Techno-Economic Feasibility Report for Development of Port at Vadhavan

20th April 2015

Techno-Economic Feasibility Report for Development of Port at Vadhavan - Final

Prepared for

Ministry of Shipping
Government of India

Ministry of Shipping / Indian Ports Association

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April 2016

Quality Information

Client: Ministry of Shipping / Indian Ports Association		Contract No. (if any): NA
Project Title: **Development of Port at Vadhavan**		Project No.: DELD15005
Document No: DELD15005-REP-10-0000-CP-WAP1002 SharePoint Ref:		Controlled Copy No:
Document Title: Techno-Economic Feasibility Report for Development of Port at Vadhavan - Final		
Covering Letter/ Transmittal Ref. No:		Date of Issue: 20 April 2016

Revision, Review and Approval Records

2.	Techno-Economic Feasibility Report for Development of Port at Vadhavan - Final	RP 20.04.2016	Amit M. 20.04.2016	Sanjeev Gupta 20.04.2016
1.	Techno-Economic Feasibility Report for Development of Port at Vadhavan - Final	RP 7.02.2016	Amit M. 7.02.2016	Sanjeev Gupta 7.02.2016
A.	Techno-Economic Feasibility Report for Development of Port at Vadhavan - Final	RR/ASM 30.11.2015	Amit M. 30.11.2015	Sanjeev Gupta 30.11.2015
Revision	**Description**	**Prepared by/ date**	**Reviewed by/ date**	**Approved by/ date**

Document Revision Register

Issue no.	Date of issue	Section	Revision Details	Revision By Name & Position

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Executive Summary

INTRODUCTION

Maharashtra has two major ports i.e. Mumbai and JNPT which cater the hinterland of Maharashtra, including NCR, Punjab, Rajasthan and UP. Out of these ports, Mumbai port has constraint in evacuation of cargo for the past several decades due to development of city around it also due to availability of limited depths in the harbour. JNPT was basically developed as a satellite port of Mumbai port and has coped up well in becoming the largest container port of the country. The development of 4th container terminal is underway and after its full development there is little space for further expansion. Apart from that due to the presence of bed rock at or very close the existing bed level JNPT cannot be deepened further economically to handle the future generation of mega container ships drawing draft of 16 m or more.

With the projected demand for containers to go up, it is necessary to locate a new mega port site which can cater to increased requirement of capacity and also could be developed to handle the future deep draft ships.

Considering the above it has been decided to develop Vadhavan port as a satellite port for JNPT.

TRAFFIC PROJECTIONS FOR THE PROPOSED PORT

Vadhavan is assumed to cater to spill over traffic from JNPT port once its expanded capacity of 10 million TEUs is fully utilized. However, since Vadhavan is closer to South Gujarat, parts of Madhya Pradesh (e.g., Vapi, Surat, Ahmedabad, Indore) as compared to JNPT, it will attract a part of the total traffic from these hinterlands even before JNPT reaches full capacity utilization. Based on the above, Vadhavan is expected to handle ~0.8 MTEUs in its first year of operation (FY23).

The proposed port could be used as a gateway port for the import and export of cargo for Tarapur industrial area. The cargoes that are likely to be handled at the port are steel rods, steel coils, scrap etc. In addition, in order to cater to the power demand of state, Vadhavan might handle coal for coastal power complex of 2.5 GW to be constructed in three phases starting FY25.

The traffic for the Vadhavan port is projected to be around 15 MTPA in 2023 increasing to around 254 MTPA in 2038.

PORT DEVELOPMENT PLAN

The development of port shall be taken up in phases. Accordingly it is proposed to consider the following options for phasing of depths in approach channel and harbour basin:

- Design depths to be based on the largest container vessel with 400 m LOA, 59 m beam and 16 m draft.
- Design depths to be based on the largest coal vessel of 200,000 DWT with 300 m LOA, 50 m beam and 18.3 m draft.

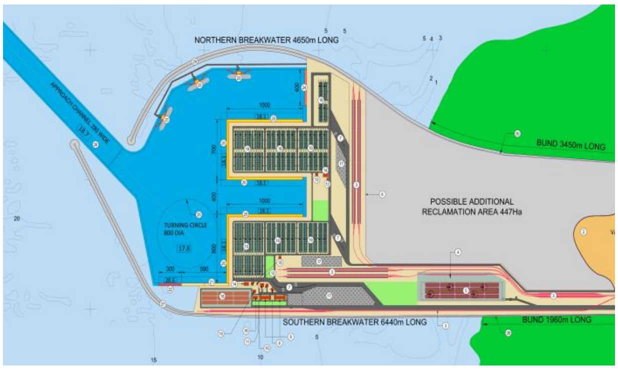
Considering that the containers would be the key commodity for the proposed port, it is important that Phase 1 port facilities are able to handle the largest container ships plying currently i.e. 16 m draft.

Phase 1 layout has been developed with minimum dredging investment to cater 18,000 TEU vessels (16m draft) taking tidal advantage.

State of the art material handling system shall be provided to ensure faster turnaround of ships. In Phase 1, quay length of 1390 m is provided which shall go up to 5390 m in the master plan phase.

Master Plan layout has been developed to cater 200,000 DWT design vessels (18.3m draft) and 18,000 TEU vessels to be called anytime without tidal restrictions.

The master plan accommodates total container berth length of 4500m, 2 multipurpose berths, 1 coal berth and provision for 3 liquid berths and 1 coastal berth is also provided.



COST ESTIMATES

The capital cost of overall port development up to the master plan phase is expected to be INR 29,860 crores. The capital cost for Phase 1 development is expected to be INR 9,297 crores. The major exclusions in cost estimates are, Cost of land acquisition for Rail/Road Corridors, Port craft, Financing and Interest Costs.

FINANCIAL APPRAISAL

A profitability analysis for the proposed development has been carried out with the objective of assessing the viability of the project in terms of Financial Internal Rate of Return (FIRR).

