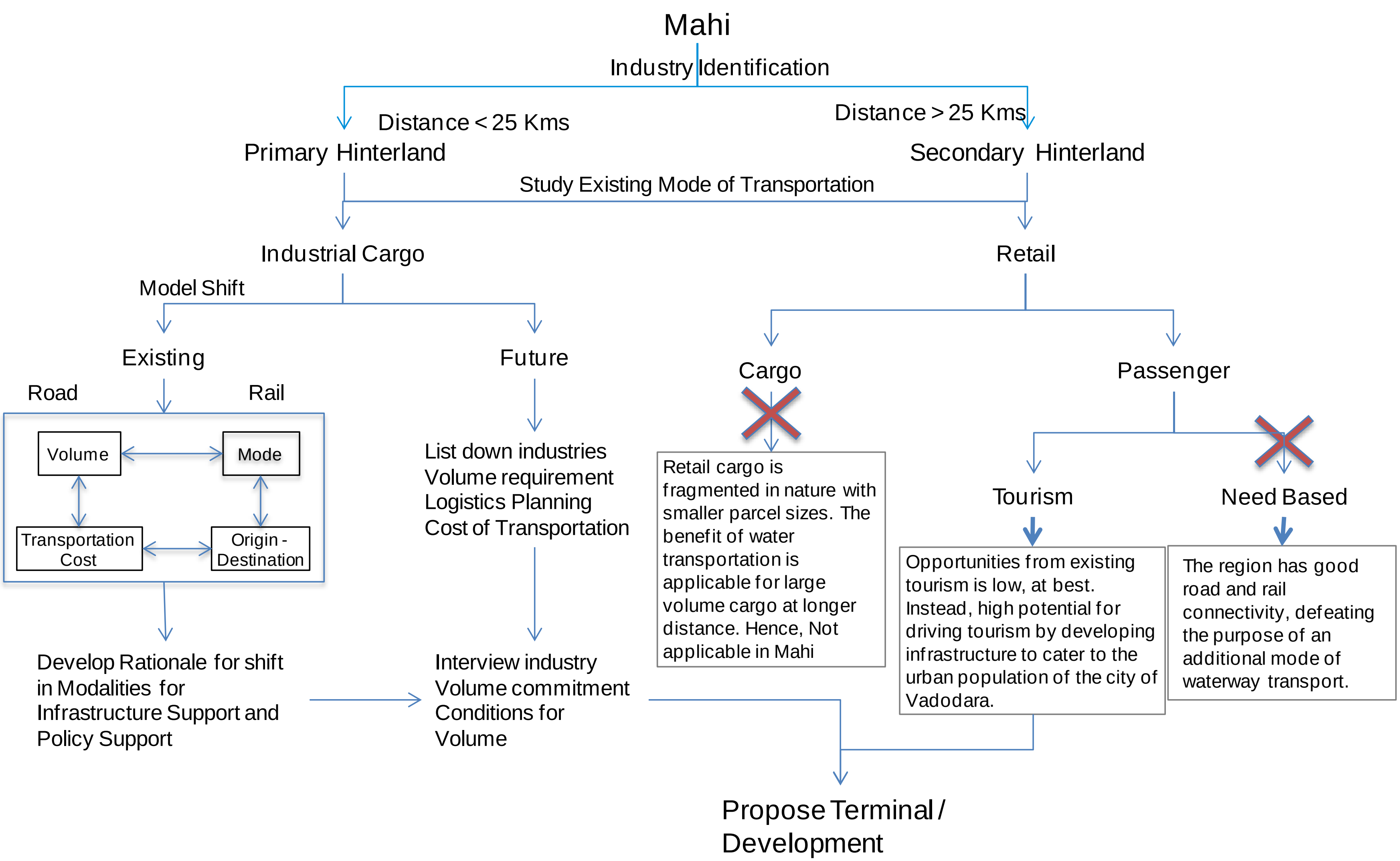


Figure 4-6 Rationale for the traffic study and the projections

Overall, there is potential in both tourism and cargo traffic for River Mahi. However, for the former, new developments are needed in order to extract commercial potential from the region. Only after the requisite infrastructure is set-up can tourism opportunity can be realized. In service of such opportunities, an amusement park and a floating restaurant have been recommended near Sindhrot Dam.

From cargo traffic viewpoint, both existing and new cargo movements could be targeted and handled via River Mahi. Hence, It is recommended that two terminals be built along River Mahi, one near Sindhrot dam & other near Wanakbori. The image below shows both location for the proposed terminal. First one would be recreational centre at Sindhrot dam whereas second would be near Wanakbori Thermal Power Plant, the proposed SCTPS, and Ultra Tech Cement's 2.4 MMTA grinding unit.

Figure 4-7 Location of Terminal 1 near Sindhrot Dam, Kotna

Figure 4-8 Location of Terminal 2 at Pali near Wanakbori TPS

Potential Tourism Traffic

Tourist traffic estimations for the proposed amusement park and floating restaurant are calculated together. Individually, the restaurant will have a daily capacity of 300 patrons, which is 0.1 million on an annual basis, operating 360 days a year. Similarly, the amusement park is pegged to have a theoretical annual capacity of 0.7 million visitors. Together, the total footfall for the infrastructure translates to 0.83 million per year. Considering a development timeframe of 5 years from FY18, business is likely to commence at the parks in FY22. Traffic in the first year is driven by the number of people visiting the location near Sindhrot Dam at present. Based on the site visit, weekly traffic is estimated at 850 visitors, resulting in an annual footfall of 44,200. This is the initial traffic assumption based on which the entire projections are carried out.

From a practical standpoint, reaching the maximum capacity is unlikely, especially for a modest-scale facility being proposed here. Also, the park is likely to compete with other similar facilities such as S-Cube Water Park & Gujarat Fun World near Ajwal Lake, located 23 km from Vadodara. There is another water park call Ajwa Water Park, 2 km from the S-Cube Park and 21 km from Vadodara. Both these parks target visitors from the city of Vadodara, and the district in general. Another practical scenario the traffic estimation borrows from is the Kingdom of Dreams amusement park in Gurgaon. Launched in 2010, the facility is spread across 6 acres of land, and has a theoretical annual capacity of 0.7 million visitors. However, in 2015, the park attracted a total traffic of only 0.4 million, which is less than 60% of its absolute limit. Owing to such mitigating factors and real-life scenarios, it's estimated that the total traffic at the proposed facilities near will not exceed 75% by FY45. Before that, it's assumed these facilities will manage to utilize 60% of its total capacity by FY30. So, between FY22 and FY30, visitor traffic will grow at a 7-year CAGR of 35.6%. Between FY30 and FY45, this traffic will grow at a 15-year CAGR of 1.5%.

On a standalone basis, it's assumed that the floating restaurant will attract 20% of the total traffic, peaking at 0.1 Million visitors annually. It's likely for a restaurant to operate at its peak capacity, but not so much for an amusement park. In the event the park reaches its near-maximum capacity, it can raise its upper limit by adding more rides and attractions. However, these plans will be dictated by land available for expansion.

Cargo traffic at the proposed Terminal

The existing Wanakbori TPS has an annual coal requirement of around 5.2 Million T, bulk of which is sourced from domestic mines, and the remaining 20% is imported coal. At the moment, the plant has ceased its import operations, but is likely to resume soon. Due to design constraints, the plant is unlikely to exceed the maximum viable import share of 30%. For projection purposes, it's assumed that this share will be achieved by FY45. Based on the plant's current import share (15% - 20%), it's assumed that its FY18 import traffic will be 15% of the total coal requirements. By FY25, the plan will increase its import share to 20%, growing at a 7-year CAGR of about 40% between FY18 and FY25. This import share will inch upwards to 25% by FY35, with a 10-year CAGR of 2.3% between FY25 and FY35. Similarly, on the back of 10-year CAGR of approximately 2% between FY35 and FY45, the plant's import share will peak at 30% of the total coal requirement.

A similar series of assumptions supports the coal traffic forecast for the upcoming SCTPS at Wanakbori. The boiler unit to be installed for that plant does not carry the aforesaid design restrictions. However, impetus from the Government of India is to increase reliance on domestic coal rather than imports. Considering these extenuating circumstances and applying moderation, this new plant is also assumed to achieve 30% share of imported coal by FY45. Operation for this plant should begin by late FY19 or early FY20, at the latest. Assuming a nominal volume of 0.1 Million TforFY20, the plant will import 10% of its coal requirements by FY25, growing at 5-year CAGR of almost 23%. Between FY25 and FY35, import at the plant will grow at 10-year CAGR of 7.2% to reach an import share of. Attaining the ultimate share of 30% by FY45, this import volume will grow by 10-year CAGR of just over 4%.

At the existing Wanakbori TPS, 1.2 Million T of fly ash can be targeted for transportation on River Mahi, against the total of 1.8 Million T of fly ash that gets generated. This volume is distributed to Surat for domestic consumption using roadways. Hence, for projection purposes, it's assumed that a maximum of 75% of this volume will shift to River Mahi by FY45. Between FY18 and FY25, fly ash traffic on the proposed waterway is estimated to grow at a 7-year CAGR of about 20%, and then at a 10-year CAGR of 5.2% between FY25 and FY35. By FY35, River Mahi is expected to move 50% of the potential ash volume, reaching 75% by FY45, while growing at a 10-year CAGR of 4.1% in between. Almost, identical growth rates will be seen for fly ash traffic from the upcoming SCTPS at Wanakbori. Distribution of the surplus 1 Million T should start by FY20, translating into waterway traffic of 0.1 Million T. Growing y-o-y at a 5-year CAGR of nearly 27%, River Mahi will be transporting 30% of the surplus fly ash volume by FY25. Fly ash potential traffic between FY25 and FY35will follow the growth trend expected for the existing plant. This will also be the case for growth trend between FY35 and FY45.

Clinker for the UltraTech Cement grinding unit is more of a speculative cargo, in comparison to the above discussed cargo of coal and fly ash. Assuming an optimistic scenario where the company starts importing clinker from its units in Amreli, a maximum 75% of their annual demand can be moved using River Mahi by FY45. As per cement plant standards, clinker requirement to produce Portland cement varies between 90% and 95%. Hence, it's assumed that the Wanakbori unit will require around 90% of its total capacity in clinker, as one of the raw materials. Based on this proportion, an estimated annual clinker requirement is taken at 2 Million T. Beginning with 0.1 Million T in FY18, traffic on the proposed waterway will increase at a 7-year CAGR of just over 29%, to capture 30% of the import requirement. In the next 10 years, this share will grow at a 10-year CAGR of 5.2% to capture 50% of the total import requirement. Between FY35 and FY45, traffic will increase at a 10-year CAGR of nearly 4% to peak at 75% of the total import requirement.

4.10 Terminal wise IWT Traffic Analysis

Figure 1 10 shows the proposed location of cargo Terminal and the tentative location for the proposed facilities for tourism development around the River. Cargo handling opportunities will result from, mostly, the cement plants and the power plants in Wanakbori.

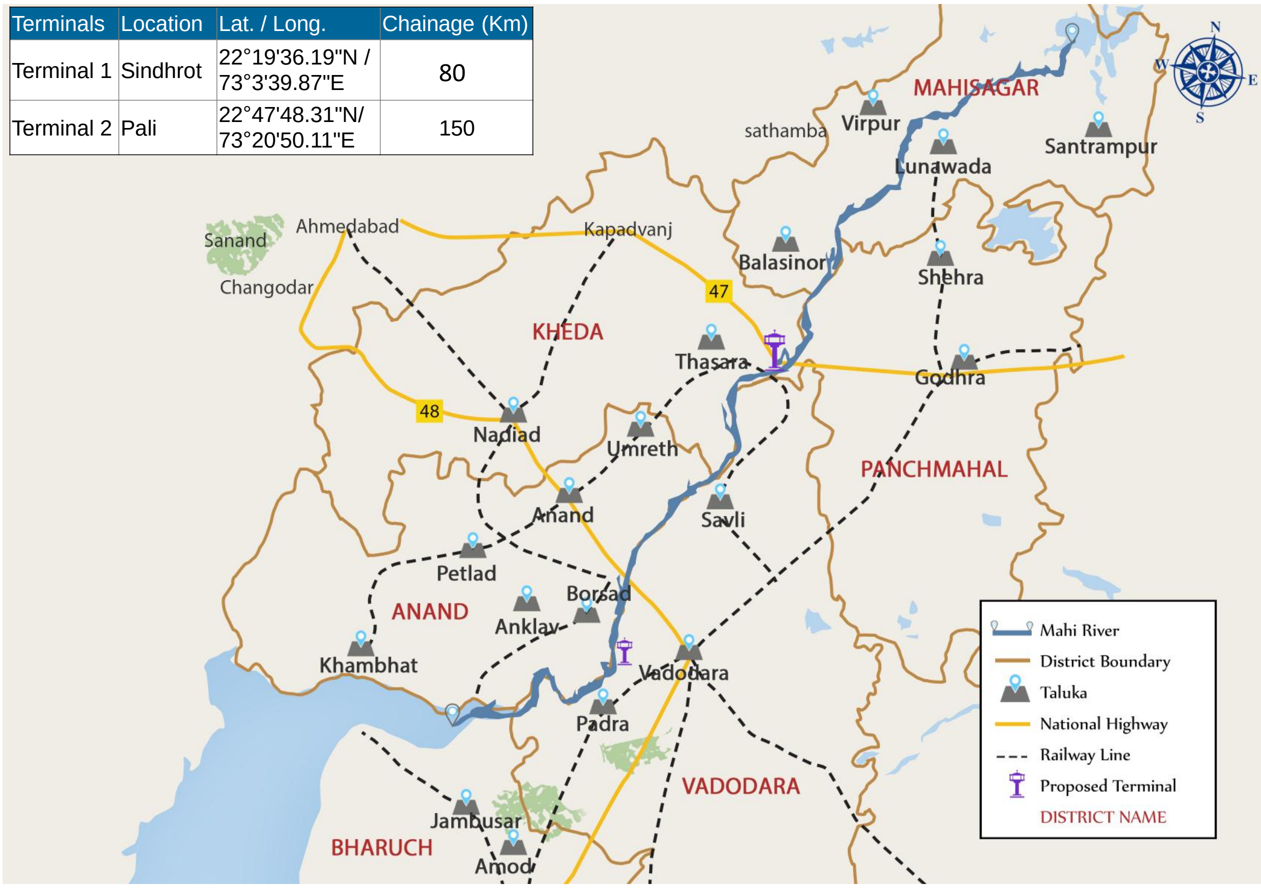


Figure 4-9 Proposed Terminal location along with Chainage distance

Proposed	Place	Location	Purpose	Chainage (km)
Terminal 1	Sindhrot	22°19'52.76"N / 73° 3'33.68"E	Tourism	80
Terminal 2	Pali	22°47'48.31"N/ 73°20'50.11"E	Cargo	150

Table 4-10 Proposed terminal distance matrix

Tourism Traffic Analysis

The following table depicts growth in traffic once the proposed water park, amusement rides, and the floating restaurants open for business at Sindhrot Dam:

	FY23	FY25	FY30	FY35	FY40	FY45
Amusement Park	9	22	99	107	108	108
Floating Restaurant	35	88	397	428	468	513
Total	44	110	497	535	576	621

Table 4-11 Traffic projections at the proposed tourist attractions ('000 visitors)

Based on the assumptions discussed in an earlier section, total footfall at the park and restaurant together will grow from 44,200 in FY22 to 0.6 Million in FY45.The amusement park will handle at least 80% of the total projected traffic. By FY45, the park is likely to see 0.5 Million visitors, which is just over 71% of its theoretical capacity. At most, 20% of the total traffic will be contributed by the visitors of the floating restaurant. However, due to its capacity constraints, the traffic will peak at 0.1 Million (1,08,000) visitors, which it's likely to hit by FY36. Beyond this, visitor traffic at the restaurant will remain constant, or fluctuate across a range that's negligible for the traffic projection purpose.

Cargo Terminal Analysis

The following table lists all the cargo, along with preliminary estimates of the corresponding traffic for the cargo Terminal near Wanakbori:

Industries	Commodities	Traffic Estimates (M T)	Reasoning
Wanakbori TPS	Coal	1.6	Of the total 5.2 Million T of coal requirement, 30% has been targeted here. This volume is currently brought on rails, but has very good chances of shifting to the waterway, potentially resulting in net logistic savings.
	Fly ash	1.2	This target volume currently goes by road to Surat and even Saurashtra. The volume designated for Surat can be distributed via River Mahi.
Wanakbori SCTPS	Coal	0.8	This potential traffic volume is 30% of the annual coal requirement for the upcoming plant, which could also be catered to by using River Mahi
	Fly ash	0.75	Similar to the rationale for distribution of existing fly ash volume, this potential traffic can also be moved via River Mahi.
UltraTech Cement	Clinker	1.5	This volume carries lower probability of being attracted for movement on River Mahi. However, with the proposed waterway, the likelihood for the switch should increase dramatically.

Table 4-12 Commodity-wise traffic estimate for the proposed Terminal

Majority of the potential traffic volume to be handled on River Mahi will be generated from the Wanakbori TPS and the upcoming SCTPS. Prior to stoppage in coal imports at the existing plant, it imported about 20% of its coal requirements, transported from Hazira to the plant site via rail. Shifting this volume to the waterway should be a logistically superior alternative. Adhering to the blending ratio of 70:30 in favour of domestic coal, import volume is unlikely to exceed 30% of the total requirements.

Fly ash from the existing TPS and the upcoming plant will be another certain cargo, once the proposed Terminal is set up and waterway is declared operational. Consumption is local, and the waterway will be most suitable for transportation to Surat, primarily for consumption by UltraTech's Surat unit.

Part speculative cargo, clinker can be handled on the proposed waterway for UltraTech Cement. For this, the company will have to switch to procuring its requirements from the Amreli cement plants. The likelihood for shifting will increase once the requisite terminal is set up and the waterway is developed.

The following table depicts projections for Terminal 2 along River Mahi:

Cargo	Source/Destination	FY20	FY25	FY30	FY35	FY40	FY45
Coal	Wanakbori TPS	0.2	1.0	1.2	1.3	1.4	1.6
	Wanakbori SCTPS	0.1	0.3	0.4	0.6	0.7	0.8
	Coal Total	**0.3**	**1.3**	**1.6**	**1.9**	**2.1**	**2.4**
Fly Ash	Wanakbori TPS	0.1	0.4	0.5	0.6	0.7	0.9
	Wanakbori SCTPS	0.1	0.3	0.4	0.5	0.6	0.8
	Fly Ash Total	**0.2**	**0.7**	**0.9**	**1.1**	**1.3**	**1.7**
Clinker	UltraTech Cement	**0.2**	**0.6**	**0.8**	**1.0**	**1.2**	**1.5**
	Grand Total	**0.7**	**2.6**	**3.3**	**4.0**	**4.6**	**5.6**

Table 4-13 Traffic projections for the proposed Terminal

Applying a maximum of 30% import share at the existing and upcoming plants in Wanakbori, the proposed Terminal will handle a total traffic of 1.6 Million T and 0.8 Million T by FY45, respectively. Up until FY25, the growth rate is assumed to be aggressive, moderating gradually over a period of next 20 years. Despite modest assumptions, the projected coal traffic will have the largest traffic share at the Terminal.

Banking on regular coal handling at the proposed Terminal, operations can be easily extended to fly ash handling as well. Furthermore, transporting the commodity via waterway is likely to streamline the cargo's local distribution, currently done by road mode. Assuming the Terminal can attract 75% of the surplus fly ash volume from the existing and future plants, fly ash will represent second largest traffic volume, after coal. By FY45, the Terminal may handle close to 2 Million T. This volume may increase, marginally, in case 100% of fly ash from the upcoming SCTPS is moved via waterways.

Projected clinker traffic depends, exclusively, on UltraTech Cement's decision to alter its current logistics. There is a strong likelihood that availability of River Mahi for cargo movement may influence their decision in favour of the shift. Traffic volume for this cargo will be close second to that of fly ash.

CHAPTER – 5
TERMINALS

5.1 General Review

Terminal is a place where a particular type of cargo is handled. Terminals can be classified as general cargo terminal, bulk cargo terminal and passenger terminals. Inland water terminals are different from sea terminals in the sense that water levels during flood and dry season varies considerably.

5.2 Identification and site location

Site selection is the most important factor as it dictates investments for establishing the terminal facilities. Therefore, utmost care is taken to select most reliable locations to minimize the capital and the recurring cost for the terminals.

In the stretch of Mahi, two terminals have been proposed on the basis of traffic potential. There is potential in both tourism and cargo traffic for River Mahi. However, for the former, new developments are needed in order to extract commercial potential from the region. Only after the requisite infrastructure is set-up can tourism opportunity can be realized. In service of such opportunities, an amusement park and a floating restaurant have been recommended near Sindhrot Dam.

From cargo traffic viewpoint, both existing and new cargo movements could be targeted and handled via River Mahi. Hence, It is recommended that two terminals be built along River Mahi, one near Sindhrot dam & other near Wanakbori. Proposed terminal locations are shown in **Drawing PT-01 to PT-02**. Following are the proposed terminals in the stretch of river Mahi:

Terminal 1: Sindhrot Tourist Jetty

Analysed traffic for terminal 1 is as follows:

	FY23	FY25	FY30	FY35	FY40	FY45
Amusement Park	9	22	99	107	108	108
Floating Restaurant	35	88	397	428	468	513
Total	44	110	497	535	576	621

Table 5.1 Traffic projections at the proposed tourist attractions ('000 visitors)

Terminal 2: Wanakbori Cargo Jetty

Analysed traffic for terminal 2 is as follows:

Cargo	Source/Destination	FY20	FY25	FY30	FY35	FY40	FY45
Coal	Wanakbori TPS	0.2	1.0	1.2	1.3	1.4	1.6
	Wanakbori SCTPS	0.1	0.3	0.4	0.6	0.7	0.8
	Coal Total	**0.3**	**1.3**	**1.6**	**1.1**	**2.1**	**2.4**
Fly Ash	Wanakbori TPS	0.1	0.4	0.5	0.6	0.7	0.9
	Wanakbori SCTPS	0.1	0.3	0.4	0.5	0.6	0.8
	Fly Ash Total	**0.2**	**0.7**	**0.9**	**1.1**	**1.3**	**1.7**
Clinker	UltraTech Cement	0.2	0.6	0.8	1.0	1.2	1.5
	Grand Total	**0.7**	**2.6**	**3.2**	**4.0**	**4.7**	**5.5**

Table 5.2 Traffic projections for the proposed Terminal

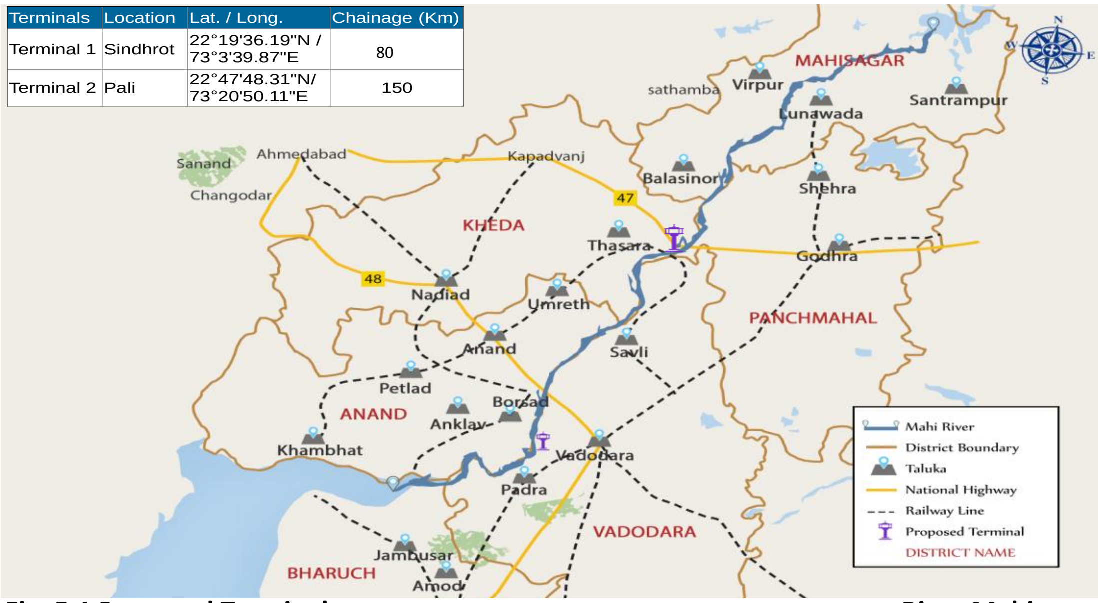


Fig. 5.1 Proposed Terminal on River Mahi

5.2.1 Criteria for Selection of site

I. River morphology and behaviour

II. Stable river channel with natural depths so as to avoid problems of scouring or siltation at the terminal locations. This also reduces the capital cost as well as annual recurring cost on maintence dredging and training works.

III. Hydraulic conditions to be favourable for berthing of barges and cargo handling operations during most part of the year.

IV. Adequate backup space to be available for cargo handling operations and for providing ancillary facilities.

V. Better connectivity to rail and road transport.

VI. Location should be close to traffic centres.

VII. Site so selected should be favourable for the projected traffic as well as for future development.

5.2.2 Description of selected sites

5.2.2.1 Terminal – 1 (Sindhrot Tourist Jetty)

The location is just 7 km beyond the outskirts of the city of Vadodara. This proximity will serve as an advantage to any tourist attraction that could be developed near the Dam. Couple of recommended infrastructure that can be erected at the said location is an amusement park, inclusive of water-sports facilities and amusement rides for kids. In addition, a floating restaurant alongside the park will further help drive traffic. A precedent is already established in Singanpore, near Weir-cum-Causeway on the bank of River Tapi. A floating restaurant and a water sports facility is already in operation, run by a company called Blue Adventure. A similar development strategy could be applied for the proposed tourist attraction at Sindhrot Dam.

Tourist traffic estimations for the proposed amusement park and floating restaurant are calculated together. Individually, the restaurant will have a daily capacity of 300 patrons, which is 0.1 million on an annual basis, operating 360 days a year. Similarly, the amusement park is pegged to have a theoretical annual capacity of 0.7 million visitors. Together, the total footfall for the infrastructure translates to 0.83 million per year. Considering a development timeframe of 5 years from FY18, business is likely to commence at the parks in FY22. Traffic in the first year is driven by the number of people visiting the location near Sindhrot Dam at present. Based on the site visit, weekly traffic is estimated at 850 visitors, resulting in an annual footfall of 44,200. This is the initial traffic assumption based on which the entire projections are carried out.

From a practical standpoint, reaching the maximum capacity is unlikely, especially for a modest-scale facility being proposed here. Also, the park is likely to compete with other similar facilities such as S-Cube Water Park & Gujarat Fun World near Ajwal Lake, located 23 km from Vadodara. There is another water park call Ajwa Water Park, 2 km from the S-Cube Park and 21 km from Vadodara. Both these parks target visitors from the city of Vadodara, and the district in general. Another practical scenario the traffic estimation borrows from is the Kingdom of Dreams amusement park in Gurgaon. Launched in 2010, the facility is spread across 6 acres of land, and has a theoretical annual capacity of 0.7 million visitors. However, in 2015, the park attracted a total traffic of only 0.4 million, which is less than 60% of its absolute limit. Owing to such mitigating factors and real-life scenarios, it's estimated that the total traffic at the proposed facilities near will not exceed 75% by FY45. Before that, it's assumed these facilities will manage to utilize 60% of its total capacity by FY30. So, between FY22 and FY30, visitor traffic will grow at a 7-year

CAGR of 35.6%. Between FY30 and FY45, this traffic will grow at a 15-year CAGR of 1.5%.

On a standalone basis, it's assumed that the floating restaurant will attract 20% of the total traffic, peaking at 0.1 Million visitors annually. It's likely for a restaurant to operate at its peak capacity, but not so much for an amusement park. In the event the park reaches its near-maximum capacity, it can raise its upper limit by adding more rides and attractions. However, these plans will be dictated by land available for expansion.

5.2.2.2 Terminal – 2 (Wanakbori Cargo Jetty)

Majority of the potential traffic volume to be handled on River Mahi will be generated from the Wanakbori TPS and the upcoming SCTPS. Prior to stoppage in coal imports at the existing plant, it imported about 20% of its coal requirements, transported from Hazira to the plant site via rail. Shifting this volume to the waterway should be a logistically superior alternative. Adhering to the blending ratio of 70:30 in favour of domestic coal, import volume is unlikely to exceed 30% of the total requirements.

Fly ash from the existing TPS and the upcoming plant will be another certain cargo, once the proposed Terminal is set up and waterway is declared operational. Consumption is local, and the waterway will be most suitable for transportation to Surat, primarily for consumption by UltraTech's Surat unit.

Part speculative cargo, clinker can be handled on the proposed waterway for UltraTech Cement. For this, the company will have to switch to procuring its requirements from the Amreli cement plants. The likelihood for shifting will increase once the requisite terminal is set up and the waterway is developed.

The existing Wanakbori TPS has an annual coal requirement of around 5.2 mn T, bulk of which is sourced from domestic mines, and the remaining 20% is imported coal. At the moment, the plant has ceased its import operations, but is likely to resume soon. Due to design constraints, the plant is unlikely to exceed the maximum viable import share of 30%. For projection purposes, it's assumed that this share will be achieved by FY45. Based on the plant's current import share (15% - 20%), it's assumed that its FY18 import traffic will be 15% of the total coal requirements. By FY25, the plan will increase its import share to 20%, growing at a 7-year CAGR of about 40% between FY18 and FY25. This import share will inch upwards to 25% by FY35, with a 10-year CAGR of 2.3% between FY25 and FY35. Similarly, on the back of 10-year CAGR of approximately 2% between FY35 and FY45, the plant's import share will peak at 30% of the total coal requirement.

A similar series of assumptions supports the coal traffic forecast for the upcoming SCTPS at Wanakbori. The boiler unit to be installed for that plant does not carry the aforesaid design restrictions. However, impetus from the Government of India is to increase reliance on domestic coal rather than imports. Considering these extenuating circumstances and applying moderation, this new plant is also assumed to achieve 30% share of imported coal by FY45. Operation for this plant should begin by late FY19 or early FY20, at the latest. Assuming a nominal volume of 0.1 MillionT for FY20, the plant will import 10% of its coal requirements by FY25, growing at 5-year CAGR of almost 23%. Between FY25 and FY35, import at the plant will grow at 10-year CAGR of 7.2% to reach an import share of. Attaining the ultimate share of 30% by FY45, this import volume will grow by 10-year CAGR of just over 4%.

At the existing Wanakbori TPS, 1.2 MillionT of fly ash can be targeted for transportation on River Mahi, against the total of 1.8 MillionT of fly ash that gets generated. This volume is distributed to Surat for domestic consumption using roadways. Hence, for projection purposes, it's assumed that a maximum of 75% of this volume will shift to River Mahi by FY45. Between FY18 and FY25, fly ash traffic on the proposed waterway is estimated to grow at a 7-year CAGR of about 20%, and then at a 10-year CAGR of 5.2% between FY25 and FY35. By FY35, River Mahi is expected to move 50% of the potential ash volume, reaching 75% by FY45, while growing at a 10-year CAGR of 4.1% in between. Almost, identical growth rates will be seen for fly ash traffic from the upcoming SCTPS at Wanakbori. Distribution of the surplus 1 MillionT should start by FY20, translating into waterway traffic of 0.1 MillionT. Growing y-o-y at a 5-year CAGR of nearly 27%, River Mahi will be transporting 30% of the surplus fly ash volume by FY25. Fly ash potential traffic between FY25 and FY35will follow the growth trend expected for the existing plant. This will also be the case for growth trend between FY35 and FY45.

Clinker for the UltraTech Cement grinding unit is more of a speculative cargo, in comparison to the above discussed cargo of coal and fly ash. Assuming an optimistic scenario where the company starts importing clinker from its units in Amreli, a maximum 75% of their annual demand can be moved using River Mahi by FY45. As per cement plant standards, clinker requirement to produce Portland cement varies between 90% and 95%. Hence, it's assumed that the Wanakbori unit will require around 90% of its total capacity in clinker, as one of the raw materials. Based on this proportion, an estimated annual clinker requirement is taken at 2 MillionT. Beginning with 0.1 MillionT in FY18, traffic on the proposed waterway will increase at a 7-year CAGR of just over 29%, to capture 30% of the import requirement. In the next 10 years, this share will grow at a 10-year CAGR of 5.2% to capture 50% of the total import requirement. Between FY35 and FY45, traffic will increase at a 10-year CAGR of nearly 4% to peak at 75% of the total import requirement.

5.3 Terminal Layout / Master Planning including phases of development

5.3.1 General Considerations

The main requirement of a terminal is that it should offer adequate shelter and protection against adverse impact action. Vessels must be able to load / unload during severe weather conditions. No terminal can be designed to exclude all weather conditions. Navigability of vessel needs a fair access, with sufficient wide entrance followed by adequate space to slow down and turn. As vessels can be affected by wind and currents, their requirements impose pronounced criteria for the design.

5.3.2 Water Depth

It goes without saying that the water depth on the channel and around the terminal should be enough for safe vessel movements. Possible shoaling of entrance and terminal basin should be checked. Removal of shoaling is often a recurrent and costly affair. Also, salinity of the water and sediment properties can have a very great influence upon the residual sediment transport, a thorough investigation of the above phenomena is required.

5.3.3 Water Level

Most terminal experience water level variations due to tide, seismic activities and wind action. Movement restricted to high water level may be a nuisance, but the only possibility for an economic design. Terminals with a soft and muddy beds situated in areas with large tidal ranges allow vessels to go around low water with lesser risks.

5.3.4 Sea Bed Characteristics

For the foundations of the port structures and other activities like, breakwaters, the possibility of dredging and construction Berth, Geotechnical investigations and soil penetration tests, are essential for proper detailed design, cost estimation and execution.

5.3.5 Water Side Requirements:

a) Easy accessibility of ships to terminal area with safe entrance channel

b) Protection against currents while they are anchored or moored alongside a berth for safe and efficient cargo discharge or loading

c) Sufficient draft below the lowest tidal level to cater to the maximum vessels frequenting the terminal

d) Minimum capital (or initial) dredging and maintenance dredging

e) Low tidal range

f) Port geometry should ensure that it is free from range of schedule phenomena

g) Ship within the harbour should have adequate area for maneuvering to berthing place and also have a turning basin of desired diameter

5.3.6 Requirement at interface between water and land

a) Zoning of harbour area and movements for small craft vessels requiring low drafts as distinct from the areas of deep drafts for larger vessels

b) Zoning in terms of segregation of different types of cargo or allocation berths for different cargos

c) Optimum number of berths to reduce waiting time

d) Quay or wharf dimensions like length and width to accommodate different sizes of ships and space for loading and unloading operations, space for crane tracks, rail tracks, roads for truck movement etc.

e) Soil profile should be such that it is strong enough to take the loads and at the same time does not pose dredging problems

5.3.7 Landside requirements

a) Modern cargo handling equipments for quickest evacuation / loading of cargo.

b) Storage facilities

c) Area for open storage

d) Road and rail connections from quay to storage area

e) Space for railway yards

5.3.8 Planning of water front and navigation facilities

5.3.8.1 The planning of water front and navigation facilities is discussed in this section. This planning is based on the all national standards, codes of practice and PIANC regulations applicable for the planning of berthing and operational areas of the ships.

5.3.8.2 Design Vessel Size

The planning of water front and navigation facilities should be carried out to accommodate all vessels, for which, the first requirement is to determine the dimensions of the Design Vessel Size. In present case, **we have planned channel for class IV**, while in case of jetty class-VII has been considered as design vessel based on futurist approach. Following are details of various classes:

Class	Self-propelled vessel	Tug with barges
I.	Self-propelled, carrying capacity 100 DWT, Size (32m X 5m), Loaded draft 1m	1 Tug + 2 barges – 200 DWT, length 80m X breadth 5m , loaded draft 1m
II.	Self-propelled, carrying capacity 300 DWT, Size (45m X 8m), Loaded draft 1.2m	1 Tug + 2 barges – 600 DWT, length 110m X breadth 8m , loaded draft 1.2m
III.	Self-propelled, carrying capacity 500 DWT, Size (58m X 9m), Loaded draft 1.5m	1 Tug + 2 barges – 1000 DWT, length 141m X breadth 9m , loaded draft 1.5m
IV.	**Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m**	**1 Tug + 2 barges – 2000 DWT, length 170m X breadth 12m , loaded draft 1.8m**
V.	Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m	1 Tug + 2 barges – 2000 DWT, length 170m X breadth 24m , loaded draft 1.8m (moulded with 24 m)
VI.	Self-propelled, carrying capacity 2000 DWT, Size (86m X 14m), Loaded draft 2.5m	1 Tug + 2 barges – 4000 DWT, length 210m X breadth 14m , loaded draft 2.5m
VII.	Self-propelled, carrying capacity 4000 DWT, Size (86m X 14m), Loaded draft 2.9m	1 Tug + 4 barges – 8000 DWT, length 210m X breadth 28m , loaded draft 2.5m

Table 5.3 Vessel Size details

5.3.9 Berth Planning

5.3.9.1 Length of Berth

As per BIS: 4651 (Part V) – 1980, for preliminary assessment, the length of the berth is recommended to be 10% more than the overall length of the largest vessel expected, subject to a minimum of 15 m. This may however be increased upto 20% in basin exposed to strong winds and tidal conditions. Consolidating the results of functional planning exercise the information such as the average ship size chosen for ship handling capacity provided, Length of the berth provided at following terminal are as follows:

Sr. No.	Terminal name	Length of berth(m)
1	**Terminal 1: Sindhrot Tourist Jetty**	70
2	**Terminal 2: Wanakbori Cargo Jetty**	100

Table 5.4 Length of Berth

Proposed length of jetty is more than specification laid in BIS: 4651 (Part V) – 1980, Hence, berths can easily accommodate class-IV vessels.

Width of Berth:

Width of the berth is based on the functional requirement of rail-mounted cranes and adequate manoeuvring space for other equipments. For cargo berth 15.0 m and for passenger jetty 10.0 m has been provided.

Required Depth:

Class of Channel	Depth (m)	Bottom width (m)	Bend radius (m)	Vertical clearance (m)	Horizontal clearance (m)
Class- III	1.7	50	700	6	50
Class- IV	2.0	50	800	8	50
Class- V	2.0	80	800	8	80

Deck Elevation:

BIS: 4651 (Part V) – 1980 recommends that the deck elevation is recommended to be at or above highest high water springs plus half height of an incident wave at the berth location plus a clearance of 1 m. the deck elevation works out to be +7.74 m above CD.

5.3.9.2 Land Related

For terminal planning land related considerations are as follows:

- **Availability of water front land**
- **Soil conditions and elevation**
- **Utilities connections**
- **Environmental and social Impacts**

Availability of water front land

Generally, lands adjacent to river banks are under cultivation due to availability of sweet water for crops. Acquisition of land for the inland terminal has to be done, if Government land is not available. In order to locate the terminal, a conceptualplan of terminal requiring minimum linear water frontage area along with storage area and area required for future expansion is to be planned.

Soil conditions and elevation

For designing and planning of inland terminals soil strata and its elevation from water levels are very essential. Geotechnical investigations are required to be carried out at terminal location as it can substantially affect construction costs. Land areas for loading / unloading and stacking of materials in the terminal aresubjected to high dynamic and static loads due to movement ofheavy lifting equipment along with stacking of heavy cargoes. In case of weak soil strata at the site then it will have to be properly strengthened by proper treatment.

Land elevation is a very important consideration as low lying land is exposed to periodical flooding and may need adequate protection. Another important factor is distance between navigation channel and high flood line as this will decide size offshore structure and cargo handling machinery.

Utilities connections

Utilities such as fresh water connection, sewerage facilities, effluent treatment plant, electricity and telephone connections etc. shall be provided at terminal for efficiently coordinating all activities.

Environmental and Social Impacts

The environmental impacts arising during the dredging and construction activities will be mitigated using required mitigation measures. Both direct and indirect employment potential is anticipated during construction and operations of inland terminal.

5.3.9.3 Transportation

In case of Sindhrot Jetty, approach road should be developed.

In case of terminal 2 approach roads of 5km needs to be developed at the site.

5.3.9.4 Traffic related

To undertake planning of terminal it is necessary to know the volume and type of cargo that is required to be handled. The expected cargo data from various industrial areas have been collected. The traffic data have been compiled in Chapter 4.

5.3.9.5 Cargo Related

In the present case the main cargo is such as

- Coal
- Fly Ash
- Clinker

5.4 Land Details

Approximately 2 hectares of land will be required for development of terminal. The land records were collected for the proposed terminal locations.

Terminal	Location	Land details
Terminal 1	Sindhrot	Govt. land
Terminal 2	Wanakbori	Govt. land

Table. 5.5 Land Details

Locations of proposed terminal are shown in **Fig. no. PT-01 to PT-03**

5.5 Geotechnical Investigations

Geotechnical investigations report has been presented in Volume IV.

5.6 Terminal Infrastructure including equipment

Terminal facilities can be grouped into 3 main categories.

- Mooring
- Storage Yard
- Gate and land Transport Access

5.6.1 Mooring Structures

16-nos 20 T @ 16c/c bollards for mooring will be required.

5.6.2 Storage Yard

The main function of terminal yard includes.

a) Storage of cargo before and after loading or unloading.
b) Parking of trucks.
c) Provision of general services such as equipment maintenance, administrative offices, amenities for labour etc.

5.6.3 Gate and transport access

The main function of the gate and related facilities can be divided into.

a) Cargo and equipment exchange
b) Traffic control
c) Parking
d) General Security.

The gate activities are security check, cargo check, equipment check etc. The gate and the terminal entrance should include a two lane road (in/out) with traffic bumps to slow down the terminal traffic. There must be parking lot for trucks and passenger cars.

5.6.4 Water Supply Requirement

It is assumed that 125 liters per capita per day (LPCD) will be required. A total of 400 nos. of personnel consisting of barge operators, crane operators, truck operators and maintenance operators are assumed to be working on the terminal every day. Hence the total water requirement works to be 50,000 liters per day. Ground storage reservoir (GSR) and over head tank of suitable size needs to be provided for taking care of this requirement.

5.6.5 Power requirement

There will be one cranes on the terminal 2, crane will require power of 125 kW, and the general lighting on jetties, offices and stacking yard will require 60 kW of power. The sewage treatment plant, water treatment plant and water supply will require 65 kW of power. Thus a total of approx. 250 kW of power will be required at this terminal. Terminal 1 is passenger terminals. Approx 100 kW of power will be required at passenger terminal.

5.6.6 Cargo Handling Equipments

Cargo handling equipments are characterized by

- Capacity – Size and type of cargo.
- Distance or reach – the distance
- Speed – the travelling, swinging and hoisting speeds of the various moving components and the resulting overall rate or productivity.

Cargo can be moved in following three principle ways –

- Trucking – rolling of cargoes on wheels
- Lifting – picking up and moving
- Conveying – carrying cargoes continuously

Each cargo handling machine includes combination of the above mentioned principle methods. The configuration of portal cranes is based on pedestal support structure and elevated turn table. In some designs, the support structures come with four sets of steel wheels which move on rail tracks mounted on the quay. The driver cab in most of the cranes is elevated to enable an unobstructed view of the entire vessel. The pedestal configuration allows the crane to stand closer to the vessel and use shorter boom and smaller swinging radius.

In the present case mobile harbour crane is proposed.

However, description of various handling process is shown below for information.

5.6.7 General Cargo Handling Process

General cargo will involve different sizes and weights, so it is difficult to handle the cargoes efficiently and quickly they must be unitized and palletized. The dispersive units of cargo will be unitized in larger units say 5-10 tons depending on the capacity of the crane. For the forklift to pick it up, the cargo should be mounted on pallets or skids. When General cargo is unitized, cranes or forklifts can be used and transportation by trucks or wagons can be used.

5.6.8 **Bulk Cargo Handling Process**

The bulk cargo handling process at bulk terminals involves two systems, one island-to water, and another is water-to-land. The land-to-water system is for the unloading of the trucks to storage or direct shipment, and this system is in the use at most inland terminals. The water-to-land system is unloading the vessel to storage and then loading the trucks or railcars.

5.6.9 Cargo Handling Equipment

Cargo handling equipment is the most basic handling equipment at the inland waterwayterminals. The equipment will load or unload barges / vessels directly from the truck, or another vessel. The cargo is first transferred between the vessel and dock, held or stored for short period and taken by trucks to the final destination. For cargo handling rubber tyre gantry crane, level luffing crane, fixed crane and forklift etc. are used. Details of cargo handling equipment are given below:

5.6.9.1 Rubber Tyre Gantry Crane

A rubber tyre gantry crane (Fig. No. 5.2) is a multipurpose machine and is widely used in inland ports. The crane is not limited to vessel handling but can be used for handling trucks as well. The carriage system is on rubber tyres. The tyre cranes are equipped with outriggers. The capacity of these cranes is 5 to 25 tons in most cases. The crane can move to any place easily and fast which is a merit but operation is slow and lift capacity is lower than level luffing crane. However, during hoisting the tyres cannot bear the load of the crane and has to be jacked for sustaining the load hence these are inferior to RMG for speedy loading and unloading.

Fig No. 5.2 Rubber Tyre Gantry Crane

5.6.9.2 Level Luffing Crane

These level luffing cranes (Fig No. 5.3) are used on small inland ports whose throughput is small. It has got four sets of wheels at each corner of structures which enables the crane to move on tracks along the dock. The pedestal configuration allows the cranes to stand closer to the vessel and use smaller boom. Improved boom design called level luffing is based on an articulated boom, which allows through counter movement of the two boom segments for leveled traverse traveling which is more energy efficient and has better maneuverability. These cranes have higher productivity and better reach than tyre cranes. These cranes are operated by electricity thus reducing operational cost.

Fig No.5.3 Level Luffing Crane

5.6.9.3 Grab Type Level Luffing Crane

All general cargo cranes, almost all these cranes can be fitted for handling bulk cargoes. The conversion to bulk cargo handling is quite simple: replacing the hook by a clam-shell or grab attachment and installing additional power (mechanical or electrical). The grab can be attached to any crane system but most commonly it is used with crawler and portal or gantry cranes. Usually, crawler cranes fitted with grabs are very versatile machines; they can both load and unload vessels, and can also load and unload trucks and trains. However, portal and Grab Type Level Luffing Crane (Fig No. 5.4) are usually limited to vessel operation.

The productivity of a grab crane in handling bulk cargo is determined by the capacity (tonnage) of the shell, the path it has to cover and the speed of hoisting, swinging and opening / closing the grabs.

The size of the grab itself is a function of the density of the material it carries; smaller grabs are used with denser and heavier materials on common inland ports. Many ports have been equipped with portal or gantry cranes fitted with grabs to unload the vessels. At present, it is the main method to unload the bulk cargo from vessels.