The capex spending has been planned over 4 phases. First phase is spread over 5 years and subsequent phases over three years. The total project capex is around INR 29,860 crores (at current prices). For the master plan phase the capacity expansion of the port for handling containers is restricted to ~9.87 M TEUs.

It has been assumed that Vadhavan port charges of ~7500 per TEU (current all inclusive prices at competing ports). The pre-tax IRR for the project on the basis of the above assumptions comes out to be 17.8%.

The following sensitivity scenarios have been worked out for Vadhavan Port:

- **Slow traffic growth:** Assuming the traffic growth is reduced to 6.5% until FY 25 and 4.5% from FY 26 to FY 35 and 1.5% thereafter, the IRR drops to 6.7%
- **Increase in capex**: Increase in capex by 20% in all phases results in IRR dropping to 14.3%
- **Lower tariff:** Assuming that tariff is 20% lower than JNPT – or INR 6,000/TEU versus INR 7,500/TEU in the base case – causes the IRR to drop to 15.4%

Therefore the IRR appears comfortable even under negative assumptions.

RECOMMENDATIONS

Considering the long construction time for port development, it is recommended that this project is taken up as landlord model, where in the basic infrastructure such as breakwaters, dredging, reclamation and navigational aids shall be developed by the project proponents i.e. JNPT and MMB. The project proponents shall also be responsible for the following:

- Environmental Clearance for the Port including the terminals
- Land acquisition for providing the rail and road connectivity to port
- Onshore infrastructure such as linkage to water, power sources, communication, drainage network etc.

The individual terminals can be given to private players through competitive bidding where they will be investing in berths, equipment, utilities etc. This could foster greater competition but since the cost of the marine infrastructure is significant, substantial upfront government investment would be needed.

1.0 Introduction

1.1 Background

The Sagarmala initiative is one of the most important strategic imperatives to realize India's economic aspirations. The overall objective of the project is to evolve a model of port-led development, whereby Indian ports become a major contributor to the country's GDP.

As shown in **Figure 1.1**, the Sagarmala project envisages transforming existing ports into modern world-class ports, and developing new top notch ports based on the requirement. It also aspires to efficiently integrate ports with industrial clusters, the hinterland and the evacuation systems, through road, rail, inland and coastal waterways. This would enable ports to drive economic activity in coastal areas. Further, Sagarmala aims to develop coastal and inland shipping as a major mode of transport for the carriage of goods along the coastal and riverine economic centres.

As an outcome, it would offer efficient and seamless evacuation of cargo for both the EXIM and domestic sectors, thereby reducing logistics costs with ports becoming a larger economy.

Sagarmala aims to optimize the Logistics route for Port and Increase focus on Port led development for the country

	Details	Description
Why is Sagarmala needed?	1 Dual institutional structure at ports	▪ Due to segregation of major and minor ports, ports of India have grown as due unconnected entities and not benefitting from co-location or economics of scale
	2 Weak infrastructure at ports and beyond	▪ Weak modes of evacuation from both major and minor ports leading to sub – optimal modal mix presently ▪ Limited hinterland linkages that increases cost of transportation
	3 Limited economic benefit of location & to community	▪ Limited conscious skill development and leverage to peripheral trades (fisheries, tourism etc.) ▪ Limited development of centres of manufacturing near ports
What does Sagarmala want to achieve?	1 Ports led development	▪ Undertake development of coastal economic zones with projects like – port based industrialization, coastal tourism, Logistics parks, warehousing, fisheries etc.
	2 Port infrastructure enhancement	▪ Action points on transforming existing ports into world class ports be developing deep drafts, mechanization of existing berths, creation of new capacity and greenfield ports
	3 Efficient evacuation	▪ Expansion of rail / road network connected to ports and identification of congested routes ▪ Find optimized transport solution for bulk and container cargo

Figure 1.1 Aim of Sagarmala Development

In order to meet the objectives, Indian Port Association (IPA) appointed the consortium of McKinsey and AECOM as Consultant to prepare the National Perspective Plan as part of the Sagarmala Programme.

1.2 Scope of work

We have distilled learnings from our experience in port-led development and examined major engagement challenges to develop a set of governing principles for our approach as shown in **Figure 1.2** below.

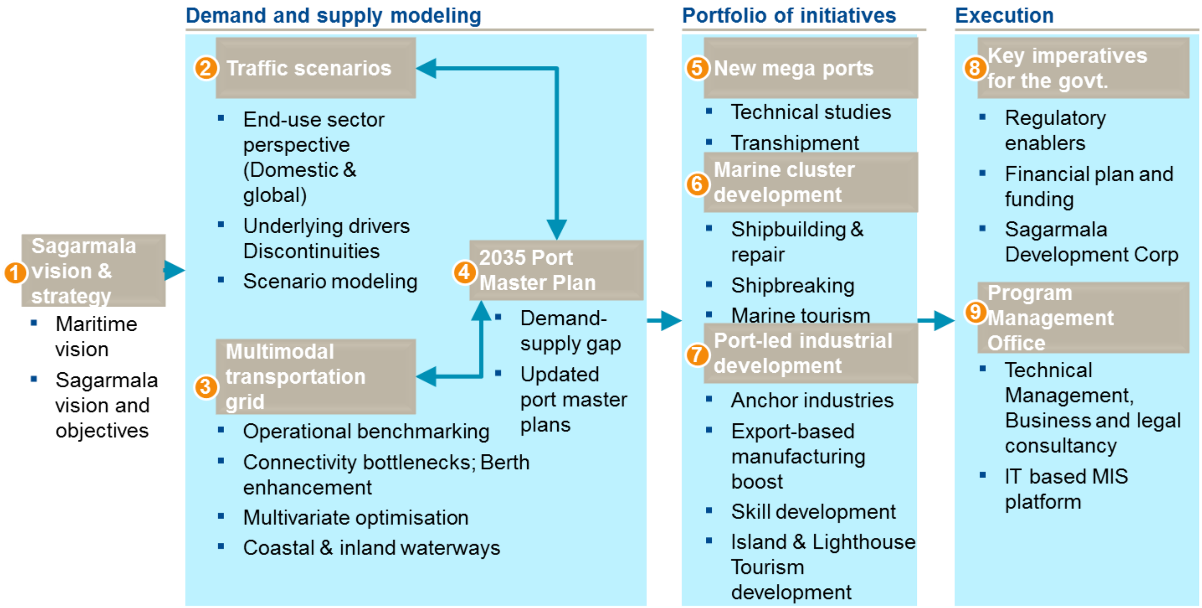


Figure 1.2 Governing Principles of our Approach

As indicated above, the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports shall be mapped to develop traffic scenarios for a period of next 20 years. The forces and developments that will drive change in the cargo flows shall also be identified. This would lead to the identification of regions along the coastline where the potential for the development of Greenfield port or expansion of existing port exists. These regions shall be further evaluated based on the technical, socio-economic and environmental aspects to arrive at the suitable location of a major port.