Fig No. 5.4 Grab Type Level Luffing Crane

5.6.9.4 Fixed Crane

The fixed cranes (Fig No. 5.5) as name suggests can't move on the dock because it has no traveling gear and as such is cheaper and lighter than traveling crane. These cranes are cheaper and are used on small inland ports and can be located on pontoon or on the dock. In the throughput is small fixed cranes are preferable.

Fig No.5.5 Fixed Crane

5.6.9.5 Crawler Crane

The crawler cranes (**Fig No.5.6**) are very versatile and can move on tracks and can both load and unload barges. They can also load and unload trucks. They can crawl on the jetty and take a position wherever loading and unloading is required to be done. This movement of the crane prevents moving of barges/vessels thus reducing the time of loading / unloading.

Fig No.5.6 Crawler cranes

5.6.9.6 Forklift

The forklift (**Fig No.5.7**) combines trucking and lifting of cargo units. The inland ports use 3- 5 ton capacity forklift and for larger terminals it may use 10 tons. All terminals forklifts are use for loading / unloading or storage in yard or warehouse. These are not used for transport the cargo over large distance. For large capacity transport trailers can be used over a large distance. Forklifts are probably the most common cargo handling and moving machine. Their versatility is achieved through various attachments which either go over the forks or simple replace them.

These are generally used for handling general cargo such as steel plates, paper bales, coils etc.

Fig No.5.7 Forklift cranes

5.6.9.7 Belt Conveyor

The belt conveyor is probably the most common piece of equipment in material handling. The main advantage of the conveyor is that it usually offers the lowest costal tentative for horizontal movement of cargo. This is an important property in inland areas. The main disadvantage of conveyor stems from the fact that it provides only a point-to point connection and requires fixed support structures, unlike dump trucks and loader, which can move anywhere.

The belt conveyor consists of a belt and idlers, or rollers, which support the belt. The idlers and the belt are usually arranged either “flat” or “troughed”, depending on the properties of the material to be conveyed. Flat belts fit materials which have a steep repose angle (e.g. damp sand) while troughed belts fit lumpy materials (e.g. coal and ore). In addition to the belt and idlers, each conveyor has a support structure, a feeder and discharge device (for loading and unloading) and a tension-maintaining arrangement.

The capacity of the conveyor is the function of the belt width, speed and of course, the specific weight of the conveyed material. The speed is mainly determined by the size of the particles. The speed is adjusted to avoid dust in powdery material and spillage in bulky material. Energy consumption, is a function of both density and speed, and is another consideration. It is important to note that the conveyer is only a means to move materials between machines. Therefore, the conveyer capacity is not only a function of its speed but also a function of the endpoint capacities where the material is fed onto / from the belt.

5.6.9.8 Gantry Stacker and Reclaimer

The gantry stacker and reclaimer (**Fig No.5.8)** and boom stacker and reclaimer are handling and transfer machines in the inland ports, their characteristics and operations are the same, but the configuration is different. The gantry type is more efficient and economical than the boom type. The gantry stacker and reclaimer is composed of the main gantry and conveyer beam, two legs mounted at the two ends of the top beam, under which the truck can move, and two gears of the bucket wheel mounted on the conveyer beam, it is powered by electricity. The two bucket wheels can move along the conveyer beam to discharge the bulk cargo from the stockpile.

Fig No.5.8 Gantry stacker and Reclaimer

5.6.9.9 Handling Attachments

In handling the cargo, cranes or forklifts, from the hatch of the vessel or truck, special tools – Handing attachments such as,

- Crane attachments
- Forklift attachment is required.

The crane attachments are very simple. They hook on to the hook of the crane, and can pick up the cargo. They are of different sizes and types for different cargoes.

The most popular of them include a side shifter for better positioning; clamps handle baled cargo, paper reels or large carton, grip and backrest devices to handle drums; hanging beam for handling cargoes with hooks; centrally mounted ram for handling reels.

- Bucket Type Grab
- Pal finger type grab
- Tong
- Spreader

Fig No.5.9 Bucket Type Grab

Fig No.5.10 Pal finger type grab

Fig No.5.11 Tong

Fig No.5.12 Spreader

5.6.9.10 Equipment at Terminals

1- Mobile harbour crane of 100 TPH at terminal 2.

5.7 Berthing Structure

Berthing structures are to be designed such that they provide safe berthing of barges/ vessels without damaging the barges / vessels as well as the structure. These structures should also cater to the requirements of the various equipments to be used for loading/ unloading of vessels. The requirements of the berth differ depending on the nature of cargo being handled at the berth. The size of the structure depends on the largest vessel likely to use the berth and the type of handling equipment to be used on the deck. The berth should be designed for all possible loads that are likely to act on the structure. The total number of berths required for the proposed terminal and their arrangement was fixed based on the nature of cargo, traffic, alignment of contours and predominant wind, water levels. The berth is planned for handling 4000 DWT Vessels.

The proposed jetty is required to handle Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m (Class-IV). The jetty is planned as a berthing structure proposed to be on piles, which provide least resistance to natural equilibrium and ease of extension/addition of facilities at a later date. The berthing structure is of length 100 m and width 15m.

Plan, elevation & cross-section of proposed jetty is shown in FigAD-1

The deck level of jetty is w.r.t CD. The thickness of the deck slab of jetty is 0.45 m. The slab at deck level is supported on Cross beams of 1.0m x 1. 0 m in the lateral direction, secondary beams of 0.50 m x 0.65m in the longitudinal direction. The Cross beams rest on the pile caps / pile muffs which in turn support the longitudinal beams. The 600 mm diameter bored cast in situ piles with 6mm thick liner are fixed to the pile caps at the top and fixed into the ground at the bottom. The plan and cross section of jetty is shown as Fig AD-1.

5.8 Terminal Costing

5.8.1 Capital Cost

The estimate of capital cost is made for the various items of civil, mechanical, electrical and utilities works cost estimate is given below:

Capital Cost	In Crores
Terminal Cost	
Sindhrot Tourist Jetty	10.00
Wanakbori Cargo Jetty	22.29
Storage Area(Including roads, warehouse, dyke, parking area etc)	7.50
Total Cost(I)	39.79
3% Contingencies and 7% Supervision charges on Base cost	3.98
Total Civil Cost	**43.77**
(II) Handling Equipment & Utilities	
Mechanical & electrical	10.1
3% Contingencies and 7% Supervision charges on Base cost	1.01
Total Handling Equipment & Utilities Cost	**11.11**
Total Capital Cost	**54.88**

Table 5.6 Capital Cost

5.8.2 O&M Cost

The annual operation and maintenance cost on different components of the project will be dependent on a number of variables such as the life of the component, repair and maintenance requirements, wages of crew of consumables, etc. Hence, accurate assessment of cost is not possible. Further even if all the variables are fixed such as the maintenance schedules for each structure and equipment is determined, crew strength is fixed, requirement of consumables quantified, etc., the estimation of O&M costs cannot be precise because of unpredictable breakdowns incurring considerable expenditure on repairs and replacement. The only practicable approach in this scenario is to fix the annual repair expenditure as a percentage of capital cost of project. This percentage is to be fixed on the basis of the past performance of similar structures and equipment functioning in the project or elsewhere under similar marine conditions.

Based on above criteria, the annual maintenance cost is estimated as a percentage and is given below:

	O & M Cost	**In Crores**
(i)	Civil works @ 1% (Terminal Cost)	7.09
(ii)	Mechanical & Electrical Cost @ 5%	0.56
	Total	**7.65**

Table 5.7 Operation & Maintenance Cost

CHAPTER – 6

PRELIMINARY ENGINEERING DESIGNS

6.1 River Training

In order to make river navigable certain interventions along and across the river is required. The effect of the structure on the hydraulics of the river and the best ways to train the river such that the structure performs satisfactorily and also there is no significant damage to the riverine environment should be kept in mind while proposing any structure.

Detailed Methodology:

Step 1: Detailed study of river bathymetry especially dry patches/Dry Stretches in the river.

Step 2: Detailed study of all hindrances (Dams/Barrage/weir/Bridges) &Interventions needed along the river.

Step 3: Preliminary Designs of Proposed Structure

Step 1:

This is already covered in chapter 2; however, brief summary of dry patches/Dry stretch along River Mahi is mentioned in Table shown below:

Sr.No.	Stretch Details	Length
D-1	Ch-0.0 to Ch79.0	79 Km
D-2	Ch-97.0 to Ch134	37 Km
D-3	Ch-144.0 to Ch172	28 Km

Table 6.1: Summary of dry patches/Dry stretch

Details are shown in **Dwgs. DP-01 to DP-07**

Step 2:

This is also covered in chapter 2 of this report; however, brief summary of hindrances details are shown below:

1) Details of Dams/ *Barrages, Weirs, Anicut*
2) *Details of Bridges*

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	HT wrt MSL	Remarks
		Lt Bank	Rt Bank	Lt Bank	Rt Bank				
Kadana Dam	246.9	23°18'12.90"N 73°49'21.16"E	23°18'41.02"N 73°50'1.32"E	379598.26 2577616.43	380746.00 2578472.00	1551	10.54	131.414	-
Tantroli Check Dam	232	23°15'57.20"N 73°43'54.85"E	23°15'47.76"N 73°44'1.41"E	370292.67 2573521.46	370476.96 2573229.20	350	77.49	84.8	-
Wanakbori Dam	172.6	22°56'59.60"N 73°25'30.60"E	22°56'44.84"N 73°25'53.52"E	338535.41 2538838.71	339183.52 2538377.23	795.52	16.52	66.77	-
Umeta Check Dam	80	22°19'49.28"N 73° 3'14.22"E	22°19'50.94"N 73° 3'33.83"E	299568.80 2470687.25	300130.13 2470731.86	571	12.58	8.034	Navigation lock is proposed

Table 6.2 – Details of Dam, Barrages, Weirs, Anicut

Structure Name	Ch(km)	Position (Lat Long)		Position (UTM)		Length (m)	Width (m)	Remarks
		Lt Bank	Rt Bank	Lt Bank	Rt Bank			
Gambhira Bridge	69.3	22°16'4.32"N 72°59'46.09"E	22°15'38.10"N 72°59'58.20"E	293520.065 2463845.24	293856.197 2463034.451	872.6	10.29	Demolition & Reconstruction
Umeta Bridge	81.37	22°20'29.98"N 73° 3'3.17"E	22°20'36.20"N 73° 3'25.59"E	299268.974 2471943.882	299912.383 2472126.77	669.13	10.26	Demolition & Reconstruction
Under Construction Bridge	86.15	22°22'56.90"N 73° 3'32.65"E	22°22'42.24"N 73° 3'45.54"E	300169.83 2476451.56	300532.86 2475995.68	588.29	-	Demolition & Reconstruction
Vasad Rail Bridge	92.86	22°26'21.38"N 73° 4'14.19"E	22°26'9.45"N 73° 4'28.00"E	301439.218 2482726.912	301829.364 2482354.12	548.57	31.41	Demolition & Reconstruction
Vasad NH-8 Bridge	93.1	22°26'28.96"N 73° 4'19.96"E	22°26'15.09"N 73° 4'34.42"E	301607.667 2482957.175	302015.633 2482525.21	594	60.12	Demolition & Reconstruction
Ahmedabad Vadodara Expressway Bridge (NE1)	98.58	2°28'54.54"N 73° 5'14.58"E	22°28'56.53"N 73° 5'34.99"E	303226.094 2487415.236	303810.942 2487469.396	587.287	27.84	Demolition & Reconstruction
Poicha Bridge	116.71	22°36'12.12"N 73°10'48.04"E	22°35'57.02"N 73°10'54.96"E	312922.54 2500756.337	313114.573 2500289.941	504.33	7.36	Demolition & Reconstruction
Raniya UC Bridge	128.65	22°40'8.15"N 73°15'56.12"E	22°40'4.56"N 73°16'12.52"E	321805.72 2507911.19	322272.92 2507795.21	520.00	-	Demolition & Reconstruction
Galteshwar Bridge (SH-63)	142.62	2°46'58.88"N 3°16'33.50"E	22°46'42.45"N 73°16'35.18"E	323019.542 2520532.104	323061.754 2520026.2	504.42	6.9	Demolition & Reconstruction

Table 6.3 – Details of Bridges

Details are shown in **Dwgs. EC-1 to EC-3**

Navigation Lock

The functional requirements of a lock are mainly intended for navigation. The most important general functional requirement is that vessels have to be able to pass as rapidly and safely as is deemed socially (macro-economically) acceptable. Speed expressed as passing time is used to indicate the extra time required by a vessel participating as part of a fleet (with a particular number and composition) to progress from one side of the lock to the other, compared to the situation if the lock would not have been there. In this sense, the word lock is understood to mean a coherent whole of the lock approaches, lock heads and chamber(s) as well as the lay out and facilities provided in this. The passing time is determined by the time necessary for waiting, sailing in and out, mooring and unmooring and the operational time (closing and opening the gates and levelling out the chamber). This time largely depends on the amount of traffic (being the lock load or the relation between the intensity and capacity of the lock). Safe passage through the lock complex is determined by the degree of certainty in which navigation traffic can be dealt with (smoothly), without danger and/or damage to people, material and the environment and still guarantee quality of life in the direct vicinity.

The main parts of locks are mentioned below;

- The lock chamber;
- Lock approach structures;
- Filling/emptying systems;
- Lock gates;
- Mechanical and electrical equipment;
- Control systems,
- Instrumentation (including water level and flow monitoring equipment),
- Power supplies;
- Communications systems;
- Mooring equipment;
- Lighting and signaling equipment;
- Safety equipment;
- Stocks of spares;
- Maintenance equipment;

Lock Chamber

The necessary chamber dimensions mainly depend on:

- The dimensions of the largest vessel;
- The volume and pattern of navigation;

• Optimal chamber filling with several vessels;
• The marine, inland or recreational navigation purpose.

Methods for determining chamber dimensions of a capacity lock

It starts with an assumption of preliminary chamber dimensions and number of chambers.

For the provisionally chosen lock complex and a normative volume of navigation, one of the modelsused to determine the value of characteristic parameters to test the design at hand on:

- the average passing through time (particularly important to the captain because of costing,
- the permitted intensity;
- the necessary waiting space (-length),
- the locking time cost for navigation, per week (possibly converted to cost per annum).

Following are various method for determination of lock chamber dimesions.

- VAT model
- Simulation Model
- Rough review of lock capacity

In our case, Rough review of lock capacity method has been adopted for preliminary engineering.

Lock approach structures

The lock approach is the navigation area between the connecting waterway and the lock complex, where approaching vessels have the opportunity to decrease speed and moor to a guiding structure if necessary (mooring is usually not an option for large vessels; they keep their position, whether or not with tugboats). With this, sufficient view and overview should be ensured both by day and by night. The lock approach should therefore be free of obstacles and not be situated in a bend. In addition, transverse and longitudinal currents in the lock approach should be avoided as much as possible, in view of the reduced manoeuvrability of the vessel when reducing speed and stopping.

The lock approach is functionally divided into:

The line-up area

This area has to be equipped with proper mooring facilities and be situated as such that moored vessels are not an obstruction to departing vessels. This area is intended for vessels that will be locking through in the next locking process. From the mooring area, vessels should be able to enter the chamber quickly via the leading jetties. A mooring area is required per chamber and per side. The size of the mooring area corresponds with a completely filled chamber. A general guideline is a length of 1.2 or 1.3 times the chamber length.

The waiting area

This area is also equipped with mooring facilities. This area is only created at locks where the expected navigation intensity will be such that, on busy days, the mooring area will be too small for all the waiting vessels. This area is intended for vessels that will not be able to lock through at the next locking process after arrival. For a lock with one chamber, one waiting area per side is necessary or a communal area for a lock complex with several chambers.

Free area

Meant to provide vessels with the opportunity to decrease speed and start manoeuvres to moor in the line-up or waiting area. Furthermore, the free area provides the opportunity to, where necessary; adjust the profile of the waterway to the profile of the lock approach. For stopping and mooring, the following length should be available; an indication of inland navigation is approximately 2.5 times the normative vessel length.

Chamber and heads

The number of important parts of the primary function of the locking process take place in the chamber and the heads, namely

- The sailing in and tying up of one or several vessels,
- The untying and sailing out of one or several vessels,
- The closing and opening of gates and
- The levelling of the water level in the chamber.

Cables and mains

In general, we strive for an integration of crossing cables and mains (the small infrastructure) in the lock and/or lock approaches, as long as this does not result in unnecessary risks for the locking process. During construction, existing cables and mains will have to be moved temporarily if necessary or other facilities could be necessary in order to disrupt the performance as little as possible. This is executed under instructions of the authorities in charge of small infrastructure. Often, these authorities will function as customers in relation to the moving or execute the moving under own management. To reduce costs, every effort will be made to consider the definite situation when planning the temporary diversions. In the definite situation, the crossing itself will generally be under the bottom of the lock or the lock approaches. Certain cables and mains of third parties could be housed in cable manholes and tunnels for lock operation, which can be made larger to allow for this. Between the cable manholes, extra lead through pipes can be added to the lock floor for these cables and mains. This is only possible if your operation is not exposed to additional risks or hindrance.

Cables and mains that cross a lock and/or lock approaches and the facilities that have to be made or provided for this, have to meet the following requirements:

- The cables should not yield unacceptable risk for the lock, lock operation and navigation.
- That which is unacceptable should be substantiated with a risk analysis.
- Gas mains are not included in a lock.
- Navigation must be unable to damage the cables and mains.
- Where visual inspection is impossible (and this will generally be the case) the condition of the cables and mains will have to be established in a different way, certainly in those cases where failure will have serious consequences.
- Cables and mains, with serious failure consequences, must immediately be disconnected or be free of electrical charge when necessary.
- Replacement, expansion or maintenance should take place without prolonged hinder to navigation.

Furthermore, attention has to be paid to possible transmission lines that cross the lock or the lock approaches.

Illumination, signalling and boarding

- For the average value of illumination intensity on horizontal surfaces of the lock is 10 lux.
- For the uniformity (E) of the illumination, a minimum value of $E_{min}/E_{max} = 0.3$ should be adhered to for both vertical and horizontal areas.
- Unsafe situations due to dazzling should be avoided. The correct combination of armature, lamp and positioning is of importance.
- The colour of the light is one of the factors in the recognition of boards and signalling. Both white and yellow light can be used. In the lamp choice of illumination, both high-pressure and low-pressure lamps as well as energy saving lamps qualify. In the application of low-pressure (monochromatic) sodium (vapour) light, colour recognition is impossible. If this is the case, separate illumination of traffic signs is recommended.

Safety facilities

Design and management of safety facilities of personnel will be executed in accordance with Health and Safety Regulations, construction regulations, labour regulations and safety regulations. A number of facilities are mentioned below.

Railings are attached to the top of gates. If the lock coping is more than 2.5 m above minimum locking level, fencing is placed behind the bollards. This fencing is always desirable where it concerns recreational navigation and where tourists are allowed on the lock coping.

Steel ladders should not be in regular use. Straight stairs, a spiral staircase or step ladders should be installed.

Basement chambers that could possibly flood (for instance those of operating mechanisms of mitre gates) have to be provided with an exit that can be opened from the inside. In addition, sufficient natural ventilation will be required as well as plunger pumps.

Navigation lock of 70 m x 15.5m has been provided at Sindhrot check dam.

6.2 Bank Protection

On the basis of topographic and hydrographic survey of Mahi River, no bank protection is required in such a big river.

6.3 Navigation Aids

6.3.1 General Principles of the System

Within the IALA Buoyage System there are 5 types of marks which may be used in combination. The mariner can easily distinguish between these marks by readily identifiable characteristics.

Lateral marks differ between Buoyage Regions A and B as described below, whereas the other 4 types of mark are common to both regions.

6.3.2 Lateral Marks

Following the sense of a conventional direction of buoyage, Lateral marks in Region A utilize red and green colours by day and night to denote the port and starboard sides of channels respectively. However Region B these colours are reversed with red to starboard and green to port.

A modified lateral mark may be used at the point where as channel divided to distinguish the preferred channel, that is to say the primary route or channel which is so designated by an authority.

6.3.3 Cardinal Marks

Cardinal marks indicate that the deepest water in the area lies to the named side of the marks. This convention is necessary even though for example, a North mark may have navigable water not only to the North but also East and West of it. The mariner will know he is safe to the North, but must consult his chart for further guidance.

Cardinal marks do not have a distinctive shape but are normally pillar or spar. They are always painted in yellow and black horizontal bands and their distinctive double cone top-marks are always black.

Cardinal marks also have a special system of flashing white lights. The rhythms are basically all “very quick” (VQ) or “ quick” (Q) flashing but broken into varying lengths of the flashing phase. “Very quick flashing” is defined as a light flashing at a rate of either 120 or 100 flashes per minutes, “quick flashing” is a light flashing at either 60 or 50 flashes per minutes.

The characters used for Cardinal marks will be seen to be as follows.

North: Continuous very quick flashing or quick flashing
East: Three “very quick” or “quick” flashes followed by darkness
South; Six "very quick" or "quick" flashes followed immediately by a long flash, then darkness
West: Nine "very quick" or "quick" flashes followed by darkness.

The concept of three, six, nine is easily remembered when one associates it with a clock face. The long flash, defined as a light appearance of not less than 2 seconds, is merely a device to ensure that three or nine "very quick" or "quick" flashes cannot be mistaken for six, It will be observed that two other marks use white lights. Each has a distinctive light rhythm which cannot be confused with the very quick or quick flashing light of the Cardinal marks.

Isolated Danger Mark

The Isolated Danger mark is placed on a danger of small area which has navigable water all around it. Distinctive double black spherical top marks and Group flashing (2) white lights, serve to associate Isolated Danger marks with Cardinal marks.

Safe Water Marks

The Safe Water mark has navigable water all around it but does rot mark a danger. Safe Water marks can be used, for example, as mid-channel or landfall marks.

Safe water marks have an appearance quite different from danger marking buoys. They are spherical, or alternatively pillar or spar with a single red spherical top marks. They are the only type of mark to have vertical stripes (red and white). Their lights, if any, are white using is phase, occulting, one long flash or morse“ A” rhythms.

Special Marks

Special marks are not primarily intended to assist navigation but are used to indicate a special are or feature whose nature may be apparent from reference to a chart or other nautical document.

Special marks are yellow. They may carry a yellow “X” top mark, and any light used is also yellow. To avoid the possibility of confusion between yellow and white in poor visibility, the yellow lights of special marks do not have any of the rhythms used for while lights.

Their shape will not conflict with that of navigational marks, this means, for example, that a special buoy located on the port hand side of a channel may be cylindrical, but will not be conical. Special marks may also be lettered or numbered to indicate their purpose.

New Dangers

It should be specially noted that a “new danger” which is one not yet shown in nautical documents, may be indicated be exactly duplicating the normal mark until the information is sufficiently promulgated. A “new danger” mark may carry a Racon coded Morse “D”.

Body	:	ABS Plastic sealed to IP68 Standard.
Lens	:	185 dia moulded UV stabilized Poly- carbonate lens
Color	:	Red, Green, Yellow, White
Range	:	2 to 3 NM at 0.74 ATF (Specify while ordering)
Light Control	:	Automatic on/off by Photo diode
Light Source	:	High Intensity light emitting diodes LEDS with 100, 000 hours of life
Divergence	:	360^0Horiz. X 15^0 Vertical (at 50%) of Peak Intensity
Character	:	Any one character from 256 IALA recommended character can achieved
Input Voltage	:	Nominal 12 VDC
Battery	:	Maintenance free lead-acid fitted with inside Base
Autonomy	:	200 to 300 Hours period
Solar Panel	:	Fitted on the Lantern Dome
Fixing	:	Four – 10 mm dia Hole on 200 PCD
Weight	:	3 Kg approx.

Marine Lantern @ 3km C/C is provided along the river Mahi in has been provided. Designed aid is on the basis of light intensity, soil condition and wind direction and velocity

General assembly of proposed buoy is shown in Fig. 6.1 (A) & 6.1(B)

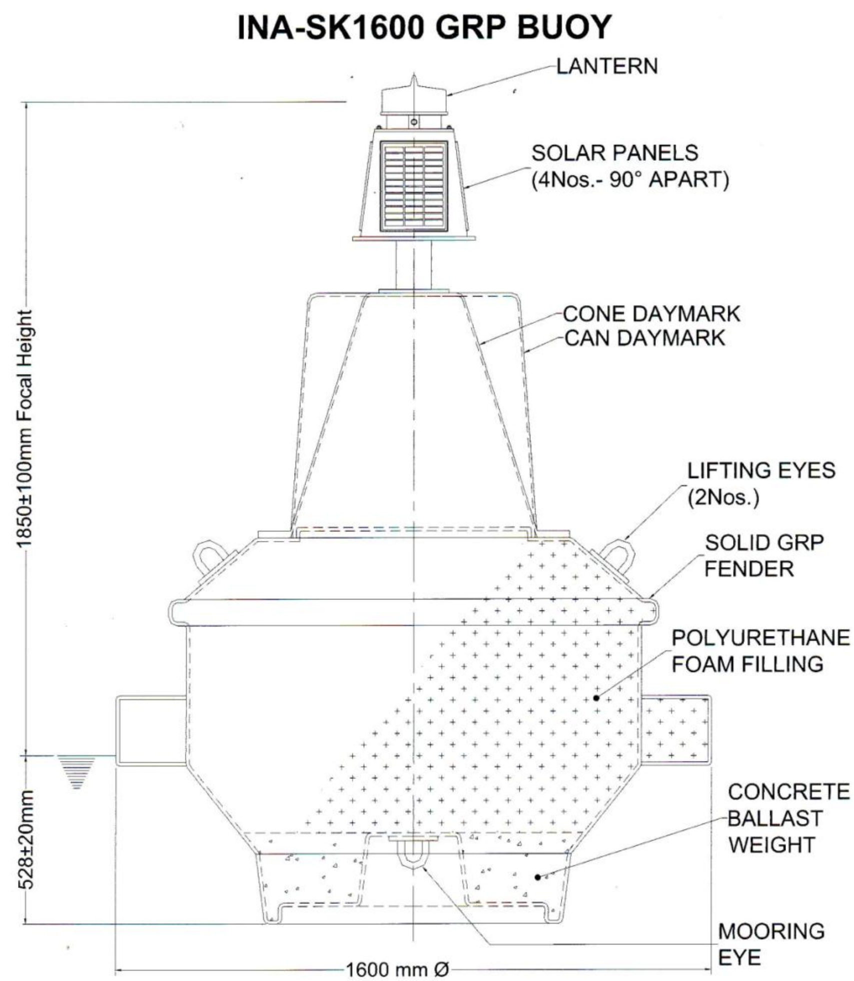


Fig. 6.1 (A) General assembly-partial

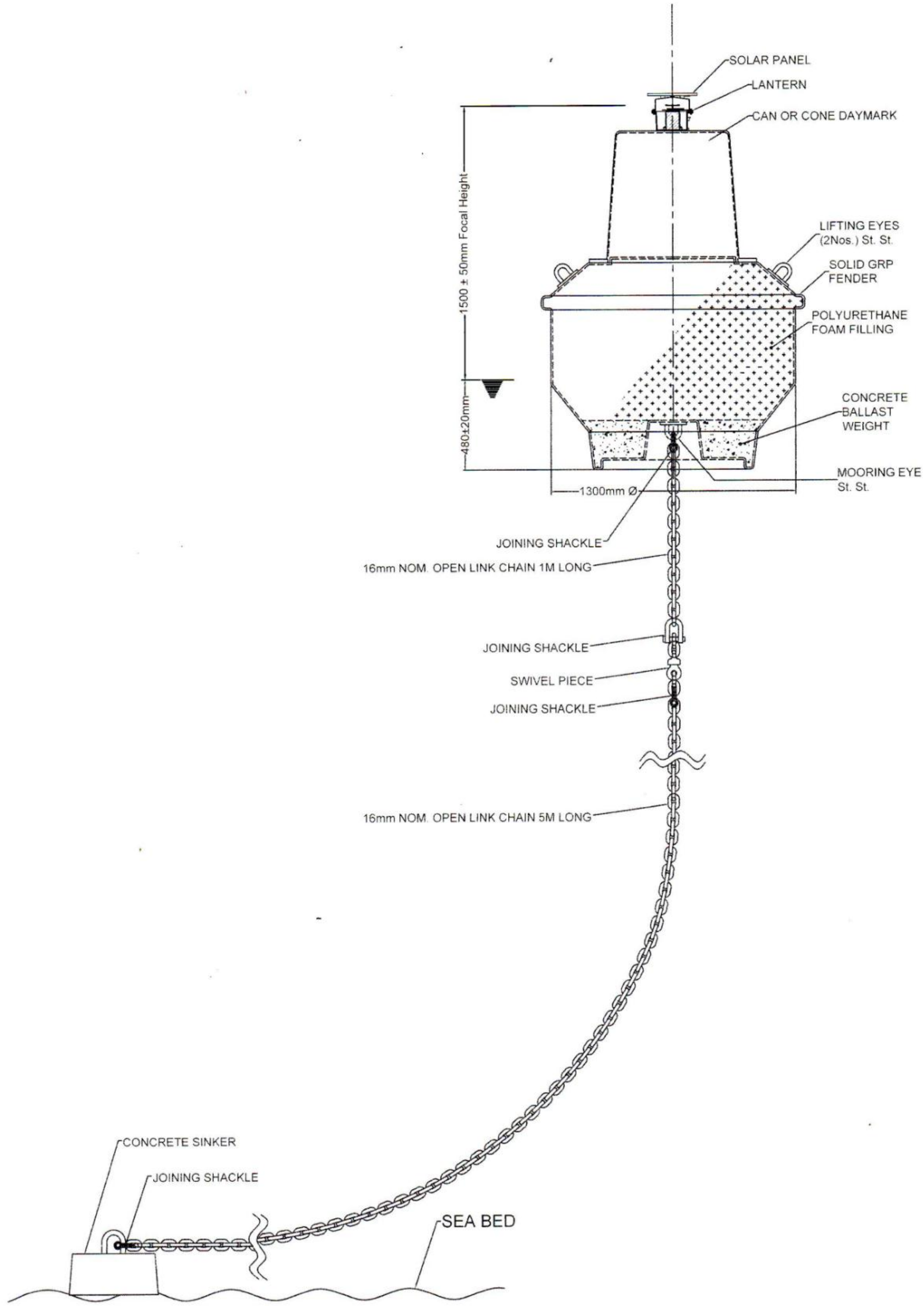


Fig. 6.1 (B) General assembly-Full

6.4 Cargo Terminals and River Ports

Design Codes and Standards

All works shall satisfy the requirement of the latest relevant codes and standards. Generally Indian Standards shall be followed. Wherever, the details for part of works are not defined adequately in Indian standards, the relevant acceptable International Standards shall be adopted. The List of codes and standards covering the major part of the works to be followed are listed below:

IS: 456	Code of practice for Plain and Reinforced Concrete
IS: 875	Code of practice for Design Loads for Buildings & Structures
IS: 1893	Criteria for Earthquake Resistant Design of Structures
IS: 4326	Earthquake resistant design and construction of Buildings – Code of practice
IS: 4651	Code of practice for Planning and Design of Ports and Harbours
IS: 9527	Code of practice for Design and Construction of Port and Harbour Structures
UFC4-152-01	US navy corps of engineer unified criteria Piers and Wharves
BS 6349-part 2	Code of practice for Marine structure quay, Wharves, jetties & Dolphins
IS: 800	Code of practice for General Construction in Steel
IS: 1786	Specification for High Strength Deformed Steel bars and wires for Concrete Reinforcement
IS: 13920	Ductile detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice
IS: 2911	Code of practice for Design and Construction of Pile Foundations
IS: 1904	Code of practice for Design and Construction of Foundations in

	Soils : General Requirements
SP: 7	National Building Code of India
SP: 16	Design aids for Reinforced Concrete to IS: 456
SP: 34	Hand book on Concrete Reinforcement and Detailing
IRC : 21	Standard Specifications and Code of Practice for Road Bridges Section III
IRC : 6	Standard Specifications and Code of Practice for Road Bridges Section II

Table 6.4 List of Codes and Standards

6.4.1 Design of Terminals

Terminal 1 (Near Sindhrot Dam):

Permanent construction is not viable near Sindhrot Dam, floating Jetty is best possible option & proposed under the project, for embarking & dis-embarking of passengers. To cater to the berthing requirements for easy embarkation/disembarkation to the taxi, a floating jetty of 70 m x 10 m is considered suitable.

Floating jetties to be supplied shall meet the following broad technical specifications:

Sr.	Particulars	Details
A.	JETTY	
1.	Size	70m. x 10m.
2.	Max. loaded Draft	1.7 m.
3.	Minimum Free Board	0.5 m. for loading of 2 KM/m2on total deck area of 120 sq. m.
4.	Load Capacity	Deck designed for UDL of 3 KN/m2 or concentrated load of 4.5 KN over an area of 0.3m x 0.3m.

Sr.	Particulars	Details
5.	Material for construction of module/block	Concrete
6.	Deck/Top Cover	Concrete
7.	Minimum Reserve	25% under design loading conditions
8.	Frames	Aluminum Alloy Grade – 6082 T5/T6 marine grade or equivalent
9.	Working Life	50 years or more
10.	Handrails	Fabricated out of Stainless Steel, 750 mm high. Reflective stickers to be provided on all the four sides.

Mooring arrangements

Eight bollards, on the berthing side for water taxi will be fixed for the safe mooring of the water taxi.

Fenders

Protective fenders shall be provided on berthing side to prevent damage at the interface area.

Approach trestle/gangway

The gangway proposed is floating type with all the specifications, including material of construction, similar to Para - 2.1.

The broad dimensions are tabulated below: -

Length Over All	50.00 m
Breadth Over All	3.00 m
Draft not more than	1.2 m
Free board minimum	0.50 m for loading of 2kN/m2

Terminal 2 (Wanakbori)

The proposed jetty is required to handle Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m (Class-IV). The jetty is planned as a berthing structure proposed to be on piles, which provide least resistance to natural equilibrium and ease of extension/addition of facilities at a later date. The berthing structure is of length 100 m and width 15m.

Plan, elevation & cross-section of proposed jetty is shown in Fig. **AD-1**

The deck level of jetty is w.r.t MSL. The thickness of the deck slab of jetty is 0.45 m. The slab at deck level is supported on Cross beams of 0.60m x 0.60 m in the lateral direction, secondary beams of 0.60 m x 0.60m in the longitudinal direction. The Cross beams rest on the pile caps / pile muffs which in turn support the longitudinal beams. The 600 mm diameter bored cast in situ piles with 6mm thick liner are fixed to the pile caps at the top and fixed into the ground at the bottom. The plan and cross section of jetty is shown as Fig. **AD-1**. The important design levels taken into consideration are discussed as follows:

Table 6.5 Design Parameters for Terminal 2 (Wanakbori)

Top Level of Jetty (Deck slab)	+28.00 m
Top level of Piles	+26.60m
Diameter of piles (D)	0.6m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of sea water	10.025 KN/m^3
Unit wt. of Steel	78.50 KN/m^3
Founding Level of Piles	-25.00 m below bed Level

6.4.2 Analysis of Jetty

STAAD Pro Modeling

The dimension of the jetty is 100m x 15m. The analysis of the structure has been performed in STAAD Pro 2007 as shown in **Fig. 6.2**. In the model the piles are assumed to be fixed at base. The pile length used in analysis is based on fixity length i.e. 15m. The cut off level of piles is +1.0m for inner pile.

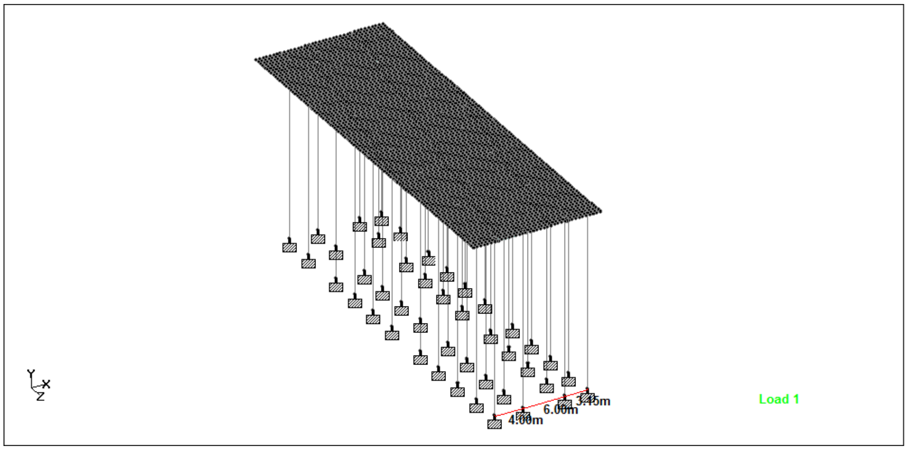


Fig. 6.2: STAAD Panel of the Jetty

6.4.3 Design Loads and Load Combinations

The jetty, approach and bay have been designed considering the following loads:

A. Vertical Loads

a) Dead Load
b) Live Loads
   i) Uniform loading
   ii) Truck loading (IRC Class)

B. Horizontal Loads

c) Berthing load
d) Mooring load
e) Wind load
f) Current load
g) Seismic load

C. Combination of above

The loading has been considered taking into account the guidelines of IS 4651 (Part III): 1974, IRC 6:2000, IS 1893: 2002 (Part 1), IS 875 : 1987 (Part 1 and Part 3). UFC 4-152-01 2005.

(a) Dead Load

The dead load consists of the weight of the entire structure, including all the permanent attachments such as mooring hardware, light poles, utility booms, brows, platforms, vaults, sheds, and service utility lines. A realistic assessment of all present and future attachments has been made and included. Overestimation of dead loads generally will not adversely affect the cost of the structure. However, overestimation of dead loads would not be conservative for tension or uplift controlled design. Standard unit weights have been used to calculate dead loads. Dead load of the structure can be applied on STAAD MODEL.

Table 6.6 Dead Weight of Slab

Component	Depth of Slab (mm)	Unit Weight (KN/m^3)	Load (KN/m^2)
Jetty	450	25	11.25

Dead weight of Rails

(b) Live Loads

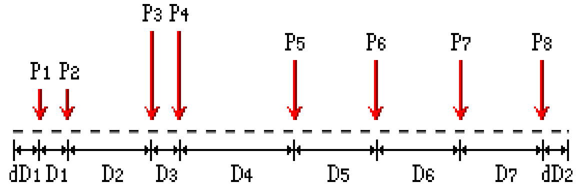
Uniform Live Loads

(i) 30 KN/m^2 (As per IS 4561: part-3,Page-5, Cl. 5.1.2)
(ii) 38KN/m^2 (As per UFC 4-152-01 2005, Page-54,Cl. 3-3.2, Table-3-2)

Critical Load is 38KN/m^2

Truck Loading

IRC Class A truck load has been applied as moving load. The load specification of IRC Class A train of vehicles (with impact factor) is given as under:



P_1 =27 KN	dD_1 = 0.5 m
P_2=27 KN	D_1 = 1.1 m
P_3= 114 KN	D_2 = 3.2 m
P_4= 114 KN	D_3 = 1.2 m
P_5=68 KN	D_4 = 4.3 m
P_6=68 KN	D_5 = 3.0 m
P_7 =68 KN	D_6 = 3.0 m
P_8 =68 KN	D_7 = 3.0 m

(c) Berthing Force

Berthing force is calculated for Self-propelled, carrying capacity 1000 DWT, Size (70m X 12m), Loaded draft 1.8m. According to UFC 4 15202, there are several factors that modify the actual energy to be absorbed by the fender system. The actual kinetic energy E absorbed by the fender system is calculated as per the following

E_{fender} = Energy to be absorbed by the fender system

$E_{fender} = M_D Vb^2 (C_m C_e C_s C_c) /2$

Where:

W_D	Displacement Tonnage (DT) of the vessel, (t)
V_b	Velocity of vessel in m/s, normal to the berth
C_m	Mass coefficient
C_e	Eccentricity coefficient
C_s	Softness coefficient
C_c	Configuratinal Coefficient

Type of Fender			=	**G2 Grade MCS 400 Cell Fender**	
Energy Absorption			=	**21.60**	kN*m
Reaction Force			=	**129**	kN

Details of above calculation is shown in **Annexure 6.1**

(d) Mooring Force

This force is taken according to IS-4561- 1974-Part-III,

(i) Mooring force due to wind

Mooring Force due to wind: $F_w = C_w A_w P$

C_w= Shape Factor

A_w= Windage Area in sqm = 1.175*Lp (D_m-D_L)

P = Wind Speed pressure in N/sqm = $0.6\ V_z^2$

Vz =V_b *k_1 * k_2* k_3 , where the k_1, k_2 and k_3 are probability factor and terrain height and structure size factor and Topography factor respectively. Values of coefficients are taken from IS-875-Part-III,

k_1 = 1

k_2 = 1

k_3 = 1

- The wind speed is considered as 50m/s for coastal Gujarat (IS - 875-III Part 3 1987, cl-5.4 & pg-9)
- Shape Factor C_w=1.5 is taken for calculation of Mooring force due to wind.

Calculation summery of mooring force is given below

$A_w = 1.175*L_p (D_m\text{-}D_L)$

$= 167.49\ m^2$

P $= 0.6\ V_z^2 = 0.6*(50*1*1*1)^2$

$= 1500\ N/m^2$

$F_w = 37.7T$

As per IS : 4651(Part III) – 1974 When the ships are berthed on both sides of a pier, the total windforce acting on the pier, should be increased by 50 percent to allow forwind against the second ship.

Accordingly, $F_w = 1.5*38$

$= 60\ t$

(ii) Mooring force due to current

Mooring force due to current: $F_c = L_{pp} D_r\ P_c$

F_c = Mooring Force due to current in kg

L_{pp}= Length between the perpendiculars in m

D_r = Loaded draft of vessel in m

P_c = Pressure due to current in kg/sq.m

The current velocity is assumed as 0.6 m/s

$F_c = L_{pp} * D_r * P_c$

$= 4.7\ T$

Assuming that the mooring force due to current and wind act simultaneously in the same direction.

Total Mooring Force (F_T) = $F_w + F_c$

$= 64.7\ t$

Considering at least 4 nos. of bollards per vessel, mooring force at each pile,

F_T= 64.7/4 = 16.17 t   Say 17 t

Details of above calculation is shown in **Annexure 6.2**

(e) Wind Load

The wind loads on the structure has been considered as per IS 875:Part3. The basic wind speed for Vadodara is 39 m /sec. Design Wind Speed can be obtained by the following formula:
Design Wind Speed $V_z = K_1*K_2*K_3*V_b$

Where,

K_1, Risk Coefficient as 1.00

K_2, Terrain (Category 2), Height (10m) and structure size factor (class C) as 1.00

K_3, Topography Factor as 1.0

Accordingly, the design wind pressure, $p_z = 0.6\ V_z^2$

p_z $= 0.6\ V_z^2 = 0.6*(50*1.00*1.00*1)^2$

$= 1500\ N/m^2$

(f) Current Force

The current force is given by $\gamma V^2/2g$

Where γ	=	Unit weight at water = 1.025 t/m^3
V	=	Current velocity = 0.6 m/sec.
F_C	=	$\gamma V^2/2g$
	=	1.025*0.6^2/(2*9.81)
	=	0.018t

(g) Seismic Force

The seismic force has been calculated as per IS-1893-2002. The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$A_h = (Z/2)*(I/R)*(S_a/g)$$

Where,

Z = Zone factor given in Table 2, IS-1893-2002. Z at the site has been adopted as 0.16 corresponding to Zone III. Map showing the seismic zone from IS 1893-part – I, Gujarat falls in Zone – III.

I = Importance factor =1.5 has been used.

R = Response reduction factor has been taken as 3.0 for RCC Structures as per Table 7 of IS-1893-2002.

S_a/g = Average response acceleration coefficient has been taken as 1.4 as per Figure 2 of IS-1893(Part 1):2002 corresponding to T=0.91 seconds. The earthquake force has been applied in X as well main as Z directions.

(h) Load Combinations as per IS 4651 Part IV 2007

Method of Design: The Berth and its structural components have been designed as per Limit State Method. The partial safety factors for loads in limit state design method has been used. Accordingly, following load combinations have been considered as per IS : 4651-2007 (Draft copy)

Limit state of serviceability

1.0(DL+LL)

1.0(DL+LL+BF-S)

1.0(DL+LL+BF-(L)

1.0(DL+LL+MF-S)

1.0(DL+LL+MF-L)

1.0(DL+LL+SFX)

1.0(DL+LL+SF-X)

Limit state of collapsibility

1.2(DL+LL)+(CLX)

1.2(DL+LL)+(CL-X)

1.5(DL+LL+BF-S)+1.0CLX

1.5(DL+LL+BF-L)+1.0CLX

1.5(DL+LL+BF-S)+1.0CL-X

1.5(DL+LL+BF-L)+1.0CL-X

1.5(DL+LL+MF-S)+1.0CLX

1.5(DL+LL+MF-L)+1.0CLX

1.5(DL+LL+MF-S)+1.0CL-X

1.5(DL+LL+MF-L)+1.0CL-X

1.2(DL+LL)+1.0CLX

1.2(DL+LL)+1.0CL-X

1.2(DL+LL)+1.0CLX+1.5SFX

1.2(DL+LL)+1.0CL-X+1.5SFX

1.2(DL+LL)+1.0CLX+1.5SF-X

1.2(DL+LL)+1.0CL-X+1.5SF-X

1.2(DL+LL)+1.0CLX+1.5SFZ

1.2(DL+LL)+1.0CL-X+1.5SFZ

1.2(DL+LL)+1.0CLX+1.5SF-Z

1.2(DL+LL)+1.0CL-X+1.5SF-Z

1.2(DL+LL)+1.5SWLX+1.0CLX

1.2(DL+LL)+1.5SWLX+1.0CL-X

1.2(DL+LL)+1.5SWL-X+1.0CLX

1.2(DL+LL)+1.5SWL-X+1.0CL-X

1.2(DL+LL)+1.5SWLZ+1.0CLX

1.2(DL+LL)+1.5SWLZ+1.0CL-X

1.2(DL+LL)+1.5SWL-Z+1.0CLX

1.2(DL+LL)+1.5SWL-Z+1.0CL-X

DL – Dead Load

LL – Live Load

MF-S – Mooring Force Sea Side

MF-L – Mooring Force Lee Side

BF-S – Berthing Force Sea Side

BF-L – Berthing Force Lee Side

SF – Earthquake load

CL-Current Load

WL-Wind Load

6.4.4 Design of jetty

The governing STAAD Results for Longitudinal Beams, Cross Beams, and columns have been summarized as below:

6.4.5 Detailed Engineering

Table 6.7 Critical Forces in structural members of jetty

Beams	**Design Moment (KNm)**	**Shear (KN)**
	1224	1900

Piles	**P (KN)**	**M_{ux}(KNm)**	**M_{uy} (KNm)**
	920	1100	19

Slab	**Design Moment (KNm)**
	320

Details are shown in **Dwg. AD-01**

6.5 Construction schedule

Construction of various structures mentioned above will be constructed in order to develop the waterway for navigation as well as for handling of cargo through following sequence of activities.