The scope of the assignment includes the preparation of development/investment plan for at least 5 mega ports sites based on the technical study, traffic scenarios and constraints in existing ports.

1.3 Need for the New Mega Port at Vadhavan

Maharashtra has two major ports i.e. Mumbai and JNPT which cater the hinterland of Maharashtra, including NCR, Punjab, Rajasthan and UP. Out of these ports, Mumbai port has constraint in evacuation of cargo for the past several decades due to development of city around it also due to availability of limited depths in the harbour. JNPT was basically developed as a satellite port of Mumbai port and has coped up well in becoming the largest container port of the country. The development of 4th container terminal is underway and after its full development there is little space for further expansion. Apart from that due to the presence of bed rock at or very close the existing bed level JNPT cannot be deepened further economically to handle the future generation of mega container ships drawing draft of 16 m or more.

With the projected demand for containers to go up, it is necessary to locate a new mega port site which can cater to increased requirement of capacity and also could be developed to handle the future deep draft ships.

Considering the above it has been decided to develop Vadhavan port as a satellite port for JNPT and for this purpose the present report has been prepared to assess its technical suitability and cost economics.

1.4 Present submission

The present submission is the Final Techno-economic Feasibility Report for “Development of the port at Vadhavan”, Maharashtra. This report duly incorporates comments of the stakeholders on the draft final report submitted during February 2015 and various model study results for the proposed port. This report is organised in the following sections:

Section 1	: Introduction
Section 2	: Site Conditions
Section 3	: Traffic Projects for Vadhavan Port
Section 4	: Design Ship Sizes
Section 5	: Port Facility Requirements
Section 6	: Preparation of Vadhavan Port Layout
Section 7	: Engineering Details
Section 8	: Environmental Settings and Impact Evaluation
Section 9	: Cost Estimates and Implementation Schedule
Section 10	: Financial Analysis
Section 11	: Conclusion and Recommendations

2.0 Site Conditions

2.1 Port location at Vadhavan

The location plan of proposed Vadhavan Port with respect to JNPT and Mumbai Port is shown in **Figure 2.1** below.

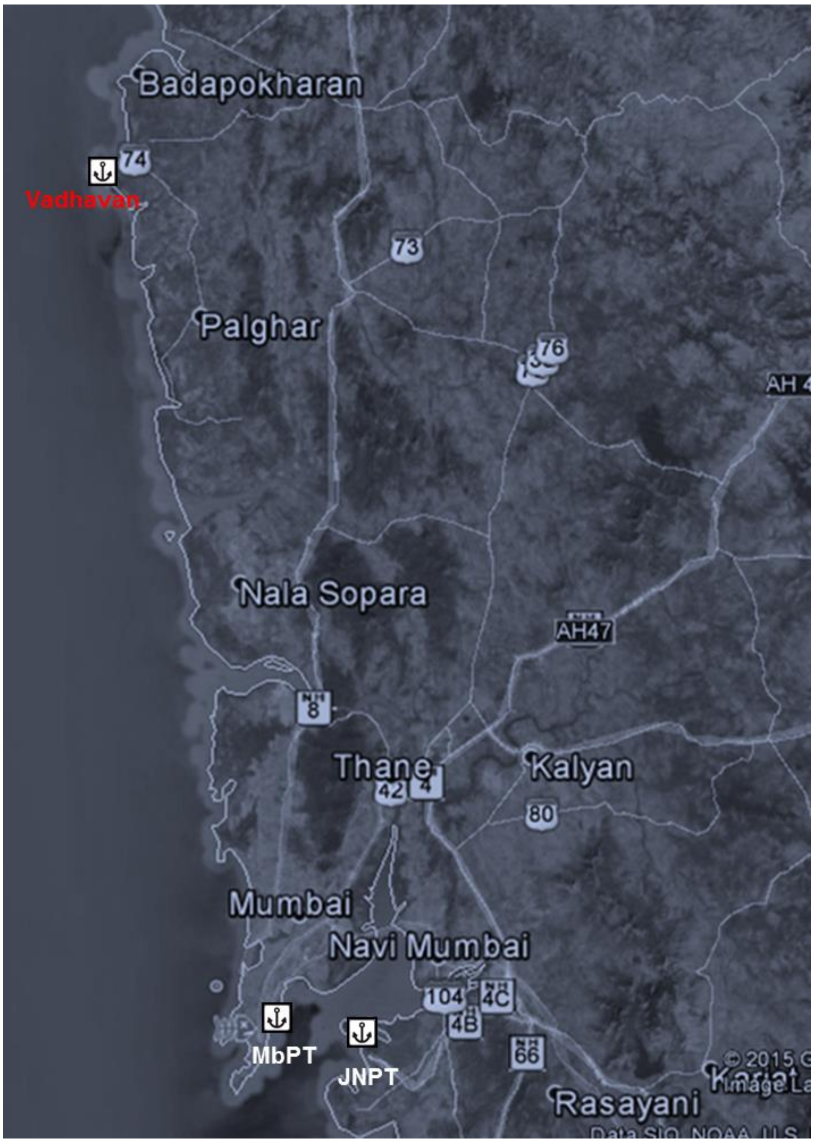


Figure 2.1 Vadhavan Location with reference to JNPT & Mumbai Port

The Vadhavan port is planned to be located on reclaimed land on inter tidal zone at Vadhavan Point. The site is surrounded on the West, North and South by Arabian Sea, various villages on East with discreetly habited land as shown in **Figure 2.2**.