Activity 1: Demolition & Reconstruction of bridges.

Activity 2: Construction of terminals & ancillary structures.

Activity 3: Dredging

Activity wise Construction schedule of Phase-I Terminal 1 and Terminal 2 is shown below

PHASE-1

For Piled jetty (Terminal 1)

Sr.No.	Activity	Time in weeks from LoA
1	Submission of Detailed Construction Drawing & Methodology	04 Weeks
2	Proof Checking of construction drawing	08 Weeks
3	Construction of dyke/Filling/Approach Trestle	20 Weeks
4	Construction of piles	20 Weeks
5	Installation of Precast Beam	30 Weeks
6	Installation of Precast Slab	35 Weeks
7	Laying of cast in-situ slab	43 Weeks
8	Installation of accessories	47 Weeks
9	Testing, commissioning & handing Over of site	55 Weeks

For Fixed jetty (Terminal 2)

Sr.No.	Activity	Time in weeks from LoA
1	Submission of Detailed Engineering Drawing & Methodology for Installation	03 Weeks
2	Pre-dispatch third party inspection	04 Weeks
3	Supply of Primary units(Float)	09 Weeks
4	Onsite Inspection of supplied unit	15 Weeks
5	Installation of Gangway	17 Weeks
6	Installation of Jetty along with Accessories	19 Weeks
7	Testing, commissioning & trial	26 Weeks

CHAPTER – 7
VESSEL DESIGN

7.1 General Review

An optimum sized vessel has to be selected for carrying coal via Mahi. Wanakbori TPS would require periodic shipments of imported coal from Hazira. After set up of the 800 MW SCTPS, this volume will increase. At present, imported coal is procured from Hazira Port on the mouth of river Tapi, followed by railway evacuation to the TPS. The cost of operating vessel in Mahi should be lower compared to the total end-to-end logistics cost using alternate mode of transportation, viz. railways. The cost of transportation of any commodities using waterways is dependent upon the length of travel and volume of cargo. Large volume of cargo reduces per-tonne cost of transportation using waterways. Availability of return cargo, in case of the Terminal at Wanakbori TPS and later the SCTPS, would further add to the viability of the operation. In the absence of return cargo, barges have to make return trips with just ballast. Such an operation becomes a cost overhead, as barges' operational cost still applies, but without maximizing its commercial viability by carrying cargo.

The section to follow gives development details for the only terminal on River Mahi. This terminal will be for handling cargo like coal and fly ash.

7.1.1 Cargo Terminal

This terminal will present opportunities for two-way cargo. Imported coal can be transported from Hazira via River Mahi using barges, and fly-ash from Wanakbori TPS can be the return cargo. Although coal import is facing a temporary stoppage at the plant, the operations are likely to resume in a year's time.

The size, type, carrying capacity, and speed of the vessel proposed to be deployed in River Mahi should result in a lower cost of operation. The cost of transporting coal using waterways to Mahi TPS has to be lower compared to the existing cost of transporting coal using railways from Hazira port. One-to-one cost comparison has been undertaken for comparing all the activities including cargo handling, stacking, loading in to rakes, transportation and finally unloading at Wanakbori TPS. This cost comparison has been undertaken both for coal and fly ash. As an alternative to plying barge on just ballast, it's recommended that fly ash be transported instead. The cargo is in extensive demand among cement manufacturers across the country. At present, there is only road movement of the cargo on an ad-hoc basis, in low volumes. Therefore, in case of fly ash, waterway logistics will be competing with the current road logistics.

7.2 Design Basis

The classification of vessels described by IWAI requires certain length and certain draft of vessel to be maintained for optimum use. Under this condition, there are other factors that will also influence the specific class of vessels that should be deployed on River Mahi to handle traffic to and from the cargo terminal. The following flowchart illustrates the decision-making involved in making the recommendation for the specific classes of vessels IWAI should invest for this Terminal:

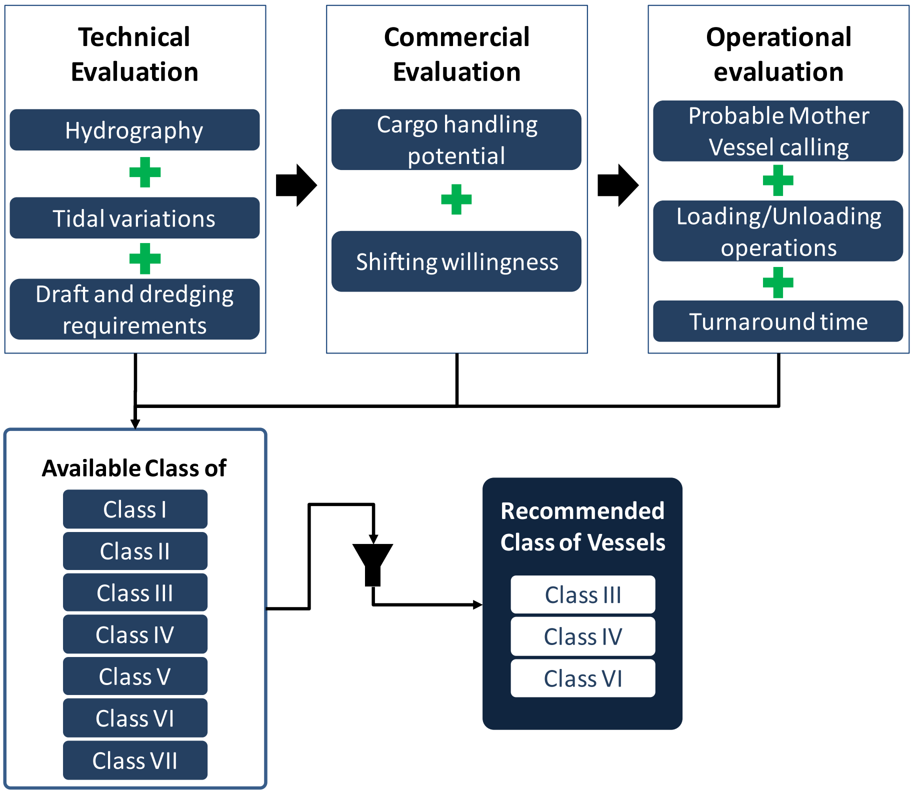


Figure 7-1Decision process for vessel design

The technical evaluation acts as the ultimate framework, within which the vessel design selection has to be made. Primarily, hydrographic study, tidal study, draft available and required, together, helps evaluate technical conditions that the vessel needs to meet in order to ply on River Mahi. Next, commercial evaluation involving projected traffic volume for the cargo Terminal, and willingness of the potential client (Wanakbori TPS) to shift to waterways further helps narrow down the type of vessels to be recommended. Traffic evaluation makes way for the probable operational conditions under which barges will be operating. This requires knowledge of mother vessels that will be calling at Hazira Port, followed by loading/unloading duration, which will further dictate the turnaround time for barges.

Prevailing maritime conditions on River Mahi, probable commercial demands that could be met via the proposed waterway, frequency of cargo movement, and total duration for the suggested operation is the overall understanding applied to the available class of vessels classified by IWAI. Vessel from class III, IV, and VI are the recommendable options for IWAI to invest in to cater to the potential traffic at the Terminal. Higher the class of vessels, larger the capacity, and lower the logistics cost will be.

7.3 Type of proposed Vessels

The following images depict typical Class IV and Class VI vessels that are used for river cargo transportation. These are for illustrative purposes only:

Figure 7-2 Class IV & Class VI vessels

7.4 Proposed vessel size and specifications

Vessels listed in Table 7-1 are the entire allowed fleet of river-class vessels that IWAI has classified. Among these, the highlighted ones are the vessels that are recommended to be deployed on River Mahi.

Class	Size (m)		Loaded Draft (m)	Capacity (DWT)	Charter Rates - Barge (Rs./Day)	Power (KW)	Consumption			Speed (Knots)
	L	B					Fuel		Ltr/Hr	
I	32	5	1.0	100	18,000	-	DO	1.0	42	6-7
II	45	8	1.2	300	30,000	337	DO	1.6	67	6-7
III	58	9	1.5	500	60,000	-	DO	2.0	83	6-7
IV	70	12	1.8	1,000	80,000	432	DO	2.4	100	6-7
V	70	12	1.8	1,000	80,000	432	DO	2.4	100	6-7
VI	86	14	2.5	2,000	110,000	597	DO	4.4	220	6-7
VII	86	14	2.9	4,000	130,000	-	DO	8.4	350	6-7

Source: IWAI

Table 7-1 Different Class vessels & logistics cost analysis

Class III, IV, and VI are all pliable on the river, primarily because the river has enough draft to accommodate all of these vessels. Even Class V vessels are a good contender, as their specifications are identical to Class IV vessels. Also, these are all self-propelled type vessels.

7.5 Turnaround Time

Table 7-2 and Table 7-3 show the computed turnaround time required per barge for every class of vessels classified by IWAI. The entire waterway logistic analysis computed herein is based on the assumption that only day-time navigation will be allowed.

Description	Class - I	Class - II	Class - III	Class - IV	Class - V	Class - VI	Class - VII
	100	300	500	1000	1000	2000	4000
Along side time at Anchorage	2	2	2	2	2	2	2
Loading time - Hours	1	1	1	2	2	3	5
Tide Margin	8	8	8	8	8	8	8
Sailing Time - Loaded (Zamdi Anchorage to Pali) Hr	15	15	15	15	15	15	15
Discharge time @ Pali - Hours	1	3	5	5	5	9	18
Sailing Time - Pali to Zamdi Anchorage Hr	10	10	10	10	10	10	10
Total Time	37	38	40	41	41	47	58

Table 7-2 Turnaround time (One-way Ballast)

Description	Class - I	Class - II	Class - III	Class - IV	Class - V	Class - VI	Class - VII
	100	300	500	1000	1000	2000	4000
Along side time at Anchorage	2	2	2	2	2	2	2
Loading time - Hours	1	1	1	2	2	3	5
Tide Margin	8	8	8	8	8	8	8
Sailing Time Loaded (Zamdi Anchorage to Wanakbori) Hrs.	15	15	15	15	15	15	15
Discharge time @ Wanakbori - Hours	1	3	5	5	5	9	18
Loading time - (Return Cargo) Hrs	1	1	1	2	2	3	5
Sailing Time - (Wanakbori TPS to Zamdi) Hr	15	15	15	15	15	15	15
Total Time	43	44	46	48	48	55	68

Table 7-3: Turnaround time (No Ballast)

An anchorage needs to be set up at Zamdi (near Khambhat) for undertaking the waterway operation suggested herein. One of the basic assumptions here is that mother vessel calling on Zamdi Anchorage will be of Panamax type (75,000 DWT), with a parcel size of 68,000 DWT. Although other types of smaller-sized mother vessels like Supramax and Handymax can also call at the anchorage. However, optimum utilization-wise, Panamax will be the best fit for the suggested operation. These will be geared ships, meaning unloading of coal cargo on to the barges will be done by the cranes mounted on the mother vessel itself. This saves time that would otherwise involve loading and unloading operations at the Port.

Loading time is dictated by ship discharge rate and the carrying capacity of barges. The typical discharge rate for the mother vessel being considered is 800 tonnes per hour (TPH), while barge parcel size will vary based on the Class they fall under. This could be anywhere from 90 MT to 3,600 MT. Tide margin of 8 hours has been assumed. Sailing time of barges are limited by their loaded speed, which is assumed here as 6 nautical-miles per hour (nmh). This speed has been kept constant for all class of vessels. Discharge rate at Pali jetty is directed by the discharge rate of cargo, taken as 100 TPH. After unloading of coal, the barge will have to return to Hazira anchorage for the next round of coal transport. In the absence of return cargo, barges will sail to Hazira Anchorage with Ballast only. An unloaded barge will, hence, travel at 9 nmh speed.

In case of fly-ash as return cargo, all the logistics considerations and calculation will be retained. However, after unloading coal, barges will have to be loaded with fly-ash. Here, the discharge rate of the loading equipment at Pali jetty is assumed to be the same as that of coal discharge rate. Hence, discharge time for coal and loading time for fly ash will be, nearly, the same. On its trip back to Magdalla / Surat with return cargo, the barge's speed will be 6 nmh, as it's loaded with cargo. It's assumed that fly ash will be unloaded at the Port using port-side unloader. This discharge rate is taken to be the same as that of the mother vessel, i.e. 800 TPH. Therefore, time taken to unload fly-ash from barge will be same as the discharge time taken for loading it with coal from the mother vessel. Naturally, the total turnaround time in case of return cargo will be more than when barges return with just Ballast water. However, the former helps maximize commercial opportunities, allowing faster recovery of the overall project cost.

7.6 Number of Vessel Required

The following table gives an estimate of the total barges IWAI may have to invest in. These requirements will differ based on the class of vessels that is ultimately chosen to move cargo on River Mahi.

Description	Class - I	Class - II	Class - III	Class - IV	Class - V	Class - VI	Class - VII
	100	**300**	**500**	**1000**	**1000**	**2000**	**4000**
Mother Vessel - Parcel Size	68,000	68,000	68,000	68,000	68,000	68,000	68,000
Barge Parcel Size	90	270	450	900	900	1,800	3,600
Turnaround of Barges - Day & No Ballast	37	38	40	41	41	47	58
Coal (MT) (FY20 volume)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
No. of Mother Vessels Per Year	14	14	14	14	14	14	14
No of Days required for operation	119	119	119	119	119	119	119
No of Days available for Operation	240	240	240	240	240	240	240
Cargo Unloaded by Each Barge	7,025	20,08	31,977	62,401	62,401	110,10	178,21
No. of Barges	**128**	**45**	**28**	**14**	**14**	**8**	**5**

Table 7-4: Number of barges/vessels required (One-way Ballast)

Description	Class - I	Class - II	Class - III	Class - IV	Class - V	Class - VI	Class - VII
	100	**300**	**500**	**1000**	**1000**	**2000**	**4000**
Mother Vessel - Parcel Size	68,000	68,000	68,000	68,000	68,000	68,000	68,000
Barge Parcel Size	90	270	450	900	900	1,800	3,600
Turnaround of Barges - Day &No Ballast	43	44	46	48	48	55	68
Coal (MT) (FY20 volume)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
No. of Mother Vessels Per Year	14	14	14	14	14	14	14
No of Days required for operation	119	119	119	119	119	119	119
No of Days available for Operation	240	240	240	240	240	240	240
Cargo Unloaded by Each Barge	6,044	17,395	27,861	53,406	53,406	94,103	1,52,028
No. of Barges	**149**	**52**	**32**	**17**	**17**	**10**	**6**

Table 7-5: Number of barges/vessels required (No Ballast)

Similar to the turnaround time, requirements for total number of barges in case of return cargo will be more. Also, higher the class of vessels, lesser the number of barges IWAI will have to invest in. Hence, total number of barges required to unload cargo from one mother vessel will be between 6 and 17, depending on the class of vessels that are ultimately deployed on River Mahi.

The following table shows the probable number of mother vessels that will call on Hazira, based on the projected traffic volume for coal for Wanakbori TPS and Wanakbori SCTPS

Cargo	Fy 20	Fy 25	Fy 30	Fy 35	Fy 40	Fy 45
Coal	0.9	1.3	1.6	1.9	2.1	2.4
No. of Mother Vessels per year	14	20	24	28	31	36

Table 7-6 No. of Mother Vessels calling on Zamdi Anchorage per year

	Fy 20	Fy 25	Fy 30	Fy 35	Fy 40	Fy 45
Coal	0.9	1.3	1.6	1.9	2.1	2.4
No. of Mother Vessels per year	14	20	24	28	31	36
No of Days required for operation	119	170	204	238	264	306
No of Days available for Operation	240	240	240	240	240	240
Cargo unloaded by Each Barge	62,401	89,145	106,974	125,852	125,852	125,852
No of Barges	**14**	**15**	**15**	**15**	**17**	**19**

Table 7-7 Barges Projection (One-way Ballast)

	Fy 20	Fy 25	Fy 30	Fy 35	Fy 40	Fy 45
Coal	0.9	1.3	1.6	1.9	2.1	2.4
No. of Mother Vessels per year	14	20	24	28	31	36
No of Days required for operation	119	170	204	238	264	306
No of Days available for Operation	240	240	240	240	240	240
Cargo unloaded by Each Barge	53,406	76,294	91,553	106,812	107,709	107,709
No of Barges	**17**	**17**	**17**	**18**	**19**	**22**

Table 7-8 Barges Projection (No Ballast)

At the least, barges on River Mahi for transporting coal will be utilized for 119 days, gradually increasing to 240 days by FY45. However, considering the monsoon period of 4 months, net operational days available to conduct cargo movement will not be more than 240 days. Therefore, barging on River Mahi will be on for at least 119 days, but not exceeding 240 days. Separate assessment with respect to fly-ash movement is not needed, as the figures will be within the 119 days – 240 days limits.

7.7 Vessel Costing

As per directives received from IWAI 11.10.2017 in IWAI office, now the vessel will not be procured by IWAI. Hence, Vessel cost has been excluded from capital cost.

7.7.1 Capital Cost

As above.

7.7.2 O&M Cost

As Above.

CHAPTER – 8
NAVIGATION & COMMUNICATION SYSTEM

8.1 General Requirement

Navigational system is considered as an important aid for any vessel movement in coastal and river channel. Navigational Safety in Port's Committee was formed in India known as NSPC to ensure navigational safety in waterways.

8.1.1 VHF/HF

VHF communication system is a part of VTS/VTMS system i.e. Vessel Traffic system or Vessel Traffic Management System. This navigational system is required when there is heavy traffic at port or terminals. Though there are international standards published by IMO, each Country and each state or province also follows its own standard. It helps to locate exact position for berthing of vessels and decide traffic lane for vessels accordingly. VHF also comes under Marine Communication Systems. VHF Radio also known as very high frequency radio used for communicating between shore & vessels or between two vessels. Depending upon area of operations of various ships activity of VHF system differs. As per nautical miles from shore of vessels, various types of VHF radio frequency system are used for communication. For Mahi river vessels could contact terminal Manager via VHF system and would be provided guidance for berthing or for anchorage etc. This system would also help in planning vessels arrival & departure schedule for terminal or port.

8.1.2 Differential Global Positioning System (DGPS)

DGPS is satellite-based system. Generally DGPS system has two reference stations, two integrity monitors, control computer, communication system, marine radio beacons and continuous power supply. All these equipment's are necessary for DGPS system to function. Vessel monitoring & controlling could be done from various DGPS stations or remotely from other control stations. Using DGPS corrections could be made in GPS receiver to increase the accuracy of navigation. It is the advance version of GPS system. AT present there are 23 DGPS stations installed on entire coastline of India. In Gujarat, DGPS stations are installed at Okha, Hazira, Porbandar and Gopnath.

8.1.3 RIS/AIS/Radar/VTMS

- River Information System (RIS)

First RIS system has been introduced in India on NW 1 in Fy-16. RIS is a combination of software & hardware equipment used for optimization of traffic & vessels movement in Inland waterways for navigation purposes. RIS is used for electronic data transfer between vessels & shore. Using RIS system many waterway transportation risks like vessels collisions, Vessel – bridge collisions could be avoided. Mahi River also has many bridges on it. Vessels/barges that would use river could be benefitted by using RIS system and safely navigate in complete stretch of the river.

- Automatic Identification System (AIS)

AIS & RIS system together provide safe navigation for vessels. Both these systems are used simultaneously. Under AIS, vessels that would ply on whole river stretch are monitored. Remote stations/base stations site would be installed/developed for monitoring vessels and identify it. This would further strengthen safe navigation for vessels.

- Radar

Radar is basically used to locate other ships and nearby land area. In radar system there are X frequency & S frequency. X stands for secret & S for small range. Radar screen on ship display each and every object that are in the coverage of particular radar on ship. There is antenna on the top of radar, which continuously rotates, & flashes in order to find out any objects on the navigable path of the ships. It not only identifies objects but also shows its distance from ship. This also helps in avoiding accidents in the waterways. Radar system is also considered as user friendly and economical to install due to less consumption of power & electricity.

- Vessel Traffic Management System (VTMS)

Radar, VHF all are part of VTMS. Together it helps to plan ships arrival & departure, monitor anchorage activities, provide traffic guidance to ships and control traffic in the waterways. In case of emergency or rescue operations would be carried out successfully using VTMS system. Some of the vessels arriving at terminals on Mahi River would not be complying necessary norms for berthing purposes. In this case anchorage/pilotage or barges need to be used in order to access terminals on Mahi River. This could be done successfully using VTMS. Overall it helps to have complete control over management of vessels & terminal.

LIST OF EQUIPMENTS:

Sensor System

a. AIS Base Station

b. RADAR

c. VHF System

d. Meteo Sensor

e. Automatic Tank Gauge

Tracking

a. RIS Hardware (Servers & Computers)

b. RIS Software

Power Supply

a. UPS

b. DG Set

Civil Deliverables

a. Trestle Tower for installation RADAR

b. Building for installing RIS equipment / Porta cabin

RIS SYSTEM MAHI RIVER (NW-66) is shown below:

RIS SYSTEM MAHI RIVER (NW-66)				
Sr. No.	**Equipment**	**Qty**	**Unit Price**	**Total**
1	AIS Base Station	3	3000000	9000000
2	RADAR	3	5000000	15000000
3	Meteo Sensor	3	700000	2100000
4	ATG	3	900000	2700000
5	VHF	3	500000	1500000
6	DG Set 10 KVA	3	700000	2100000
7	UPS	3	500000	1500000
8	RIS Software	3	3500000	10500000
9	RIS Hardware	3	10000000	30000000
10	Installation Testing & Commissioning	3	2000000	6000000
11	Porta cabin	6	1200000	7200000
12	Trestle Tower	3	1000000	3000000
			Total	**90600000**
	Operation			-
1	Engineer 1 * Site 1 * Months 12 per year	12	35,000.00	1260000
	Operator 3 * Site 1 * Months 12 per year	108	20,000.00	2160000
	Security 3 * Site 1 * Months 12 per year	108	15,000.00	1620000
2	Second Year			5392800
3	Third Year			5770296
4	Fourth Year			6174216.72
			Total	**22377312.72**
	CAMC for 4 Years			-

RIS SYSTEM MAHI RIVER (NW-66)				
Sr. No.	Equipment	Qty	Unit Price	Total
1	1st Year	1	9060000	9060000
2	2nd Year	1	9966000	9966000
3	3rd Year	1	10962600	10962600
				-
			Total	**29988600**

Overall Cost	**14,29,65,912.7**

8.2 Existing System

At present there is no navigable or communication system developed on Mahi River.

8.3 Additional requirement

Once the terminals on Mahi 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

8.4.1 Capital Cost

Navigation & Communication Cost	In Crores
DGPS	1.00
VTMS	1.00
Marine Lantern/Buyos (50 nos.)	1.00
RIS	14.30
Total Cost(III)	17.30
3% Contingencies and 7% Supervision charges on Base cost	1.73
Total Navigation & Communication Cost	**19.03**

Table 8.1 Capital Cost

8.4.2 O&M Cost

For navigational aids 5% of the capital cost is kept as operation & maintenance cost please refer chapter 11 for details.

CHAPTER 9

ENVIRONMENTAL AND SOCIAL ASPECTS

9.1 Objective of Environmental and Social Studies

Objective of Environmental and Social Studies is to acquire an awareness of the environment as a whole and its related problems. Participate in improvement and protection of environment and develop the ability to evaluate measures for the improvement and protection of environment.

Need of the Project

IWAI, Govt. of India intends to find the viability of Mahi River (NW-66) as an Inland navigational waterway. The development of national waterway will help in transportation of cargo and passengers which will help in decongestion of traffic on roads and railways. The transportation through waterway is cheaper and requires less fuel which ultimately reduces the carbon emission and is environment friendly, the development of waterway will contribute to the economy of the country.

This section discusses the global concept of the environmental problem arising as a result of the development of Inland waterway navigation project in Mahi River, construction of terminals and effects on environment due to movement of cargo. The section will cover the land usage pattern along the study area, Physiography of the area, Presence of any National Park, Wild life protected sanctuaries, Wetlands, flora and fauna, Protected sites, Archaeological survey of India declared sites present within 10km radius will be shown. It will also cover the Geology pattern, air quality and susceptibility to natural hazards of the study area.

Some of the environmental problems are air, land and water pollution, environmental health degradation, rehabilitation, wildlife migration etc. The continuous increase in concentration of air pollutants in the atmosphere has threatened the Green House and atmospheric ozone layer at global level. The carbon dioxide is mainly responsible for Green House effect. Navigation development projects are also of great concern for the environmental degradation. These ecological environmental changes may be reversible or irreversible, due to many interacting parameters. In general the combined effect of two parameters is greater than that of individual one. Consequently these impacts could have repercussions on others. The internationally accepted practice of studying environment impact involves its identification, prediction and evaluation.

Environmental Management Plan (EMP) based on the environmental baseline conditions, planned project activities and impacts assessed earlier, this section enumerates the set of measures to be adopted to minimize the adverse impacts.

To sum up, the objectives of environmental and social studies are to develop a world in which persons are aware of and concerned about environment and the problems associated with it, and committed to work individually as well as collectively towards solutions of current problems and prevention of future problems.

For collection of data related to environment setting in the project area the correspondence Letter *to Additional Principal Conservator of Forests, Gandhinagar dated 6th April, 2017 by WAPCOS has been attached in page no.250-251.*

9.2 Environmental Setting in the Project Area

Mahi River originates from Minda Village, which is situated in Dhar district of Madhya Pradesh. The river rises in the western Vindhya Range, just south of Sardarpur, and flows northward through Madhya Pradesh state. After flowing through the Vagad region of Rajasthan, it enters Gujarat and flows into the Arabian Sea by a wide estuary past Khambhat. The river flows for about 538 km through Dhar, Jhabua and Ratlam districts of Madhya Pradesh, Banswara and Dungarpur in Rajasthan and Panch Mahal, Mahisagar, Anand and Vadodara district of Gujarat before falling into the Arabian Sea through the Gulf of Khambhat in Kheda district of Gujarat.

The silt brought down by Mahi river has contributed to the shallowing of the Gulf of Khambhat and the abandonment of its once prosperous ports. The riverbed lies considerably lower than the land level and is of little use for irrigation. It is one of three rivers, along with Tapi and Narmada River, to flow from East to West in India. There exist many temples and places of worship along the bank of Mahi River. It is also known as Mahisagar, due to the vastness of the river. The industrial area in Gujarat is located nearby to the ports. Many of the companies own captive jetties taking the advantage of the coastal movement of the raw materials for cost effective logistics. The port nearest to the Mahi River proposed stretch is Dahej Port. The districts that are located in the catchment area, i.e. within 25 km. of Mahi river are Anand, Kheda,Vadodara, Bharuch, Panchmahal and Mahisagar.

The length under consideration for present studies is detailed below:

246.989 km length of the river from Kadana Dam to confluence with Gulf of Khambhat near Kavi railway station (National waterway 66)	From: $23^0$18’22.35”N $73^0$49’37.45”E	Up to: $22^0$10’34.71”N $72^0$30’36.31”E

The map showing entire Mahi basin (Source: INDIA WRIS wiki) and Present study stretch is attached as Figure 9.1(also A3 size map of basin attached after last page-256 of this chapter) & Figure 9.2 respectively.

Fig. 9.1 Mahi River Basin *Source: india-wris*

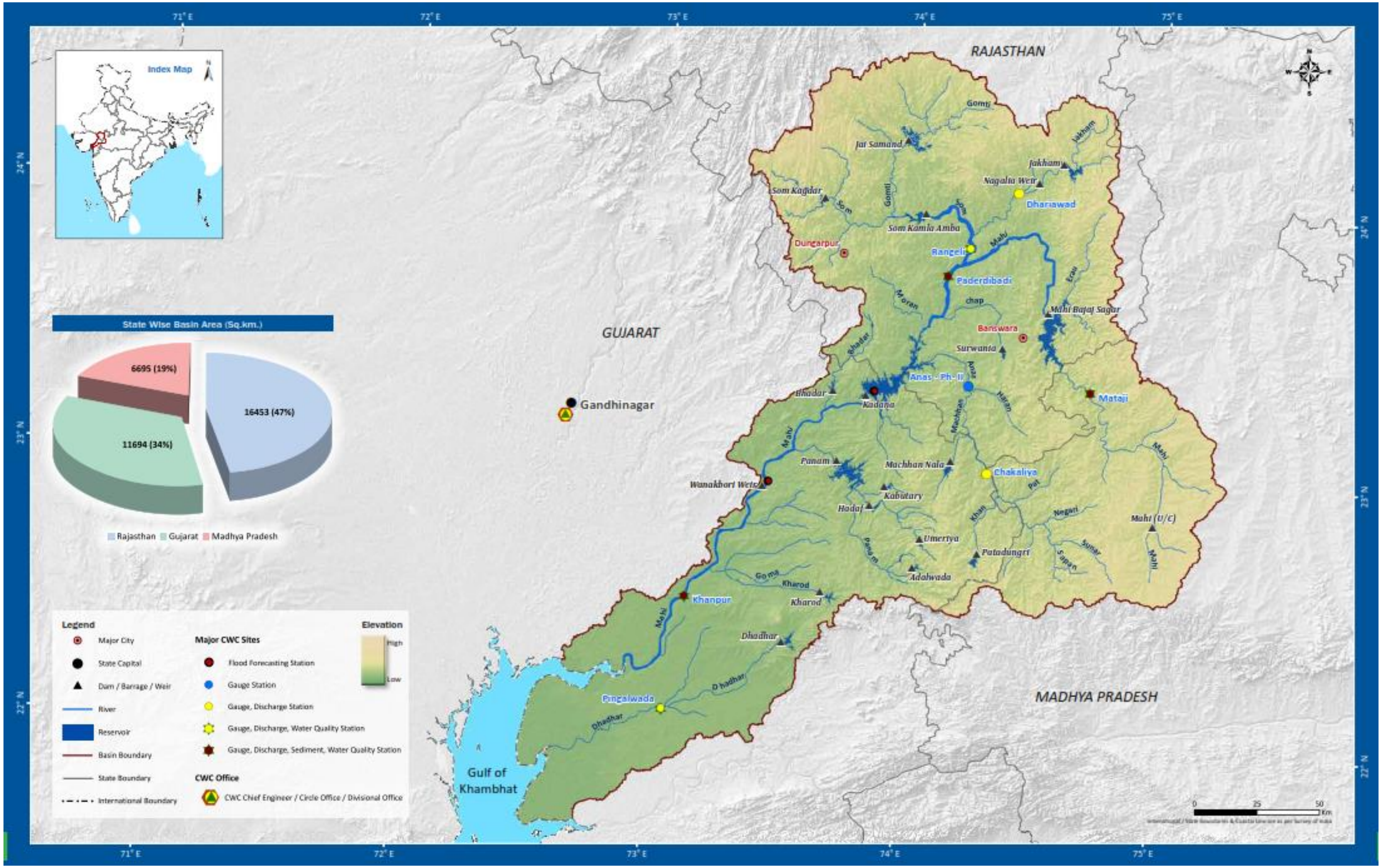
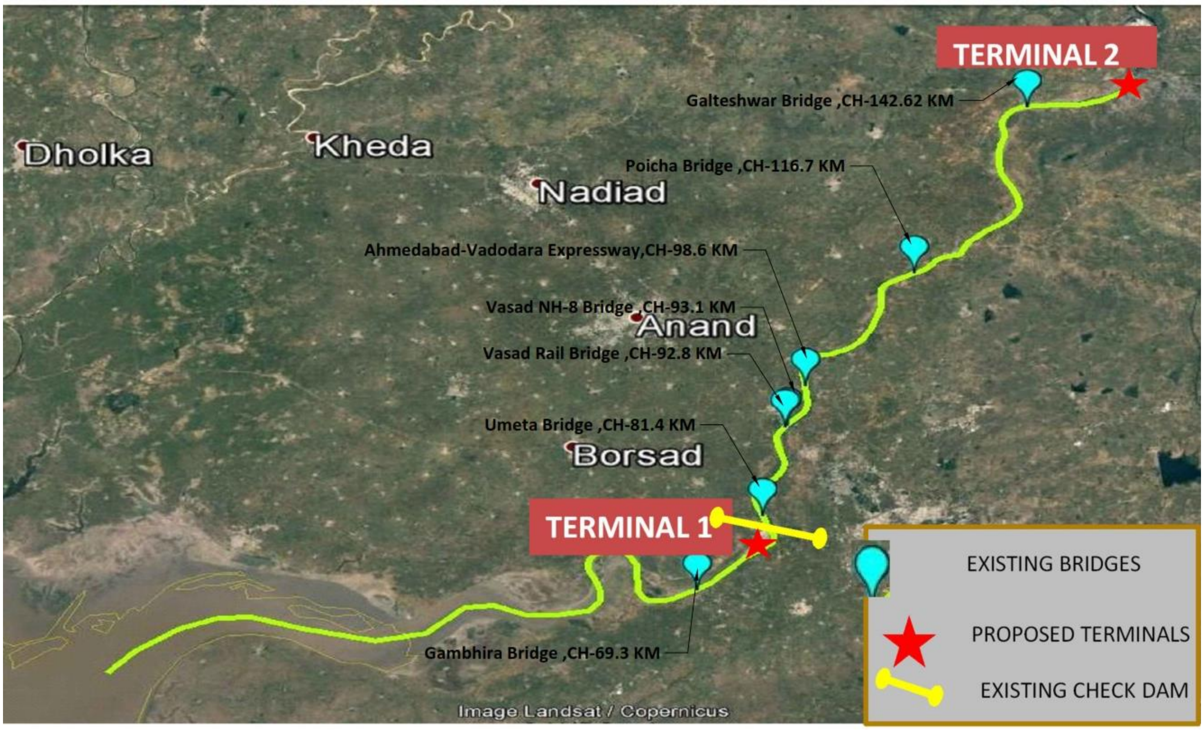


Fig:-9.2 Map showing present stretch of study of River Mahi



Source: - Google Earth

9.3 Physiographic

Physiography of India shown in Fig: 9.3 India Physical map

The Tropic of Cancer passes through eight states in India – Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura and Mizoram.

Between the Western and Eastern longitudes there is a difference of 30 degrees which causes a difference of about two hours between the western-most and eastern most areas of the country. The Standard Meridian lies on 82°30′ East longitude, which falls in the middle of the country. It sets the Indian Standard Time (5 and half hour ahead of GMT).The Standard Meridian passes through Mirzapur near Allahabad in Uttar Pradesh.

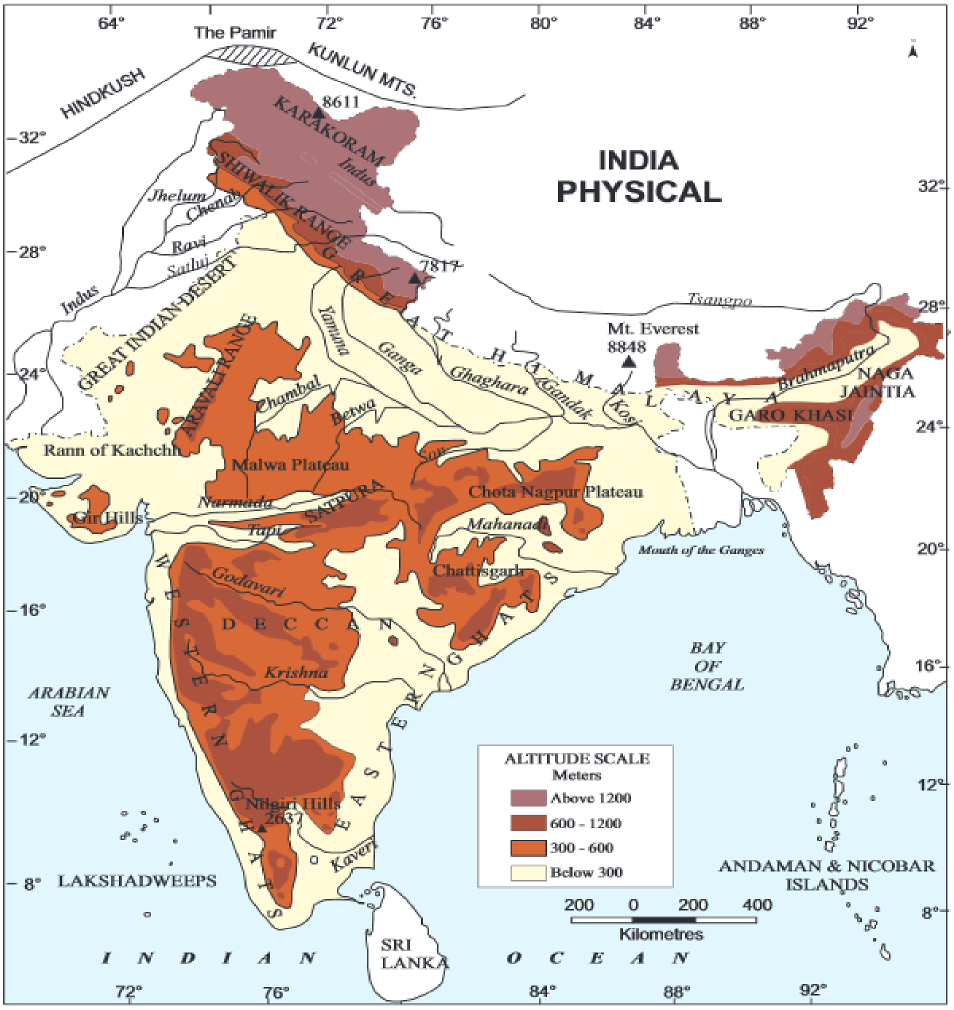
The coastal plains in India are situated parallel to the Arabian Sea and Bay of Bengal. On the basis of location and active geomorphic processes, it is divided into Western and eastern Coastal Plains.

The Western Coastal Plain – Extends from Rann of Kutch to Kanyakumari. It has four divisions:

Kutch & Kathiawar coast in Gujarat, Konkan coast in Maharashtra, Goan coast in

Karnataka Malabar coast in Kerala(has backwaters aka 'kayal')The western coast is narrow in middle and gets broader in north and south. The rivers in Western Coast do not form delta.

Fig: 9.3- India Physical map

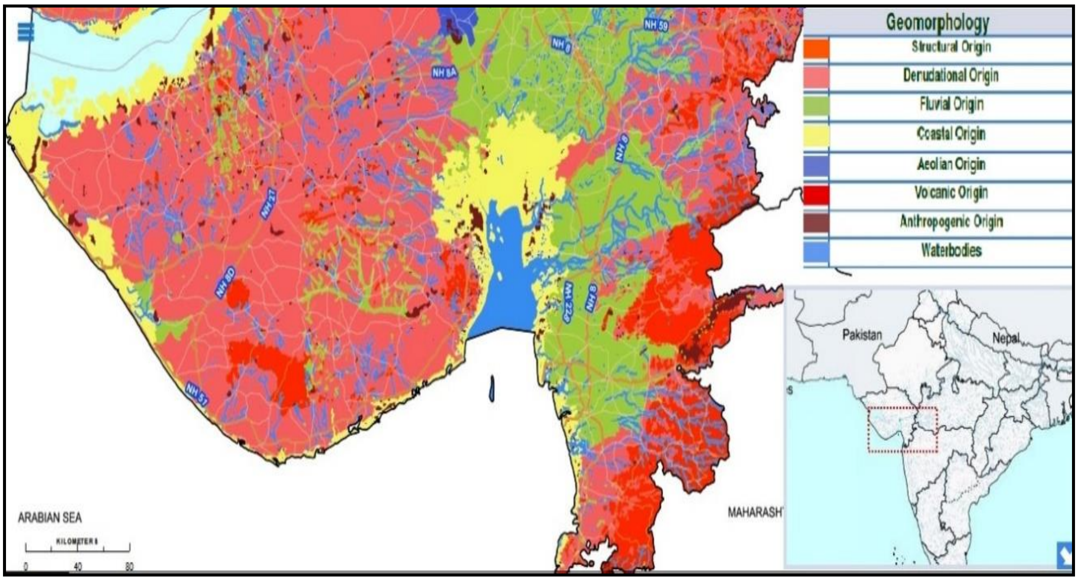


9.4 Geology and Seismicity (From Primary / Secondary Sources)

9.4.1 Geology

The Geology and seismicity pattern of the region is discussed **Fig 9.4 & 9.6 respectively**

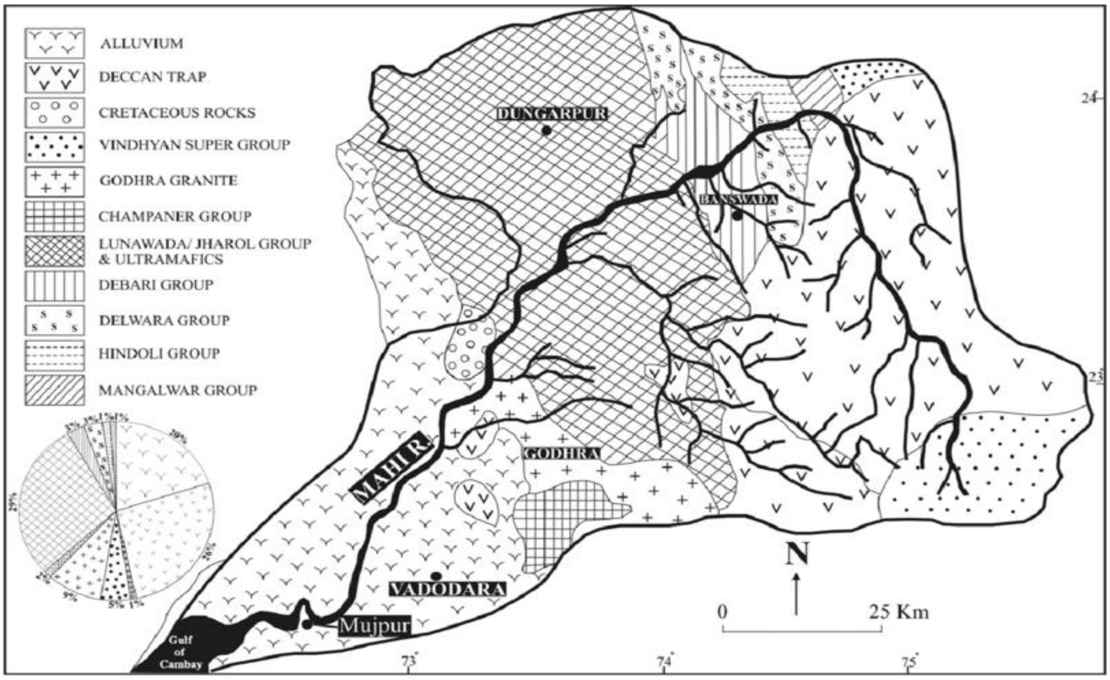
Fig: - 9.4 Geology pattern of Gujarat



As per figure shown above our project area is in Gujarat comprises of fluvial and structural origin.

Geological map of the Mahi River catchment showing exposed lithological units. The tributaries of the Mahi River mostly drain the Deccan province and the Precambrian crystallines of Rajasthan–Gujarat. The relative distribution of lithology is shown in the pi diagram. Fig. 9.5

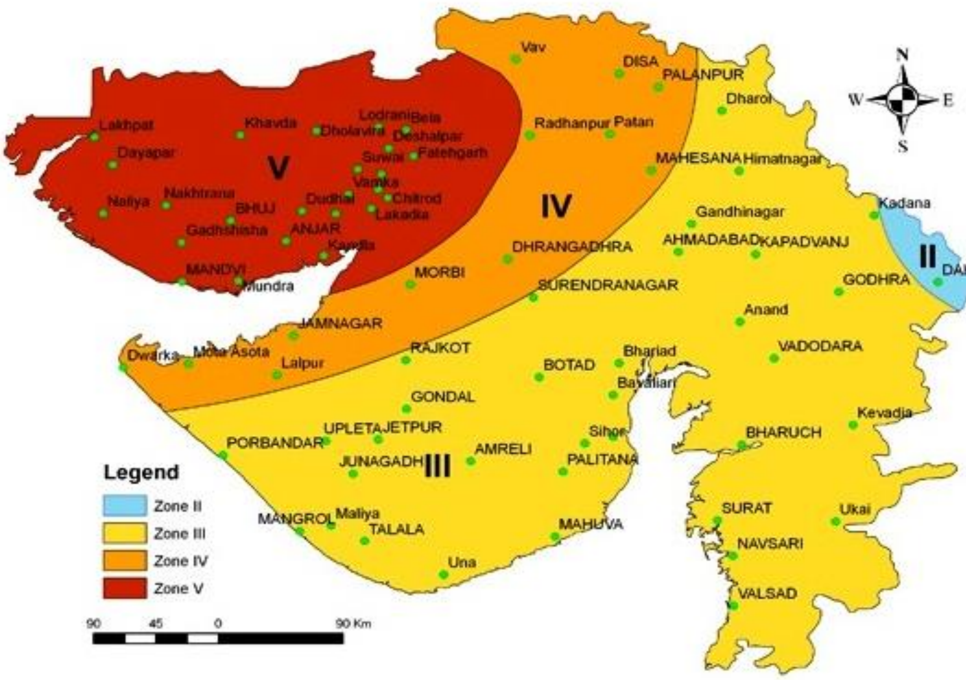
Fig:-9.5 Distribution of Lithology



Neotectonic activity along pre-Quaternary tectonic trends has played a major role in the evolution of Mahi drainage basin. The Mahi basin is controlled by NE-SW and WNW-ESE Aravalli trend in the uplands and by NNW-SSE Tertiary basement faults in the distal part. Lineament analysis shows three structural trends in the area which are related to major regional tectonic trends. Stream orientations indicate that the NNE-SSW and NNW-SSE trends represent lineaments which were active during the youngest tectonic phase. The NE-SW and WNW-ESE trends are slightly older. The evolution of overall configuration of the basin is attributable to neotectonic activity along WNW-ESE and NESW trends which have been modified by a later phase of tectonic activity along NNW-SSE trend. Morphotectonic analysis has been helpful in assessing the relative degree of tectonic activity in the different geomorphic zones of the Mahi river basin. An increasing degree of tectonic activity towards the NE conforming to the northeastward extension of the Aravalli range where the central axis of the range.

9.4.2 Seismicity

Fig: - 9.6 Seismic Map of Gujarat



As per Map shown above it is clear that our project area lies in the Zone III of seismic zone.

9.5 Climate

On the basis of the local climate conditions, there are three seasons including summer (March to May), monsoon (June to September) and winter (October to

February) from the available data & record, the basin contains two climatic regions, the northern part of the basin comprises sub tropical wet climate (generally basin area occupied by Rajasthan). The major part of basin comprises tropical wet climate, caused mainly due to existence of Vindhyas & the Western Ghats. Due to relatively high elevation in forest land, the area of the basin near the origin of the river experiences relatively cooler & moderate rainfall climate which gradually changes to warm & dry climate as the river flows northwards entering into & flowing through Rajasthan. After the river bends south westwards and enters Gujarat the climate gradually changes towards tropical wet climate again.

The annual average maximum, minimum and mean temperature for the basin recorded at the CWC sites Chakaliya,Mataji,Khanpur,Paderdibadi,Dharaiwad and Rangeli for the years from 2008 to 2009 is found to be 44.38 °C, 32.76°C and 38.57°C respectively. Secondary data after 2009 were not available for the proposed project location.

9.6 Soils

The important soil types found in the basin are red soil, black soil, sandy soil and mixed soil. Soil samples were collected at 26 different location along the stretch of present study which are mentioned **Table 9.1**

Table 9.1 Soil sample at different stretch

Sample No.	Chainage	Soil Strata	Depth (m)
MAHI 1	0	Sandy Silt	4.4
MAHI 2	10.8	Sandy Silt	4.2
MAHI 3	22	Sandy Silt	2.4
MAHI 4	32.6	Sandy Silt	0.6
MAHI 5	40.6	Sandy Silt	0.5
MAHI 6	50	Sandy Silt with gravel	3.5
MAHI 7	60	Sandy Silt	2.7
MAHI 8	70	Sandy Silt	4
MAHI 9	80	Sandy Silt	1.2
MAHI 10	90	Sandy Silt	6.3
MAHI 11	100	Sandy Silt	4.2
MAHI 12	110	Sandy Silt with traces of	3.6
MAHI 13	120	Sandy Silt with traces of	2.8
MAHI 14	130	Sandy Silt with traces of	1.4
MAHI 15	140	Sandy Silt with traces of	7
MAHI 16	150	Sandy Silt with traces of	4.7
MAHI 17	160	Sandy Silt with traces of	2.7
MAHI 18	170	Sandy Silt with traces of	4.5
MAHI 19	180	Sandy Silt with traces of	10
MAHI 20	190	Sandy Silt with traces of	6.8

Sample No.	Chainage	Soil Strata	Depth (m)
MAHI 21	200	Sandy Silt	8.9
MAHI 22	210	Sandy Silt with gravel	5.3
MAHI 23	220	Sandy Silt with gravel	4.8
MAHI 24	230	Sandy Silt with gravel	5
MAHI 25	240	Sandy Silt with gravel	5.4
MAHI 26	246.8	Sandy Silt with gravel	2.8

The same has been mentioned in the Volume IIIA Annexure 11 Hydrographic survey Report of Mahi River.

9.7. Land Use Pattern

Major part of the basin is covered with agricultural land with about 60% of the total geographical area. It shows that agriculture has been practiced quite extensively in the basin. About 4.34% of the basin is covered by water-bodies. The Built-Up Land is spread in 1.25% area. Forest cover in the basin accounts for 19.29% of total area. Wasteland in the basin occupies 11.26%, Grassland accounts for 0.23%. The other main categories of land use/land cover in the basin are fallow land, scrub land, scrub forest, river/stream/canal, rural, urban, mining, swamp/mangrove etc.

Table 9.2 Land use pattern of the districts along the Mahi river stretch

District	Forest	Non-Agriculture	Net Sown Area	Uncultivable Barren Land	Fallow lands	Cultivable Waste	Others	Total Area
Anand	NIL	27,000	205,000	27,000	1.1	20,500	11,499	291,000
Vadodara	79,667	125,931	520,266	0	20,188	6,724	0	752,776
Panchamahal	116,793	37,022	280,982	26,740	24,230	27,029	1,051	513,847
Kheda	7,900	1,500	297,000	9,800	7,300	15,800	55,000	394,300

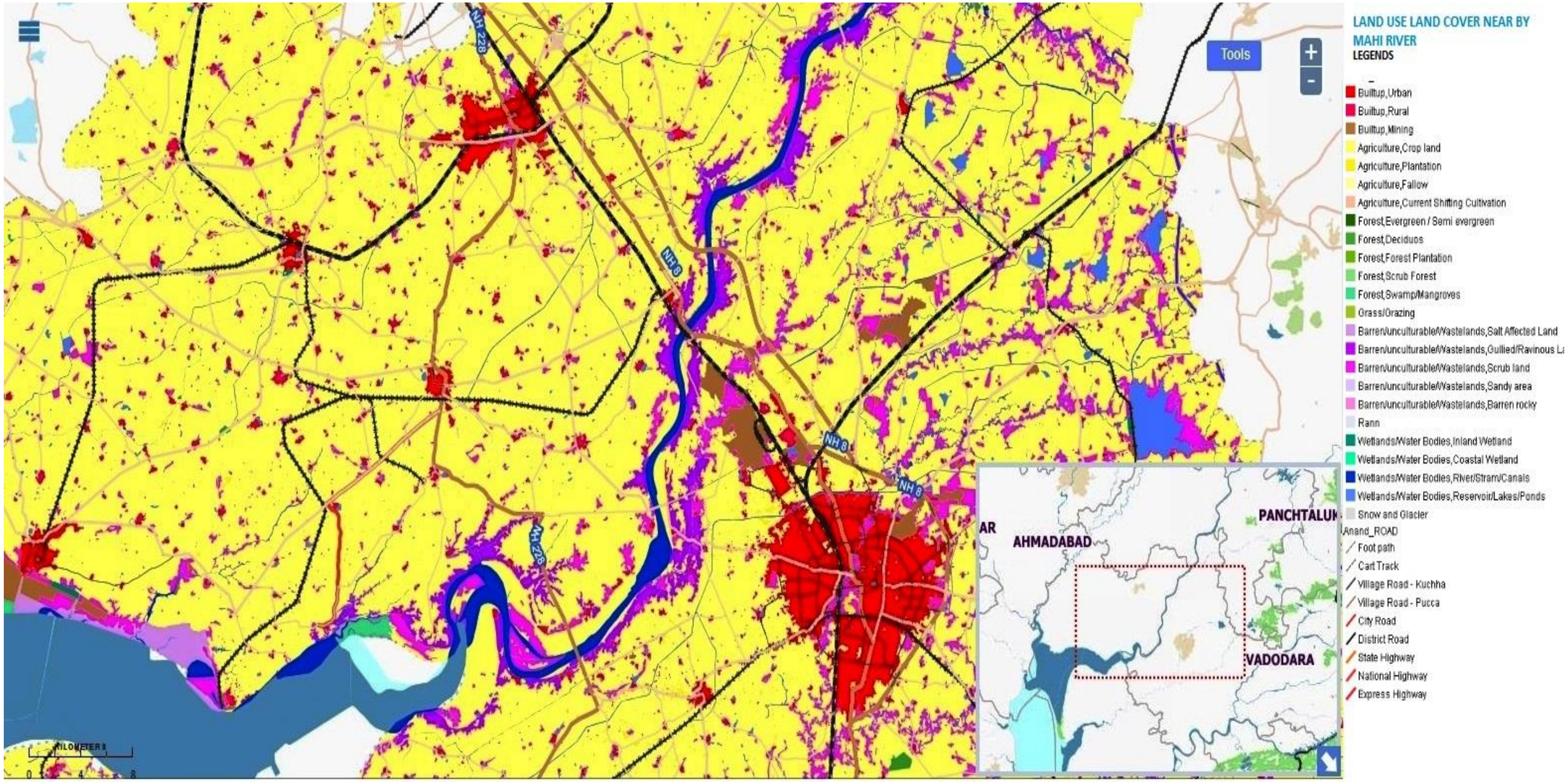
of total area in the Anand district, vast portion i.e. 70% comes under net sown category. This is followed by Non-agricultural land and cultivable waste land, each at 10%.The district has no forest area cover. Out of these, more than 56% have only less than 1 hectare lands each. The combined land holdings held by theses farmers is around 78,387 in numbers. The farming is predominantly peasant farming in the region. Only 4% of total land holdings (140,015) are held by farmers who have area more than 10 hectares.

In Vadodara district, more than 69% of area is net sown. This is followed by non agriculture land (17%) and forest area (11%). The district also has 3% of fallow land less than 15 areas is occupied by cultivable wasteland. Out of these, only 39% have less than 1 hectare land. Medium and large scale farmers (31% of total land holdings) take up to 68% of total land in the district. The combined land occupied by small and medium scale farmers (i.e. less than a hectare and between 1-2 hectare lands) is only 32%.

In Panchmahal the average landholding is 3.7 acre per farmer. The farming is dominated by small land holdings farming. About 50% of total number of land holdings is less than 1 hectare in the Panchamahal district. Only 20% of land holdings belong to medium and large scale farmers. Over 55% of the area in the district is net sown area. Apart from this, other major land uses in the district are non-agricultural land (7%) and fallow land is (5%). About 22% of land is covered by forest area. The Jambughoda wildlife sanctuary lies in this district.

In Kheda the average land holding is 3.7 acre per farmer. The farming is dominated by small land holdings farming. About 63% of total numbers of land holdings are less than 1 hectare in the Kheda district. Only 10% of land holdings belong to medium and large scale farmers. Of total area in the Kheda district, vast portion i.e. 75% comes under net sown category. This is followed by barren land and cultivable waste land, each at2% and 4%. The district has 2% forest area cover.
The satellite image of the present scope of the study is shown in figure 9.7

Figure 9.7 Satellite image of land use pattern



Source:- Bhuvan,ISRO

Crops and Agriculture in the Region:

Agriculture:

Anand:

The major crops in the district are Rice, wheat, banana, tobacco, papaya, potato, mango, gooseberry, onion & cabbage. Cereal, pulses and cotton are also widely grown in the region. Rice and wheat are widely cultivated and occupy more than 50% of the net sown area.

Table 9.3 Major crops for Anand District

Major Crops	Area in (00 Hectares)	Production in (00 tonnes)
Paddy *(Oryza sativa)*	944	2389
Wheat *(Triticum aestivum)*	634	1789
Pearl Millet *(Pennisetum glaucum)*	318	1364
Tobacco *(Nicotiana tabacum)*	639	1177
Cotton *(Gossypium arboreum)*	465	54

Vadodara:

The district areas have varied agriculture crops, both food crops &non-food crops. Main food crops consist of food grains such as paddy, wheat, jowar, bajra, maize etc., and pulses. Other food crops are sugarcane, fruits & vegetables. Non-food crops consist of cotton, oil ground nut, castor, tobacco, fodder etc. The majority of the production is dominated by Cotton, maize and cereals.

Table 9.4 Major crops of Vadodara District

Major Crops	Area in (00 Hectares)	Production in (00 tonnes)
Paddy *(Oryza sativa)*	551	681
Cotton *(Gossypium arboreum)*	1663	6616
Maize *(Zea mays)*	1243	2513
Wheat *(Triticum aestivum)*	475	1326
Others Cereals	2485	4895

Panchmahal:

The district areas have varied agriculture crops, both food crops &non-food crops. Main food crops consist of food grains such as paddy, wheat, jowar, bajra, maize etc., and pulses. Other food crops are sugarcane, fruits & vegetables. Non-food crops consist of cotton. The majority of the production is dominated by rice, maize and cereals.

Table 9.5 Major crops for Panchmahal District

Major Crops	Area in(00 Hectares)	Production in(00 tonnes)
Paddy *(Oryza sativa)*	704	596
Wheat *(Triticum aestivum)*	181	380
Bajara *(Pennisetum glaucum)*	44	33
Sorghum (*Sorghum vulgare*)	10	11
Maize *(Zea mays)*	1151	1607
Other Cereals	1917	2254
Tur (*Cajanus cajan*)	236	333

Kheda:

The principal crops grown in Kheda are the ordinary millets and pulses, rice, wheat, tobacco and a little indigo. Bajri is the principal crop and the staple grain food.Tobacco is the most valuable crop produced in the district. It is grown mostly in the charotar tract. Castor seed and sesame are the only oilseeds grown in the district.

Table 9.6 Major crops for Kheda District

Major Crops	Area in(00 Hectares)	Production in(00 tonnes)
Paddy*(Oryza sativa)*	873	2105
Bajara*(Pennisetum glaucum)*	389	542
Other Cereals	1462	2982
Wheat *(Triticum aestivum)*	1004	2712
Maize*(Zea mays)*	242	448
Cotton *(Gossypium arboreum)*	215	853
Tobacco*(Nicotiana tabacum)*	261	437
Potato(*Solanum tuberosum)*	47	920

9.8 Ambient Air Quality (From Primary / Secondary Sources)

Ambient air quality was collected from the Gujarat Pollution Control Board under the following programme for the Year 2014-15 average is presented below

1. National Air Quality Monitoring Programme (NAMP)

Under this project Ambient Air Quality monitoring is carried out at 38 stations in the state with the financial help of the Central Pollution Control Board, Delhi. The ambient air quality samples were collected as per the standard norms for ambient air quality monitoring prescribed by CPCB. Status of Ambient Air Quality monitoring NAMP Project The air quality data of city near to Mahi River is presented in **Table 9.7**

Table 9.7 Air quality data *[Yearly average 2014-15]*

Yearly average 2014-15]

S. No	City	LOCATION	PM 10	PM 2.5	SO2	Nox	O3	NH3	CO	Pb	As	Ni	Benzene	Benzo-a-pyrene
		NATIONAL AMBIENT AIR STANDARDS	60	40	50	40	100	100	2	0.5	6	20	5	1
1	BHARUCH	DAHEJ SEZ	85	30	13.3	20.8	12.1	9.4	1.42	0.09	<1.0	1.7	1.9	<0.5
2	BHARUCH	SARASVATI T/S	82	30	13	20.7	11.8	9.2	1.46	0.08	<1.0	1.7	1.9	<0.5
3	BARODA	NANDESARI CETP	96	37	15.2	22.3	10.1	11.5	1.97	0.3	<1.0	1.6	2.5	<0.5
4	BARODA	GPCB OFFICE	80	30	12.6	19.4	11.3	9.6	1.41	0.06	<1.0	1.3	1.4	<0.5
5	BARODA	DANDIYA BAZAR	91	34	14	21.7	11.2	9.9	1.6	0.27	<1.0	2.2	2.7	<0.5
6	BARODA	STERLING GELATIN	90	35	13.6	21.4	11.1	9.3	1.48	0.1	<1.0	1.9	2	<0.5

All parameter are express in µg/r

Source:-Gujarat pollution control board

2. State Air Quality Monitoring Programme (SAMP):

Under this project Ambient Air Quality monitoring is carried out at 24 stations in the state. The ambient air quality samples were collected as per the standard norms for ambient air quality monitoring prescribed by CPCB.

Status of Ambient Air Quality monitoring SAMP Project the air quality data of city near to Mahi River is presented in **Table 9.8** for Year **2014-15** average is presented below

Table 9.8 Air quality data *[Yearly average 2014-15]*

Yearly average 2014-15]

S. No	City	LOCATION	PM 10	PM 2.5	SO2	Nox	O3	NH3	CO	Pb	As	Ni	Benzene	Benzo-a-pyrene
		NATIONAL AMBIENT AIR STANDARDS	60	40	50	40	100	100	2	0.5	6	20	5	1
1	BARODA	BAPOD	84	31	13	20.3	10.7	10.5	1.41	0.08	< 1	1.3	1.3	< 0.5
2	BARODA	CHHANI	93	34	14.5	21.5	11.5	10.4	1.45	0.14	< 1	1.6	1.9	< 0.5
3	BARODA	GOTRI	87	32	13.8	21.1	10.1	9.9	1.3	0.08	< 1	1.3	1.4	< 0.5

All parameter are express in µg/m3

Source:-Gujarat pollution control board

9.9 Noise Levels (From Primary / Secondary Sources)

Noise levels of the Vadodara and Anand district were collected from pollution control board of Gujarat shown **Table 9.9**

Table 9.9 Noise Levels Report

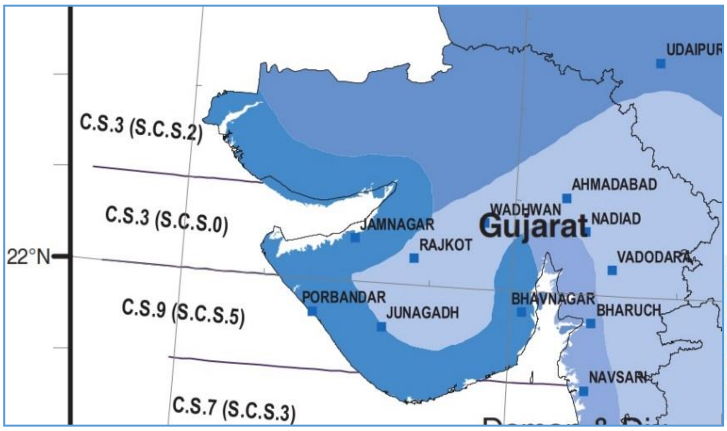
Regional Office	Place	Day	Date	Avg. Equivalent in dB
Vadodara	Bapod Area, Vadodara	Pre Diwali	15/10/2014	55.83
		Diwali	23/10/2014	72.77
Vadodara	Gotri, Vadodara	Pre Diwali	15/10/2014	56.58
		Diwali	23/10/2014	78.02
Vadodara	Dandia bazar, Vadodara	Pre Diwali	15/10/2014	55.41
Anand	Govt. staff quarters, Nr. Circuit house, Anand.	Pre Diwali	15/10/2015	55.95
		Diwali	23/10/2014	74.33
Anand	Ganesh Chowkadi, Amul Dairy Road, Anand.	Pre Diwali	15/10/2015	66.68
		Diwali	23/10/2014	78.46
Anand	Shastri Garden, Mota bazar, V.U.Nagar, Anand.	Pre Diwali	15/10/2015	50.66
		Diwali	23/10/2014	64.9

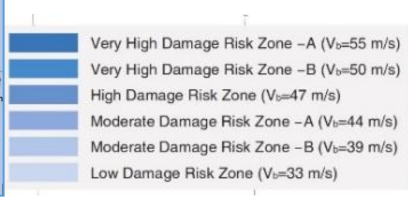
Source:-Gujarat pollution control board

9.10 Susceptibility to Natural Hazards

Susceptibility to Natural hazards like cyclone, flood and earthquake is shown **Fig 9.8 , Fig 9.9** in the map.

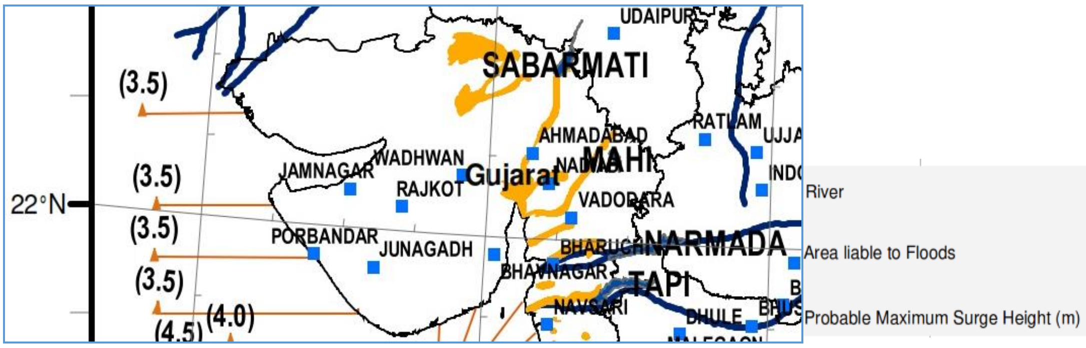
Fig 9.8 Wind and cyclone hazard Map





It can be seen from the above map of wind and cyclone hazard that our project area is falling in low to moderate range of risk.

Fig 9.9 Flood Hazard Map



The above figure shows the areas liable to flood and probable maximum surge height.

Earthquake prone areas has been already discussed in point 9.4 which shows our project area falls in seismic zone III.

Hence, the project area is not prone to natural hazards.

9.11 Estuary and Coastal Zone

An estuary is a partially enclosed body of water along the coast where freshwater from rivers and streams meets and mixes with salt water from the ocean. Estuaries and the lands surrounding them are places of transition from land to sea and freshwater to salt water. Although influenced by the tides, they are protected from the full force of ocean waves, winds, and storms by such land forms as barrier islands or peninsulas.

Important coastal area

Important Coastal and Marine Biodiversity Areas(ICMBAs)

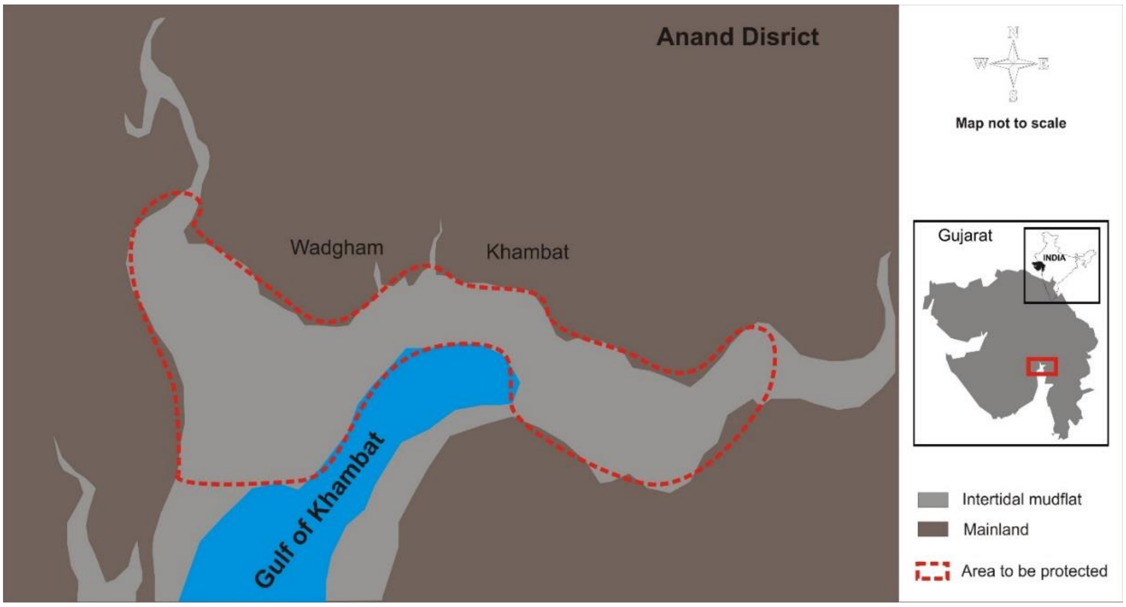
India has taken several steps to achieve the National Biodiversity Target no 6 and Aichi Biodiversity Target no 11 which aim to conserve a substantial portion of the coastal and marine areas in the country and world respectively. Towards achieving these two targets, 106 coastal and marine sites have been identified and prioritized as Important Coastal and Marine Areas (ICMBAs) by the Wildlife Institute of India. Sixty-two ICMBAs have been identified along the west coast of India, and 44 have been identified along the east coast. Of these, 22 ICMBAs have been prioritized for immediate conservation actions and proposed to be upgraded as Protected Areas under categories such as Conservation or Communities Reserve to increase participation of the local communities in governance.

Important Coastal area at the Estuary of Mahi River is shown in table 9.10 below

Table: 9.10 Estuary of Mahi river

Figure	District	Identified Site	North	East	Area (Sq.Km)	Suggested category
9.11	Anand	Wadgham	22°16.414	72° 27.661	927	Cons. / Comm. Reserve

Fig: - 9.10 Protected site Wadgham



Source:-MOEF & CC

The Wadgham site(fig 9.10) in Anand district is at the confluence point of sea and Estuary of Mahi river which is important coastal and marine biodiversity area(ICMBA) declared by Govt. of India. Since dredging is required for the navigation in the Estuary near Khambat. Hence it may requires wild life clearances from NBWL.

9.12 Archaeological and Heritage Locations

Archeological and Heritage Location was found along and nearby the present scope of study of Mahi River within 10 km radius from river bank which is shown below. There are four sites found within 10 km radius mainly Jami masjid at chainage 13 km and 600m from right bank, Microlithic site Chainage 121km and approx. 2km from left bank, Temple of Galteshwar at chainage 144 km on the right bank of river and Temple of Ratneshwar at chainage 154 km and ~6 km from left bank of Mahi river.

The same has been shown in figure 9.11A and fig 9.11B below

Fig 9.11A ASI site Jami Masjid & Microlithic site

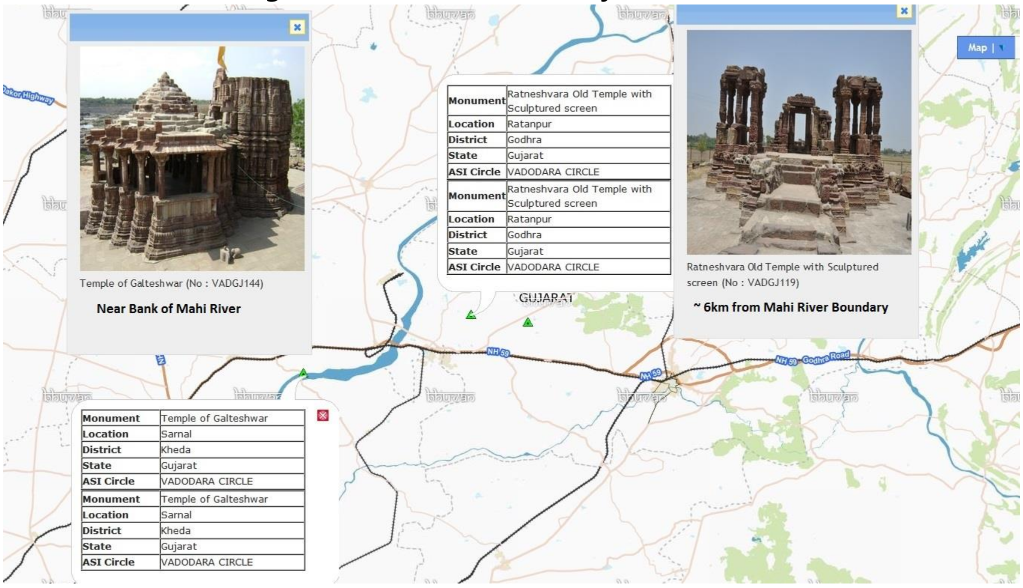
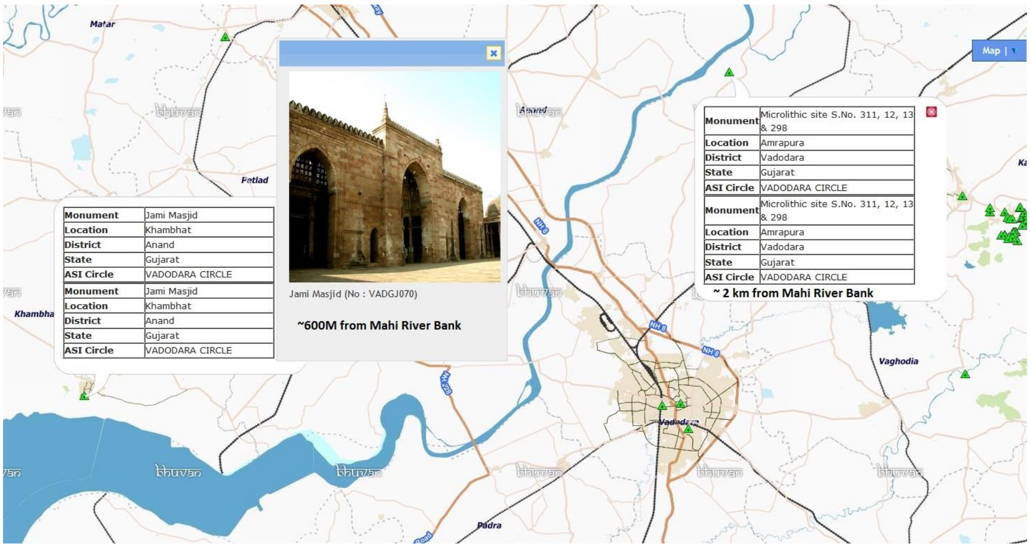


Fig 9.11B Galteshwar Temple & Ratneshwar Temple



Source:-Bhuvan,ISRO

9.13 Flora and Fauna

9.13.1 Flora

A total of 328 species of flowering plants belonging to 230 genera and 73 different families was recorded from the study area. Of these, the Monocotyledons were represented by 51 species belonging to 34 genera and 8 families; whereas the Dicotyledons were represented by 275 species belonging to 195 genera and 65 families.

With respect to the plant habits, the herbs dominate the study region with 178 species (56%) followed by trees with 55 species (17%), shrubs with 50 species (15%) and climbers with 40 species (12%) .The plant families namely Poaceae, Asteraceae, Fabaceae, Euphorbiaceae and Amaranthaceae contributed almost 50% of the herbaceous flora in the study region. The higher percentage of herbaceous flora in the study region can be attributed to the edaphic and climatic factors such as high temperatures and low rainfall. Most of the herbaceous plants were annuals and emerged only during the monsoon season. However some herbs like Argemone mexicana, Solanum xanthocarpum, Alternanthera sessilis, Xanthium strumarium and Tridax procumbens were found growing widespread throughout the year.

The most dominant family in the study region was Poaceae (Graminae) with 37 species and 27 genera. The members of Poaceae generally occur in open environments, are generally anemophilous and represent the principal component of grasslands worldwide (Londe & Silva, 2014). In the study area too, the grasses, along with other herbaceous plants, were growing in good numbers in the open canopy regions along Mahi River, otherwise dominated by agricultural landscapes.
The details of common flora in shown in table below

Table 9.11: List of Existing Flora Found in the study area

Sl. No.	Common Name	Scientific name
1.	Limdo	*Azadirachta indica*
2.	Gulmohar	*Delonix regia*
3.	Aduso	*Adathoda vasica*
4.	Kanthar	*Capparis sepiaria*
5.	Garmalo	*Cassia fistula*
6.	Vans	*Bambusa sp*
7.	Deshi Baval	*Acacia nilotica*
8.	Papaya	*Carica papaya*
9.	Amla	*Emblica officinalis*
10.	Peepal	*Ficus religiosa*
11.	Mehandi	*Lawsonia inermis*
12.	Mitholimdo	*Murraya koenigii*
13.	Bakan limdo	*Melia azedaracha*
14.	Asopalav	*Polyalthia longifolia*
15.	Saragvo	*Moringa oleifera*
16.	Dadam	*Punica granatum*
17.	Gando Baval	*Prosopis juliflora*
18.	Ambo	*Mangifera indica*
19.	Jambu	*Syzygium cumini*
20.	Bor	*Zizyphus mauritiana*
21.	Khati Amli	*Tamarindus indica*
22.	Kaner	*Nerium indicum*
23.	Pili Kener	*Thevetia paruriana*
24.	Arando	*Ricinus communis*
25.	Peltophorum	*Peltophorum petrocarpum*
26.	Pilu	*Salvadora oleoidis*
27.	Khajuri	*Phoenix sylvestris*

Sl. No.	Common Name	Scientific name
28.	Tecoma	*Tecoma undulata*
29.	Goras Amli	*Pithocelobium dulce*
30.	Sag	*Tectona grandis*
31.	Kothu	*Feronia elephantum*
32.	Badam	*Terminalia catappa*
33.	Karamda	*Carisa carandas*
34.	Dandaliya thor	*Euphorbia tirucalli*
35.	Sitafal	*Annona squamosa*
36.	Puvadiya	*Cassia tora*
37.	Arduso	*Ailanthus excelsa*
38.	Gunda	*Cordia myxa*
39.	Nilgiri	*Eucalyptus teriticornis*
40.	Shami	*Prosopis cineraria*
41.	Kamboi	*Phyllanthus reticulata*
42.	Suaeda	*Suaeda sp.*
43.	Ratanjyo	*Jatropha curcas*
44.	Ketaki	*Agave americana*
45.	Karir	*Capparis deciduas*
46.	Kanthar	*Capparis sepiaria*
47.	Gorad	*Acacia Senegal*
48.	Arni	*Clerodendron phlomidis*

Source: Forest Division, Anand District

9.13.2 Fauna

Fauna are important features of the environment. The changes in biotic community are studied in terms of their distribution, density and diversity. These changes through time can be utilized to assess the impacts of project on fauna of the region, which are important components of biological environment. For this purpose, the baseline condition of the area needs to be studied. Data of fauna collected from various forest Government Departments is mentioned below

Table 9.12: List of Existing Fauna Found in the study area

Sl. No.	Common Name	Scientific Name
	Birds	
1	Blue rock pigeon	*Columba livia*
2	Cattle Egret	*Bubulcus ibis*
3	Asian koel	*Eudynamys scolopacea*
4	Indian Cuckoo	*Cuculus micropterus*
5	Grey Heron	*Ardeola cinerea*
6	Little Heron	*Butorides striatus*
7	Indian Pond Heron	*Ardeola grayii*
8	Indian Cormorant	*Phalacrocorax fuscicollis*
9	Little Cormorant	*Phalacanus niger*
10	Black winged Stilt	*Himantopus himantopus*
11	Red-vented Bulbul	*Pycnonotus cafer*

Sl. No.	Common Name	Scientific Name
12	Imperial Eagle	*Aquila heliaca*
13	White Ibis	*Threskiornis aethiopica*
14	Black Ibis	*Psudibis papillosa*
15	Glossy Ibis	*Plegadis falcinellus*
16	Western Reef Egret	*Egretta gularis*
17	Little Egret	*Egretta garzetta*
18	Intermediate Egret	*Mesophoyx intermedia*
19	Lesser Flamingo	*Phoenicopterus minor*
20	Greater Flamingo	*Phoenicopterus ruber*
21	Purple Sunbird	*Nectarinia sperata*
22	Painted Stork	*Mycteria leucocephala*
23	Woolly-necked Stork	*Ciconia episcopus*
24	Asian Openbilled Stork	*Anastomus oscitans*
25	Comb Duck	*Sarkidiornis melanotos*
26	Common Crane	*Grus grus*
27	Magpie Robin	*Copsychus saularis*
28	Little Tern	*Sterna albifrons*
29	Red-wattled Lapwing	*Vanellus indicus*
30	Spoonbill	*Platalea leucorodia*
31	Black kite	*Milvus migrans*
32	Black winged Stilt	*Himantopus himantopus*
	Reptiles	
1	Indian Monitor	*Varanus bengalensis*
2	Garden Lizard	*Calotes versicolor*
3	Common Rat Snake	*Ptyas mucosus*
4	Common Vine Snake	*Ahaetulla nasuta*
5	Common tree Snake	*Dendrelaphis tristis*
6	Indian Cobra	*Naja naja*
	Mammals	
1	Bander	*Presbytis entellus*
2	Chachunder	*Suncus murinus*
3	Sasalu	*Lepus nigricollis*
4	Chamarchidiyu	*Pteropus giganteus*
5	Nolio, nyula	*Herpetes auropunctatus*
6	Nilgai	*Baselaphus tragocamelus*
7	Lamba Kanwado Sedo	*Hemiechinus auritus*
8	Jarakh	*Hyaena hyaena*
	Aquatic Animals	
	Common name	**Habitat**
1	Karchala	Salty Water
2	Bhangra	Salty Water
3	Lapta	Salty Water
4	Bakara	Salty Water
5	Jinga	Salty Water

Source: Forest Division Anand District

9.14 National Parks, Forests, Wildlife Sanctuaries and Reserves

There is no wild life sanctuary present near the bank within 50km radius River in the present stretch of study which is in the region of Gujarat does not have any wild life sanctuary within 25km radius from river bank shown in fig:-9.12.*The Map of Wildlife Protected Areas of Gujarat is shown in Fig. 9.13 and enclosed in page no.252*

Fig 9.12 Mahi River Map showing No Wild life sanctuary along the stretch

Source:Google Earth

9.15 Socio-economic Profile

Demography

It traverses through Dhar and Jhabua districts of Madhya Pradesh, Bansawara and Dungarpur district of Rajasthan, Panchmahal, Mahisagar Kheda Anand and Vadodara districts of Gujarat. However, the present stretch of 246.9 km is limited to Gujarat state only. The main towns in the vicinity of Mahi River are Banaswara, Santrampur Lunawada, Borsad,Vasad, Anand and Vadodara.

Our area of present study is for the Gujarat region only which consists Anand, Vadodara, Panchmahal and Kheda districts.

Industrial Profile of the Anand District:

According to MSME- DEVELOPMENT INSTITUTE the focused industry sectors in the Anand district include, Food & Agriculture, Engineering & Auto parts, Chemicals, Port & Ship Building, Minerals and Cement industries. Amul Dairy Co-operatives is the largest dairy co-operative of India. The existing clusters of Micro & Small Enterprises are rice processing, tobacco steaming, and spinning & weaving of cotton, wood industry, printing, painting & varnish, non-ceramics and casting & forging in the district.

Industrial Profile of the Vadodara District:

The industrial clusters include Chemicals & fertilizers, Pharmaceuticals, Biotechnology, Cotton Textiles, Machine Tools, Glass, Engineering, Tobacco, Fisheries and Dairy. Other key small scale industries include textiles, metal works, chemicals, equipment, rubber products and food products etc. There are thirteen Industrial estates namely Sankheda, Jetpur Pavi, Dabhoi, Ranoli (Autonagar), Limda, Por Ramangamdi, Nadesari, Waghodia, Makarpura, PCC, Savli, Savli Biotech Park and Sehra are at present operating in the district. Moreover, there are also three Special Economic Zones (SEZs) namely Savli SEZ, Suzlon SEZ and Nipam Infrastructure Ltd.

Industrial Profile of the Panchamahal District:

The major industrial locations in the district are Kalol, Panchmahals Halol and Godhra. The Industries like minerals, engineering & automobiles, tourism, irrigation projects, dairy farming are predominant. The district is a manufacturing base for steel products, automobiles and cryogenic equipment. Major players in the district include General Motors India Pvt. Ltd, Maruti Koatsu Pvt. Ltd, Inox India Ltd., MJ Pharmaceuticals Ltd and Panchmahals Steel Ltd.

Industrial Profile of the Kheda District:

Kheda district is also known by the name "Golden Leaf" since it is the major producer of tobacco in the State. Moreover, the district is also major producer of cotton in the State. Nadiad tehsil is the main industrial center in the district with major concentration of industries in sectors like- textiles, - Paper, Electrical equipment and food Processing etc. Core Emballage Ltd. One of the largest corrugated boxes manufacturing company is operating in the district. Thermal Power Station at Wanakbori in Kheda district with a total installed capacity of 1,470 MW is the largest coal-based Thermal Power Station in the State.

Focus sectors include Agriculture; Mineral based industries, Plastic & its Products, Cement & Gypsum, Engineering and IT etc. There are huge natural gas reserves in Matar tehsil of the district. Oil and Gas Company Sheel India Ltd. has its bottling pand filling plant in the district. One of the oldest Textile industries New Shorock Mills (Division of Mafatlal Industries) is still operating in the district since its inception in 1912.Cattle Feed Plant Amul Daan is operating at Kanjari Village of Nadiad Tehsil since its inception in 1964.

There are 8,186 Small Scale Industries operating in Kheda district. Some of the main industries are Chemicals, miscellaneous manufacturing industries, repairing services, food products and non-metallic mineral products industries. Approximately 2,521units are related to Repairing Services followed by Textile industry with approximately 1,086 units in the district. Most of the small scale industries are concentrated in Nadiad, Kapadvanj, Thasara and Mehmadabad tehsil.Major portion of the small scale industries belongs to Repairing Services with nearly33 %, followed by Textiles with 14 %, Misc. Manufacturing units with 13%, Food &Wood products and with 8 %, Machinery & parts and metal products 4%, non-metallic mineral products and other industry with 3 % respectively contributes in the manufacturing and services to GDP of the district.

9.16 Potential Environmental and Social Impacts of the Project

The impact of project on potential environment is not much as it will not produce any harmful wastes. The project will provide the employment to the local villagers nearby to the terminal area during construction as well as in operational phase this will improve the social and economic conditions of the nearby commuters. Also by shifting of traffic from distant ports or terminals, mode of operation like from road to waterway to this terminals will reduce the overall carbon emission. Hence ultimately will bring a positive impact to the environment.

There is no wild life sanctuaries nearby 50km radius of the present scope of study of river stretch i.e 0-247 km

9.16.1 Impacts due to construction activities

Pre-construction activities generally do not cause significant damage to environment. Preparatory activities like the use of existing access road, construction of storage sheds, etc. being spread over a large area, would have no further significant impact once the land is acquired and its existing use changes. Clearing, stripping and leveling of sites, construction of bunds for protection from flooding, earth filling and excavation for foundations, will lead to some disturbance to the habitat. The level of construction activities in the proposed project is not of such level and nature, to cause any significant adverse impact on this account.

a) Operation phase

Generation of garbage at Terminal area

The problem envisaged during operation phase could be the disposal of garbage. This could comprise floating materials, packaging, polythene or plastic materials, etc. accumulated from the fishing trawlers and boats. Garbage accumulated on the deck also needs to be suitably disposed. Therefore, a system needs to be developed, whereby undue quantity of garbage is not permitted to accumulate in the fishing harbour area and the same could be disposed off on the low lying areas in a scientific manner.

Handling of material like coal at terminals should follow standard guidelines of operation and the heap of material stacked should not be greater than 5m.The clear distance of 5m should be maintained between two heaps.

9.16.2 WATER ENVIRONMENT

a) Construction phase

Impacts due to effluents from labour camps

The average and peak labour strength likely to be deployed at the Terminal will be about 100 and 200 respectively. Most of the labour force will come from this village or from nearby village. The labour force engaged by the contractor could come from outside areas. A part of the labour population would stay in area. The balance labour population is likely to stay in labour camps close to the project site during construction phase. It is assumed that about 50% i.e. 100 labourers will stay at the site. Based on the above assumptions, total water requirement for the labour congregating in the area for constructing fishing harbour who will stay during the construction phase are estimated as below:

- Peak labour strength : 200
- Labours likely to stay at construction site (50%) : 100
- Married families (80% of 100) : 80
- Single : 20
- Husband and wife both working (80% of 80) : 64
- Families (64/2) : 32
- Families where only husband is working (50% of 32) : 16
- Family size (assumed) : 5
- Total number : 32x5+16x5+20=260 --(A)
- Add 5% for the persons who will be service provider like shops, repairing facilities, etc. : 13
- 50% of service providers will have families : 7
- Total number : 7x6+6=48 --- (B)

Total population (A+B) : (A + B) = 260+48=308

Say 310 Water requirement : 70 lpcd

Total water requirement : 21.7 m^3/day

About 100 labour would stay at the construction site, only during working hours. The water requirement for such labour shall be 4.5 m^3/day @ 45 lpcd. Thus, total water requirement works out to (21.7 + 4.5) about 26 m^3/day. Water requirement for construction purpose has been estimated to be of the order of 50,000 lpd, apart from domestic water requirements. The source of water will be nearby water supply authority and bore wells.

The sewage generated is normally taken as 80% of the total water requirement i.e. (0.8 x 26) 21 m^3/day. The domestic water normally contains high BOD, which needs proper treatment and disposal, otherwise, it can have an adverse impact on the DO levels of the receiving body. The disposal of sewage without treatment can cause problems of odour and water pollution. The typical composition of untreated sewage is given in Table-9.13

Table-9.13 Typical composition of untreated sewage

Parameters	Value
Total Solids, mg/l	720
Total Dissolved Solids, mg/l	500
Total Suspended Solids, mg/l	220
BOD mg/l	220
Oil and grease, mg/l	100
Alkalinity (as $CaCO_3$), mg/l	100
Total Phosphorus, mg/l	80
Total Nitrates, mg/l	40
Bicarbonates, mg/l	100
Carbonates, mg/l	10
Nitrates, mg/l	40
Phosphates, mg/l	40
Chlorides, mg/l	50
Sulphates, mg/l	30
Calcium, mg/l	40
Magnesium, mg/l	40
Potassium, mg/l	15
Sodium, mg/l	70

It is clear from Table-9.13 that BOD is the major pollutant, as far as sewage is concerned. Normally untreated sewage would find its way to natural drainage system which ultimately confluences into the sea. However, these natural drains are seasonal in nature and are likely to remain dry in the non-monsoon months. During this period, the flow of untreated sewage from the labour colonies in these drains can lead to development of anaerobic conditions, with associated water quality problems. However, in the present case it must be mentioned that the total quantity of sewage (21 m^3/day) generated as a result of congregation during construction phase is quite small and is not expected to cause any adverse impact on the marine water quality. However, it is proposed to treat the sewage from labour camps before disposal.

9.16.3 Impacts due to dredging

The dredging and other construction activities normally increase the turbidity levels in the water column. The total quantity of material to be dredged will be disposed at nearby low lying areas or areas in the bank of rivers for strengthening or as suggested by the authorities. The dredged material would be dumped at designated disposal sites. The identified site is shown in drawing folder Volume-2 , Dwg. No.-DL01

The change in water-column turbidity during dredging is a short-term impact. The increase in turbidity lasts as long as the material is being dredged. The turbidity level returns to the pre-project level sometime after the stoppage of the disposal of the dredged material. The time required for the turbidity level to return to its original turbidity level increases with the increase in clay content. The turbidity increase also depends on the type of dredging method adopted. Normally dredging in similar type of projects is done by a `Cutter Suction Dredger' (CSD). The method is preferred as it has minimal environmental impacts as far as increase in water turbidity is concerned. This is because of the fact that the dredged material is sucked before it gets an opportunity to spread. The sediments near the construction sites have high amount of fine portion. Due to the operation by CSD, the majority of clayey sediments would be sucked by the suction pipe. However, a small quantity of clay particles is likely to escape the cutter-suction head which may enter the water environment in the immediate vicinity of the dredging site. Since, the clay particles are in the range of 2 to 10μ, it would take about a week for these particles to settle down. The increase in turbidity level is likely to last for a period of 10 to 15 days, once the dredging activities are over.

The other impact of dredging on water quality is chemical in nature. Sediments take up various cations from water through the process of sorption. The cations and anions absorbed by sediments are weakly bonded and are generally released back to the water whenever there are slight changes in the physico-chemical characteristics of the environment. In the marine environment, due to prolonged residence time between water and sediments, cations and anions sorbed by the sediments are in equilibrium with the elemental concentration in water. When the sediments are removed, the concentration gradient between the liquid and the solid phase changes and there could be elemental transfer between the two phases. In the proposed project, it is suggested that dredging be done by a `Cutter Suction’ dredger as it does not provide adequate time for the elemental transfer between the sediments and the water phase. Thus, no major change in marine water quality due to transfer of ions from sediments to water is anticipated. It can be concluded that apart from short-term increase in turbidity levels, no other significant effect on marine quality due to dredging is anticipated.