Figure 2.2 Vadhavan Port site

The port limits for the proposed Vadhavan port is as shown in **Figure 2.3**.

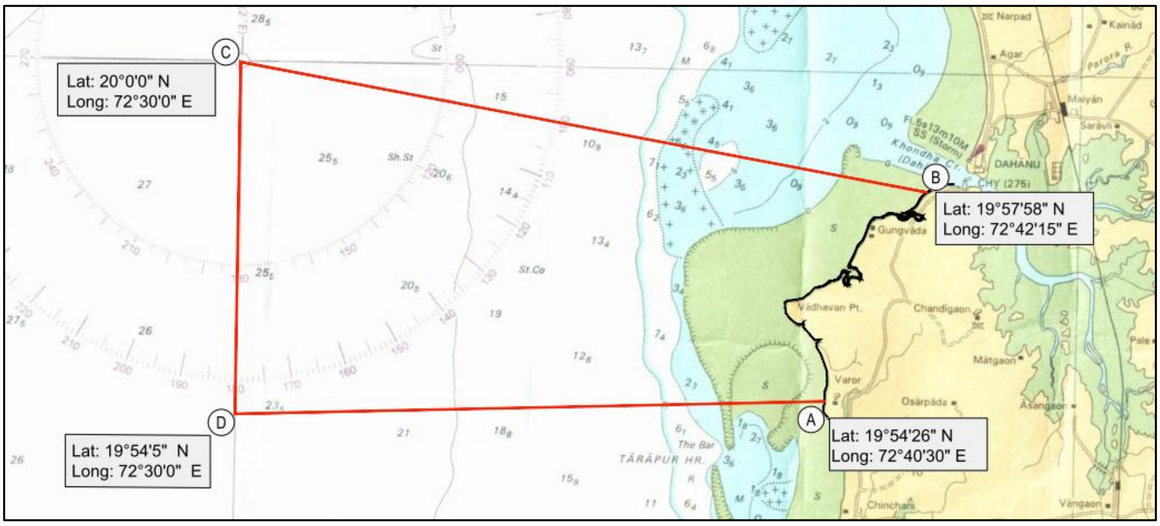


Figure 2.3 Vadhavan Port Limits

The **Figure 2.4** below shows the Vadhavan Port location with respect to Tarapur Atomic Power Station , BSES Power Plant and Western railway main line.

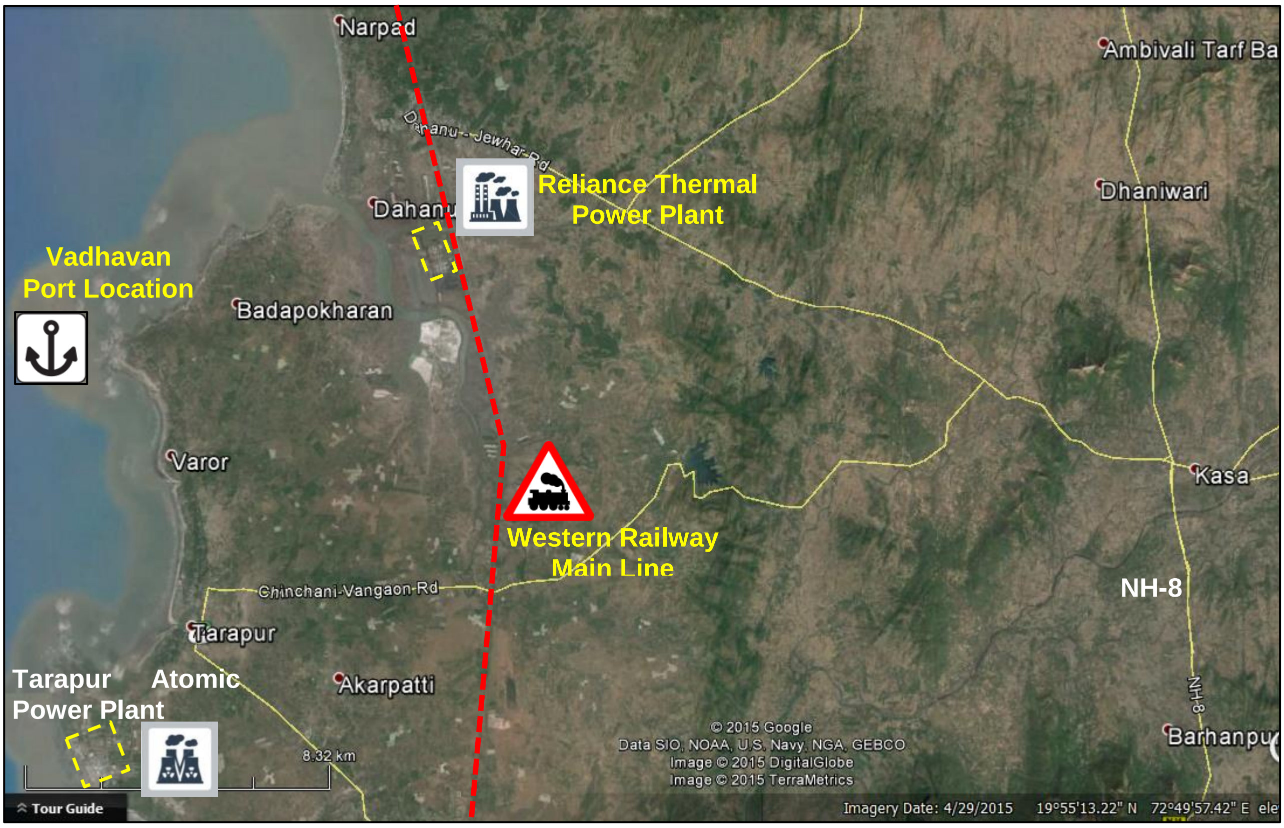


Figure 2.4 Vadhavan Port w.r.t. Rail line, NH-8 and Power plants

The area nearby site is mostly inhabited barring some habitation observed near the access route to the Vadhavan point. The intertidal rock shelf is exposed during low tide condition.