9.16.4 IMPACTS ON NOISE ENVIRONMENT

a) Construction phase

The major sources of noise during construction phase are due to operation of various construction equipment. The noise levels generated by various construction equipments are given in Table-9.14

Table-9.14 Average noise levels generated by the operation of various construction equipment

Equipment	Noise level [dB(A)]
Floating pontoon with mixer	70
Winch machine	80
Transit mixer	75
Dumpers	75
Generators	85
Batching plant	90
Air compressors	90
Pile drivers	115

Under the worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all the equipments are operating at a common point. Likewise, to predict the worst case scenario, attenuation due to various factors too have not been considered for noise modeling.

Modelling studies were conducted to assess the increase in noise level due to operation of various construction equipment, and the results are given in Table-9.15

Table-9.15 Predicted noise levels due to the operation of construction equipment

Distance (m)	Ambient Noise Level (dB(A))	Increase in noise level due to construction activities (dB(A))	Noise level due to construction activities (dB(A))	Increase in Ambient Noise Level due to construction activities (dB(A))
30	45	70	70	25
50	45	66	66	21
100	45	60	60	15
200	45	54	55	10
500	45	46	49	4
1000	45	36	46	1
1500	45	36	45.5	0.5
2000	45	34	45	-

It is clear from Table 9.15, that at a distance of 100 m and 200 m from the construction site, the increase in noise levels will be about 10 dB(A) and 15 dB(A) respectively. The other source of noise during construction phase will be due to movement of trucks, which will transport the construction material.

9.17 EMP and Mitigation of Environmental Effects

Based on the environmental baseline conditions, planned project activities and impacts assessed earlier, this section enumerates the set of measures to be adopted to minimize the adverse impacts.

Environmental Measures during Construction Phase

Provision of Community Kitchen, Sanitation and Drinking Water Facilities in Labour Camps

A community kitchen could be provided where workers have their meals. The fuel used in these community kitchens is LPG or diesel. The labour camps will be provided with adequate arrangement for disposal of solid waste, liquid waste, and ventilation, ample and clean supply of drinking water.

Provision for Free Fuel Distribution in Labour Camps

As a part of the contract, it is proposed to make it mandatory for the contractor to provide community kitchen facilities to its labour and supply of free fuel to avoid falling/cutting of trees in the project area for fuel wood purpose.

Sewage Treatment

One community toilet should be provided per 200 persons. The sewage from community toilets shall be treated in septic tanks. For each 500 persons, one septic tank would be provided. Using the above norms, adequate number of community toilets and septic tanks shall be constructed.

Solid Waste Management

About 200 labour and 20 technical staff is likely to congregate in the area during construction phase. The increase in population is expected to be of the order of 800. The average per capita solid waste generated is of the order of 210 gm/day/person. The solid waste likely to be generated from labour camps shall be of the order of 46.20 kg/day. Adequate facilities for collection, conveyance and disposal of solid waste shall be developed.

For solid waste collection, number of masonry storage vats should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and the collected waste can then be transported to landfill site.
About 1 tonne per day of spoil shall be generated. The spoils shall be suitably disposed at low lying areas as a landfill site. The site shall be selected in consultation

with the district administration. During construction phase, labour colonies are proposed to be located close to the project site.

For solid waste collection, number of masonry storage vats should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and the collected waste can then be transported to landfill site.
One covered truck to collect the solid waste from common collection point and transfer it to the disposal site should be put to service. A suitable landfill site shall be selected in consultation with the local administration to store municipal waste.

Control of Air Pollution

During construction and operation phases, use of various construction equipment is the major source of noise. However, based on the modeling studies, the noise due to operation of various construction equipment is not likely to have any adverse impact on the habitations in nearby villages. However, efforts need to be made to reduce the noise generated by the various construction equipment. The various measures that could be implemented are as follows:

- Noise from air compressors could be reduced by fitting exhaust mufflers and intake mufflers.
- Chassis and engine structural vibration noise can be dealt by isolating the engine from the chassis and by covering various sections of the engines.
- Noise levels from the drillers can be reduced by fitting of exhaust mufflers and the provision of damping on the steel tool.
- Exposure of workers near the high noise levels areas can be minimized. This can be achieved by job rotation/automation, use of ear plugs, etc.

The effect of exposure of high noise levels on the workers operating the various construction equipment is likely to be harmful. It is known that continuous exposure to high noise levels above 90 dB (A) affects the hearing acuity of the workers/operators and hence, has to be avoided. To prevent the adverse impacts, the exposure to high noise levels should be restricted as per the exposure period suggested by Occupational Safety and Health Association (OSHA).

Greenbelt Development

It is proposed to develop greenbelt around the perimeter of Terminal/port area, colony etc. Sufficient budgetary provisions for its implementation shall be made.

Environmental Monitoring Programme

The Environmental Impact Assessment is basically an evaluation of future events. It is necessary to continue monitoring certain parameters identified as critical by relevant authorities under an Environmental Monitoring Programme. This would anticipate any environmental problem so as to take effective mitigation measures. An Environmental Monitoring Programme will be formulated for implementation during project construction and operation phases shown in table 9.16

Table 9.16 Environmental Monitoring Programme

Sl. No.	Environmental Attributes	Parameters	Monitoring Frequency	Unit	Agency Responsible for Action
1.	Ambient Air Quality	$PM_{2.5}$, PM_{10}, CO, SO_2, NO_2 *etc.*	24 Hourly sampling (Day & Night time) to be done at each location.	Per Sample with various parameters	Govt. of Gujarat or Designated Agency
2.	Water Quality monitoring	***Physical Properties:*** pH, Temp., DO, Conductivity, ***Chemical Properties:*** TSS, Alkalinity, Hardness, BOD, COD, NO_3, PO_4, Cl, SO_4, Na, K, Ca, Mg, Silica, Oil & grease, Phenolic compounds, Residual Sodium Carbonate. ***Bacteriological Properties:*** Total Coliform.	Surface and ground water to be monitored separately	Per Sample with various parameters	
3.	Noise Quality monitoring	Day & Night Time monitoring to be done at each location	24 Hourly sampling (Day & Night time) to be done	Per Sample with various parameters	
4.	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.	Per Sample with various parameters	
5.	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 at this stage.	-	

9.18 Applicable Legal and Regulatory Framework

9.18.1 Legislations formulated by the Govt. of India for 'Environmental Safeguards'

- *The National Waterway Act, 2016.*
- *The Environment (Protection) Act, 1986 with applicable Rules/Legislation.*
- *The EIA Notification, 14th Sep., 2006 and its latest amendments up to 2017.*
- *The Water (Prevention and Control of Pollution) Act and Rules, 1974 & 1975.*
- *The Air (Prevention and Control of Pollution) Act, Rules and Amendments, 1981, 1982, 1983 & 1987;*
- *The Municipal Solid Waste (Management and Handling) Rules, 2000.*
- *The Hazardous Waste (Management and Handling) Rules, 2008.*
- *The Forest (Conservation) Act, 1980 Forest Conservation Rules, 1981.*
- *The Wildlife (Protection) Act, 1972.*
- *The Wildlife (Protection) Amendment Act, 2006 and Bill, 2013.*
- *The Biodiversity Act, 2002.*
- *The Wildlife Conservation Strategy, 2002.*
- *The Disaster Management Act, 2005.*
- *The Wetlands Rules, 2010.*
- *The Ancient Monuments, Archaeological Sites and Remains Act, 2010*
- *CRZ Notification 2011*

9.19 Need for Environmental Clearance

Environmental clearance is required due to the demolition and construction of structures like bridges. However for maintenance dredging Environmental clearance is not required as per Notification issued By GoI dated 21 Dec 2017 "Non-requirement of Environmental clearance for maintenance dredging for the purpose of navigation"(Office Memorandum of MoEF & CC enclosed in Page No. 253-255).

9.20 Other Major Clearances / Approvals / Permits Applicable to the Project

- Coastal Regulation Zone(CRZ) Govt. of Gujarat
- Environmental Clearance from MoEF & CC
- Consent to Establish and Operate from state pollution control board, Gujarat
- National Board on Wildlife (NBWL)
- Gujarat Maritime Board

9.21 Cost Implications

As per the scope of services for further environmental and social impact assessment (EIA & SIA) studies and requirement of obtaining all mandatory statutory clearances for the project approximately 1 to 1.5 year is adequate period for consultancy services (1 year for non-CRZ and 1.5 year for CRZ waterways) related to EIA & SIA studies. In this regard, the project authority may engage to QCI/NABET accredited

EIA consultant for Category – A projects, who shall conduct rapid EIA & SIA studies and shall prepare a stand-alone EMMP (EMP & EMoP) for inclusion in the contractor bid documents. The generation of environmental baseline data at pre-construction stage along with environmental monitoring during construction and operation stages shall be carried out by the NABL/MoEF&CC approved laboratory to assess the project performance during entire project cycle.

The estimated cost for conducting EIA-EMP & SIA studies along with obtaining all mandatory statutory clearances at pre-construction stage and timely and effective implementation of EMMP (EMP & EMoP) during construction and operation stages have been described in the following sections:

9.21.1 Estimated Cost at Pre-Construction Stage

As, the statutory fee shall be paid by the project authority for obtaining all mandatory statutory clearances. The estimated environmental and social budget for EIA & SIA studies have been summarized below:

Table – 9.17: Summarized estimated cost for Consultancy Services -Pre-construction

Sl. No.	Particulars of Estimated Budget	Amount	Remark (if any)
1.	Salary of 12 Professionals/Domain Experts on intermittent based input (as per QCI/NABET scheme)	50 Lakhs	Lump-sum cost on intermittent basis ranging 2-5 months
2.	Cost of one Time Baseline Data Generation at Pre-Construction Stage	5.90 Lakhs	To be done for one season (**Table – 9.18**).
3.	Public / Stakeholders Consultation Meeting	5 Lakhs	Lump-sum cost
4.	Reports / Document Printing	1 Lakhs	Lump-sum cost
5.	Travelling Cost for Site Visits (Bus, Taxi, Boat etc.)	3 Lakhs	Lump-sum cost
6.	Lodging & Boarding Cost	3 Lakhs	Lump-sum cost
7.	Cost for collection of metrological data and other information like Maps	1 lakhs	Lump-sum cost
	Grand Total (Rs)	**68.90 Lakhs**	

In words: (i) *Rs. Sixty eight lakhs ninety thousand only*

Note: No. of Key Experts: 12 as per QCI/NABET Scheme on intermittent basis. Which may increase or decrease by the project proponent as per actual scope of work.
(i) Above consultancy Fee is without GST
(ii) The breakup of Sl. No. 2 is given in Table 9.18.

Table – 9.18: Estimated Sub-Cost for One Time Baseline Data Generation at Pre-Construction Stage

Sl. No.	Environmental Attributes	Parameters	Monitoring Frequency	Unit	No. of Tentative Locations	Unit Rate (Rs)	Amount (Rs)
1.	Ambient Air Quality	$PM_{2.5}$, PM_{10}, CO, SO_2, NO_2 *etc.*	24 Hourly sampling (Day & Night time) to be done at each location.	Per Sample with various parameters	10	15,000	150000
2.	Water Quality monitoring	***Physical Properties:*** pH, Temp., DO, Conductivity, ***Chemical Properties:*** TSS, Alkalinity, Hardness, BOD, COD, NO_3, PO_4, Cl, SO_4, Na, K, Ca, Mg, Silica, Oil & grease, Phenolic compounds, Residual Sodium Carbonate. ***Bacteriological Properties:*** Total Coliform.	Surface and ground water to be monitored separately	Per Sample with various parameters	10	10,000	100000
3.	Noise Quality monitoring	Day & Night Time monitoring to be done at each location	24 Hourly sampling (Day & Night time) to be done	Per Sample with various parameters	10	6,000	60000
4.	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.	Per Sample with various parameters	10	8000	80000
5.	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 at this stage.	-	10	20,000	200000
	Sub-Total (Baseline Environmental Data Generation Cost)						**5,90,000**
				In Words: *Rs. Five Lakhs ninety thousand only.*			

Note: Proposed length of NW-66 (River Mahi) is 246.9 Km / @ 25 Km/station = tentatively 10 Locations will be monitored

9.21.2 Estimated Cost for Construction Stage

The civil work contractor during construction stage shall depute a well experience environmental & safety Officer (ESO), who shall conduct Environmental Monitoring at Construction Stage as per stipulated conditions in the contractor documents. He/she shall also prepare environmental monitoring report to be submitted timely to the project proponent and statutory authorities as per project requirement.

Table-9.19: Estimate Environment Management during Construction

Sl. No.	Particulars of Estimated Budget	Cost (Rs. Lakhs)	Remark (if any)
1.	Environmental Monitoring Cost at Construction Stage.	17.70	To be done one season for three years (**Table –9.20**)
2.	Solid Waste Management	5	Lump-sum cost
3.	Sanitary facilities at labour camps	5	Lump-sum cost
4.	Greenbelt Development nearby terminal Premises by Contractor	5	Lump-sum cost
5.	Purchase of noise meter	1	Lump-sum cost
6.	Water tanker with sprinkler	6	Lump-sum cost
7.	Disaster Management Plan	4	Lump-sum cost
	Total (Lakhs)	**43.70**	
	In Words: *Rs. Forty Three lakhs seventy thousand only*		

Table – 9.20: Environmental Management Cost for Construction Stage

Sl. No.	Environmental Attributes	Parameters	Monitoring Frequency	Unit	No. of Tentative Locations x Years	Unit Rate (Rs.)	Amount (Rs.)
1.	Ambient Air Quality	PM $_{2.5}$, PM_{10}, CO, SO_2, NO_2 *etc.*	24 Hourly sampling (Day & Night time) to be done at each location.	Per Sample with various parameters	10x3=30	15,000	4,50,000
2.	Water Quality monitoring	***Physical Properties:*** pH, Temp., DO, Conductivity, ***Chemical Properties:*** TSS, Alkalinity, Hardness, BOD, COD, NO3, PO4, Cl, SO4, Na, K, Ca, Mg, Silica, Oil & grease, Phenolic compounds, Residual Sodium Carbonate. ***Bacteriological Properties:*** Total Coliform.	Surface and ground water to be monitored separately	Per Sample with various parameters	10x3=30	10,000	3,00,000
3.	Noise Quality monitoring	Day & Time time monitoring to be done at each location	24 Hourly sampling (Day & Night time) to be done	Per Sample with various parameters	10x3=30	6,000	1,80,000
4.	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.	Per Sample with various parameters	10x3=30	8000	2,40,000
5.	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 at this stage.	-	10x3=30	20,000	6,00,000
	Sub-Total (Baseline Environmental Data Generation Cost)						**17,70,000**
	In Words: *Rs. seventeen lakhs seventy thousand only*						

9.21.3 Estimated Cost at Operation Stage

Like preconstruction stage, the environmental monitoring and supervision to be done by the project proponent.

Table-9.21: Estimated Environmental Management cost during Operational Stage

Sl. No.	Particulars of Estimated Budget	Cost (Rs. Lakhs)	Remark (if any)
1.	Environmental Monitoring Cost at Operational Stage once in a year.	5.9	To be done for one season as per Table-9.18 given above.
2.	Solid Waste Management	2.5	Lump-sum cost
3.	Maintenance of Greenbelt Development nearby terminal Premises by Contractor supervision	2.0	Lump-sum cost
	Total (Lakhs)	**10.40**	Per year

9.21.4 Summary of Estimated Environmental & Social Environmental Budget

This covers the consultancy fee at pre-construction stage along with implementation of EMMP (EMP & EMoP) during construction and operational stages of the project. The statutory fee along with the cost of private and government land acquisition shall be borne by the project proponent. This has been summarized in Table given below:

Table-9.22: Summary of Estimated Environmental & Social Costs for various Stages

Sl. No.	Project Stages	Cost (Rs.Lakhs)
1.	Pre-Construction Stage	68.90
2.	Construction Stage	43.70
3.	Operational Stage	10.40
Total Estimated Budget (Except Statutory Fee & Land Acquisition & R&R Costs)		**123.00**

Hence Total Cost say 123 Lakhs.

* The basis of cost is on our previous experiences of the project but the actual cost will be based on the Approved TOR by MoEF & CC.

Note:-

- The EMP should be available at each project location along with availability of all safety PPEs to each worker and First-Aid facility should be easily approachable for all staff.The contractor should also provide separate toilet facility for male and female workers at site.
- Contractor will take prior all the necessary clearances for setting of labour colony near project sites.

Letter to Additional Principal Conservator of Forests, Gandhinagar

वाप्कोस लिमिटेड
WAPCOS LIMITED
(भारत सरकार का उपक्रम)
जल संसाधन, नदी विकास व गंगा संरक्षण मंत्रालय
(A Government of India Undertaking)
Ministry of Water Resources, River Development & Ganga Rejuvenation

ISO 9001 : 2008
- Consultancy Services
- Engineering, Procurement & Construction (EPC)

NO: WAP/P&H/GUJ/ENVR/APR/2017

Date: 06.04.2017

To,
The Additional Principal Chief Conservator of Forests,
D&M
Aranya Bhawan,Block B,3rd Floor,Sector-10/A,
Gandhinagar
Phone:-079 23254135
E-mail:gj050@ifs.nic.in

Sub: Requirement of Environment baseline data for Two Stage DPR of Proposed 04 Inland Waterways in the State of Gujarat & Maharashtra for official use.

Sir,

Ministry of Shipping (MoS), Govt. of India had directed IWAI to identify the viable waterways In India for their phased development; accordingly, 106 new waterways were identified and intimated to MoS. These rivers are in the process of being declared as National Waterway and a bill to this effect has already been passed in the lok Sabha during this winter season. Inland Waterways Authority of India (IWAI) a statutory body under the Ministry of Shipping, Govt. of India has been entrusted with the responsibility for conducting preparation of Detailed Project Report of the proposed waterway.

In order to assess the latest hydro-morphological condition of the rivers, IWAI has awarded the work of preparation of DPR s to M/s WAPCOS LIMITED is a "MINI RATNA-Category I" Public Sector Enterprise under the aegis of the Union Ministry of Water Resources, River Development & Ganga Rejuvenation for below mentioned river

Sl. No.	Name of the River / Canal	Name of the River / Canal Description of Inland Waterway
1.	MAHI RIVER	248 kms length of the river from Kadana Dam at Lat 23°18'22.35"N, Long 73°49'37.45"E to confluence with Gulf of Khambhat near Kavi railway station at Lat 22°10'34.71"N, Long 72°30'36.31"E Baseline Data of 25km from both side of river bank.

76-C, Institutional Area, Sector - 18, Gurgaon - 122 015 (Haryana), INDIA
Tel. : +91-124-2399421 • Fax : +91-124-2397392
E-mail : ho@wapcos.co.in ; mail@wapcos.co.in • Website : http://www.wapcos.co.in
CIN : U74899DL1969GOI005070

2.	NARMADA RIVER	227 km length of the river from Pandhariya at Lat 21°57'10.37"N, Lon 74° 8'27.46"E to confluence of Narmada with Arabian Sea at Gulf of Khambhat Lat 21°38'26.81"N, Lon 72°33'28.24"E Baseline Data of 25km from both side of river bank.
3.	TAPI RIVER	436 kms length of the river from Hatnur Dam near Mangalwadi at Lat 21° 4'21.99"N,Long 75°56'44.88"E to confluence with Gulf of Khambhat (Arabian Sea) at Lat 21°2'15.51"N, Long 72°39'29.63"E Baseline Data of 25km from both side of river bank.

The following data is required for the Project

Terrestrial Ecology

- Description on forest type
- Checklist of floral species
- Forest map covering the study area
- Name and location of Reserve/Protected Forest, Mangrove etc

Wildlife

- Checklist of wild life including Mammals, Reptiles, butterfly, Avifauna etc Major threat to wild life.if any
- Map of migratory path of wild animals if any
- Name and location of National Park/Wildlife Sanctuary etc

It is therefore requested to kindly provide the below required

Thanking you and with best regards,

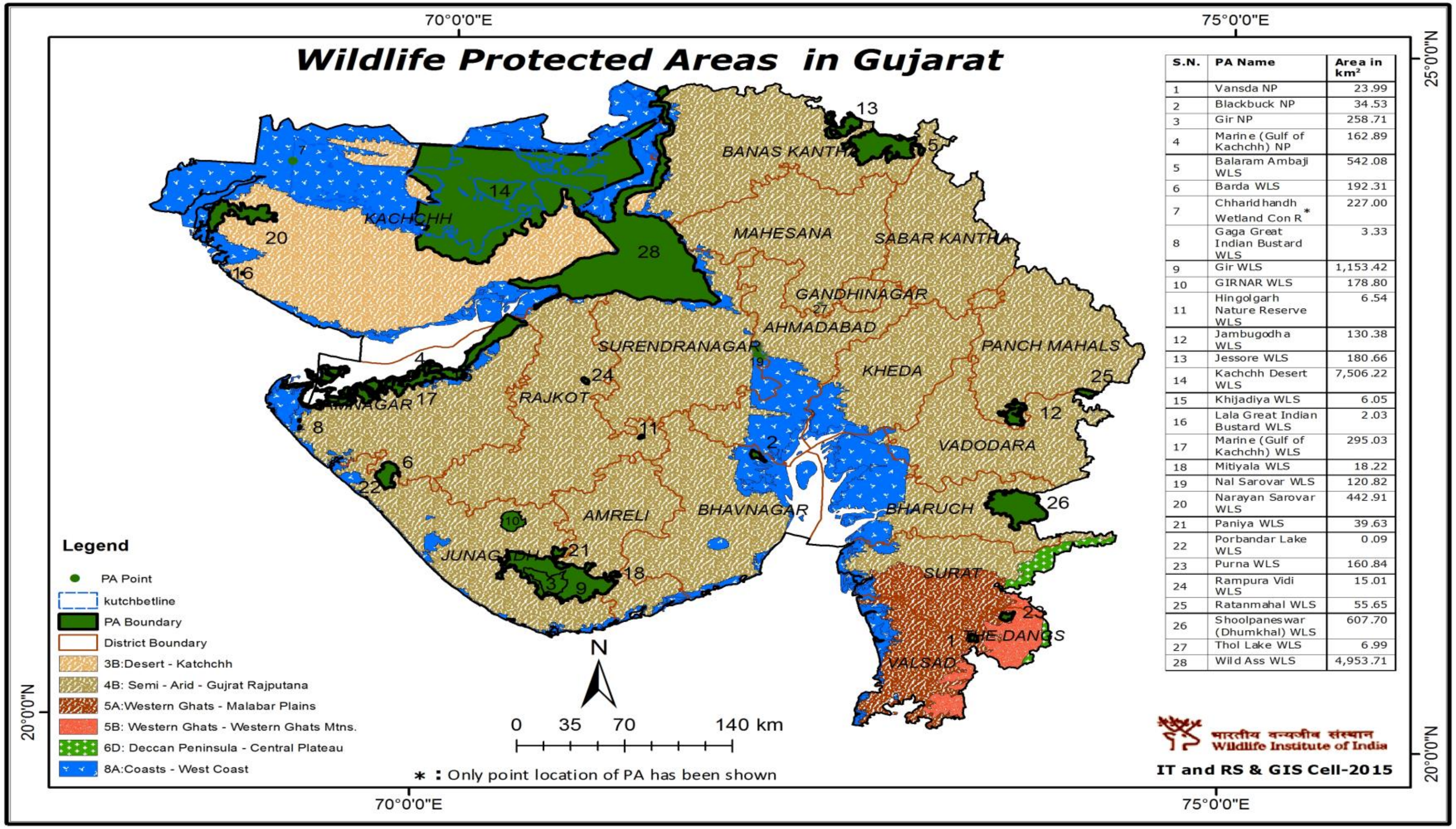
Yours truly,

Jatinder Kumar
Chief Engineer(Ports&Harbour)
WAPCOS Limited
Email:-Ports@wapcos.co.in

जतिन्द्र कुमार / JATINDER KUMAR
मुख्य अभियंता (प. एवं बं.) / Chief Engineer (P&H)
वाप्कोस लिमिटेड / WAPCOS LIMITED
(भारत सरकार का उपक्रम / A Govt. of India Undertaking)
76–सी, सैक्टर –18, गुड़गाँव–122015 (हरियाणा)
76-C, Sector - 18, Gurgaon -122015 (Haryana)

As per above letter regular follow ups were done with the department and our Team has collected the data from the concerned forest divisions.

Fig 9.13 Wildlife Protected Areas of Gujarat



S.N.	PA Name	Area in km²
1	Vansda NP	23.99
2	Blackbuck NP	34.53
3	Gir NP	258.71
4	Marine (Gulf of Kachchh) NP	162.89
5	Balaram Ambaji WLS	542.08
6	Barda WLS	192.31
7	Chharidhandh Wetland Con R*	227.00
8	Gaga Great Indian Bustard WLS	3.33
9	Gir WLS	1,153.42
10	GIRNAR WLS	178.80
11	Hingolgarh Nature Reserve WLS	6.54
12	Jambugodha WLS	130.38
13	Jessore WLS	180.66
14	Kachchh Desert WLS	7,506.22
15	Khijadiya WLS	6.05
16	Lala Great Indian Bustard WLS	2.03
17	Marine (Gulf of Kachchh) WLS	295.03
18	Mitiyala WLS	18.22
19	Nal Sarovar WLS	120.82
20	Narayan Sarovar WLS	442.91
21	Paniya WLS	39.63
22	Porbandar Lake WLS	0.09
23	Purna WLS	160.84
24	Rampura Vidi WLS	15.01
25	Ratanmahal WLS	55.65
26	Shoolpaneswar (Dhumkhal) WLS	607.70
27	Thol Lake WLS	6.99
28	Wild Ass WLS	4,953.71

OFFICE ORDER FOR NON REQUIREMENT OF ENVIRONMENT CLEARACE FOR DREDGIG IN RIVER

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.

21/12/17

Sharath Kumar Pallerla
Director

To

The Secretary,
Ministry of Shipping,
Parivahan Bhavan, 1, Parliament Street,
New Delhi - 110 001

Page 1 of 3

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.

Page 2 of 3

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.

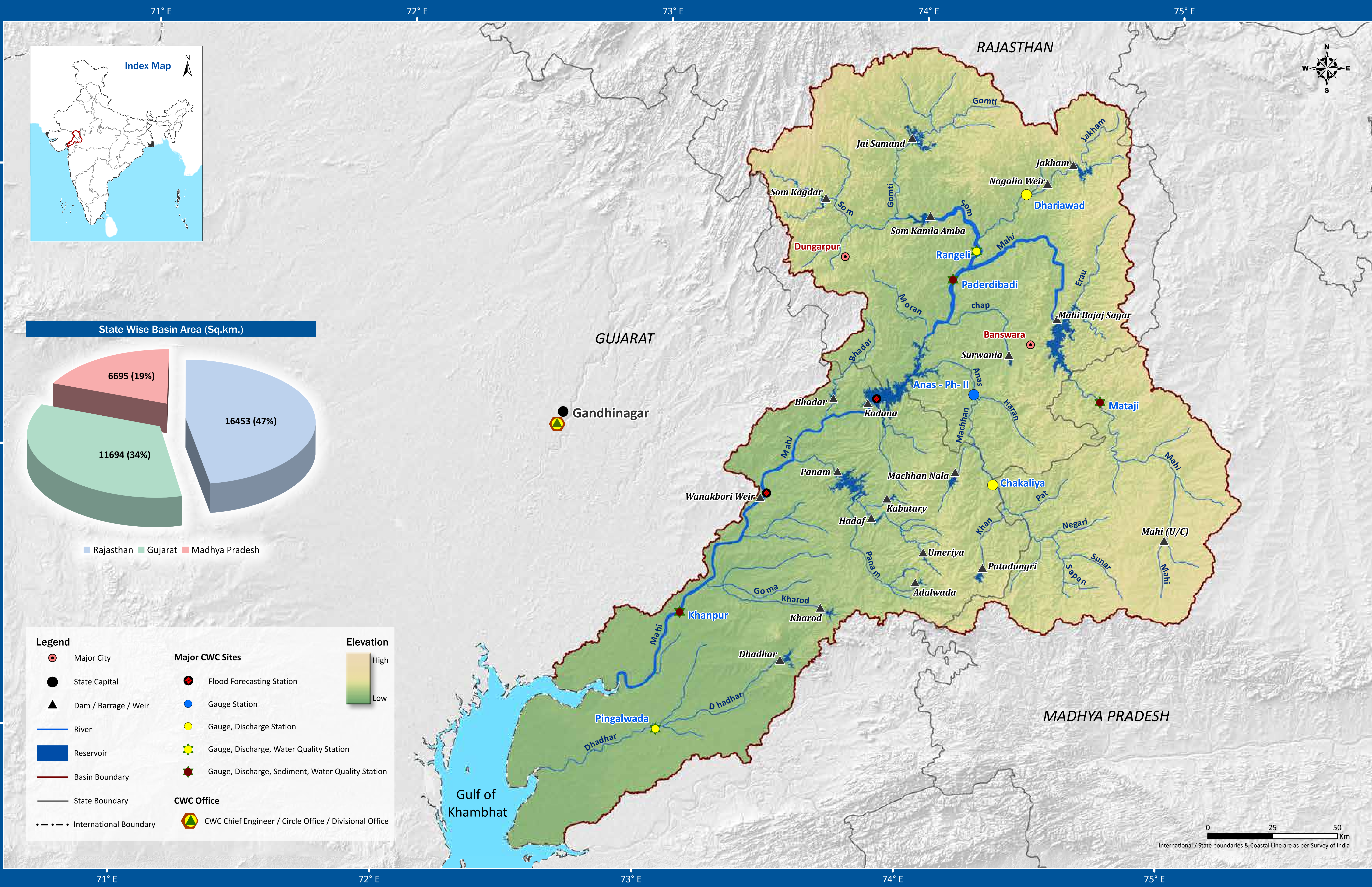
xxix. All safety measures are to be implemented in coordination with the respective state government departments such as State Forest Department, Public Works Department, State Pollution Control Board etc.

21/12/17

Sharath Kumar Pallerla
Director

Page 3 of 3

MAHI BASIN



71° E
72° E
73° E
74° E
75° E
24° N
23° N
22° N
Index Map
N
RAJASTHAN
GUJARAT
MADHYA PRADESH
Gandhinagar
Gulf of Khambhat
Jai Samand
Gomti
Jakham
Nagalia Weir
Dhariawad
Som Kagdar
Som
Som Kamla Amba
Dungarpur
Rangeli
Mahi
Paderdibadi
Erau
Moran
chap
Mahi Bajaj Sagar
Banswara
Surwania
Bhadar
Anas - Ph- II
Anas
Haran
Kadana
Mataji
Machhan
Panam
Machhan Nala
Chakaliya
Wanakbori Weir
Kabutary
Hadaf
Pat
Khan
Negari
Mahi (U/C)
Umeriya
Patadungri
Sunar
Sapan
Adalwada
Goma
Kharod
Khanpur
Dhadhar
Pingalwada
State Wise Basin Area (Sq.km.)
6695 (19%)
16453 (47%)
11694 (34%)
Rajasthan
Gujarat
Madhya Pradesh
Legend
Major City
State Capital
Dam / Barrage / Weir
River
Reservoir
Basin Boundary
State Boundary
International Boundary
Major CWC Sites
Flood Forecasting Station
Gauge Station
Gauge, Discharge Station
Gauge, Discharge, Water Quality Station
Gauge, Discharge, Sediment, Water Quality Station
CWC Office
CWC Chief Engineer / Circle Office / Divisional Office
Elevation
High
Low
0
25
50
Km
International / State boundaries & Coastal Line are as per Survey of India

CHAPTER –10

INSTITUTIONAL REQUIREMENTS

10.1 Organizational Set up / Establishment

The Authority envisaged is Navigational waterway maintenance, transportation enterprise dealing with passenger and cargo handling, transit and transfer as well as being an administrative unit and an organ of Government which implements Government policies. This organization should integrate administrative functions with operation, maintenance and development function and run this enterprise on sound Business Management Principals. The set up should also have jurisdiction and control over all other Government, Public and Private Vessel Operators on the Mahi River (NW-66)

Other Government, Public and Private Parties can be allowed to carry on their present business as usual but under the administrative control on IWAI which frames rules and regulations for such operation.

The conceptual set up of such organization is given in chart 10.1. This envisages setting up of Inland Waterway Authority construction and maintenance division for Mahi River with its headquarters at Vadodara.

The Inland waterways authority, GMB & DPT will specifically control and will be responsible for following in Mahi River (NW-66).

- Developing and maintaining navigable waterway.
- Enforcement of rules and regulations of IWT Act.
- Channel Patrol.
- River route survey
- Issue of river notices, river, chart, river warnings
- Rescue and salvage operations on route.
- River training and maintenance works such as bandalling, bottom – paneling, dredging, bank protection etc. required to the extent of maintaining navigable waterway.
- Registration of vessels and issue of certificate of survey (compulsory for any sailing vessel)
- Issuing certificate of competency to masters, seamen, watch-keeping officers, engineers and to all the crew members of the sailing vessel.
- Policing the waterway through patrol and police boats. Checking, catching and prosecuting offenders, cancellation of registration certificates and taking other appropriate legal action.
- Providing pilotage to vessels wherever required.

- Levy and collection of vessel registration fee which will be related to capacity of vessels and river route it travels. (Normally this levy will be related to river route development and maintenance expenditure).
- Operation and maintenance of terminals run by IWAI and collection of berthing, handling and storage charges.
- Operation and levy of pilotage charges on river route.
- Operation and maintenance of various vessels, equipments and other facilities owned by IWAI.
- Maintaining liaison with Gujarat Maritime Board, Deendayal Port Trust (DPT) and Inland Waterway Authorities to ensure smooth passage of vessels and loading / unloading of cargo.
- Purchasing new equipment/ floating craft as and when required.
- Planning and developing new terminals in Gujarat depending on traffic and additions to existing terminals, fleet and other facilities.
- Liaison with various concerned organization to ensure efficient functioning.
- Business development and expansion of facilities.
- Financial / administrative/ technical control of operations with a view to raise efficiency, reduce cost and accomplish better handling.

10.2 Man Power Requirement

Man power requirement for Development of waterway in Mahi River includes for terminal operations and departmental requirement. Departmental regional office will be set up at Surat. Every terminal will require institutional setup for proper functioning of terminal operations. Terminal manager will be the head at terminal responsible for overall terminal operations.

S.No.	Staff detail	No. of Personnel Required
1	TERMINAL MANAGER	2
2	ADM OFFICER	2
3	OPERATION MANAGER	2
4	MAINTENANCE MANAGER	2
5	SURVEYOR	2
6	Mechanical	4
7	Civil	4
8	Electrical	4
9	Office Staff	
10	Clerical Staff	4

S.No.	Staff detail	No. of Personnel Required
11	Security Staff	6
	Total (Nos.)	**32**

However, it is to be noted that River Mahi (NW-66) has been allocated to Deendayal Port trust (DPT) for development. In present case scenario, officer at level of assistant director and junior account officer at Head Office may be required to monitor various developments & monitoring of fund utilization.

10.3 Training Requirement / Capacity Building

Capacity Building is the process by which the Organization assesses and assists in sustainable development and improvement of the performance. Capacity Building involves more than training. It should be a strategy that involves a long time vision towards the enhanced production, modernization, and development of human resources leading to overall organizational objectives. In order to improve the efficiency of the navigation education & training in the field of inland navigation should be provided to the man power required.

Training Module

Dredging Technical Training
Safety training courses
Dredging management
Terminal Management & Operation Courses

10.4 Infrastructure

10.4.1 Immovable

Immovable infrastructure established includes Administrative building, Security office, Electrical substation, parking area etc.

10.4.2 Movable

Movable cranes, vehicles and survey boats will be required at terminal 2.

10.5 Cost Implications

Cost implication for establishing institutional requirement will include salaries of employees deployed at terminals, navigational lock and regional offices. Institutional setup required for operation and maintenance of waterway, locks and terminals. Capacity building through education and training to the staff and employees will also have cost implications. Average annual salary of top management is taken as Rs. 1600000. Average annual salary of officers and staff at Dy. Director, Terminal Mangers offices is taken as Rs. 700000.

Item	Quantity	Rate	Amount
Salaries(Top Management)	8	1600000	12800000
Middle Management	14	700000	9800000
Clerical Staff	4	400000	1600000
Unskilled	6	120000	720000
Misc	Lump sum		29904000
Total(Annual)			**54824000**

CHAPTER – 11

PROJECT COSTING

11.1 General and Financial Assumptions

The technical aspects of development of National Waterways for handling of the projected traffic are dealt with in the previous chapters. In the present chapter project cost estimates has been done. In order to arrive at capital cost for the proposal it is necessary to ascertain, for budgetary purposes, unit rates of materials used for construction, dredging etc. Accordingly, efforts were made to obtain the above information from the relevant sources.

Modification in existing cross structures has to be done for providing clear passage of vessels. Most of the bridges are not having vertical clearance in that case deck elevation of bridges may be raised by strengthening of piers and foundations. Bridges not having horizontal clearance may be modified as Cable Bridge. Bridges which are more than fifty years of age may be dismantled and reconstructed. New bridges should be constructed keeping in mind the guidelines for navigation of vessel in rivers. Navigational locks have been proposed at weir and barrages.

11.2 Basis of Costing

An estimate of the capital cost of various facilities is made. The cost arrived at are based on the budgetary quotes and the in-house data base available on cost estimates. The rates for various items of work have been prepared on the basis of current rates for various items of work prevailing in the region.

The items and costs have been arrived at broadly on the following:

- Rates taken from current works of similar nature
- Updated rates of work of similar nature completed in the recent past.
- Consultant's in house data bank of cost estimates and budgetary quotations.
- These are tentative cost for indicating the total project cost which is subject to verification/discussion.

Gujarat Maritime Board Schedule of Rate, 2013-14 has been followed and escalated by 5% per annum to arrive at 2018 for computation of cost. However, for dredging (2015-16) rates has been considered as substantial change has not been observed.

11.3 Fairway Development Cost

Development cost of waterway in Mahi River is given as below:

Capital Cost	In Crores
(I) Civil Cost	
Navigation Locks	45.56
Demolition & Reconstruction of bridges	559.51
Total	605.07
3% Contingencies and 7% Supervision charges on Base cost	60.51
Total civil Cost	**665.58**
(II) Navigation & Communication Cost	
DGPS	1.00
VTMS	1.00
Marine Lantern/Buyos (50 nos.)	1.00
RIS	14.30
Total Cost(II)	17.30
3% Contingencies and 7% Supervision charges on Base cost	1.73
Total Navigation & Communication Cost	**19.03**
(III) Dredging	
Dredging **(12.8 Mm3)**	**384.00**
Total Fairway Development Cost	**1068.61**

Table 11.1 Fairway Development Cost

11.4 Capital Expenditure

The estimate of capital cost is made for the various items of civil, mechanical, electrical and utilities works for the development of terminals in the waterway stretch, cost estimate is presented in Table11-2.

The capital cost worked out is excluding land cost for construction of terminals.

Capital Cost	In Crores
(I) Civil Cost	
Navigation Locks	45.56
Demolition & Reconstruction of bridges	559.51
Total	605.07
3% Contingencies and 7% Supervision charges on Base cost	60.51
Total Fairway Development Cost	**665.58**
Terminal Cost	
Sindhrot Tourist Jetty	10.00
Wanakbori Cargo Jetty	22.29
Storage Area(Including roads, warehouse, bio-toilets,ETP/STP, disposal	7.50

Capital Cost	In Crores
facilities, parking area etc)	
Total Cost(I)	39.79
3% Contingencies and 7% Supervision charges on Base cost	3.98
Total Civil Cost	**43.77**
(II) Navigation & Communication Cost	
DGPS	1.00
VTMS	1.00
Marine Lantern/Buyos (50 nos.)	1.00
RIS	14.30
Total Cost(II)	17.30
3% Contingencies and 7% Supervision charges on Base cost	1.73
Total Navigation & Communication Cost	19.03
(III) Handling Equipment & Utilities	
Mechanical & electrical	10.1
3% Contingencies and 7% Supervision charges on Base cost	1.01
Total Handling Equipment & Utilities Cost	**11.11**
Other cost including financing cost and interest during construction (10% of (I))	70.82
Total Cost (I)+(II)+(III)	**809.20**
(IV) Dredging	
Dredging **(12.8 Mm3)**	**384.00**
Total Cost	
Total Capital Cost	**1194.42**

Detailed BOQ for the capital cost estimate is given in Annexure-11.

Table 11.2 Capital Cost Estimate

11.5 Operation and Maintenance Expenditure

The annual operation and maintenance cost on different components of the project will be dependent on a number of variables such as the life of the component, repair and maintenance requirements, wages of crew of consumables, etc. Hence, accurate assessment of cost is not possible. Further even if all the variables are fixed such as the maintenance schedules for each structure and equipment is determined, crew strength is fixed, requirement of consumables quantified, etc., the estimation of O&M costs cannot be precise because of unpredictable breakdowns incurring considerable expenditure on repairs and replacement. The only practicable approach in this scenario is to fix the annual repair expenditure as a percentage of capital cost of project. This percentage is to be fixed on the basis of the past performance of similar structures and equipment functioning in the project or elsewhere under similar conditions.

Based on above criteria, the annual maintenance cost is estimated as a percentage and is presented in Table 11.3.

	O & M Cost	**In Crores**
(i)	Dredging @ 10%	38.40
(ii)	Civil works @ 1%	7.09
(iii)	Mechanical & Electrical Cost @ 5%	0.56
(iv)	Ports Crafts/Nav. Aids @ 5%	0.95
(v)	Fuel Cost	1.00
(vi)	Power Cost	2.00
(vii)	Manpower Cost	5.50
(viii)	Miscellaneous	0.5
	Total II	**56.00**

Table 11.3 Operation & Maintenance Cost

CHAPTER – 12
IMPLEMENTATION SCHEDULE

12.1 Time Frame

Time scheduling is the assigning of start dates and completion dates to the various activities that take place in project implementation. The important points to be noted to schedule the time are:

- The earliest time that an activity can start
- The latest time that an activity may be completed without delaying the project completion
- The leeway or float or degree of freedom available in scheduling an activity
- The resultant critical path

Before scheduling time of a project with different activities of work, following facts have been considered.

- Determination the parts or implementation phases of the project and the sequence in which the associated activities shall be carried out
- Then estimate the amount of time required for each activity
- List the activities that can be carried out at the same time and identify those to be carried out sequentially

Detailed time schedule is shown in **Annexure-12.1**. Total time of the project completion will be 3 years.

12.2 Phasing:

Phasing of activities has been done keeping importance of the event in project completion. However, ultimate aim was stick to early completion of project.

Phase-1: Fairway development

Activity 1: Demolition &Reconstruction of bridges

Activity2: Construction of Navigation locks

Phase 2: Construction of terminals & ancillary structures at following locations.

Activity	Terminal No.	Chainage	Purpose
Activity-1	Terminal 1: Sindhrot Tourist Jetty	80	Tourism
Activity-2	Terminal 2: Wanakbori Cargo Jetty near pali	150	Cargo

Phase 3: Dredging, Port Crafts &Navigational Aids

Activity 1: Dredging in all stretches

Activity 2: Purchase &installation of navigational aids

Sequence of all activities are shown in time schedule i.e. **Annexure 12.1.**

12.3 Suggested Implementation Mechanism

If the availability of funds with IWAI to implement e-governance initiatives is limited, IWAI can go for PPP models to implement these projects. PPP initiatives not only save the costs but also inject the much needed private sector efficiency in the government sector domain. While there is a need to create PPP deals, these need to be structured to ensure a win – win for all the stakeholders.

In the new regime, standard norms are prescribed for determining the investment and operational efficiency of the project. Target revenue is then calculated as the sum of operating cost, depreciation and an allowable return on capital employed. Target revenue is then categorized into revenue from various services based on estimated demand for each service. These ceiling tariffs are indexed to WPI and escalated year on year, there by removing the effects of varying demand on tariffs (as used to happen in the previous regime during tariff revisions).

Contractual Framework of PPP projects

- All intentions need to be set out in a contract
- Concession Agreement - bundle of rights & obligations and consequences in case of non-fulfilment
- Usually the only tangible security available
- Contracting parties : Government Agency – Concessioning Authority and Private Party – Concessionaire

- Other parties – state government, Lenders, Suppliers of services
- A concession is a license – rights enjoyed for obligations performed

Issues

- Striking a balance between differing concerns & objectives of parties
- Legislative Back up
- Rights and obligations of parties
- Identification and allocation of risks
- Penalties and rewards which would ensure performance

Design Phase

The Independent Engineer shall review the Designs and Drawings submitted by the Concessionaire and provide its comments/observations and suggestions on the same within 21 (twenty one) Days from the date of the receipt of such Designs and Drawings.

In the event that the Independent Engineer has observed that the designs and drawings are not in conformity with the Project Requirements, the Concessionaire shall promptly and without any undue delay revise and resubmit the Designs and Drawings or satisfy the Independent Engineer with regards its compliance.

If the Independent Engineer does not make any observation/comments with respect to the Designs and Drawings submitted to it by the Concessionaire within 21 (twenty one) Days of the submission, it shall be deemed that the Independent Engineer has no suggestions to make with respect to the Designs and Drawings and the Concessionaire shall be entitled to proceed with the Project accordingly.

The Concessionaire shall not be entitled to any extension of time for completing construction or any other relief on account of delay caused due to providing any clarification or in resubmitting the Designs and Drawings. Provided however the Concessioning Authority at its sole discretion may suitably extend the Construction Phase or provide other relief to compensate for any such delay not attributable to the Concessionaire.

Notwithstanding the review by the Independent Engineer, the Concessionaire shall be solely responsible for any defect and/or deficiency in the Designs and Drawings relating to the Project or any part thereof and accordingly the Concessionaire shall at all times remain responsible for its obligations under this Agreement.

Any review of the Designs and Drawings conducted by the Concessioning Authority is solely for the Concessioning Authority's own information and that by conducting such review, the Concessioning Authority does not accept any responsibility for the same.

The Concessionaire shall in no way represent to any Person that, as a result of any review by the Independent Engineer, the Concessioning Authority has accepted responsibility for the engineering or soundness of any work relating to the Project/ the Project Facilities and Services or part thereof carried out by the Concessionaire and the Concessionaire shall, in accordance with the provisions of this Agreement, be solely responsible for the technical feasibility, operational capability and reliability of the Project/ the Project Facilities and Services or any part thereof.