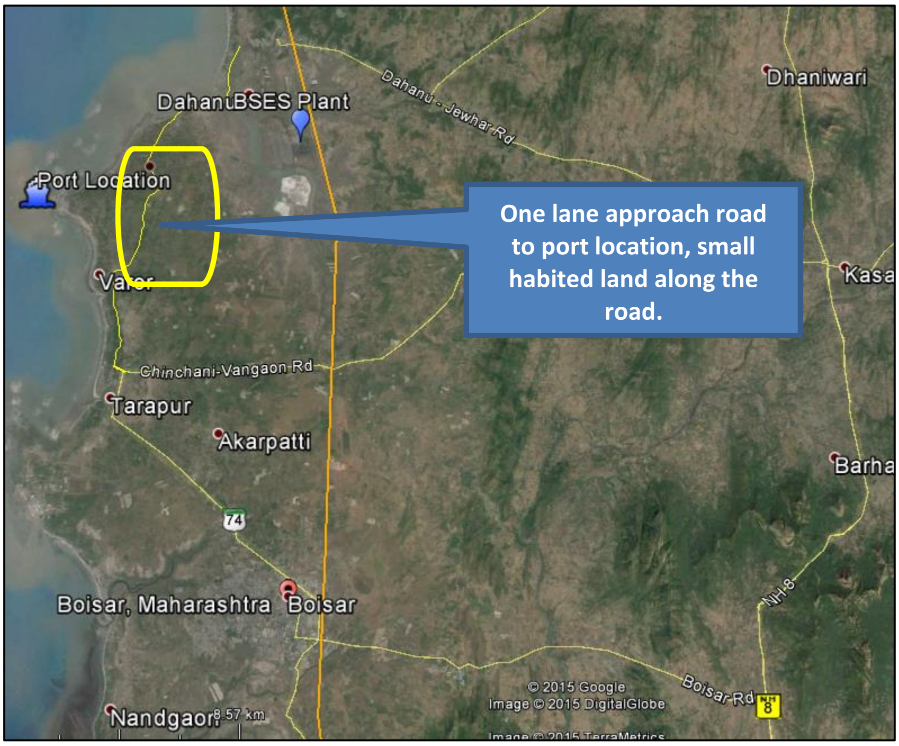


Figure 2.5 Existing Access to Vadhavan Port

First two snapshots below show the existing road connectivity to the Vadhavan Port site. Last two images show the intertidal zone and port site.

Figure 2.6 Snapshot of Approach to Vadhavan Port and Inter Tidal Zone

2.2 Onshore Area

Onshore area is proposed to be developed in the intertidal zone. The intention is to locate all port facilities and operational requirements within the reclaimed area without any major land acquisition process. However, minor land acquisition would be required for providing connectivity to the port.

2.3 Field survey and investigations for Vadhavan port development

Following site data is proposed to be collected for the preparation of Techno Economic Feasibility report:

1. Bathymetry survey
2. Seismic Survey
3. Topographic Survey

For the purpose of TEFR, the survey data carried out at the Vadhavan site have been referred.

2.4 Meteorological data

For meteorological data, well-documented, observed data over a period of 30 years are available for Mumbai (Lat. 18°54' N, Long. 72° 49' E) and Surat (Lat. 21° 12' N, Long. 72° 50' E) in the West Coast

Pilot. Surat is closer to the Vadhavan area and hence the data at Surat could be considered representative for the Vadhavan site as well. The data given in the West Coast Pilot as well as that of Indian Climatological Table have been used.

2.4.1 Rainfall

The average annual rainfall is 1163 mm with the total number of rainy days of 51 per year. June to August is the wettest months of the year with an average rainfall in excess of 274 mm per month, with a maximum of 451 mm in July during the southwest monsoon period. February and March are dry months with average rainfall below 1 mm per month.

2.4.2 Temperature

The mean daily maximum temperature is 31°C and with 34°C the highest occurring in April. Mean daily minimum temperature is 24°C and with 18°C the lowest occurring in December.

2.4.3 Relative Humidity

Relative humidity is generally high and rises to about 85% during the monsoons in the month of August.

2.4.4 Visibility

Throughout the year visibility is good as the region has zero fog days. However, during rains and squalls, the visibility deteriorates.

2.4.5 Cyclone

In general the west coast of India is less prone to cyclonic storms compared to the east coast. From the information reported by India Meteorological Department (IMD) it is observed from the tracks of the cyclones in the Arabian Sea from 1877 to 2012 that only 10 storms endangering the Mumbai coast have occurred in the above said period i.e. at a frequency of once in 12 years.

2.5 Site Seismicity

Vadhavan Port site is in **Zone III** of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone.

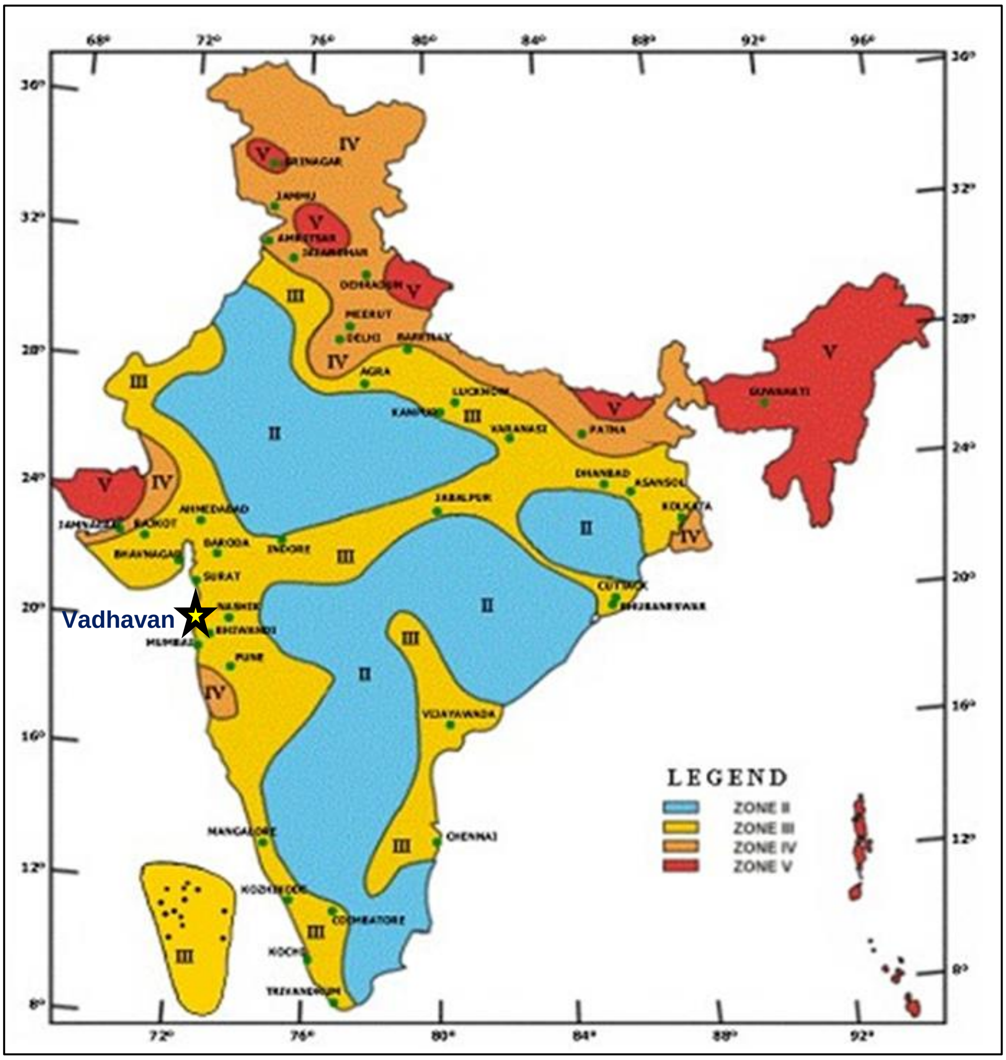


Figure 2.7 Seismic Zoning Map of India as per IS-1893 Part 1-2002

2.6 Oceanographic Information

2.6.1 Bathymetry

Bathymetry survey chart and NHO hydrography chart has been presented in **Figure 2.8** and **Figure 2.9** below respectively. As per the bathymetry survey, 0m contour is at around 1800m away from Vadhavan Point. 5m contour is approximately 3500m distance from the Vadhavan Point. Bathymetry is steeper after 5m contours with 10m, 15m contours approximately 4400m and 5000m away from Vadhavan point. 20m contour is at distance around 7000m from Vadhavan point.