12.3.1 Construction Phase

The Concessionaire shall promptly commence and complete the works, including installation of equipment in accordance with the Project Schedule and shall also obtain from the Independent Engineer a certificate as to completion of construction of Project Facilities and Services

During the Construction Phase, the Concessionaire shall:

- Arrange for, in a timely manner all necessary financial and other resources required for construction and installation of the Project Facilities and Services.
- Engage professionally competent Persons for project management and construction and ensure that all works are carried out in compliance with the Construction Standards;
- Give written notice to the Concessioning Authority within 7 (seven) Days of any material modification or change to any of the Financing Documents and/or any Equity Documents and shall simultaneously therewith also furnish copies of such modified/ amended documents to the Concessioning Authority. Provided no such modification/amendment will be made if it in any manner whatsoever has the effect of imposing an additional financial obligation or increasing the financial obligation of the Concessioning Authority in addition to that contemplated under the Financing Documents provided on Financial Close, without the prior written consent of the Concessioning Authority. For avoidance of doubt any such modifications/amendments made without the prior written consent of the Concessioning Authority will not be enforceable against the Concessioning Authority;
- Obtain Applicable Permits, comply with Applicable Laws and Applicable Permits and give priority to safety in its construction and planning activities in order to protect life, health, property and environment;

- Provide to the representative(s) of the Concessioning Authority, at reasonable times and upon prior intimation, access to the Project Site to review progress in construction and to ascertain compliance with any of the requirements of this Agreement. Provided that non-inspection by the Concessioning Authority of any works shall not, in relation to such works,
- Amount to any consent or approval by the Concessioning Authority nor shall the same be deemed to be waiver of any of the rights of the Concessioning Authority under this Agreement; and (ii) release or discharge the Concessionaire from its obligations or liabilities under this Agreement in respect of such work;
- Provide monthly reports on the progress of Construction Works or such other relevant information as may be required by the Independent Engineer;
- Promptly carry out at its cost such further works as may be necessary to remove any defects or deficiencies observed by the Independent Engineer and ensure timely completion of construction of the Project / the Project Facilities and Services in all respects in accordance with the provisions of this Agreement; and
- to ensure safe and timely construction and completion of the Project/Project Facilities and Services, the Concessionaire may, at its cost, interrupt and divert/create barriers on the flow of water or on the road or port traffic, adjacent to the Project Site if such interruption and diversion is imperative for the efficient progress of Construction Works and conforms to Good Industry Practice; provided that such interruption and diversion shall be undertaken by the Concessionaire only with the prior written approval of the Independent Engineer which approval shall not be unreasonably withheld. For the avoidance of doubt, it is agreed that the Concessionaire shall at all times be responsible for ensuring safe operation of Construction Works and shall remove the interruption or diversion within the period specified by the Independent Engineer.

12.3.2 Operations & Maintenance

The Concessionaire shall manage, operate, maintain and repair the Project Facilities and Services, entirely at its cost, charges, expenses and risk in accordance with the provisions of this Agreement. The Concessionaire’s obligations shall include but shall not be limited to the following:

(i) Berth and Terminal Operations:

The Concessionaire shall:

- Promptly commence operations upon the Project Facilities and Services being declared by the Concessioning Authority as ready for operations;
- Make efforts to maximize cargo handled so as to achieve optimal utilization of the Project Facilities and Services;
- Ensure compliance of the Project Facilities and Services at least with the Project Requirements;

- Ensure compliance of the Project Facilities and Services at least with the Performance Standards;
- Ensure that the Project Facilities and Services shall adhere to the Operations and Maintenance Standards and SafetyStandards and there is safe, smooth and uninterrupted flowof traffic normal operating conditions;
- Minimize disruption to traffic in the event of accidents or other incidents affecting the safety and use of the Project Facilities and Services by providing a rapid and effective response and maintaining liaison with emergency services of the Concessioning Authority or other agencies;
- Make available all necessary financial, technical, technological, managerial and other resources for operation, maintenance, repair and replacement of the Project Facilities and Services in a timely manner;
- Except for the priority and preferential berthing that may be authorized in terms of guidelines issued by the Government from time to time, manage and operate the Project Facilities and Services on a first come - first serve, common-user basis, open to any and all shipping lines, importers, exporters, shippers, consignees and receivers, and refrain from indulging in any unfair or discriminatory practice against any user or potential user thereof;
- Ensure maintenance of proper and accurate record/data/accounts relating to operations of the Project Facilities and Services and the revenue earned there from;
- Obtain, maintain and comply with Applicable Permits and comply with the Applicable Laws including those relating but not limited to dock side safety, health, environment and labour;
- Subject to the provisions of this Agreement, perform, undertake or provide, in connection with the Project, all services which the Concessioning Authority is authorized to perform, undertake or provide under the provisions of the MPT Act; and
- Prevent, with the assistance of concerned law enforcement agencies, any encroachment or unauthorized use of the Project Facilities and Services.

12.3.4 Repairs, Maintenance and Replacement

The Concessionaire at its own cost promptly and diligently maintain, replace or restore any of the project facilities or part thereof which may be lost, damaged, destroyed or worn out.

While carrying out the repairing, maintaining and replacing the project facilities, the Concessionaire acknowledges and accepts that it is holding and maintaining the concession or assets, project facilities in trust for eventual transfer to the Concessioning Authority on termination of the agreement and therefore, will not do any act as a result of which the value of Port Assets and Project Facilities and Services is diminished.

The Concessionaire shall, at all times during the Concession Period, at its own risk, cost, charges and expenses, performance and pay for maintenance repairs, renewals and replacement of various type of assets and equipment in the concessionaire premises and /or the project or any parts thereof, whether due to use and operations or due to deterioration of materials and /or parts, so that on the expiry or termination of Concession, the same shall except normal wear and tear be in good working condition as it were at the time of commencement of the Concession.

While carrying out the repair, maintenance and replacement of the project facilities, the Concessionaire shall carry out the work in accordance with the manufacturer's recommendations and the relevant latest Indian Standards or in its absence ISO/OISD Standards. In the event that the concessionaire, by necessity or otherwise need to follow any other country standard and it shall be equal or superior to the standard specified above.

The repairs and maintenance shall generally conform to the following specifications.

E.1 Maintenance Standards

ISO 4308-1-2003	Maintenance of lifting appliances
ISO 4309-2004	Cranes wire rope care, maintenance and discard
IS 13367: Part 1: 1992	Safe use of cranes – Code of Practice Part 1 General
BS 7121-2-2003	Code of Practice for safe use of cranes, inspection, testing & examination
BS 7121-4-1997	Code of Practice for safe use of cranes (Lorry Loaders)
BS 7121-5-2006	Code of Practice for safe use of cranes (Tower Cranes)

12.3.5 Safety Standards

The Concessionaire shall ensure compliance with the safety standards set out under Applicable Law/international conventions, as relevant, from time to time including those required under the following:

- Dock Workers (Safety, Health and Welfare) Act, 1986 & Regulations framed thereunder of 1990.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
- The Petroleum Act, 1934 along with the Petroleum Rules, 2002.
- OISD – Guidelines – 156 (Oil Industry Safety Directorate): Fire Protection Facilities for Port Oil Terminals.
- The Explosives Act, 1884 along with The Explosive Substance Act, 1983 & The Explosive Rules, 1983
- Guidelines by Fire Advisor, CCE & DG FASLI, Government of India
- National Fire Codes (National Fire Protection Association – USA)
- Drill Manual for the Fire Services of India.
- International Safety Guide for Oil Tankers & Terminals.
- ISPS (International Ship & Port Facility Security) Code (2003 Edition)
- MARPOL CONVENTION
- International Maritime Dangerous Goods Code

CHAPTER – 13
ECONOMIC AND FINANCIAL ANALYSIS

Cost-benefit analysis

Cost-benefit analysis (CBA), sometimes called benefit-cost analysis (BCA), is an economic decision-making approach, used particularly in government and business. CBA is used in the assessment of whether a proposed project, programme or policy is worth doing, or to choose between several alternative ones. It involves comparing the total expected costs of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

In CBA, benefits and costs are expressed in money terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "present value." This is often done by converting the future expected streams of costs and benefits into a present value amount using a suitable discount rate.

13.1 Revenue

A major source of revenue should arise from the coal, fly ash and clinker. Their traffic projection is given in the table below.

Mahi Phase-1 (Fig in Lakhs)						
Cargo - Coal, Flyash and Clinker	**FY 20**	**FY 25**	**FY 30**	**FY 35**	**FY 40**	**FY 45**
Wharfage Charges	686	2548	3234	3920	4508	5488
Berth Hire Charges	13.16	48.88	62.04	75.2	86.48	105.28
Mooring Charges	1.96	7.28	9.24	11.2	12.88	15.68
Cargo related revenue	**701.12**	**2604.16**	**3305.28**	**4006.4**	**4607.36**	**5608.96**

Table 13.1 Traffic Projections for various terminals

13.2 Possible ancillary revenue

As far as now, there is no possible ancillary revenue.

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. Economic and Financial analysis shall be carried out for the feasible stretches.

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.

Capital costs generally involve:

- Land acquisition,
- Dredging,
- Bridges,
- Civil works,
- E & M works
- Navigational aids

Economic benefits

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, Traffic Jam & Pollution etc.

Shadow Pricing

The value of Project cost and benefits have been expressed in terms of market prices. These prices do not reflect the real resource cost and value of benefits derived from the project to the economy. The market prices are distorted due to variety of factors. These factors could be controlled/administered prices of inputs, monopolistic market of inputs, Tax structure etc. The factors used for converting project inputs and outputs to economic costs are given in following Table:

Table 13.2 Shadow Pricing

S. No	ITEM	FACTOR
1	Capital Cost	0.67

Considering life of project to be 30 years, the ***EIRR analysis*** is shown in table 13.3:

Cases considered	EIRR
Phase 1	13.74 %

Table 13.3 EIRR Analysis

Total Economic benefits are shown below;

YEAR	Fuel savings	*Caron Credit*	*Other Benefits*	*Emp benefits*	
	Rs lakhs	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*
					0
					0
					0
2022	2248	77	1496	507	4328
2023	2248	77	1496	507	4328
2024	2248	77	1496	507	4328
2025	2248	77	1496	507	4328
2026	8349	285	5558	1885	16076
2027	8349	285	5558	1885	16076
2028	8349	285	5558	1885	16076
2029	8349	285	5558	1885	16076
2030	8349	285	5558	1885	16076
2031	10597	361	7054	2392	20404
2032	10597	361	7054	2392	20404
2033	10597	361	7054	2392	20404
2034	10597	361	7054	2392	20404
2035	10597	361	7054	2392	20404
2036	12845	438	8550	2900	24732
2037	12845	438	8550	2900	24732
2038	12845	438	8550	2900	24732

YEAR	Fuel savings	*Caron Credit*	*Other Benefits*	*Emp benefits*	
	Rs lakhs	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*
2039	12845	438	8550	2900	24732
2040	12845	438	8550	2900	24732
2041	14772	503	9833	3335	28442
2042	14772	503	9833	3335	28442
2043	14772	503	9833	3335	28442
2044	14772	503	9833	3335	28442
2045	14772	503	9833	3335	28442
2046	17983	613	11970	4059	34625
2047	17983	613	11970	4059	34625
2048	17983	613	11970	4059	34625

13.4 Financial Analysis / FIRR

For projects involving heavy investment, it becomes very important to analyze the benefits of owner i.e. IWAI/ Govt. & users, i.e. Barge/ ship operators who would use the IWT facility as compared to other modes of transport. FIRR shall be evaluated for IWAI/ Government and Users (barge / Ship operators).

FIRR for IWAI / Govt.

The financial analysis shall be carried out to drive possible levy charges per tonne kilometer of cargo transported through IWT that IWAI / Govt may levy to recover the costs of project from users. For calculations, economic cost along with cargo projection shall be considered for various scenarios.

FIRR for Barge/Ship operators

The development of waterway that include heavy investments is completely defined and meaningful if the user or Barge operator is getting minimum financial benefits as compared to other modes and is therefore attracted to invest money and time. The total cost to be invested by the barge operator may be classified as Capital cost and Operation and maintenance cost (O & M cost)

Capital/Initial cost depends upon the infrastructure proposed and depicts the future planning. A high initial cost may act as burden on the operator and therefore phase-wise development of all infrastructure and allied facilities shall be proposed.

The running profits are usually governs by less operating cost and operational viability. Operating viability depends upon various factors as:

- Vehicle costs,
- Fuel costs
- Crew costs / Administrative expenses
- Repair and Maintenance costs
- Loading Unloading costs
- Cost of insurance
- Manpower cost

Considering life of project to be 30 years, the ***FIRR analysis*** is shown in table 13.4:

Charges of using the channel	FIRR
Rs 1 per tonne	Negative value

Table 13.4 FIRR Analysis

Detailed calculation is shown in **Annexure 13**

13.5 Risk Factors

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 (e.g., 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.

13.7 SWOT Analysis

Strength	**Weakness**
• Presence of industrial conglomerates like General Motors India Pvt. Ltd, Maruti Koatsu Pvt. Ltd, Inox India Ltd., Amul Dairy Co-operatives, Reliance, Indian Oil in the districts near river bank. • Dahej Port is located at the gulf of khambat. • More environment friendly mode of transport, reduces carbon footprint and decongestion of existing road and rail traffic.	• No navigational locks on existing Check dam/ Weir/ Barrage / Dam • Bridges without sufficient horizontal & vertical clearance • No Intermittent Traffic • Lack of awareness among people regarding IWT.
Opportunities	**Threats**
• Possibility of Tourism, recreational and local ferry services. • Opportunities for cargo movement of Coal & Fly ash. • Socio-Economic development of nearby project areas.	• During period of high tidal range, tidal bores appear at outfall which causes bank erosion. • Social problem have been faced during reconnaissance survey. • Presence of important ICMBA in the Estuary

Chapter – 14
Conclusions & Recommendations

14.1 Conclusions & Recommendations:

WAPCOS has proposed two terminal locations one at Sindhrot and at 2nd at Wanakbori on the basis of traffic potential. The details of these terminals are given below:

Terminal	Location	Type	Land details	Chainage
Terminal 1	Sindhrot Tourist Jetty	Floating	Govt. land	80 Km
Terminal 2	Wanakbori Cargo Jetty	Fixed	Govt. land	150 Km

There are following hindrances in Mahi River due to which the River is not feasible for navigation:

1) Total 9 Bridges are in the stretch of proposed navigational route. Modification of 9 bridges is not possible from financial point and site considerations. Also, clearance from state govt. / NHAI for modification of these brides will be difficult.

2) River is in dry state for maximum length. Some stretches are there, where dry patches and steep gradient are prominent. These stretches are 106.2-107.6km, 114-115km, 117.2-118km, 121-123.2km, and 128-128.8, 130-138km, 141.8-146.6km, 152.4-154.6km, 171-172.6km and 209-211.2km respectively.

3) Based on recent survey carried out by WAPCOS, out of total 246.9 km study stretch of river, 115.65 km is having depth below 1.2m which is 47% of the total length.

4) Dredging of the river is a very challenging task. Dredging quantity works out as approx. 13Mm^3 which is exceptionally high. Cost of the dredging works out to be Rs. 384Crores which is highly uneconomical.

5) More than 89% of the total cost is corresponding to fairway development.

6) Negative FIRR is coming out for 1Rs./tonne channel usage charges, whereas in currently operational NW-1, it is 0.5 Rs./tonne. Therefore, huge subsidy will be required in case of Mahi River.

7) There is well developed and well-connected road network around the River Mahi throughout its whole stretch. Hence, usage of River Mahi as waterway will not be economically feasible.

8) There is Limited scope of traffic is present in River Mahi. Apart from coal & fly ash there is no intermittent traffic (cargo).

By summing up all the points above, At present, Mahi River is not feasible from navigation technically and financial point of view. ***This report can be updated at a later stage when required, by considering the fresh cargo analysis, change in***

requirement of the Government or change in policy either of the state or Government of India.

Following studies must be carried out prior to any development for broad view of implications:

i. Conduct a comprehensive geomorphic study and review and analyse sedimentation processes. The sedimentation study shall be aimed at developing an improved understanding of the significant sedimentation processes within the entire river basin. The major emphasis of this work shall be on analysing major channel morphology and the sedimentation phenomenon during the last 10 year period. As a minimum the sedimentation study shall:

   a. Document the variations in sediment transport (size and quantity);

   b. Identify and quantify all major sources of sediments (bed and banks, tributaries, etc.); and

   c. Locate degrading, aggrading, and stable reaches, and

   d. Establish the range of flows transporting the majority of sediments.

ii. Correlate the results of the sedimentation study with historical changes in the basin (channel improvements, land use, barrage and reservoir construction, etc.) enabling the development of a firm understanding of past and present sedimentation processes. This information shall be used to qualitatively analyse the effects of anticipated project features. This information shall be used to determine what may or may not work when designing navigation improvements. It shall include a determination of those reaches that are stable in depth and width and thus provide the basis for all subsequent preliminary design works. Included in the analysis shall be a study of the bend-ways to determine the siltation and erosion process in the same and the minimum radius required for navigation of the reference vessels.

iii. Undertake various types of model studies to verify and / or enhance all design parameters. As a minimum this shall include a numerical model to produce detailed pictures of flow in the river system under current and future flow conditions and also the required flow/ discharge to maintain 2.5 m LAD throughout the year with or without interventions like (barrages) in River.

iv. Non-destructive testing for bridges can be carried out.

15.1 Environmental and Social Screening Template

Screening Question	Yes	No	Details/Remarks
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		No	
b) Wildlife/ Bird Sanctuary		No	
c) Tiger or Elephant Reserve	-	No	
d) Biosphere Reserve	-	No	
e) Reserved/Protected Forest	-	No	
f) Wetland	Yes		Important Coastal and Marine Biodiversity Areas(ICMBAs) at Estuary of river site Wadgham.
g) Important Bird Areas	-		
h) Mangroves Areas	Yes		Estuary of river Mahi
i) Estuary with Mangroves	Yes		Estuary of river Mahi
j) Areas used by protected, important or sensitive species of fauna for breeding, nesting, foraging, resting, overwintering, migration	Yes		
k) World heritage sites	-	No	
l. Archeological monuments/ sites (under ASI's Central / State list)	Yes		4 sites within 10km I. Jami Masjid~ 600m from river bank II. Microlithic site~2km From river bank III. Temple of Galteshwar at right bank IV. Ratneshwar temple~6km
2. Is the project located in whole or part in/near any Critically Polluted Areas identified by CPCB?	-	No	
3. Is, there any defense installations near the project site?	-	No	
4. Whether there is any Government Order/	-	No	

Policy relevant / relating to the site?			
5. Is the project involved clearance of existing land, vegetation, and buildings?	-	No	
6. Is the project involved dredging?	Yes	-	
7. Is the project area susceptible to natural hazard (*earthquakes, subsidence, erosion, flooding, cyclone or extreme or adverse climatic conditions*)	-	No	
8. Is the project located in whole or part within the Coastal Regulation Zone?	Yes	-	Tidal variation till Ch-80 Km (Part)
9. Is the project involved any demolition of the existing structure?	Yes		Bridges falling in the stretch
10. Is the project activity require the acquisition of private land?	-	No	
11. Is the proposed project activity result in loss of direct livelihood/employment?	-	No	
12. Is the proposed project activity affect schedule tribe/ caste communities?	-	No	

Sl.No.	Result of Screening Exercise	(Yes/No)
1.	Environment Impact Assessment is Required	Yes
2.	CRZ Clearance is Required	Yes
3.	Environmental Clearance is Required	Yes (due to demolition of bridges)
4.	Forest Clearance is required	No
5.	Wildlife Clearance is required	Yes (Presence of ICMBA)
6.	NOC from SPCB is required	Yes
7.	Social Impact Assessment is Required	Yes
8.	Abbreviated RAP is required	Yes
9.	Full RAP is required	
10.	Any other clearance is required	Gujarat Maritime Board

15.2 TRAFFIC TEMPLATE

15.2.1 Catchment Baseline

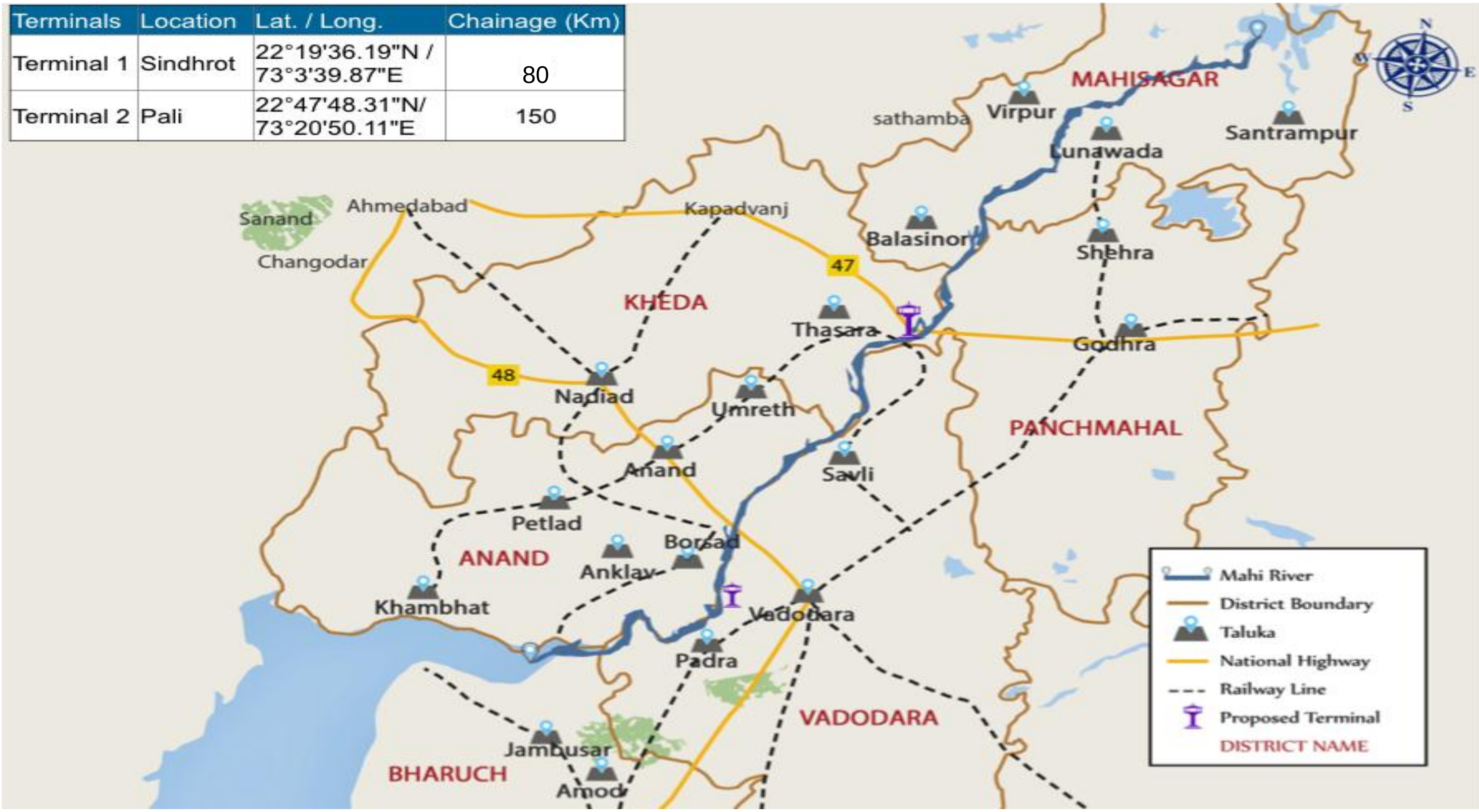
- Local economic geography - Mahi river origin – Minda village, Madhya Pradesh
- Catchment area –Anand, Kheda, Vadodara, Panchmahal & Bharuch of Gujarat and Mahi Sagar district of Maharashtra
- Population – As per census 2011, total population residing in Vadodara, Anand, Mahisagar, Kheda, Panchmahal & Bharuch Districts are around 25 Lakhs,19 Lakhs, 10 Lakhs, 9 Lakhs, 7 Lakh & 2 Lakhs respectively. Total population of the catchment area of river Mahi is 72 Lakhs.
- Economic activities –Tertiary sectors accounts around 42% whereas secondary 36%.Primary sector accounts only 22 %.Major crops produced in the catchment of river Mahi are Paddy, Wheat, Jowar, Gram, Cotton, Groundnut, Tobacco etc. Major minerals found in the catchment area of Mahi are Limestone, Dolomite, Fluorspar, Granite, Manganese ore, Marble & Quartz.
- Major industries - There are coal based Power Plants, Iron & Steel, Chemical & Fertiliser manufacturing industries in the catchment area. Some major units are Wanakbori Thermal Power plant, Ultra tech Cement, GFCL, GSFC etc.
- Connectivity
  - Major roads - NE 1, SH 63, SH 83 & SH 12. (NH 87, NH 205, NH 95, NH 141, NH 49, SH 458, SH 508 etc.)
  - Major railway –Vadodara, Anand, Kathana, Khambat, Kavi, Vasad.
- Specific Developments
  - Gujarat Infrastructure Development Board (GIDB) has undertaken the construction of two industrial parks in the stretch of river Mahi, in Akalbara, Padra and in Khambhat, Anand. The park will be developed over an area of 500 hectares and budget of INR 200 crores. It will consist of 3 estates- Chemical in 32% land area, Engineering in around 55% of total area and General in the

remaining 13% of land. A pipeline will be drawn from GACL (Gujarat Alkalies and Chemicals Limited) for water supply.

- Proposal of another industrial park in Khambhat taluka of Anand district. The park is being developed in 800 hectares of land with a budget of INR 320 crores. The park will consist of engineering and chemical estates.

- The Govt. of Gujarat has projected Kheda, Vadodara and Bharuch as a hub for defence manufacturing in the Vibrant Gujarat 2017 Global Summit. .

Catchment area Map



Terminals	Location	Lat. / Long.	Chainage (Km)
Terminal 1	Sindhrot	22°19'36.19"N / 73°3'39.87"E	80
Terminal 2	Pali	22°47'48.31"N/ 73°20'50.11"E	150

15.2.2 Navigation Baseline

- Existing Waterway Usage
    - ➢ Currently, there doesn’t exist any waterways movement inriver Mahi.
    - ➢ There exist no major or non-major port on the bank of river Mahi.
    - ➢ There are two dams on the river namely Wanakbori dam and Kadana dam.
    - ➢ There are several bridges on river Mahi, namely Gambhira Bridge, Sindhrot bridge, Vasad Mahisagar Bridge, Poicha Bridge, Galteshwar Bridge, Sevaliya Bridge.
    - ➢ There is no Ferry Service available on the identified stretch of river Mahi

15.2.3 Market Baseline

- Potential Market
    - ➢ Bulk commodities – Thermal Coal, Fly Ash, and Clinker

Commodity	Source	Reasoning
Coal	Wanakbori Thermal/ Captive Plant	Coal Consumption is around 5.2 mn Tonne. Domestic Coal is obtained from Chhattisgarh coalfields. Imported Coal can be transported using Waterways.
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	Based on reliable inputs, it is very likely that this critical power plant would mostly use imported coal. This volume can be lightered to the plant using river Mahi.
Fly ash	Wanakbori TPS	Fly Ash from Wanakbori TPS is procured by UltraTech cement plant. A small volume is utilized at the plant, while the rest gets

Commodity	Source	Reasoning
		transported to its Surat Unit by road. The volume moved by road could be shifted to the waterway.
	Proposed Wanakbori Critical Power Plant Unit (800 MW)	This will be mostly surplus volume, suitable for distribution using the waterway in Mahi.
Clinker	UltraTech Cement	A prospective cargo that can be moved via River Mahi from UltraTech's integrated clinker plant in Kutch.

15.2.4 Forecasting Years

- IWT Share
  - The currently operational Wanakbori TPS imports 15% - 20% of imported coal requirements from Hazira. By FY45, it's projected that IWT will move 30% of the plant's total imported coal requirements.
  - Similarly, the upcoming SCTPS at the same site will use IWT for moving the entire 30% share of the imported coal requirements.
  - Of the total fly ash volume from the existing Wanakbori TPS, 75% will shift to IWT. The estimated 1 mn T fly ash from the upcoming SCTPS, IWT will move this entire volume.
  - Diverting from the current share of clinker movement between Gulf of Kutch and to UltraTech Cement plant in Wanakbori, IWT is estimated to account for 75% of this movement by FY45. This shift is based on the presumption that the company will decide to import clinker from its Amreli unit in Jaffrabad.

Sr. No	Name of Cargo	Type of Cargo	Origin	Original Terminal on NW	Final Destination	Destination Terminal on NW	Co-ordinates	Unit p.a	Fy-20	Fy-25	Fy-30	Fy-35	Fy-40	Fy-45
1	Coal	Bulk	Hazira Port	n/a	Wanakbori TPS	Terminal 2 (Pali)	21°40'55.65"N / 72°36'46.81"E	mn T	0.2	1	1.2	1.3	1.4	1.6
					Wanakbori SCTPS				0.1	0.3	0.4	0.6	0.7	0.8
2	Fly Ash	Bulk	Wanakbori TPS	Terminal 2 (Pali)	Surat & Saurashtra	n/a			0.1	0.4	0.5	0.6	0.7	0.9
			Wanakbori SCTPS						0.1	0.3	0.4	0.5	0.6	0.8
3	Clinker	Bulk	Amreli	n/w	UltraTech plant (Wanakbori)	Terminal 2(Pali)			0.2	0.6	0.8	1	1.2	1.5
	Total								0.7	2.6	3.3	4	4.6	5.6

15.2.5 Presentation of Forecast

Sr. No	Name of Cargo	Type of Cargo	Origin	Final Destination	Co-ordinates	Unit p.a	Fy-20	Fy-25	Fy-30	Fy-35	Fy-40	Fy-45
1	Coal	Bulk	Hazira Port	Wanakbori TPS	21°40'55.65"N / 72°36'46.81"E	mn T-km	73	367	440	477	514	587
				Wanakbori SCTPS			37	110	147	220	257	294
2	Fly Ash	Bulk	Wanakbori TPS	Surat& Saurashtra			37	147	184	220	257	330
			Wanakbori SCTPS				37	110	147	184	220	294
3	Clinker	Bulk	Amreli	UltraTech plant (Wanakbori)			73	220	294	367	440	551
	Total						257	954	1211	1468	1688	2055

15.2.6 Market Success Factors

15.2.6.1 Fairway availability

- Wanakbori power plants (TPS & SCTPS) and UltraTech Cement plant would need fairway for smooth cargo movement of up to 150 km from the mouth of River Mahi.

    - UltraTech Cement requirement is mostly speculative in nature, as it requires the company to bring a drastic change in its current transport logistics for clinker procurement.

Reliable waterway transportation with adequate depth and other navigable conditions is imperative for Wanakbori TPS & upcoming SCTPS for operation. The same logic could be extended to UltraTech Cement's plant in the vicinity. Hence, it is important that IWAI develops and maintain round-the-year navigable conditions across the 150-km stretch on River Mahi.

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15.2.6.2 Vessel types

The following table lists the range of RSVs recommended to move cargo on River Mahi.

Terminals	Type - Capacity	Fleet capacity (No. of Barges)						Loading Point	Discharge Point
		FY20	FY25	FY30	FY35	FY40	FY45		
Terminal 2 (One-way Ballast)	Class IV - 1,000 DWT	152	624	758	929	1,084	1,267	Hazira Port (Coal);	Terminal 2 (Coal),
	Class V - 1,000 DWT	152	624	758	929	1084	1267	Terminal 2 (Fly ash),	Surat& Saurashtra (Fly ash),
	Class VI - 2,000 DWT	83	341	414	507	592	692	Amreli (Clinker)	Terminal 2 (Clinker)
Terminal 2 (No Ballast)	Class IV - 1,000 DWT	272	988	1220	1516	1793	2125		
	Class V - 1,000 DWT	272	988	1220	1516	1793	2125		
	Class VI - 2,000 DWT	149	540	666	828	979	1161		

The total number of vessels required per vessel type varies based on traffic projections estimated for each of the above terminals. No-ballast computation in case of Terminal 2 has been considered because of the availability of return cargo (fly ash) at the Terminal from the Wanakbori TPS and SCTPS.

15.2.6.3 Complementary Investment

IWAI is only required to develop fairway, construct the terminal, and install the necessary handling facilities there. Specific to connectivity, there's adequate-width road connecting Terminal 2 to Wanakbori TPS & SCTPS and UltraTech Cement.

15.2.7 Forecasting Methodology

- The existing Wanakbori TPS has an annual coal requirement of around 5.2 mn T. Majority is sourced from domestic mines, and the remaining 20% is imported coal. At the moment, the plant has ceased its import operations, but is likely to resume soon. Due to design constraints, the plant is unlikely to exceed the maximum viable import share of 30%. For projection purposes, it's assumed that this share will be achieved by FY45. Based on the plant's current import share (15% - 20%), it's assumed that its FY18 import traffic will be 15% of the total coal requirements. The plan will increase its import share to 20%, growing at a 7-year CAGR of about 40% between FY18 and FY25. This import share will increase to 25% by FY35, growing at a 10-year CAGR of 2.3%. Similarly, with 10-year CAGR of around 2% between FY35 and FY45, the plant's import share will peak at 30% of the total requirement.

- A similar series of assumptions supports the coal traffic forecast for the upcoming SCTPS at Wanakbori. The boiler unit to be installed for that plant does not carry the aforesaid design restrictions. However, impetus from the Government of India is to increase reliance on domestic coal rather than imports. Considering these circumstances and applying moderation, this new plant is also assumed to achieve 30% share of imported coal by FY45. Operation for this plant should begin by late FY19 or early FY20, at the latest. Assuming a nominal volume of 0.1 mn T for FY20, the plant will import 10% of its coal requirements by FY25. Here, the import figures are likely to grow at a 5-year CAGR of almost 23%. Between FY25 and FY35, the plant will grow at 10-year CAGR of 7.2% to import 20% of the total requirement. Attaining the ultimate share of 30% by FY45, this import volume will grow at a 10-year CAGR of just over 4%.

- At the existing Wanakbori TPS, 1.2 mn T of fly ash can be targeted for transportation on River Mahi. This volume is distributed to Surat for domestic consumption using roadways. It's assumed that a maximum of 75% of this volume will shift to River Mahi by FY45. Between FY18 and FY25, fly ash movement on River Mahi is estimated to grow at a 7-year CAGR of about 20%. For the next 10 years, this growth will be at 5.2%, and then 4.1% for the subsequent 10 years. Almost, identical growth rates will be seen for fly ash traffic from the upcoming SCTPS at Wanakbori. Distribution of the surplus 1 mn T should start by FY20, translating into waterway traffic of 0.1 mn T. With a 5-year CAGR of 27%, River Mahi is estimated to transport 30% of the surplus fly ash volume by FY25. Between FY25 and FY35, growth will follow the traffic trend estimated for the existing plant. This will also be the case for growth trend between FY35 and FY45.

- Clinker for the UltraTech Cement grinding unit is more of a speculative cargo in comparison. Assuming the optimistic scenario where clinker is imported form Amreli, an estimated 75% of their annual demand will be moved using River Mahi by FY45. As per prevailing standards, clinker has a 90% - 95% composition in producing Portland cement. It's assumed that the Wanakbori unit will utilize 90% clinker, as one of the raw materials. Based on this proportion, an estimated annual clinker requirement is taken at 2 mn T. Beginning with 0.1 mn T in FY18, clinker traffic on River Mahi will grow at a 7-year CAGR of 29% to capture 30% of the import requirement. In the next 10 years, this share will grow at a 10-year CAGR of 5.2% to capture 50% of the total import requirement. Between FY35 and FY45, traffic will increase at a 10-year CAGR of nearly 4%. Clinker handling on River Mahi will peak at 75% of UltraTech's total import requirement

15.3 Project Costing Template

15.3.1 Capital Cost

Capital Cost	In Crores
(I) Civil Cost	
Navigation Locks	45.56
Demolition & Reconstruction of bridges	559.51
Total	605.07
3% Contingencies and 7% Supervision charges on Base cost	60.51
Total Fairway Development Cost	**665.58**
Terminal Cost	
Sindhrot Tourist Jetty	10.00
Wanakbori Cargo Jetty	22.29
Storage Area(Including roads, warehouse, bio-toilets,ETP/STP, disposal facilities, parking area etc)	7.50
Total Cost(I)	39.79
3% Contingencies and 7% Supervision charges on Base cost	3.98
Total Civil Cost	**43.77**
(II) Navigation & Communication Cost	
DGPS	1.00
VTMS	1.00
Marine Lantern/Buyos (50 nos.)	1.00
RIS	14.30
Total Cost(II)	17.30
3% Contingencies and 7% Supervision charges on Base cost	1.73
Total Navigation & Communication Cost	19.03
(III) Handling Equipment & Utilities	
Mechanical & electrical	10.1
3% Contingencies and 7% Supervision charges on Base cost	1.01
Total Handling Equipment & Utilities Cost	**11.11**
Other cost including financing cost and interest during construction (10% of (I))	70.82
Total Cost (I)+(II)+(III)	**809.20**
(IV) Dredging	
Dredging **(12.8 Mm3)**	**384.00**
Total Cost	
Total Capital Cost	**1194.42**

15.3.2 Operation & Maintenance Cost

	O & M Cost	In Crores
(i)	Dredging @ 10%	38.40
(ii)	Civil works @ 1%	7.09
(iii)	Mechanical & Electrical Cost @ 5%	0.56
(iv)	Ports Crafts/Nav. Aids @ 5%	0.95
(v)	Fuel Cost	1.00
(vi)	Power Cost	2.00
(vii)	Manpower Cost	5.50
(viii)	Miscellaneous	0.5
	Total II	**56.00**

15.3.3 Recurrent Cost

Mechanical & Electrical cost will be recurrent cost. Same will be added after every 10 years from completion of project.

Handling Equipment & Utilities	**(Rs. in Crores)**
Mechanical & electrical	10.1
3% Contingencies and 7% Supervision charges on Base cost	1.01
Total Handling Equipment & Utilities Cost	**11.11**

15.3.4 Cost Verification

Gujarat Maritime Board Schedule of Rate, 2013-14 has been followed and escalated by 5% per annum to arrive at for year 2018 to arrive at the cost of the project.

For dredging (2015-16) rates has been considered as substantial change has not been observed.

In annexures of chapter 11 (Annexures-11), reference of rates have been provided in to reach realistic overall cost.

15.4 ECONOMIC EVALUATION TEMPLATE

Template 15.4.1: EIRR Analysis

S.No	Year	Capital Cost	Annual O&M Cost	Total Cost	Economic costs Rs lakhs	Economic Benefits Rs lakhs	Net cash flow Rs lakhs
1	2019	320	0	320	21351		-21351
2	2020	240	0	240	15991		-15991
3	2021	240	0	240	15991		-15991
4	2022		56	56	3720	4328	608
5	2023		57	57	3832	4328	497
6	2024		59	59	3947	4328	382
7	2025		61	61	4065	4328	263
8	2026		63	63	4187	16076	11889
9	2027		65	65	4312	16076	11763
10	2028		67	67	4442	16076	11634
11	2029		69	69	4575	16076	11501
12	2030		71	71	4712	16076	11364
13	2031	7	73	80	5345	20404	15059
14	2032		75	75	4999	20404	15405
15	2033		77	77	5149	20404	15255
16	2034		80	80	5304	20404	15100
17	2035		82	82	5463	20404	14941
18	2036		84	84	5627	24732	19105
19	2037		87	87	5796	24732	18936
20	2038		90	90	5970	24732	18763
21	2039		92	92	6149	24732	18584
22	2040		95	95	6333	24732	18399
23	2041	7	98	105	7014	28442	21428
24	2042		101	101	6719	28442	21723
25	2043		104	104	6920	28442	21522
26	2044		107	107	7128	28442	21314
27	2045		110	110	7342	28442	21100
28	2046		113	113	7562	34625	27063
29	2047		117	117	7789	34625	26836
30	2048		120	120	8023	34625	26602
						IRR	**13.74%**
						NPV (in Rs lakhs)	10110

Template 15.4.2: Economic Benefits

S.No	Year	Economic Benefits				Total
		Fuel savings	*Carbon Credit*	*Other Benefits*	*Emp benefits*	
		Rs lakhs	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*	*Rs lakhs*
1	2019					0
2	2020					0
3	2021					
4	2022	2248	77	1496	507	.
5	2023	2248	77	1496	507	4328
6	2024	2248	77	1496	507	4328
7	2025	2248	77	1496	507	4328
8	2026	8349	285	5558	1885	16076
9	2027	8349	285	5558	1885	16076
10	2028	8349	285	5558	1885	16076
11	2029	8349	285	5558	1885	16076
12	2030	8349	285	5558	1885	16076
13	2031	10597	361	7054	2392	20404
14	2032	10597	361	7054	2392	20404
15	2033	10597	361	7054	2392	20404
16	2034	10597	361	7054	2392	20404
17	2035	10597	361	7054	2392	20404
18	2036	12845	438	8550	2900	24732
19	2037	12845	438	8550	2900	24732
20	2038	12845	438	8550	2900	24732
21	2039	12845	438	8550	2900	24732
22	2040	12845	438	8550	2900	24732
23	2041	14772	503	9833	3335	28442
24	2042	14772	503	9833	3335	28442
25	2043	14772	503	9833	3335	28442
26	2044	14772	503	9833	3335	28442
27	2045	14772	503	9833	3335	28442
28	2046	17983	613	11970	4059	34625
29	2047	17983	613	11970	4059	34625
30	2048	17983	613	11970	4059	34625

Template 15.4.3: Fuel Saving

Year	Total traffic potential by IWT	Total traffic potential by IWT	Fuel Saving	Fuel Saving	
	mntonnes	*million TKM*	*in million litre*	*in Rs million*	*in Rs lakhs*
2021	0.70	105	3.00	225	2248
2022	0.70	105	3.00	225	2248
2023	0.70	105	3.00	225	2248
2024	0.70	105	3.00	225	2248
2025	2.60	390	11.13	835	8349
2026	2.60	390	11.13	835	8349
2027	2.60	390	11.13	835	8349
2028	2.60	390	11.13	835	8349
2029	2.60	390	11.13	835	8349
2030	3.30	495	14.13	1060	10597
2031	3.30	495	14.13	1060	10597
2032	3.30	495	14.13	1060	10597
2033	3.30	495	14.13	1060	10597
2034	3.30	495	14.13	1060	10597
2035	4.00	600	17.13	1284	12845
2036	4.00	600	17.13	1284	12845
2037	4.00	600	17.13	1284	12845
2038	4.00	600	17.13	1284	12845
2039	4.00	600	17.13	1284	12845
2040	4.60	690	19.70	1477	14772
2041	4.60	690	19.70	1477	14772
2042	4.60	690	19.70	1477	14772
2043	4.60	690	19.70	1477	14772
2044	4.60	690	19.70	1477	14772
2045	5.60	840	23.98	1798	17983
2046	5.60	840	23.98	1798	17983
2047	5.60	840	23.98	1798	17983
2048	5.60	840	23.98	1798	17983

Template 15.4.4: Carbon Credit Earned

Year	Total traffic potential by IWT	Total traffic potential by IWT	Fuel Saving	Carbon Credit Earned	
	Mn tonnes	*million TKM*	*in million litre*	*in Rs million*	*in Rs lakhs*
2021	0.70	105	3.00	7.66	77
2022	0.70	105	3.00	7.66	77
2023	0.70	105	3.00	7.66	77
2024	0.70	105	3.00	7.66	77
2025	2.60	390	3.00	7.66	77
2026	2.60	390	11.13	28.45	285
2027	2.60	390	11.13	28.45	285
2028	2.60	390	11.13	28.45	285
2029	2.60	390	11.13	28.45	285
2030	3.30	495	11.13	28.45	285
2031	3.30	495	14.13	36.11	361
2032	3.30	495	14.13	36.11	361
2033	3.30	495	14.13	36.11	361
2034	3.30	495	14.13	36.11	361
2035	4.00	600	14.13	36.11	361
2036	4.00	600	17.13	43.77	438
2037	4.00	600	17.13	43.77	438
2038	4.00	600	17.13	43.77	438
2039	4.00	600	17.13	43.77	438
2040	4.60	690	17.13	43.77	438
2041	4.60	690	19.70	50.34	503
2042	4.60	690	19.70	50.34	503
2043	4.60	690	19.70	50.34	503
2044	4.60	690	19.70	50.34	503
2045	5.60	840	19.70	50.34	503
2046	5.60	840	23.98	61.28	613
2047	5.60	840	23.98	61.28	613
2048	5.60	840	23.98	61.28	613

Template 15.4.5: Emp. Benefits

Year	Total traffic potential by IWT	Output	Output	Output Stimulus	Emp generation	Emp benefits	
	mntonnes	*lakh tonne*	*Rs lakh*	Rs lakh	*Man years*	*Rs million*	*Rs lakhs*
2021	0.70	7	7177	10694	4613	51	507
2022	0.70	7	7177	10694	4613	51	507
2023	0.70	7	7177	10694	4613	51	507
2024	0.70	7	7177	10694	4613	51	507
2025	2.60	26	26658	39721	17134	188	1885
2026	2.60	26	26658	39721	17134	188	1885
2027	2.60	26	26658	39721	17134	188	1885
2028	2.60	26	26658	39721	17134	188	1885
2029	2.60	26	26658	39721	17134	188	1885
2030	3.30	33	33836	50415	21747	239	2392
2031	3.30	33	33836	50415	21747	239	2392
2032	3.30	33	33836	50415	21747	239	2392
2033	3.30	33	33836	50415	21747	239	2392
2034	3.30	33	33836	50415	21747	239	2392
2035	4.00	40	41013	61109	26360	290	2900
2036	4.00	40	41013	61109	26360	290	2900
2037	4.00	40	41013	61109	26360	290	2900
2038	4.00	40	41013	61109	26360	290	2900
2039	4.00	40	41013	61109	26360	290	2900
2040	4.60	46	47165	70276	30314	333	3335
2041	4.60	46	47165	70276	30314	333	3335
2042	4.60	46	47165	70276	30314	333	3335
2043	4.60	46	47165	70276	30314	333	3335
2044	4.60	46	47165	70276	30314	333	3335
2045	5.60	56	57418	85553	36904	406	4059
2046	5.60	56	57418	85553	36904	406	4059
2047	5.60	56	57418	85553	36904	406	4059
2048	5.60	56	57418	85553	36904	406	4059

Template 15.4.6: Other Benefits

Year	Total traffic potential by IWT	Total traffic potential by IWT	Other Benefits
	mntonnes	*million TKM*	*Rs lakhs*
2021	0.70	105	1496
2022	0.70	105	1496
2023	0.70	105	1496
2024	0.70	105	1496
2025	2.60	390	5558
2026	2.60	390	5558
2027	2.60	390	5558
2028	2.60	390	5558
2029	2.60	390	5558
2030	3.30	495	7054
2031	3.30	495	7054
2032	3.30	495	7054
2033	3.30	495	7054
2034	3.30	495	7054
2035	4.00	600	8550
2036	4.00	600	8550
2037	4.00	600	8550
2038	4.00	600	8550
2039	4.00	600	8550
2040	4.60	690	9833
2041	4.60	690	9833
2042	4.60	690	9833
2043	4.60	690	9833
2044	4.60	690	9833
2045	5.60	840	11970
2046	5.60	840	11970
2047	5.60	840	11970
2048	5.60	840	11970

15.5 Financial Evaluation Template

Template 15.5.1: FIRR, Revenue and Sensitivity Analysis assuming charge for using the channel is Rs. 1/tonne

S.No.	Year	Capital cost	Annual O & M Cost	Total Cost	Total Revenue	Net Cash Flow	SENSITIVITY ANALYSIS					
							Cap. Cost (+) 10%	Cap. Cost (-) 10%	ANNUAL O &M COST (+) 10%	ANNUAL O &M COST (-) 10%	REVENUE (+) 10%	REVENUE (-) 10%
	1	2	3	4 = (2+3)	5	6= (5-2)	10	11	12	13	14	15
1	2019	478	0	478	0.00	-478	-525	-430	-478	-478	-478	-478
2	2020	358	0	358	0.00	-358	-394	-322	-358	-358	-358	-358
3	2021	358	0	358	0.00	-358	-394	-322	-358	-358	-358	-358
4	2022		56.0	56.0	7.63	-48	-48	-48	-54	-43	-48	-49
5	2023		57.7	57.7	7.63	-50	-50	-50	-56	-44	-49	-51
6	2024		59.4	59.4	7.63	-52	-52	-52	-58	-46	-51	-53
7	2025		61.2	61.2	7.63	-54	-54	-54	-60	-47	-53	-54
8	2026		63.0	63.0	7.63	-55	-55	-55	-62	-49	-55	-56
9	2027		64.9	64.9	27.57	-37	-37	-37	-44	-31	-35	-40
10	2028		66.9	66.9	27.57	-39	-39	-39	-46	-33	-37	-42
11	2029		68.9	68.9	27.57	-41	-41	-41	-48	-34	-39	-44
12	2030		71.0	71.0	27.57	-43	-43	-43	-50	-36	-41	-46
13	2031	11	73.1	84.1	27.57	-57	-57	-57	-65	-48	-54	-59
14	2032		75.3	75.3	40.01	-35	-35	-35	-43	-28	-31	-39
15	2033		77.5	77.5	40.01	-38	-38	-38	-45	-30	-34	-42

S.No.	Year	Capital cost	Annual O & M Cost	Total Cost	Total Revenue	Net Cash Flow	SENSITIVITY ANALYSIS					
							Cap. Cost (+) 10%	Cap. Cost (-) 10%	ANNUAL O &M COST (+) 10%	ANNUAL O &M COST (-) 10%	REVENUE (+) 10%	REVENUE (-) 10%
	1	2	3	4 = (2+3)	5	6= (5-2)	10	11	12	13	14	15
16	2034		79.9	79.9	40.01	-40	-40	-40	-48	-32	-36	-44
17	2035		82.3	82.3	40.01	-42	-42	-42	-50	-34	-38	-46
18	2036		84.7	84.7	40.01	-45	-45	-45	-53	-36	-41	-49
19	2037		87.3	87.3	47.56	-40	-40	-40	-48	-31	-35	-44
20	2038		89.9	89.9	47.56	-42	-42	-42	-51	-33	-38	-47
21	2039		92.6	92.6	47.56	-45	-45	-45	-54	-36	-40	-50
22	2040		95.4	95.4	47.56	-48	-48	-48	-57	-38	-43	-53
23	2041	11	98.2	109.2	47.56	-62	-62	-62	-73	-51	-57	-66
24	2042		101.2	101.2	54.09	-47	-47	-47	-57	-37	-42	-52
25	2043		104.2	104.2	54.09	-50	-50	-50	-61	-40	-45	-56
26	2044		107.3	107.3	54.09	-53	-53	-53	-64	-42	-48	-59
27	2045		110.5	110.5	54.09	-56	-56	-56	-68	-45	-51	-62
28	2046		113.9	113.9	54.09	-60	-60	-60	-71	-48	-54	-65
29	2047		117.3	117.3	64.67	-53	-53	-53	-64	-41	-46	-59
30	2048		120.8	120.8	64.67	-56	-56	-56	-68	-44	-50	-63
	Total	1216	2280	3497								
FIRR (%)						Negative Value						
NPV@ discount factor 9% in Cr.						Rs. -1,380	Rs. -1,481	Rs. -1,278	Rs. -1,437	Rs. -1,323	Rs. -1,359	Rs. -1,400

ANNEXURE 6.1 Berthing Force

Design Vessel	Displacement Tonnage	L_{OA} (m)	L_{PP} (m)	Beam (m)	Draft (m)
Class-VII	**4000**	**86**	**86**	**14**	**2.9**

1) Kinetic Energy, E imparted to Fendering System

$E = M_D V_b^2 (C_m C_e C_s C_c)/2$

W_D	Displacement Tonnage (DT) of the vessel, (t)
V_b	Velocity of vessel in m/s, normal to the berth
C_m	Mass coefficient
C_e	Eccentricity coefficient
C_s	Softness coefficient
C_c	Configuratinal Coefficient

a) Displacement Tonnage, W_D (Tonnes) 4000 t

b) Approach Velocity (m/s) 0.20 m/s

Choose Site Condition - Berthing Condition from the following menu:

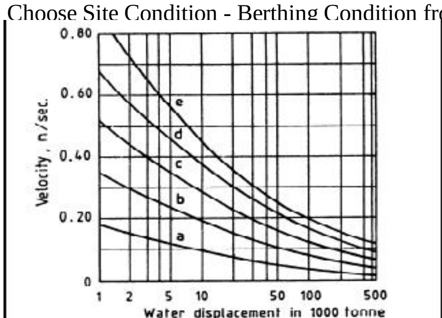


Figure 1 — Design berthing velocity as function of navigation conditions and size of vessel (Brolsma et al, 1977)

a) Good berthing, sheltered.
b) Difficult berthing, sheltered.
c) Easy berthing, exposed.
d) Good berthing, exposed.
e) Navigation conditions difficult, exposed.

c) Mass Coefficient Cm = 1.41

=

Unit Weight of sea water (g_w) = 1.0026 t/m^3

Cm = 1+ 2D/B =

d) Eccentricity Coefficient Ce = **0.60**

e) Softness Coefficient Cs = **1.00**

Kinetic energy, E = = (4000*(0.2^2)*1.41428571428571*0.6*1/(2*9.81)

= 6.92 **t-m**

Factor of safety = 1.4

Kinetic Energy, E imparted to a fendering system = **9.688** **t-m**

= **96.88** **kN*m**

According to this Kinetic energy following fender has been assumed

G2 grade of MCS 2000

Type of Fender	=	**MCS 400 Cell Fender**	
Energy Absorption	=	**21.60**	kN*m
Reaction Force	=	**129**	kN

Annexure 6.2 Analysis Of Mooring Force Due To Wind And Current

Class-VII Vessel

Design Vessel	Displacement Tonnage	L_{OA} (m)	L_{PP} (m)	Beam (m)	Draft (m) D_R
Vikrant	4,000	86.0	86.0	14.0	2.9

1) Mooring Force due to Wind:

Mooring Force due to wind: $F_w = C_w A_w P$

C_w	=	Shape Factor
	=	1.5
L_{pp}	=	Length between the perpendiculars in m
	=	86.0
D_R	=	Loaded draft in m
	=	2.9
D_M	=	Moulded depth in m
	=	3.9
	=	3.9 m
D_L/D_M	=	58%
	=	3.9 * 0.575
	=	2.2425
A_w	=	Windage area in sq. m
	=	$1.175\ L_p\ (D_M - D_L)$
	=	1.175 * 86 * (3.9 - 2.2425)
	=	167.49 m^2
V z	=	Design normal wind speed in m/s
	=	50.0
P_w	=	$0.06\ V^2$
	=	0.06 * (50 ^ 2)
	=	150

Mooring Force due to wind:	**F_w (kg)**	**=**	37,685.33
	F_w (T)	=	**37.7**
	F_w (kN)	=	**376.85**

2) Mooring Force due to Current:

Pressure due to current: $P_c = g_w V^2 / 2g$

where,

P_c =	Pressure due to current in kg/sq.m	=	18.8
g_w =	Unit weight of water in kg/cu.m	=	1025
V =	Current velocity in m/s	=	0.60
g =	Acceleration due to gravity in m/s^2	=	9.81

Mooring force due to current: $F_c = L_{pp} D_r P_c$

where,

F_c =	Mooring Force due to current in kg		
L_{pp} =	Length between the perpendiculars in m	=	86.0
D_R =	Loaded draft of vessel in m	=	2.9
Pc =	Pressure due to current in kg/sq.m (as explained abo	=	18.8

Mooring Force due to current:	**F_c (kg)**	4690.55
	F_c (T)	**4.7**

Assuming that the mooring force due to current and wind act simultaneously in the same direction, Total Mooring Force (T) **42.4**

The total force can be assumed to be equally distributed to three bollards if the ship is moored to eight bollards

Force on each Bollard (T) **14.13**

Highest of the two above calculated mooring forces for coal and container vessel is 135.5 T per bollard. Hence 150 T Bollard Pull is adopted.

MARINETEK INDIA

To,
Reshu Verma
WABCOS
Gurgaon

03 November 2017

Dear Ms Verma,

Our ref: Floating Tourist Jetty

Further to our recent discussion we take pleasure in submitting this proposal for a state-of-the-art floating tourist jetty at an undisclosed location as per your request. To facilitate our calculations we have assumed the site to be in a tidal creek with a silt riverbed located within 200 kms of Bombay. We have also assumed the site to have an existing concrete quay wall or other form of bankseat to secure the shore end of the gangway.

1. Introduction to Marinetek

The Marinetek Group is one of the world's largest designers, manufacturers, and installers of floating jetty systems. We have undertaken more than 2,000 top reference projects in 40 countries. Please see details on the Group website www.marinetekgroup.com

We enclose our Marinetek India brochure.

For your project the pontoons will be manufactured in at our production facility near Bombay and transported to your location by road.

2. Description of the Floating Jetty

We propose to supply our Premier all-concrete pontoons for your project; please see enclosed data sheet.

We propose a Type 1 jetty comprising 3No. pontoons, as shown on the enclosed drawings at Fig. 1.

The freeboard of the pontoon will be approx 0.5m. This freeboard is the international standard, and it has proved ideal for the embarkation and disembarkation of passengers. This is well illustrated in Fig. 2.

The jetty will be positioned approximately as shown on the Google Earth image enclosed as Fig. 3. However, we can adjust the location as you may require.

We will fit 150mm D-rubber fender along the berthing face of the pontoon. This fender will be secured to stainless steel cast-in sockets.

We will fit 6No. 5t capacity stainless steel twin-post mooring bollards along the 24m long berthing face, and 3No. to the rear berthing face, and 2No. on the gangway landing pontoon.

We have not at this stage quoted for guardrails or any MEP (mechanical, electrical and plumbing) on the jetty but this can be arranged, if you wish.

We have allowed for a solar-powered, double fixed-red navigation light on the jetty. This would be in accordance with IALA Regulations.

3. Advantages of Marinetek Floating Jetties

Marinetek floating jetties offer many very positive features, including:

a) They are genuinely unsinkable by virtue of their core of closed-cell foam. Unlike with steel or plastic pontoons, there are no compartments that may leak and cause them to sink.

b) The concrete deck of the pontoon is highly anti-slip, even in the pouring rain.

c) The pontoon has a design life of 50 years in normal use, with essentially zero maintenance. Unlike with a steel pontoon there is no need to regularly chip and paint, or to have a dry-docking every couple of years (as often required by insurers). And unlike with plastic pontoons, the sun's UV rays have no effect.

d) The heavy mass of the Type 1 floating jetty (about 47 tons) means that it will barely move under the weight of passengers or from waves in the river. This lack of movement ensures that passengers and tourists are safe and feel happy.

4. Gangway

The floating jetty will be accessed by a gangway fabricated of marine-grade aluminium. This aluminium is corrosion-free which means it is maintenance free. It will be designed for a live-loading of 4KPa, in accordance with international standards. The deck will be of fibre-reinforced plastic (FRP) panels with an anti-slip gritted surface.

Subject to a further site inspection and confirmation of the precise location for the jetty, we have allowed for a gangway of 10m length and 1.5m width.

Certain accessories and enhancements are available for a small additional cost. For example:

- Handrails with integral LED down-lighting.
- Painting of the gangway in your corporate colours.
- Display panels along both sides of the gangway.

5. Moorings

For your project, we propose to secure the floating jetty in position with mooring chains. This means that there will be no "construction" in the river or on the riverbed and therefore (to the best of our knowledge and understanding) there will be no conflict with the CRZ Law and no need to seek clearance from the environmental authorities.

Please note that the moorings should be checked once every two years by an engineering diver. We also recommend that sacrificial anodes on the chain be renewed as and when required.

6. Client Supply Items

Our price is based on you being responsible for the following:

- A bathymetric survey adequate for the mooring design.
- All permissions needed to install and operate the pontoon system.
- Providing free and clear access to the site for our trucks and mobile crane.

7. Price & Terms of Payment

Our lump-sum contract price will be **INR 98,00,000/-** (Rupees Ninety Eight Lacs), plus relevant taxes.

For the avoidance of doubt this price includes:

- Manufacturing and transporting the pontoons.
- Fabricating and transporting the gangway.
- Procuring and transporting the moorings.
- Laying the moorings, launching the pontoons, and connecting-up.
- Installing the gangway.

This jetty will be manufactured exclusively for your project, and therefore our terms of payment shall be:

a) An advance payment of 40% of the above lump-sum price.

b) An interim payment of 30% when the 3No. pontoons have been completed but before they are dispatched from our yard.

c) An interim payment of 20% when the gangway has been completed but before it is dispatched from our yard.

d) The balance within 14 days of the jetty and gangway installation having been completed.

For each, (a) to (d) above, the amounts shall have relevant taxes added.

8. Terms & Conditions

This offer is subject to the following.

a) Ownership of the floating jetty shall remain vested in Marinetek until all payments have been made to us. Until such time as we have received the final payment, the jetty may not be used unless with our prior permission given in writing.

b) All Intellectual Property Rights relating to the pontoon shall remain the exclusive property of Marinetek. You acknowledge the distinctiveness, validity, originality, value, goodwill and sole ownership by Marinetek of these Intellectual Property Rights.

c) Any dispute arising out of or relating to the performance, validity, or termination of the contract that arises from this offer and the commercial consequences thereof, shall be finally settled by arbitration in accordance with the Arbitration Rules of the Mumbai Chamber of Commerce then in effect, and the provisions of the Arbitration and Conciliation Act 1996 shall apply. The arbitration shall take place in Mumbai and the proceedings shall be conducted, and the award shall be rendered in the English language. There shall be one arbitrator. The arbitration award shall be final and binding on both Parties and not subject to any appeal.

d) The price in this offer is valid for 60 days unless previously withdrawn.

I trust that this offer will meet with your approval. Please do not hesitate to contact me for any further information, or to let me know if I have misunderstood any of your requirements.

Yours faithfully,

By email - no signature

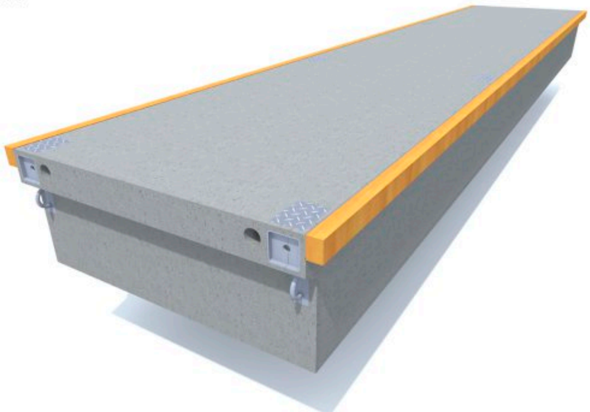
Gautama Dutta
Managing Director

Enc. Marinetek India brochure

PREMIER | M2712PE M2716PE M2720PE M3312PE M3316PE M3320PE

Premier Pontoons 2700, 3300

Based on the world famous Marinetek breakwaters, the completely new **Premier Pontoon** range represents the latest technology in concrete pontoon construction. All units can be provided with integral top entry service channels. As with all Marinetek concrete systems these are of exceptionally strong construction with continuous floatation providing a high loading capacity with higher freeboard for large boat marinas. Premier pontoons can be moored by piles, chain or Seaflex.



TECHNICAL DATA

Concrete strength: 45 N/mm^2 steel reinforced plastic fibre concrete. Exposure class according to European EN 206-1 standard

Core: Expanded polystyrene, density 15 kg/m^3

Reinforcement: Partly or fully hot dip galvanised or stainless steel

Optional accessories: Wooden deck, fixing rails, cable ducts, service channels (240x120 mm) and fenders (timber or wood plastic composite)

FLOATS	M2712PE	M2716PE	M2720PE	M3312PE	M3316PE	M3320PE
Length (m)	12,20	16,05	19,90	12,20	16,05	19,90
Width with fenders (m)	2,7	2,7	2,7	3,3	3,3	3,3
Concrete width (m)	2,4	2,4	2,4	3,0	3,0	3,0
Weight (t)	12,5	16,5	20,6	15,6	20,7	25,7
Height (m)	1,0	1,0	1,0	1,0	1,0	1,0
Net capacity (kN/m^2)	5,6	5,6	5,6	5,6	5,6	5,6
Freeboard (m)	0,56	0,56	0,56	0,56	0,56	0,56
Strenght of joint (kN)	2x322	2x322	2x322	2x322	2x322	2x322
Joint gap (mm)	35	35	35	35	35	35

Exact unit weight and freeboard are subjects to detailed specification of the unit, equipment and mooring methods. Shown numbers are for standard and unloaded units.

Marinetek operates a policy of continuous development and reserves the right to change specifications without notice.

Modification date: 14.11.2014

MARINETEK GROUP OY

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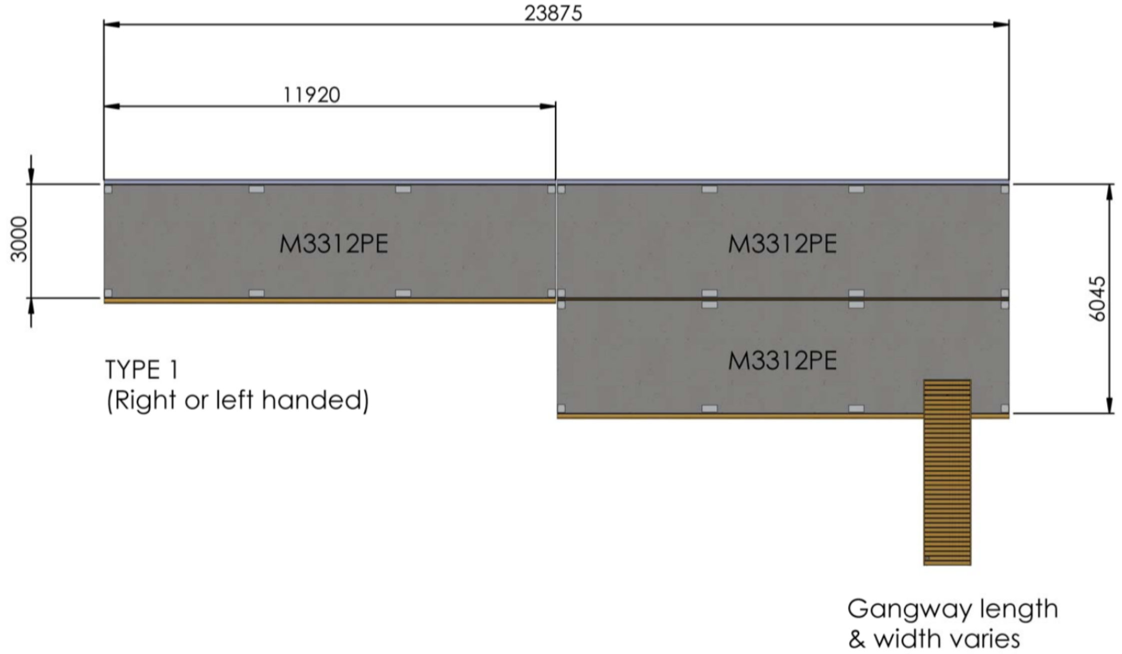
MARINETEK


23875
11920
3000
6045
M3312PE
M3312PE
M3312PE
TYPE 1
(Right or left handed)
Gangway length
& width varies

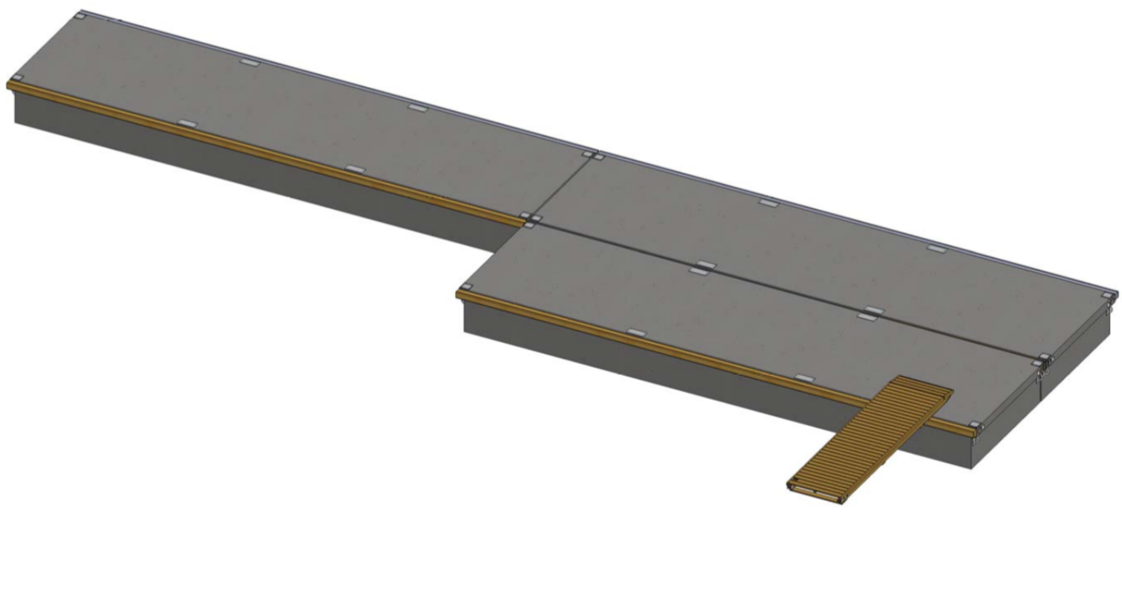


Fig. 1

Fig. 2

Fig. 2

Schematic Layout of Type 1 Floating Jetty

MARINETEK
INDIA

Fig. 3

Annexure 11.1 Cost estimate for dredging

Dredging					(In Rs.)
Sr No	**Description**	**Quantity**	**Unit**	**Rate**	**Amount**
1	Dredging by dredger in creek / channel / infront of wharf / Jetty etc. in rocky strata including disposal of materials on shore for a lead up to 1000 m and all lift (Including tidal condition).	12800000	M^3	300.00	3,840,000,000.00

Annexure 11.2 Cost estimate for Jetty

Sr No	Reference	Description	Qty	Unit	Rate	Amount
1	Ch. 1 Para 1.2 - 6	Mobilisation of plants and equipment to site for installation of bored cast-in-situ pile(600mm dia) Dembolisation of plant and equipment after piling	1.00	Job	0.05	10613230.47
2	GMB SOR Sr. No. 27014 Page No. 196	Providing , fabricating and delivering to the site 6 mm thick M .S. plate liners of specified diameter for bore piles , including cost of material , welding, labour and transportation etc. complete	619.92	Tonne	103493.79	64157737.80
3	GMB SOR Sr. No. 27015 Page No. 196	Driving of steel liners for cast in situ bore piles upto specified depth including pitching of liners using GPS, welding, jointing etc. using pile driving rig and other mechanical equipments , cutting down extra length not required etc .complete	3508.80	m	976.05	3424769.57
4	GMB SOR Sr. No. 27018 Page No. 197	Boring in all sorts of soil including boulders but other than rock using hydraulic piling rig with supporting equipment and removal of excavated earth with all lifts and lead upto 1000m including shifting of piling rig from one bore location to another etc . Complete - 600 mm dia piles.	3508.80	RM	2454.11	8610971.06

Sr No	Reference	Description	Qty	Unit	Rate	Amount
5	GMB SOR Sr. No. 5018 Page No. 37	Supplying, bending, hooking and binding thermomechanically treated (TMT) corrosion resistant Fe-415 grade bar reinforcement including placing in position etc. complete upto floor two level.	962208.00	Kg	98.57	94840031.52
6	GMB SOR Sr. No. 8010 Page No. 64	Conducting standard penetration test at requiredintervals	33.00	No.	243.10	8022.34
7	DSR Code No.. 7247 Page No. 201	Pile load test on single vertical pile (initial load test on test pile or routine load test on working pile) in accordance with IS:2911 (part-IV) or load testing on wells as directed.	2.00	per test	48984.90	97969.80
8	GMB SOR Sr. No. 27027 Page No.198	Providing and laying design mix cement concrete M40 grade using minimum cement 478 kg/cum and graded crushed stone aggregates 20 mm nominal maximum size , for RCC bored cast -in- situ piles excluding the cost of reinforcement but including lowering of reinforcement while concreting and using tremie pipe all as perdrawing and technical specifications.	3969.00	Cum	8371.19	33225259.24

Sr No	Reference	Description	Qty	Unit	Rate	Amount
9	GMB SOR Sr. No. 27034 Page No.200	Providing and laying cast -in-situ design mix cement concrete M -40 grade using minimum cement 435 kg/cum and graded crushed stone aggregates 20 mm nominal maximum size for RCC slab, wearing coat etc . of RCC jetty or such other structure using vibrator , including nominal side formwork but excluding the cost of bottom formwork and reinforcement as per drawing and technical specifications. - Pile Caps	23.80	Cum	9289.51	221090.26
10	GMB SOR Sr. No. 27040 Page No.201	Providing and laying cast -in-situ design mix cement concrete M -40 grade using minimum cement 435 kg/cum and graded crushed stone aggregates 20 mm nominal maximum size for RCC slab, wearing coat etc . of RCC jetty or such other structure using vibrator , including nominal side formwork but excluding the cost of bottom formwork and reinforcement as per drawing and technical specifications.- Deck Slab	525.00	Cum	7880.13	4137066.68

Sr No	Reference	Description	Qty	Unit	Rate	Amount
11	GMB SOR Sr. No. 27040 Page No.201	Providing and laying cast -in-situ design mixcement concrete M -40 grade using minimumcement 435 kg/cum and graded crushed stoneaggregates 20 mm nominal maximum size forRCC slab, wearing coat etc . of RCC jetty or suchother structure using vibrator , including nominalside formwork but excluding the cost of bottomformwork and reinforcement as per drawing andtechnical specifications.-Beams	236.00	Cum	7880.13	1859709.98
12	GMB SOR Sr. No. 27040 Page No.201	Providing and laying cast -in-situ design mix cement concrete M -40 grade using minimum cement 435 kg/cum and graded crushed stone aggregates 20 mm nominal maximum size for RCC slab, wearing coat etc . of RCC jetty or such other structure using vibrator , including nominal side formwork but excluding the cost of bottom formwork and reinforcement as per drawing and technical specifications. - Wearing Coat	150.00	Cum	7880.13	1182019.05
13	GMB SOR Sr. No. 27055 Page No.204	Supplying and Fixing CI Bollards all as per design/type as shown in the drawing excluding the cost of bolts, nuts, washers etc. complete including two coats of paint over one coat of red lead paint.	14.00	q	12954.26	181359.61

Sr No	Reference	Description	Qty	Unit	Rate	Amount
14	GMB SOR Sr. No. 27079 Page No.209	Manufacture and Supply of "CELL" type fenders of size 400 H, weighing approximately 75 kgs at site and installing the same on dock wall at all levels upto low water as shown in the drawing oras directed including cost of all materials , SS (non magnetic) anchor bolts of size 22 mm, transportation, testing of materials , drilling of hole , anchoring fixtures using mechanical /chemical anchors as per design etc.complete.	7.00	nos	45514.63	318602.42
		Total (Ex. Mob Demob)				212264609.33
					Total Cost	**222877839.80**

Annexure 11.3 Cost estimate for Navigational Lock

NAVIGATIONAL LOCKS						
Sr No	**Reference**	**Description**	**Qty**	**Unit**	**Rate (Rs.)**	**Amount (in Rs)**
1	GMB SOR Sr. No.250140 Page No.174	Clearing the land by uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth upto 300mm, and disposal upto 1 km. including all labour,tools & plants etc complete.	20000	Sqm	5.56	111132
2 i	GMB SOR Sr. No. 40040 Page No. 27	Excavation for foundation upto 1.5m depth including sorting out and stacking of useful materials and disposing of the excavated stuff upto 50 metre lead. (D) Soft rock not requiring blasting (up to 1.5 M depth)	31500	Cum	217.87	6862748.29
ii	GMB SOR Sr. No. 40090 Page No.27	(1.5 to 3.0 M depth)	31500	Cum	236.39	7446191.29
iii	GMB SOR Sr. No. 40140 Page No. 28	(3.0 to 5 M depth)	42000	Cum	301.21	12650989.05
3	Consolidation grouting					
a)		Consolidation grouting of foundation area by drilling holes at the rate of 1 hole per 3 sq.m area, minimum depth 5 m area and grouting with cement slurry	8000	m	700	5600000
b)		Grouting	12000	Bags	500	6000000

NAVIGATIONAL LOCKS						
Sr No	**Reference**	**Description**	**Qty**	**Unit**	**Rate (Rs.)**	**Amount (in Rs)**
4		M-30 concrete in Pier and Side walls	28900	Cum	6880	198832000
5	GMB SOR Sr. No. 26058 Page No. 187	Cement Concrete M20 grade of specified thickness in pavement using OPC grade 43 minimum @ 325 kg/cum and graded stone aggregates 25 mm nominal maximum size laid to required slope and camber in panels as required using mechanical mixer including admixture (super plasticizer) @ 0.4 % by weight of cement,formwork, vibrating, finishing, curing etc complete.	8370	Cum	5337.58	44675522.42
6	GMB SOR Sr. No. 5001 5.3.2 Page No. 35	Providing and Laying CC 1:3:6 (1 cement :3 coarse sand : 6 hand broken stone aggregate 40mm nominal size) and curing complete excluding cost of form work in. (A) Foundation and plinth	1800	Cum	3950.40	7110711.56
7		Providing water stop @ 25m c/c	420	m	500	210000
8	GMB SOR Sr. No. 27054 Page No. 204	Bitumastic filler for joints	420	m	520.93	218791.13
9	GMB SOR Sr. No. Sr. No 5017 5.4.11 page 37	Reinforcement steel in R.C.C	1985.1	tonne	66794.96	132594680.1

NAVIGATIONAL LOCKS						
Sr No	**Reference**	**Description**	**Qty**	**Unit**	**Rate (Rs.)**	**Amount (in Rs)**
10	GMB SOR Sr. No. 27054 Page No. 204	Providing and Laying filter media of specified thickness with granular material /stone crushed aggregates satisfying the requirements laid downin clause 2504.2.2 of MORT&H specifications with smaller size towards the soil and bigger size towards the wall and provided over the entire surface behind whaft wall , abutment, wing wall or return wall , including watering and compacting complete as per drawing and technical specifications	5625	Cum	1841.09	10356113.25
11		Providing swing bridge (2 Nos. x 15m clear span)	36	m	L.S	50
12		Fender	15	Nos	2000	30000
13		Security Room (4 Nos) 3m x 3m each	20	Sqm	4000	80000
14		Lock operating room (2 nos) with operating panel 3m x 7m each	42	Sqm	4000	168000
15		Power Room (2 Nos) for battery with acid resistance tiles 3m x 4m each	24	Sqm	5000	120000
16		Stand by Generator Room (2 Nos) 5m x 3m each	30	Sqm	4000	120000
17		Store Room (2 Nos) 8m x 5m each	80	Sqm	4000	320000

NAVIGATIONAL LOCKS						
Sr No	**Reference**	**Description**	**Qty**	**Unit**	**Rate (Rs.)**	**Amount (in Rs)**
19		Bollard	5	Nos	20000	100000
20		Mast	4	Nos	20000	80000
21		Fencing	250	m	200	50000
22		Lock Lighting Arrangement	L.S			1000000
23		Instrumentation	L.S			1500000
		Sub-total (1 to 23)				**446694910.7**
24		Dewatering at 2% of above cost				8933898.21
Total (Lakhs)						**4456.29**

Annexure 11.4 Cost estimate for Mechanical Equipment

Mechanical / Handling Equipments					
Sr. No.	**Description**	**Quantity**	**Unit**	**Rate**	**Amount(Rs in Lakhs)**
1	MobileHarbour crane - 100 TPH	1	Nos.	40,000,000.00	400.00
2	Crane Attachments		LS	10,000,000.00	100
3	Forklift - 10 Ton	1	Nos.	1,000,000.00	10
4	**Electrical**				500
(i)	4000 KVA Transformers- 11 KV/3.3 KV				125
(ii)	500 KVA Transformers- 3.3 KV/415 V				80
(iii)	Switch Gear				60
(iv)	Motor Control Gear				60
(v)	HT Electric Cable				35
(vi)	Illumination High Mast Towers				60
(vii)	Conventional Fittings, LT cables				50
(viii)	Misc.				30
Sub Total Mechanical / Handling Equipments (In Lakhs)					**1,010.00**

Annexure 11.5 Cost estimate for Bridges

Sr. No.	Structure Name and for road / rail	Chainage (km)	Length (m)	Width (m)	Demolition (In Crores)	Reconstruction (In Crores)	Total (In Crores)
1	Gambhira Bridge	70.4	872.6	10.29	0.5	53.9	54.41
2	Umeta Bridge	82.4	669.13	10.26	0.4	41.2	41.60
3	Under Construction Bridge	87.1	-	-	-	-	
4	Vasad Rail Bridge	94.1	548.57	31.41	1.0	103.4	104.42
5	Vasad NH-8 Bridge	94.3	594	60.12	2.1	214.3	216.41
6	Ahmedabad Vadodara Expressway Bridge (NE1)	99.8	587.287	27.84	1.0	98.1	99.08
7	Poicha Bridge	117.9	504.33	7.36	0.2	22.3	22.49
8	Raniya UC Bridge	129.85	-	-	-	-	-
9	Galteshwar Bridge	143.8	504.42	6.9	0.2	20.9	21.09
						Total	**559.51**

Annexure 11.6 Cost estimate for Utilities

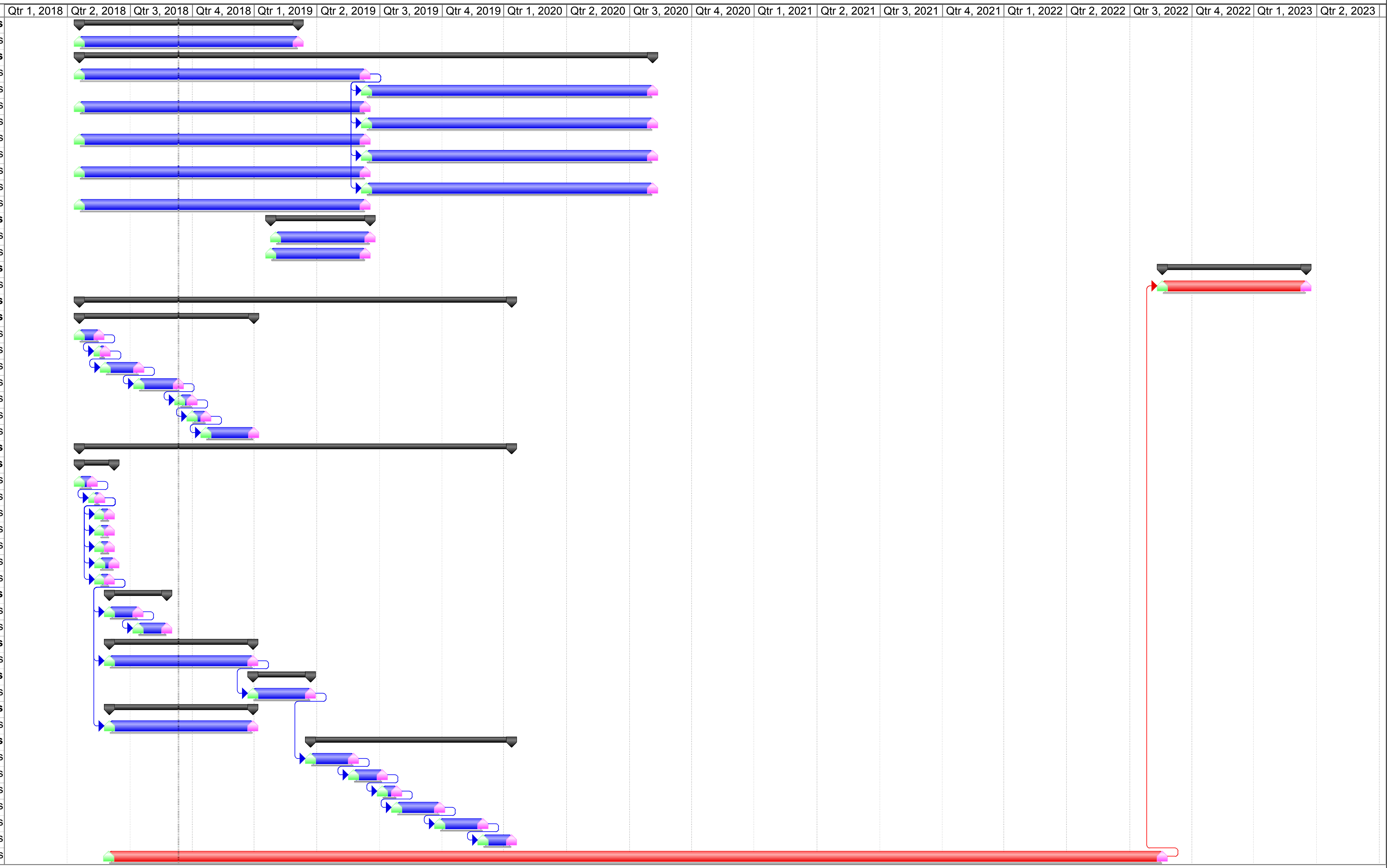
Utilities					
Sr. No.	**Description**	**Quantity**	**Unit**	**Rate**	**Amount (Rs. in Lakhs)**
1	Building	2.00	LS	10,000,000.00	200
2	Water Supply, Pipelines & OHT	1.00	LS	20,000,000.00	200
3	Fire Figthing	1.00	LS	10,000,000.00	100
4	Communcations	1.00	LS	5,000,000.00	50
5	STP / ETP	1.00	LS	20,000,000.00	200
				Sub Total Utilities (In Lakhs)	**750.00**

Annexure 11.7 Cost estimate for RIS

RIS SYSTEM MAHI RIVER (NW-66)				
Sr. No.	**Equipment**	**Qty**	**Unit Price**	**Total**
1	AIS Base Station	3	3000000	9000000
2	RADAR	3	5000000	15000000
3	Meteo Sensor	3	700000	2100000
4	ATG	3	900000	2700000
5	VHF	3	500000	1500000
6	DG Set 10 KVA	3	700000	2100000
7	UPS	3	500000	1500000
8	RIS Software	3	3500000	10500000
9	RIS Hardware	3	10000000	30000000
10	Installation Testing & Commissioning	3	2000000	6000000
11	Porta cabin	6	1200000	7200000
12	Trestle Tower	3	1000000	3000000
			Total	**90600000**
	Operation			-
1	Engineer 1 * Site 1 * Months 12 per year	36	35,000.00	1260000
	Operator 3 * Site 1 * Months 12 per year	108	20,000.00	2160000
	Security 3 * Site 1 * Months 12 per year	108	15,000.00	1620000
2	Second Year			5392800
3	Third Year			5770296
4	Fourth Year			6174216.72
			Total	**22377312.72**
	CAMC for 4 Years			-
1	1st Year	1	9060000	9060000
2	2nd Year	1	9966000	9966000
3	3rd Year	1	10962600	10962600
				-
			Total	**29988600**
			Overall Cost	**142965912.7**

Time Frame-Mahi River

ID		Task Name	Duration
1		**6.1 (a) Navigation Lock**	**230 days**
2		At Sindrot Check Dam	230 days
3		**6.1 (b) Bridges Demolition/Reconstruction**	**600 days**
4		Gambhira Bridge	300 days
5		Umeta Bridge	300 days
6		Under Construction Bridge	300 days
7		Vasad Rail Bridge	300 days
8		Vasad NH-8 Bridge	300 days
9		Ahmedabad Vadodara Expressway Bridge (NE1)	300 days
10		Poicha Bridge	300 days
11		Raniya UC Bridge	300 days
12		Galteshwar Bridge	300 days
13		**6.2 Bank Protection**	**105 days**
14		Near terminal 1	100 days
15		Near terminal 2	100 days
16		**6.3 Navigation Aids**	**150 days**
17		Marine Lantern	150 days
18		**6.4 Terminals**	**452 days**
19		**Terminal 1: Near Sindhrot Dam**	**183 days**
20		Submission of Detailed Engineering Drawing & Methodology for In	21 days
21		Pre-dispatch third party inspection	7 days
22		Supply of Primary units(Float)	35 days
23		Onsite Inspection of supplied unit	42 days
24		Installation of Gangway	14 days
25		Installation of Jetty along with Accessories	14 days
26		Testing, commissioning & trial	50 days
27		**Terminal 2: Wanakbori**	**452 days**
28		**Site mobilisation**	**37 days**
29		Site Clearance	15 days
30		Contractor's Office Establishment	7 days
31		Stores	10 days
32		Lab Establishment	10 days
33		Batching Plant Establishment	10 days
34		Cement Godown	15 days
35		Bentonite Tank	10 days
36		**PRE-CONSTRUCTION ACTIVITIES**	**60 days**
37		Setting Out	30 days
38		Fabrication Yard for Steel, Liner	30 days
39		**CONSTRUCTION ACTIVITY FOR PILING REFER: Fig. 8.32-A, B**	**150 days**
40		Construction of Piles	150 days
41		**CIVIL WORK**	**60 days**
42		Civil work for Berth Structure	60 days
43		**PRECAST SEGMENTS**	**150 days**
44		Erection of Pre Cast Segments	150 days
45		**BROUGHT OUT ITEMS**	**210 days**
46		Floating Enquiry	45 days
47		Scrutinising and Preparing Final Proposal	30 days
48		Client Approval	15 days
49		Delivery at site	45 days
50		Fixing of Fenders, Bollards and Ladders etc.	45 days
51		HANDLING OVER THE SITE	30 days
52		Dredging	1100 days



Task, Progress, Summary, External Tasks, Deadline

Split, Milestone, Project Summary, External Milestone

Chapter – 13
ECONOMIC AND FINANCIAL ANALYSIS
ANNEXURES

Annexure 13.1 EIRR Analysis when all cost bear by IWAI

S.No	Year	Capital Cost	Annual O&M Cost	Total Cost	Economic costs Rs lakhs	Economic Benefits Rs lakhs	Net cash flow Rs lakhs
1	2019	320	0	320	21351		-21351
2	2020	240	0	240	15991		-15991
3	2021	240	0	240	15991		-15991
4	2022		56	56	3720	4328	608
5	2023		57	57	3832	4328	497
6	2024		59	59	3947	4328	382
7	2025		61	61	4065	4328	263
8	2026		63	63	4187	16076	11889
9	2027		65	65	4312	16076	11763
10	2028		67	67	4442	16076	11634
11	2029		69	69	4575	16076	11501
12	2030		71	71	4712	16076	11364
13	2031	7	73	80	5345	20404	15059
14	2032		75	75	4999	20404	15405
15	2033		77	77	5149	20404	15255
16	2034		80	80	5304	20404	15100
17	2035		82	82	5463	20404	14941
18	2036		84	84	5627	24732	19105
19	2037		87	87	5796	24732	18936
20	2038		90	90	5970	24732	18763
21	2039		92	92	6149	24732	18584
22	2040		95	95	6333	24732	18399
23	2041	7	98	105	7014	28442	21428

S.No	Year	Capital Cost	Annual O&M Cost	Total Cost	Economic costs Rs lakhs	Economic Benefits Rs lakhs	Net cash flow Rs lakhs
24	2042		101	101	6719	28442	21723
25	2043		104	104	6920	28442	21522
26	2044		107	107	7128	28442	21314
27	2045		110	110	7342	28442	21100
28	2046		113	113	7562	34625	27063
29	2047		117	117	7789	34625	26836
30	2048		120	120	8023	34625	26602
						IRR	**13.74%**
						NPV (in Rs lakhs)	10110

Annexure 13.2 FIRR, Revenue and Sensitivity Analysis assuming all cost bear by IWAI and charge for using the channel is Rs. 1/tonne

S.No.	Year	Capital cost	Annual O & M Cost	Total Cost	Total Revenue	Net Cash Flow	SENSITIVITY ANALYSIS					
							Cap. Cost (+) 10%	Cap. Cost (-) 10%	ANNUAL O &M COST (+) 10%	ANNUAL O &M COST (-) 10%	REVENUE (+) 10%	REVENUE (-) 10%
	1	2	3	4 = (2+3)	5	6= (5-2)	10	11	12	13	14	15
1	2019	478	0	478	0.00	-478	-525	-430	-478	-478	-478	-478
2	2020	358	0	358	0.00	-358	-394	-322	-358	-358	-358	-358
3	2021	358	0	358	0.00	-358	-394	-322	-358	-358	-358	-358
4	2022		56.0	56.0	7.63	-48	-48	-48	-54	-43	-48	-49
5	2023		57.7	57.7	7.63	-50	-50	-50	-56	-44	-49	-51
6	2024		59.4	59.4	7.63	-52	-52	-52	-58	-46	-51	-53
7	2025		61.2	61.2	7.63	-54	-54	-54	-60	-47	-53	-54
8	2026		63.0	63.0	7.63	-55	-55	-55	-62	-49	-55	-56
9	2027		64.9	64.9	27.57	-37	-37	-37	-44	-31	-35	-40
10	2028		66.9	66.9	27.57	-39	-39	-39	-46	-33	-37	-42
11	2029		68.9	68.9	27.57	-41	-41	-41	-48	-34	-39	-44
12	2030		71.0	71.0	27.57	-43	-43	-43	-50	-36	-41	-46
13	2031	11	73.1	84.1	27.57	-57	-57	-57	-65	-48	-54	-59
14	2032		75.3	75.3	40.01	-35	-35	-35	-43	-28	-31	-39
15	2033		77.5	77.5	40.01	-38	-38	-38	-45	-30	-34	-42
16	2034		79.9	79.9	40.01	-40	-40	-40	-48	-32	-36	-44
17	2035		82.3	82.3	40.01	-42	-42	-42	-50	-34	-38	-46
18	2036		84.7	84.7	40.01	-45	-45	-45	-53	-36	-41	-49

S.No.	Year	Capital cost	Annual O & M Cost	Total Cost	Total Revenue	Net Cash Flow	SENSITIVITY ANALYSIS					
							Cap. Cost (+) 10%	Cap. Cost (-) 10%	ANNUAL O &M COST (+) 10%	ANNUAL O &M COST (-) 10%	REVENUE (+) 10%	REVENUE (-) 10%
	1	2	3	4 = (2+3)	5	6= (5-2)	10	11	12	13	14	15
19	2037		87.3	87.3	47.56	-40	-40	-40	-48	-31	-35	-44
20	2038		89.9	89.9	47.56	-42	-42	-42	-51	-33	-38	-47
21	2039		92.6	92.6	47.56	-45	-45	-45	-54	-36	-40	-50
22	2040		95.4	95.4	47.56	-48	-48	-48	-57	-38	-43	-53
23	2041	11	98.2	109.2	47.56	-62	-62	-62	-73	-51	-57	-66
24	2042		101.2	101.2	54.09	-47	-47	-47	-57	-37	-42	-52
25	2043		104.2	104.2	54.09	-50	-50	-50	-61	-40	-45	-56
26	2044		107.3	107.3	54.09	-53	-53	-53	-64	-42	-48	-59
27	2045		110.5	110.5	54.09	-56	-56	-56	-68	-45	-51	-62
28	2046		113.9	113.9	54.09	-60	-60	-60	-71	-48	-54	-65
29	2047		117.3	117.3	64.67	-53	-53	-53	-64	-41	-46	-59
30	2048		120.8	120.8	64.67	-56	-56	-56	-68	-44	-50	-63
	Total	**1216**	**2280**	**3497**								
FIRR (%)						**Negative Value**						
NPV@ discount factor 9% in Cr.						**Rs. -1,380**	**Rs. -1,481**	**Rs. -1,278**	**Rs. -1,437**	**Rs. -1,323**	**Rs. -1,359**	**Rs. -1,400**

Dear Ms Verma,

Further to our discussion and trailing mails, please find below our **Budgetary quote of Terex Gottwald Mobile Harbour Crane (4 rope)**

Proj no. 16713
CIF East Coast, India
Budgetary Price for: 1 x Model: GHMK 2305 B

FOB North Sea Port: EURO 944779.91
**including freight costs*

Included Options (per crane):

- ✓ Tropical package – Temperature Zone 3
- ✓ Second Stairway
- ✓ Emergency Descending Device

Excluded Options (not offered):

- ✓ Grabs
- ✓ Assembly equipment
- ✓ Test weights

Attached alongwith is the brochure and technical details for your reference. Please note that G HMK 2305 B is fitted with an additional axle.
The updated files for the same will be submitted to you within due course.