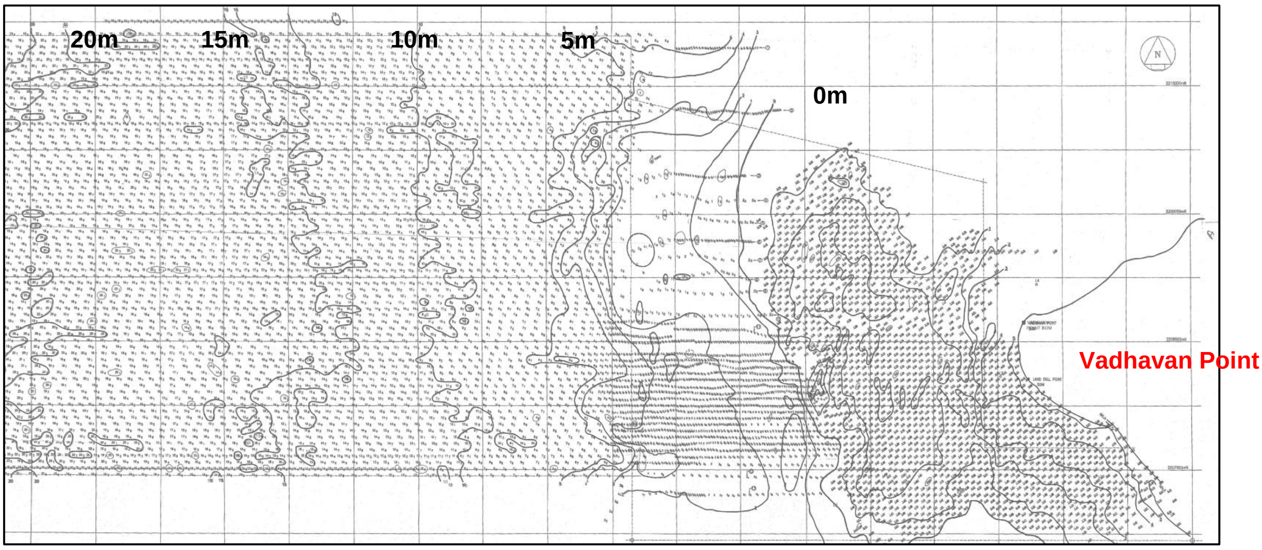


Figure 2.8 Bathymertic Survey Details at Proposed Vadhavan Port site

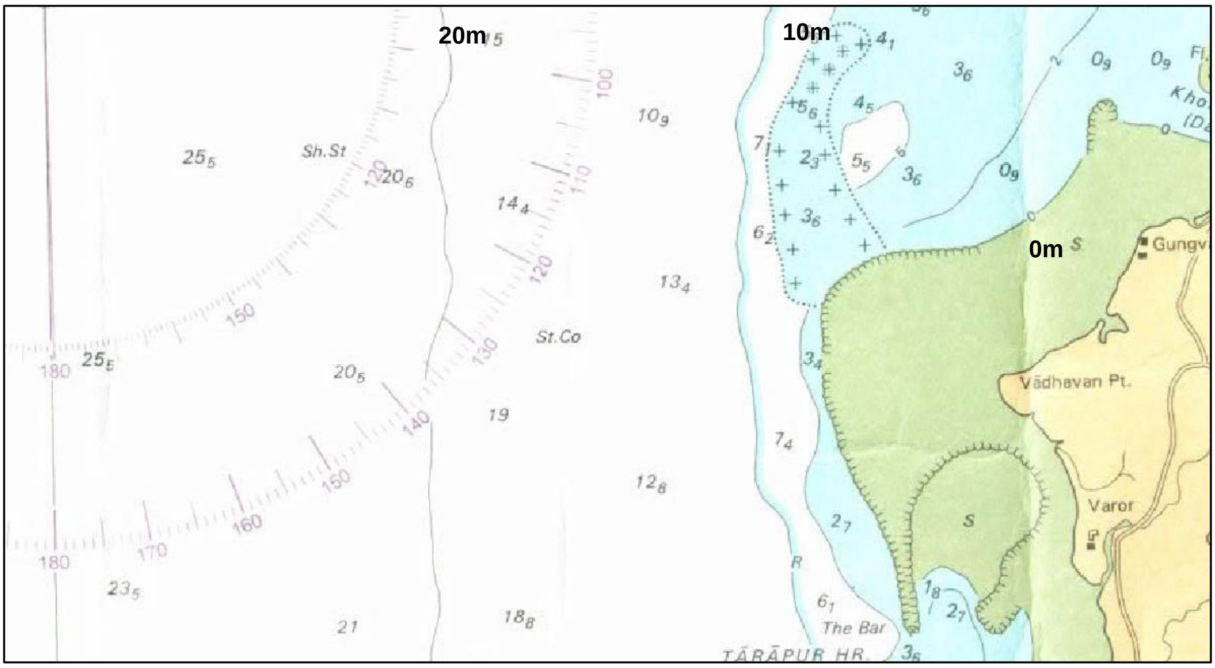


Figure 2.9 Hydrographic Chart of Vadhavan Port location
[Source: NHO Chart 210]

2.6.2 Waves

2.6.2.1 Offshore wave data

For this study, wind and wave data were obtained from the UK Met Office. The data comprises of a 6 hourly time-series of wind and wave parameters (wind speed and direction, wave height, wave period and wave direction for all resultant, sea and swell wave). The data covered a 12 year period between May 1999 and April 2012 and the point is located at 19.17°N 72.08°E at 46 m depth.

The wind speed at the offshore location was recorded more than 14 m/s from WSW direction (15%), which is also the most prominent wind direction and encountered during SW monsoon (**Figure 2.10**). About 85% of the time wind is less than 8 m/s.

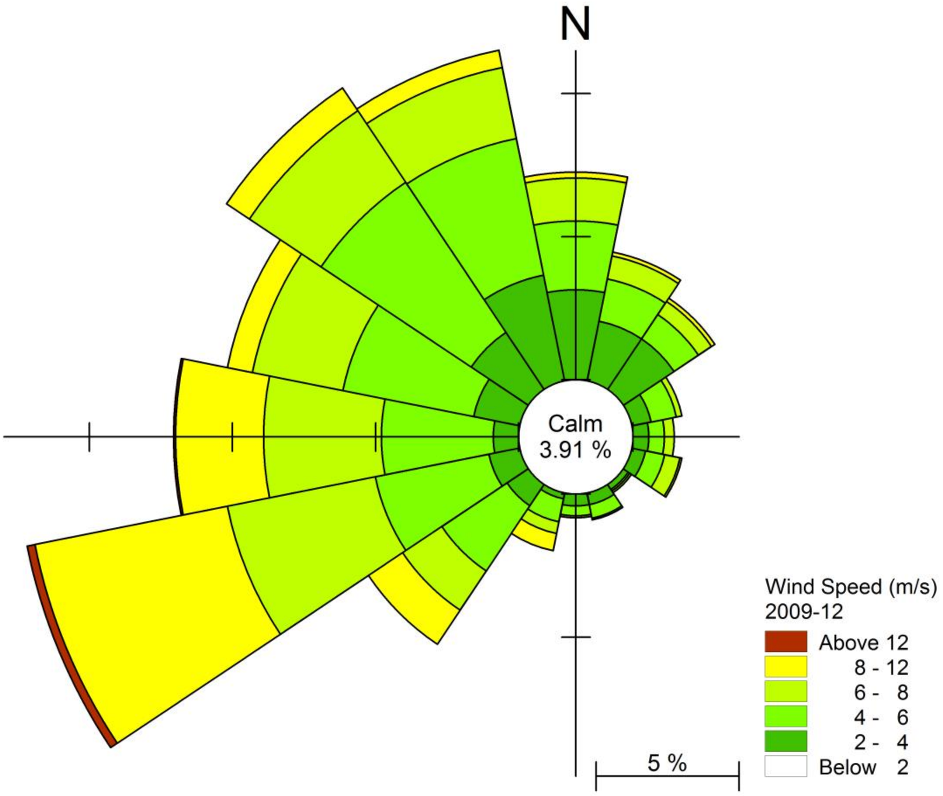


Figure 2.10 Wind Rose (UKMO: 1999-2012)

The most prominent resultant wave direction is WSW (54.2%) followed by SW (23.8 %). Wave heights were found to be less than 3 m for about 93% of the time (**Figure 2.11** and **Table 2.1**). Waves higher than 4m were recorded for only 1 % of the time from the W and WSW directions. The resultant wave period varied between 2 and 12 s for most of the time.