We request you to go through the details and reconfirm your technical suitability.

Kind Regards,
Nikhil Misal

Terex Port Solutions
T: 91 2135 61 4578
M: 91 96733 31806

G HMK 2304 Mobile Harbour Crane

Table of Contents Page

1.0 Main Dimensions

Length of chassis without stabiliser pads	approx.	14.7 m
Width of chassis without stabiliser pads *	approx.	8.1 m
Size of stabiliser pads *		1.2 m x 1.8 m
Propping base (length, width)		11.5 m x 11.0 m
Tail radius		6.1 m
Height of boom pivot point	approx.	9.8 m
Crane operator viewing height	approx.	16.1 m
Boom length		40.0 m
Maximum radius		40.0 m
Minimum radius		11.0 m
Hoisting height on hook above quay *	11 m to 15 m radius	40.0 m
	40 m radius	14.0 m
Hoisting height on hook below quay		12.0 m

2.0 Weights

Counterweight		63.0 t
Total weight of operational crane***	approx.	240.0 t

3.0 Main Drive

Type of drive system	Diesel – electric

3.1 Diesel Engine *

Manufacturer	MAN
Model	D 2868 LE122
Engine type	Diesel
Cooling	Water
Nominal output	570 kW at 1800 rpm
Number of cylinders	8
Fuel consumption (at full load)	max. 213 g/kWh

3.2 Fuel Tank

Volume of main fuel tank in chassis	approx.	5400 l
Possible operating time without refueling (depending on operating mode and intensity)		up to 200 h

3.3 Fuel Saving Potential

Savings possible using optional hybrid drive and ultracaps	to 23 %[1]

[1]Achieved under specific deployment conditions and based on experience gained from operating a Terex® Gottwald Generation 5 crane over a period of more than one year.

4.0 Hoist

Number of rope drums		1
Number of ropes		2
Hoisting speeds:		
	without load	85.0 m/min
	10.0 t	67.0 m/min
	45.0 t	38.0 m/min
	63.0 t	30.0 m/min
	80.0 t	25.0 m/min

5.0 Slewing Gear

Number of slewing gear drive units		1
Slewing speeds:		
	to 47.0 t	to 1.4 rpm
	to 80.0 t	to 0.6 rpm
Maximum peripheral speeds at boom head:		
	to 47.0 t	to 180 m/min
	to 80.0 t	to 80 m/min

6.0 Luffing Gear

Average luffing speeds:	to 47.0 t	60 m/min
	to 80.0 t	27 m/min

7.0 Travel Gear

Travel speed	up to	80.0 m/min
Total number of axles		4
Number of steered axles		4
Number of driven axles		2
Number of wheels		16
Tyre size		14.00-24
Climbing ability		6.0 %
Vertical axle compensation		+250 mm / -250 mm
Minimum inner curve radius	approx.	5.5 m
Minimum outer curve radius	approx.	13.5 m
Maximum crab steering angle	approx.	25°

8.0 Ambient Conditions

Permissible wind speeds:

Crane in operation	to	20 m/s
Crane in travel operation	to	20 m/s
Crane out of service	to	46 m/s

At wind speeds above 46 m/s, the boom head should be lowered and secured.

Permissible ambient temperatures: **	minimum	-20° C
	maximum	+45°C

9.0 Stability Requirement (Percentage of Tipping Load)

Normal-load operation / heavy-load operation	$\leq$ 75 %
Motor grab operation	$\leq$ 50 %

10.0 Classification of Crane and Mechanisms

Classification in accordance with: FEM 1.001, 3rd edition, 1998

10.1 Crane Classification

Container operation (single lift)		A6
Motor grab operation	32.0 t	A7
Normal-load operation	47.0 t	A6
Heavy-load operation	63.0 t	A5
	80.0 t	A4

10.2 Classification of Mechanisms

Hoist:		
Container operation (single lift)		M6
Motor grab operation	32.0 t	M7
Normal-load operation	47.0 t	M6
Heavy-load operation	63.0 t	M3
	80.0 t	M3
Slewing gear:		
Container operation (single lift)		M7
Motor grab operation	32.0 t	M7
Normal-load operation	47.0 t	M7
Heavy-load operation	80.0 t	M7
Luffing gear:		
Container operation (single lift)		M7
Motor grab operation	32.0 t	M7
Normal-load operation	47.0 t	M7
Heavy-load operation	80.0 t	M7
Travel gear:		M4

11.0 Lighting

Boom head *	Metal vapour lamp	1 x 2000 W
Bottom of boom *	Metal vapour lamp	1 x 2000 W
Front of tower *	Metal vapour lamp	2 x 400 W
Rear of tower *	Metal vapour lamp	1 x 400 W
Boom head obstacle beacon **		1
Tower head obstacle beacon **		1

12.0 Surface Treatment

Surface treatment of the steel structure:	EN ISO 12944
Surface preparation:	Sa 2.5 (ISO 8501-1)

Edge protection:	Two-component epoxy resin with micaceous iron ore	
Primer coat:	Two-component epoxy resin	≥ 60 μm
Intermediate coat:	Two-component epoxy resin	≥ 60 μm
Top coat:	Two-component acrylic-polyurethane	≥ 50 μm
Total coating thickness:		≥ 170 μm

Key:

* Data for basic equipment. Alternative special equipment available
** Data for special equipment
***Depending on the configuration selected

Subject to technical modification without prior notice.

9.6 - DREDGING

Sr. No.	Item Code	Name of Item	Unit	2015-16
1	DRED0001	Labour for drilling holes in Nilgiri Vertical /Horizonal piles and fitting of MS assorted size bolts and nuts with labour and material in all respect	Per Hole	191
2	DRED0002	Labour for shifting of HDPE or Steel pipe up to 500 mm dia. (Min. 10 mtrs distance). It includes shifting, lowering and shifting 500 mm dia steel OR HDPE pipes with all materials etc. within harbour area. **0- 6 mtrs length**	per mtr distance	58
3	DRED0003	Labour for shifting of HDPE or Steel pipe up to 500 mm dia. (Min. 10 mtrs distance). It includes shifting, lowering and shifting 500 mm dia steel OR HDPE pipes with all materials etc. within harbour area. **0- 12mtrs length**	Mtr	81
4	DRED0004	Labour for shifting of HDPE or Steel pipe up to 500 mm dia. (Min. 10 mtrs distance). It includes shifting, lowering and shifting 500 mm dia steel OR HDPE pipes with all materials etc. within harbour area. **0- 18 mtrs length**	Mtr	115
5	DRED0005	Marinating floating steel or HDPE pipe as well under water pipelines, ball and socket pontoons etc. including anchoring, positioning as per needs complete in all respect without any breakage leakage.	Mtr	23
6	DRED0006	Labour charges for handling, pitching and driving Nilgiri piles includeing cutting down extra un-driven length if not required in soft strata.	Mtr	69
7	DRED0007	Labour charges for handling, pitching and driving Nilgiri piles including cutting down extra un-driven length if not required in soft strata. **3.00 to 6.00 m**	Mtr	92
8	DRED0008	Labour charges for handling, pitching and driving timber including cutting down extra un-driven length if not required in hard strata. **0.00 to 3.00 m**	Mtr	92
9	DRED0009	Labour charges for handling, pitching and driving timber including cutting down extra un-driven length if not required but in hard strata **3.00 to 6.00 m**	Mtr	115

Sr. No.	Item Code	Name of Item	Unit	2015-16
10	DRED0010	Labour charges for handling pitching and driving timber piles in foundation of the structure including cutting down extra un-driven length if not required in tidal zone viz. in jetties, dolphins, wharves etc. **0.00 to 3.00 m**	Mtr	104
11	DRED0011	Labour charges for handling pitching and driving timber piles in foundation of the structure including cutting down extra un-driven length if not required in tidal zone viz. in jetties, dolphins, wharves etc. **3.00 to 6.00 m**	Mtr	138
12	DRED0012	Opening, cleaning, servicing, rousing of anchor spud guide pulley and fitting back with necessary trials. Labour charges only.	No	863
13	DRED0013	Opening, cleaning, servicing, overhauling of main derrick of Dredger and also replacing worn out parts excluding cost of materials but including satisfactory trials and consumables.	No	17538
14	DRED0014	Opening, cleaning, servicing, overhauling of hydraulic operated suction valve of dredge pump of Dredger by replacing worn-out parts with satisfactory trials and consumables. Labour job only.	No	19435
15	DRED0015	Removal and replacement of sunk fit CS coupling of output shaft for reduction gearbox of dredge pump of Dredger (a) Removal of sunk fit CS coupling. (b) Replacement of bearing and oil seal. (c) Checking trueness of shaft. (d) Checking trueness of CS coupling and machining the same as per requirement. (e) Refitting of the coupling on the shaft assembly of gearbox. (f) Alignment of gearbox. (g) Complete test and trials to be given to the satisfaction of EIC	No	37398
16	DRED0016	Checking and doing alignment of dredge pump shaft with gearbox output shaft in Dredger with standard permissible limits. Chokes and foundation bolts will be provided by department while other materials and equipments will be arranged by the contractor.	Job	36455

Sr. No.	Item Code	Name of Item	Unit	2015-16
17	DRED0017	Hopper door water tightness checking/rectification labour charges only	No	22793
18	DRED0018	Hopper door damaged sealing renewal labour charges.	Each	10833
19	DRED0019	straightening of eyes of hopper door.	Each	5635
20	DRED0020	Labour for opening, cleaning, servicing, overhauling of main derrick of dredger and also replacing workout parts excluding cost of materials but including satisfactory trials.	Each	14490
21	DRED0021	Dismantling & erecting of grab bucket after MS plate its pin and pulley bushes complete in all respect with satisfactory trials. **up to 1 cu.m. capacity**	each	6555
22	DRED0022	Dismantling & erecting of grab bucket after MS plate its pin and pulley bushes complete in all respect with satisfactory trials. **between 1.1-2.0 cu.m. capacity**	each	9085
23	DRED0023	Dismantling & erecting of grab bucket after MS plate its pin and pulley bushes complete in all respect with satisfactory trials. **Between 2.1-3.0 cu.m.**	each	10810

10.7 - DREDGING COMPONENTS

Sr. No	Component Code	Name of Components	Group Code	Unit	Unit Rate in Rs
1	DREDG00001	Dredging with Cutter Suction incl. mob-demob	DR1	Cu.M.	228
2	DREDG00002	Dredging with Trailer-suction incl. mob-demob	DR1	Cu.M.	248
3	DREDG00003	Dredging with Grab incl. mob-demob	DR1	Cu.M.	155
4	DREDG00004	Dredged material delivery by pump- pipe upto 100 m. distance	DR2	Cu.M.	10
5	DREDG00005	Dredged material delivery by pump- pipe upto 300 m. distance	DR2	Cu.M.	17
6	DREDG00006	Dredged material delivery by pump- pipe upto 1000 m. distance	DR2	Cu.M.	29
7	DREDG00007	Dredged material delivery by pipe upto 2000 m. distance	DR2	Cu.M.	41
8	DREDG00008	Dredged material delivery by barge upto 500 m. distance	DR2	Cu.M.	92
9	DREDG00009	Dredged material delivery by barge upto 2000 m. distance	DR2	Cu.M.	115
10	DREDG00010	Dredged material delivery by barge upto 5 nautical mile distance	DR2	Cu.M.	132
11	DREDG00011	Dredged material delivery by barge above 5 n. m. distance	DR2	Cu.M.	155
12	DREDG00012	Dredged material delivery by barge above 10 n. m. distance	DR2	Cu.M.	-
13	DREDG00013	Dredged material dumping by trucks upto 1000 m. distance	DR2	Cu.M.	46
14	DREDG00014	Dredged material dumping by trucks between 1000m. to 5000 m. distance	DR2	Cu.M.	69
15	DREDG00015	Dredged material dumping by trucks beyond 5000 m. distance	DR2	Cu.M.	92

Sr. No.	Component Code	Name of Component	Group Code	Unit	Unit Rate in Rs
16	DREDG00016	Dredger Toyo Pump Mob- Demob to site upto 10 Km. distance	DR3	per unit	57500
17	DREDG00017	Dredger backhoe Mob- Demob to site upto 10 Km. distance	DR3	per unit	57500
18	DREDG00018	Dredger cutter-suction Mob- Demob to site upto 10 Km. distance incl. assembly	DR3	per unit	1,72,500
19	DREDG00019	Dredger cutter-suction Mob- Demob to site upto 100 Km. distance excl.assembly	DR3	per Km	403
20	DREDG00020	Dredger cutter-suction Mob- Demob to site above 100 Km. distance excl. assembly	DR3	per Km	345
21	DREDG00021	Dredger cutter/trailing-suction Mob-Demob by sea to site upto 100 n.m. distance	DR3	per unit	2,87,500
22	DREDG00022	Dredger cutter/trailing-suction Mob-Demob by sea to site above 100 n.m. distance	DR3	per n.m.	863
23	DREDG00023	Mob-Demob of Dredger- Grab/Toyo pump/Backhoe for jobs upto 100,000 cu.m.	DR3	per cu.m.	21
24	DREDG00024	Mob-Demob of Dredger- Grab/Toyo pump/Backhoe above 100,000 cu.m.	DR3	per cu.m.	12
25	DREDG00025	Mob-Demob of Dredger- Cutter/Trailing Suction for jobs upto 500,000 cu.m.	DR3	per cu.m.	41
26	DREDG00026	Mob-Demob of Dredger- Cutter/Trailing Suction for jobs above 5 upto 1,000,000 cu.m.	DR3	per cu.m.	21
27	DREDG00027	Mob-Demob of Dredger- Cutter/Trailing Suction for jobs above 1,000,000 cu.m.	DR3	per cu.m.	12

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Sr. No.	Component Code	Name of Components	Group Code	Unit of Measurement	Unit Rate in Rs.
		DREDGING			
1	DREDG00001	Dredging with Cutter Suction incl. mob-demob	DR1	Cu.M.	198
2	DREDG00002	Dredging with Trailer-suction incl. mob-demob	DR1	Cu.M.	216
3	DREDG00003	Dredging with Grab incl. mob-demob	DR1	Cu.M.	135
4	DREDG00004	Dredged material delivery by pump- pipe upto 100 m. distance	DR2	Cu.M.	9
5	DREDG00005	Dredged material delivery by pump- pipe upto 300 m. distance	DR2	Cu.M.	15
6	DREDG00006	Dredged material delivery by pump- pipe upto 1000 m. distance	DR2	Cu.M.	25
7	DREDG00007	Dredged material delivery by pipe upto 2000 m. distance	DR2	Cu.M.	36
8	DREDG00008	Dredged material delivery by barge upto 500 m. distance	DR2	Cu.M.	80
9	DREDG00009	Dredged material delivery by barge upto 2000 m. distance	DR2	Cu.M.	100
10	DREDG00010	Dredged material delivery by barge upto 5 nautical mile distance	DR2	Cu.M.	115
11	DREDG00011	Dredged material delivery by barge above 5 n. m. distance	DR2	Cu.M.	135
12	DREDG00012	Dredged material delivery by barge above 10 n. m. distance	DR2	Cu.M.	
13	DREDG00013	Dredged material delivery by trucks upto 1000 m. distance	DR2	Cu.M.	40
14	DREDG00014	Dredged material delivery by trucks upto 5000 m. distance	DR2	Cu.M.	60
15	DREDG00015	Dredged material delivery by trucks upto 10000 m. distanc	DR2	Cu.M.	80

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Sr. No.	Component Code	Name of Components	Group Code	Unit of Measurement	Unit Rate in Rs.
		DREDGING			
16	DREDG00016	Dredger Toyo Pump mob-bemob to site upto 10 Km. distance	DR3	per unit	50000
17	DREDG00017	Dredger backhoe mob-bemob to site upto 10 Km. distance	DR3	per unit	50000
18	DREDG00018	Dredger cutter-suction mob- bemob to site upto 10 Km. distance incl. assembly	DR3	per unit	1,50,000
19	DREDG00019	Dredger cutter-suction mob- bemob to site upto 100 Km. distance excl.assembly	DR3	per Km	350
20	DREDG00020	Dredger cutter-suction mob- bemob to site above 100 Km. distance excl. assembly	DR3	per Km	300
21	DREDG00021	Dredger cutter/trailing-suction mob- bemob by sea to site upto 100 n.m. distance	DR3	per unit	2,50,000
22	DREDG00022	Dredger cutter/trailing-suction mob- bemob by sea to site above 100 n.m. distance	DR3	per n.m.	750
23	DREDG00023	Mob-demob of Dredger-Grab/Toyo pump/Backhoe for jobs upto 100,000 cu.m.	DR3	per cu.m.	18
24	DREDG00024	Mob-demob of Dredger-Grab/Toyo pump/Backhoe above 100,000 cu.m.	DR3	per cu.m.	10
25	DREDG00025	Mob-demob of Dredger-Cutter/Trailing Suction for jobs upto 500,000 cu.m.	DR3	per cu.m.	36
26	DREDG00026	Mob-demob of Dredger-Cutter/Trailing Suction for jobs above 5 upto 1,000,000 cu.m.	DR3	per cu.m.	18
27	DREDG00027	Mob-demob of Dredger-Cutter/Trailing Suction for jobs above 1,000,000 cu.m.	DR3	per cu.m.	10

List of all Team Members (In-House & Empanelled Key Experts)

Sl. No.	Name of the Key Expert	Proposed Position
1.	Sh. D. N. Deshmukh	Team Leader
2.	Sh. Prakash Krishnaji Khare	Port Planning and Infrastructure Specialist
3.	Dr. Santosh K. Sati	GIS/Remote Sensing Expert
4.	Sh. R. N. Bansal	Floodplain Specialist
5.	Sh. Bidyadhyar Thakur	Hydrographic Expert
6.	Sh. Prasanta Kumar Kundu	Soil Engineer/Foundation Engineer
7.	Capt. Gary Vaz	Traffic Surveyor
8.	Sh. M Ganesan	Transport Economist

Contact Authority:

Shri Jatinder Kumar
General Manager (PH & IW)
WAPCOS Limited
76-C, Sector-18,
Institutional Area,
Gurgaon - 122 015 (Haryana)

SECTION-6 TERMS OF REFERENCE

1.0 OBJECTIVE OF THE STUDY:

Government of India intends to explore the potential of additional waterways across the country for year round commercial navigation, for this it is planned to conduct a Feasibility Study and recommending thereafter the possibility of Composite and Integrated development of proposed waterways to achieve navigation and to develop water transport facilities across India. After carrying out the feasibility study if there is scope for navigation and potential to develop waterway transport facility, a Detailed Project Report needs to be prepared for those waterways which would include detailed hydrographic surveys and investigation, traffic survey, proposed location for terminals and cost assessment etc.

The study would consist of 2 stages:

1. **Stage-1**
2. **Stage-2**

1.1 STAGE-1

Stage-I is only for feasibility of the waterway for navigation, which may have the potential for year round navigation or at least for a few months in a year.

Stage-1 would consist of the following activities:

1A. Reconnaissance Survey

1B. Collection and review of available data

1C. Feasibility Report

1.1.1 Reconnaissance Survey

The detailed field reconnaissance survey may be taken up immediately after the analysis of available data. The primary tasks to be accomplished during the reconnaissance surveys include:

i- Single line longitudinal survey (Bathymetric survey or Topographic survey) in the deepest depths or lowest height lands, with the help of DGPS using Automatic Hydrographic Survey System. Bathymetric surveys in the proposed waterways are to be carried out in the deepest route. Deepest route can be accessed by taking two or three longitudinal line soundings at equal interval. Topographic survey, if required, is to be taken up at lowest ground levels, which can be decided on visual assessment.

ii- Details (horizontal and vertical clearances above High Flood Level of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route are to be collected and indicated on the chart and also included in the report along with their co-ordinates and location. Details about Barrages, Dams, Locks enroute are also to ~~be~~ collected. horizontal and vertical clearance is to be given as approximate on visual assessment. Photographs are required to be submitted in the report.

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iii- Topographical features of the proposed Inland Waterways.

iv- Typical physical features along the alignment i.e. land use pattern:

v- Preliminary identification of stretches having year round flow and critical depth for navigational purpose.

vi- Preliminary Traffic identification on the proposed Inland Waterways.

vii- Inventory of major aspects including proposed Inland Waterway width, Terrain, Bridges and structures across the proposed Inland Waterways (Type, size and location), urban areas (location extent). Geologically sensitive areas environmental features. Hydrological features

viii- Critical areas requiring detailed investigations and

ix- Requirements for carrying out supplementary investigations

x- Soil (textural classifications) (only visual inspection at every 10km) and drainage conditions.

xi- Type and extent of existing utility services along the alignment.

xii- Identification of various agencies of the govt. from whom the concerned project clearances for implementation are to be sought.

The data derived from the reconnaissance surveys may be utilized for planning and programming the detailed surveys and investigations. All field studies including the traffic surveys should be taken up on the basis of information derived from the reconnaissance surveys. For the critical locations, River cross sections survey needs to be carried out..

1.1.2 Collection and Review of Available Data

A review has to be done based on the existing data available with the State Agencies and Central Water Commission for the proposed Inland Waterways for determining the nature, extent, adequacy, validity of the available data and identifying the data gaps. Consultant has to collect available data for the proposed Inland Waterways from the State Agencies and Central Water Commission. An introductory letter will be issued by IWAI for collecting information from State / Central Government.

An inception report has to be prepared which would consist of the findings based on the analysis of the existing data and reconnaissance surveys.

1.1.3 Feasibility Report

The Consultant has to prepare Feasibility Report for the proposed waterways based on the available data and reconnaissance survey. It must include the following prospects:

1. **Introductory considerations:**
   The Consultant shall provide an introduction, describing the scope of the assignment, its methodology in fulfilling the assignment and the expected outcome of the assignment.

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कमां प्रशा... कु. श्रीवास्तव
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(पोत परिवहन मंत्रालय,भारत सरकार)
(Ministry of Shipping Govt. of India)

2. **Analysis of present state of affairs:**
   The Consultant shall provide a quantitative and qualitative description of the current utilization of proposed inland waterways. In addition, the Consultant shall describe the status of goods transport, including utilization of road and transport, as well as river facilities.

3. **Market Analysis:**
   The consultant shall analyze the market and potential usage of proposed Inland Waterways. This analysis shall examine both the existing market and the potential future market. Contractor has to collect the details of available Industries along the waterway, type of production in these industries, ferry services, type of crop along the waterway, previous history of movement of cargo in the waterway etc. Above is to be collected after discussion with local village people while conducting reconnaissance survey etc. and also after interaction with State Govt. Officials, Irrigation / Water Resources departments.

4. **Reconnaissance Survey:**
   Analysis of the data collected in the reconnaissance survey should reflect the possibility of year round flow in the proposed Inland Waterways to achieve the commercial navigation. It should also consist the map of proposed Inland Waterways indicating existing cross structures viz. bridges, dams etc. Navigability of the waterway (for the periods) is to correlate with CWC/Irrigation water level data.

The Consultant has to submit the Feasibility Report for proposed Inland Waterways. Consultant also has to emphasize that which stretches of proposed inland waterways has potential of possible navigation. Only for those stretches of proposed inland waterways, which have potential of possible navigation, Stage 2 has to be carried out.

After obtaining approval from IWAI for identified stretches, Consultant may proceed for Stage - 2. Based on the feasibility report, IWAI will accord the approval for Stage-II, and stretch for DPR will be based on feasibility study.

1.2 STAGE-2

For Stage-2, Consultant has to carry out detailed hydrographic survey, topographic survey, traffic survey and selection of terminal locations.

Stage-2 would consist of the following activities:

1A. Hydrographic Survey &hydro-morphological survey

1B. Traffic Survey & Techno economic feasibility

1C. Preparation of Detailed Project Report

1.2.1 HYDROGRAPHIC SURVEY & HYDROMORPHOLOGICAL SURVEY

Based on the recommendation after reconnaissance survey of proposed Inland Waterways

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Hydrographic survey may b as per the International Standards including the following for finding the pote l Inland Waterways for inland navigation:-

(i) The detailed hydro to be carried out in WGS'84 datum.

(ii) The horizontal co made using DGPS with minimum 24 hours observations at some platform/base.

The vertical control is to be established with respect to the chart datum / sounding datum from the following methods:-

i. Chart datum/ sounding datum already established by Port Authorities (Chart Datum), Central Water Commission (Average of last six years minimum Water Level) / State Irrigation Department (Full Supply Level (FSL)) and at their gauge stations along the river/canal. Secrecy undertaking forms etc. will be provided by IWAI for collection of CWC data. Introductory letter will be issued to the successful Consultant for collection of other required information from State Departments.

ii. Standard method shall be adopted for transfer of datum in rivers/canals. For tidal reaches standard transfer of datum as per Admiralty Manual shall be adopted.

iii. **By erection of tide gauges – at every 10km interval and also at upstream and downstream of Locks, Sluice gates, Barrages, Dams etc.**

Other Terms of Reference for the survey work shall be as given below: -

1.2.1.1 BENCH MARK PILLARS

a. Construct Bench Mark Pillars of dimension 0.3m x 0.3m x 1.5m (0.6m above GL) RCC pillar with 6mm thick 50mm dia GI pipe inserted (as per construction drawing of Survey Pillar in the tender document), at every 10km interval. Detailed description of the bench mark along with its position and value to be given in the report for future recovery.

1.2.1.2 WATER LEVEL GAUGES

i. Water level gauges are to be erected at every 10 km interval along the canal/river **and also at upstream and downstream of Locks, Sluice gates, Barrages, Dams etc. simultaneously.** Readings are to be taken at 1 hr interval for 12 hours (6 AM to 6 PM) or for the entire period of survey. The gauges are to be connected to a nearest Bench Mark by leveling and its datum value shall be established w.r.to MSL & CD. Water level gauges are to be installed temporarily during the survey period.

ii. At least 2 gauges (one U/s and one D/s at 10 Km apart) shall be read simultaneously and soundings to be carried out within the gauge stations. Soundings are to be reduced for datum of a gauge for 5km length of the canal/river on both side of a gauge.

1.2.1.3 BATHYMETRIC AND TOPOGRAPHICAL SURVEY

Sl. No.	Name of the River / Canal	Description of Inland Waterway
		CLUSTER-8
1	MAHI RIVER:	248 kms length of the river from Kadana Dam at Lat 23°18'22.35"N, Long 73°49'37.45"E to confluence with Gulf of Khambhat near Kavi railway station at Lat 22°10'34.71"N, Long 72°30'36.31"E

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2	NARMADA RIVER	227 km length of the river from Pandhariya at Lat 21°57'10.37"N, Lon 74° 8'27.46"E to confluence of Narmada with Arabian Sea at Gulf of Khambhat Lat 21°38'26.81"N, Lon 72°33'28.24"E
3	SABARMATI RIVER:	212 kms length of the river from Barrage near Sadoliya at Lat 23°26'49.66"N, Long 72°48'34.85"E to confluence with Gulf of Khambhat near Khambhat at Lat 22° 9'17.99"N, Long 72°27'27.81"E
4	TAPI RIVER:	436 kms length of the river from Hatnur Dam near Mangalwadi at Lat 21° 4'21.99"N, Long 75°56'44.88"E to confluence with Gulf of Khambhat (Arabian Sea) at Lat 21° 2'15.51"N, Long 72°39'29.63"E

#	River/Canal	State	Length (km)	Spacing (m)	Ave. width (m)
		CLUSTER-8			
1	MAHI RIVER	Gujarat	248	200	400
2	NARMADA RIVER	Maharashtra & Gujarat	227	200	500
3	SABARMATI RIVER	Gujarat	212	200	150
4	TAPI RIVER	Maharashtra & Gujarat	436	200	350
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Note:- Bathymetric and Topographical survey of specified Waterways is to be conducted for average width specified in above table. Average width of the Waterways is the average of narrow and wider portions of the river. For reservoir / ponding areas, only bathymetric survey of maximum 500m width in the deepest channel is to be carried out. Minimum 100m wide corridor is to be surveyed (only for rivers / canals having less than 60m water width). 100m wide corridor includes width of proposed Waterways. Bathymetric and topographic survey is to be carried out for 50m width on both side from the centre line of the channel.

a. Bathymetric and Topographical survey of proposed Inland Waterways is to be conducted for width specified in above table. Minimum 100m wide corridor is to be surveyed to assess the extent of land acquisition required for 100m wide corridor (100m wide corridor includes width of proposed Inland Waterways).
b. Cross-section sounding lines / leveling are to be run from bank to bank at spacing specified in above table, to identify the navigable channel.
c. Continuous soundings are to be taken by running the sounding boat at constant speed on the cross-section so as to get smooth contours. Intermediate line is to be run at bends, if the line spacing is more than the specified above.
d. For cross-sectional bathymetric survey more than 60m in proposed Inland Waterways, spot levels at line spacing x 20m length grid, on both banks should be taken. If Island or sandchur exist in the middle of the waterway, spot levels on the same spacing should also be taken and indicated in the charts along the same cross-section line.
e. If bathymetry cross-section is limited up to 60 mts width in waterway, then Consultant has to cover 100m corridor including spot levels in line spacing x 20m length grid on both banks.
f. If bathymetry cross-sectional is limited up to 20 mts width in waterway, then Consultant has to run three (03) nos. longitudinal lines. One in centre and one each at equal interval (near the edges of water).
g. If bathymetry cross-sectional is limited up to 10 mts width in waterway, then Consultant has to run one (01) no. longitudinal line at centre only.

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h. If Island or sandchur exist in the middle of the river, spot levels on the same spacing should also be taken and indicated in the charts along the same cross-section line.
i. Surveys in non-approachable areas are to be informed by the Consultant and joint inspection (Consultant's representative & Engineer-In-Charge or his representative) will be held to confirm the non-approachable areas.
j. The survey area may consist of canal sections, rivers, sea openings of different dimensions. Hence, Consultant has to inspect the area to be surveyed and satisfy themselves with respect to site conditions before submission of bid. However, variation in quantity will be considered only for length of the river/canal (longitudinal length).
k. The soundings are to be reduced to the chart datum/ sounding datum established at every gauge stations.

1.2.1.4 CURRENT VELOCITY AND DISCHARGE MEASUREMENT

a. The current velocity and discharge at every 10 km interval shall be observed once in a day during the survey period. Current velocity and discharge at every 10 km interval are to be measured only once at different depths while carrying out survey in that region.
b. Current meter measurement should be taken at 1m below water surface or 0.5d (if depth is less than 1m), where d is measured depth of water & values indicated in the report along with position.
c. Measurements at different depths may be taken by single equipment over three different time spans.
d. Measurement of current velocity at different depth is to be measured for at least 15 minutes or as per listed calibration period of the equipment, under use for this project.
e. Current velocity and discharge can also be measured with the help of ADCP during survey, at every 10km interval. Discharge can be measured either by ADCP or standard formulas.

1.2.1.5 WATER AND BOTTOM SAMPLES

a. Water and bottom samples are to be collected from the deepest route at every 10 km interval and are to be tested and the results/characteristics of the soil and the water are to be incorporated in the report. Soil sample can be collected by a grab and water sample at 0.5d (d-measured depth of water) by any approved systems. The following tests are to be carried out for Bottom samples:-

i) Grain size distribution
ii) Specific gravity,
iii) PH value
iv) Cu, Cc
v) Clay silt%
and Sediment concentration for Water Samples.

1.2.1.5 COLLECTION OF TOPOGRAPHICAL FEATURES

a. Photographs of the prominent features are to be taken and included in the report along with its position.

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…rmanent structures located within this corridor are also required to be indicated on …e report & charts.

…l prominent shore features (locks, bridges, aqueducts, survey pillars if available etc) …d other conspicuous objects are to be fixed and indicated on the chart and included in the report.

d. Identify cross structures which are obstructing navigation.
e. Details (horizontal and vertical clearances above High Flood Level in non-tidal area and High Tide Level in tidal area) of bridges, aqueducts, electric lines, telephone lines, pipe lines, cables en-route are to be collected and indicated on the chart and also included in the report along with their co-ordinates and location.
f. Details of water intake/ structures are to be collected and shown on the charts and include in the report.
g. Availability of berthing place, existing jetty, ferry ghats, approach roads etc. are to be indicated on the charts and include in the report.
h. During the survey, conditions of the banks are also required to be collected. It is to be noted that banks are pitched (protected) or not protected. Estimate the length of bank protection, where banks erosion is taking place.
i. Positions and levels of corners of permanent structures within the corridor are to be physically surveyed and marked on survey charts.
j. Approachable roads / rails / places outside the corridor may be incorporated from Toposheets/Google Map/Google Earth.

1.2.1.6 SURVEY CHART PREPARATION

a. The survey chart is to be prepared on a scale of 1:1,000 for Waterways width less than 100m. On a scale of 1:2,000 for Waterways width between 100m to 300m. On a scale of 1:5,000 for Waterways width between 300m to 500m and On a scale of 1:10,000 for Waterways width more than 500m.
b. Contours of 0m, 1m, 2m, 3 m, 5m and 10 m are to be indicated on the charts with respect to Chart Datum / Sounding Datum.
c. Reduced spot levels w.r.to MSL to be indicted on the charts. Spot level values are to be given w.r.t. Mean Sea Level (MSL) & Soundings w.r.t. Chart Datum / Sounding Datum. A separate file (xyz) (soft copy only) is also to be created for spot levels w.r.t. Chart Datum / Sounding Datum for dredging calculation purpose.
d. On completion of the cross-sections, dredge channel is to be identified/ established by linking deepest soundings on the cross-sections. Dredging quantity is to be estimated for developing a navigational channel of
   i. dimension of 32m x 1.8m, with side slope of 1:5, w.r.t. chart datum/sounding datum (if channel width is less than or equal to 100m).
   ii. dimension of 45m x 2.0m, with side slope of 1:5, w.r.t. chart datum/sounding datum (if channel width is more than 100m).
e. Dredging quantity is to be indicated in the report for per km length of the waterway.
f. Minimum & maximum reduced depth and length of shoal for per km length of the waterway is also to be indicated in the report.
g. Current meter measurement values shall be indicated in the report along with position.
h. The results/characteristics of the soil and the water are to be incorporated in the report.
i. Shallow patches /shoal and submerged sand-chur having less than 1.0 m depth, rocky outcrops, rapids and other navigational impediments are to be indicated on the charts.
j. A brief write up on condition of the locks, Sluice gates, Barrages, Dams etc. (…

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vailable) are also to be included in the report. Brief write up based on visual observation, photographs and information from State Irrigation Deptt. and local urces.

e chart shall also be suitably updated with prominent land features from the Topo-ets/site. Available Survey of India (SOI) Topographic sheet will be shared with cessful Consultant on receipt of Undertaking. Satellite imageries are not available IWAI for the designated area. Route map and survey plan will be provided by I to the successful Consultant.

aw data and processed data of Automatic Hydrographic Survey System are required to be submitted. Standard procedure is to be adopted for data processing. All RAW, EDIT, SORT and field data are required to be submitted by the Contractor.

m. All surveyed field data including leveling data (csv file) are required to be submitted.
n. All position data of ground features, waterway structures are to be submitted in both hard copies and soft copies.

1.2.2 TRAFFIC SURVEY & TECHNO ECONOMIC FEASIBILITY

This is a detailed study to make a forecast of the traffic prospects to facilitate the projection of the most promising route for waterway transport and to assess the quantum of traffic of vessels/cargo on that route. This survey is to be under-taken in conjunction with Reconnaissance and Hydrographic surveys so that the Techno Economic feasibility and costs of the alternative proposals can be taken into account while formulating the recommendations.

Modality of conducting traffic survey shall be based on industrial surveys and a traffic projection for a horizon period (say 5, 10, 15 and 20 years) has to be forecasted based on standard methods. Divertible traffic to IWT is also to be assessed.

1.2.3 DETAILED PROJECT REPORT

The scope of works is as follows:

a. Assessment of the morphological, hydrological, hydrographical conditions, and operation and maintenance requirements of the proposed waterways to identify works in sufficient details that are required in respect of:
    - River conservancy including river training, bank protection, dredging etc. needed for shipping and navigation.
    - Navigational aids and communication facilities.
    - Improvements with reference to horizontal and vertical clearances required on the existing or proposed cross structures such as bridges, power cables, locks etc.

b. Geo-tech investigation will be carried out by the consultant as per standard guidelines of Geological Survey of India, Government of India.

c. To conduct necessary investigations for the preliminary design, to ensure a coordinated development to cover waterways engineering works and structures, waterway crossing, navigational structures, riverine ports and terminals, land and rail access.

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d. Prepare preliminary engineering designs, drawings and estimates for the optimum structure of river training and bank protection measures and navigational aids to develop and maintain a navigable channel for the waterway system in an EPC mode.

e. For preliminary engineering designs, the data about soil characteristics shall be collected from the local sources based on the structures constructed nearby. In case of critical structures, consultant can suggest that detailed soil investigation including borehole tests etc.

f. River training/bank protection works particularly for those stretches where either the channel is narrow and needs to be widened by dredging or where it is anticipated that the bank can erode due to continuous movement of barges.

g. Identify the location and carry out preliminary designs of cargo terminals and river ports to handle the anticipated cargo as duly updated.

h. Prepare a realistic construction schedule for the whole project indicating the priority of different components of the project. The phasing of expenditure is also to be worked. Also suggest phased programs of construction including riverine terminals and ports which shall be fully integrated with the existing and planned irrigation and hydropower facilities.

i. Prepare cost estimate for various possible alternatives for the entire proposed infrastructure, handling, and other allied facilities. While comparing the different alternatives, the cost and economy factors shall also be evaluated. The most suitable alternative recommended shall have detailed costing for all the components of the project. The Consultant is to propose the River conservancy including river training, bank protection, dredging etc. needed for shipping and navigation. Alternate possible methods for water augmentation are also to be suggested in detail. FIRR, EIRR, NPV and SWOT analysis are also to be carried out by the Consultant.

j. Assess the environmental impacts due to these development works and suggest suitable environmental management plan (EMP) to mitigate the adverse impacts, if any, including its cost. Flood Plain specialist will be responsible to assess the Environmental Impact and preparation of EMP. Consultant has to identify the Authorities who will give the clearances for EIA/EMP. Consultant will not be required to take clearances from these identified Authorities.

k. Suggest horizontal and vertical clearances to be provided on cross structure such as bridges, power cables, locks etc. for commercial viable navigation in present as well as in future. For this, IWAI guidelines Section-IV, may also be referred to.

2.0 PERIOD OF SERVICES

Consultant may associate with sub Consultant(s) to enhance their expertise. The applicant shall submit a Memorandum of Understanding (MOU) with the Sub Consultant regarding the role and responsibilities of the Associate Company along with the proposal.

2.1 TIME SCHEDULE/SUBMISSION OF REPORTS:

(a) The time of completion of various sub-stages of the assignment will be a...

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	Sl. No	Activity	Cluster-8 Time in weeks**
Stage-I	a)	Mobilization of the Team and submission of Inception Report (2 copies)	15
	b)	Submission of Draft Feasibility Report (3 copies)	18
	c)	Comments from IWAI	20
	d)	Presentation and Submission of Final Pre-feasibility Report (3 copies)	22
Stage-II	a)	Acceptance of Stage-I report and go ahead for Stage-II by IWAI	24
	b)	Submission of Hydrographic Survey Charts and report (3 copies)	38
	c)	Submission of Draft Detailed Project Report (3 copies)	46
	d)	Receipt of comments of IWAI on Draft DPR.	48
	e)	Submission of Final Detailed Project Report (10 copies) after incorporating final comments of IWAI.	54
reckoned from the date of signing of Contract or 15 days from the date of issuance of work order, whichever is earlier.			

NOTE: -The consultants are required to submit the following outputs in Stage-II in the enclosed standard templates:-

vi) Traffic Template: at Annex-IV
vii) Project Costing Template: at Annex-V
viii) Financial Evaluation Template: at Annex-VI
ix) Economic Evaluation Template: at Annex-VII
x) Environmental & Social Screening Template: at Annex-VIII

3.0 Minimum Qualification of Key Professionals

Sl. No	Key Professionals	Qualification Criteria
1.	**Waterway Expert (Team Leader)**	**Educational Qualification:** • Should be Graduate in Civil Engineering. Higher professional qualification in Port and Harbor Engineering/Structural Engineering/Geo-technical Engineering will be preferred. **Professional Qualification:** • Minimum 15 years' experience in planning, design, construction, preparing Feasibility Report/Detailed Project Report for various waterway/port/river front development/river training works, terminals, trade facilitations and other infrastructures in different natural and operational conditions with at least 5 years in a reputed firm of consultants.
2.	**Port planning & Infrastructure Specialist**	**Educational Qualification:** • Should be Graduate in Civil Engineering. Postgraduate training/ studies in Port & Harbor Engineering will be preferred. **Professional Qualification:**

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Sl. No	Key Professionals	Qualification Criteria
		• Minimum 10 years' experience in Port planning, Port infrastructure Planning and development of physical facilities for port operations. Should be well conversant with different types of port structures and other physical facilities required for the provision of various port services efficiently. Should preferably have experience/ exposure of constructing several modern ports.
3.	**Remote Sensing/GIS Expert**	**Educational Qualification:** • Should be Graduate in Engineering/Geology. Higher professional qualification in Remote Sensing/ Geoinformatics will be preferred. **Professional Qualification:** • Minimum 10 years' experience in waterway/port/river mapping and a demonstrated proficiency in using the GIS software. Working knowledge of spatial data formats and related metadata issues. Working knowledge of web mapping applications, such as Google Earth/Bhuvan.
4.	**Floodplain Specialist**	**Educational Qualification:** • Should be Graduate in Civil/Environmental Engineering. Higher professional qualification in Floodplain Management/Hydrology/Water Resource Engineering will be preferred. **Professional Qualification:** • Minimum 10 years' experience in Floodplain Management. Working knowledge of water and/or wastewater modeling is desirable.
5.	**Hydrographic Expert**	**Educational Qualification:** • Should be ITI in Survey/Diploma in Civil Engineering. Higher qualification in relevant field will be preferred. **Professional Qualification:** • Minimum 8 years' experience in conducting hydrographic surveys, investigations and measurements, bathymetric surveys/Topographic Survey in a variety of geographical locations and natural.
6.	**Soil Engineer/ Foundation Engineer**	**Educational Qualification:** • Should be Graduate in Civil/Environmental Engineering. Higher qualification in Marine Structure/Geotechnical Engineering will be preferred. **Professional Qualification:** • Minimum 10 years' experience in related field. He should have experience of the soil investigation, reclamation work, soil improvement and will be associated in foundation design. He will also be responsible for preparation of cost estimates/BOQ.
7.	**Traffic Surveyor**	**Educational Qualification:** • Should be Graduate in Engineering. Higher qualification in relevant field will be preferred. **Professional Qualification:** • Minimum 10 years' experience in related field. He should have experience of traffic survey of waterways/river/canal or similar facilities.

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Sl. No	Key Professionals	Qualification Criteria
8.	**Transport Economist**	**Educational Qualification:** • Should be Graduate in transport planning management, transport economics, transport/road/rail/Civil engineering/MBA or equivalent qualifications. Higher qualification in relevant field will be preferred. **Professional Qualification:** • Minimum 10 years' experience in related field. He should have experience of estimating transport investments and implementing transport programs.

NOTE1:-If the Key Personnel proposed in the CV does not fulfill the minimum academic qualification, the overall score of his CV will be evaluated as zero. All such Key Personnel (whose CV scores less than 75% or who does not fulfill the minimum qualification) will have to be replaced by the firm. H-1 firm will be intimated for replacement of such personnel and work will be awarded after receipt of CV's fulfilling the tender criteria.

Note 2:- IWAI may call each key personnel of the preferred Consultant at the time of award of work, at the cost of Consultant.

Note 3: - In case during interaction with the key personnel, it is found that the key personnel proposed is un-suitable for the assignment position, his replacement by equivalent or better shall be provided by the consultant. The key personnel with such un-suitable CV shall not be considered in any future bids for that position for two years. No deduction for such replacement, who are not found suitable during interaction shall be made.

Note 4:- Role and responsibilities of the Key Professional shall be as per the requirement of the project and Terms of Reference of the tender document and the same has to be accessed by prospective bidder.

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