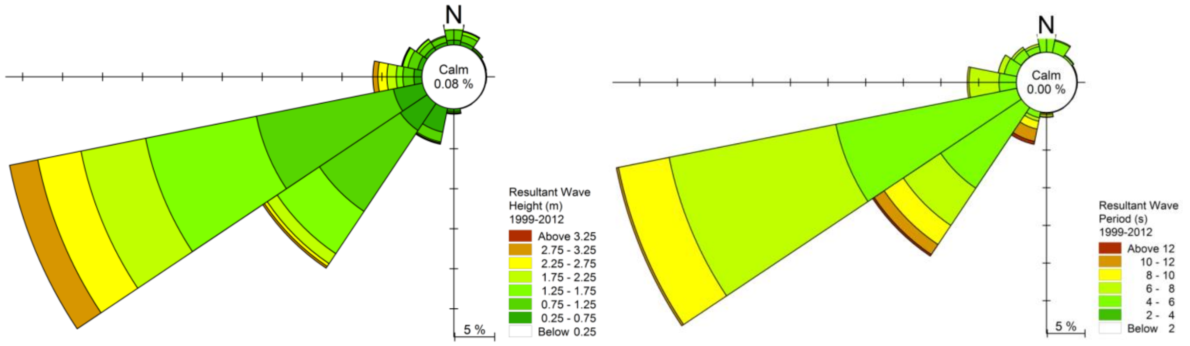


Figure 2.11 Wave rose for Resultant Wave Height and period
[Source: UKMO, 1999 – 2012]

Table 2.1 Annual Occurrence Probabilities (in %) of given Resultant Wave Height at Offshore Position

RWH (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
0 - 1	1.3	1.0	0.1	0.1	0.1	0.1		0.1	0.5	3.9	11.0	13.0	1.9	1.3	0.9	0.9	36.4
1 - 2	1.1	0.8	0.1						0.1	0.4	11.6	25.5	1.8	1.1	0.7	0.3	43.5
2 - 3	0.1								0.1	0.1	0.9	10.4	2.0	0.1			13.6
3 - 4											0.3	4.4	0.7				5.3
4 - 5												0.9	0.2				1.1
Total	**2.5**	**1.8**	**0.3**	**0.1**	**0.1**	**0.1**		**0.1**	**0.6**	**4.4**	**23.8**	**54.2**	**6.5**	**2.6**	**1.6**	**1.2**	**100.0**

Wave roses were also developed for Sea and swell for both wave height and period (**Figure 2.12** and **Figure 2.13**).

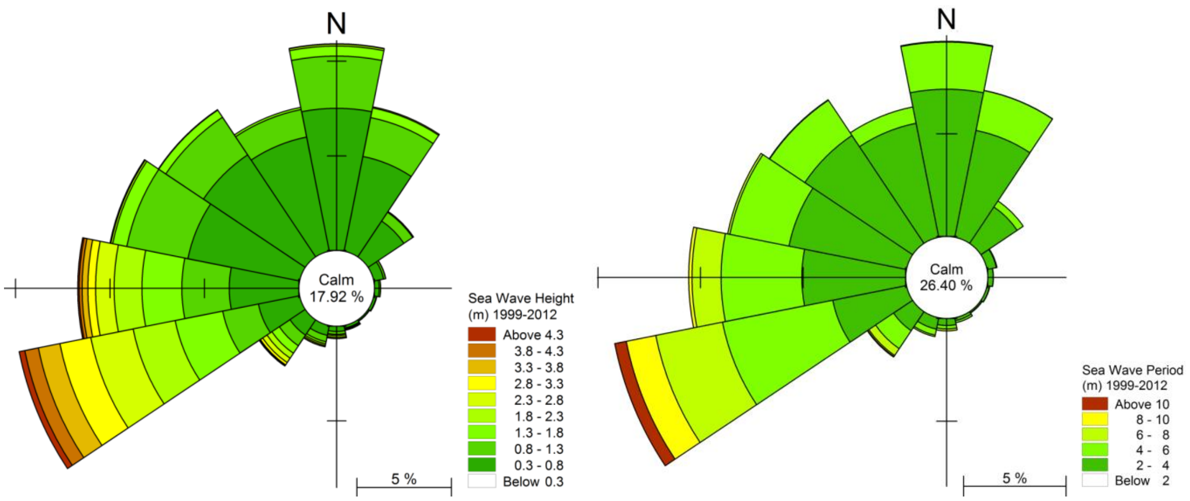


Figure 2.12 Wave rose for Sea Wave Height and Period
[Source: UKMO, 1999 – 2012]

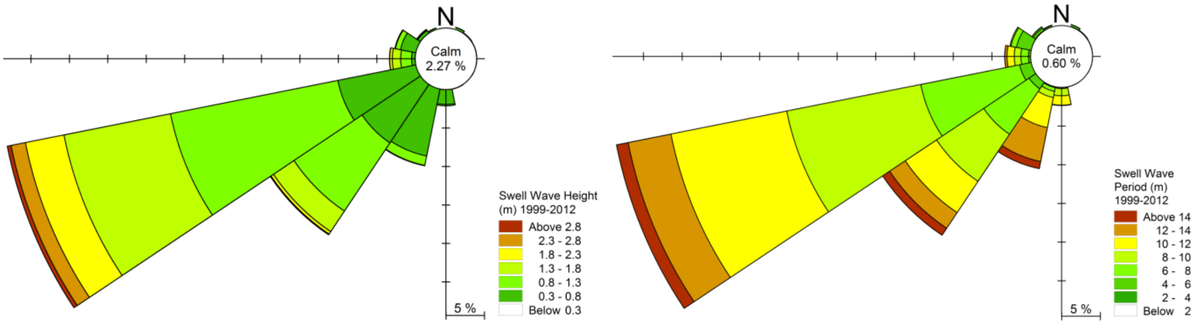


Figure 2.13 Wave rose for Swell Wave Height and Period
[Source: UKMO, 1999 – 2012]

2.6.2.2 Nearshore wave transformation

As waves propagate from deep water into the shallow water, the waves are modified due to various shallow water processes including shoaling and refraction. Wave transformation analysis from deep water to near shore has been carried out using the spectral wave model MIKE 21 SW. The model predicts the wave activity at nearshore by representing the effects of refraction and shoaling on all components of a given offshore spectrum.

The model bathymetry has been prepared using unstructured flexible mesh. The model area is approximately 80 km × 140 km (**Figure 2.14**). The UKMO data for the year of 2011 is used for transformation study (**Figure 2.15**).

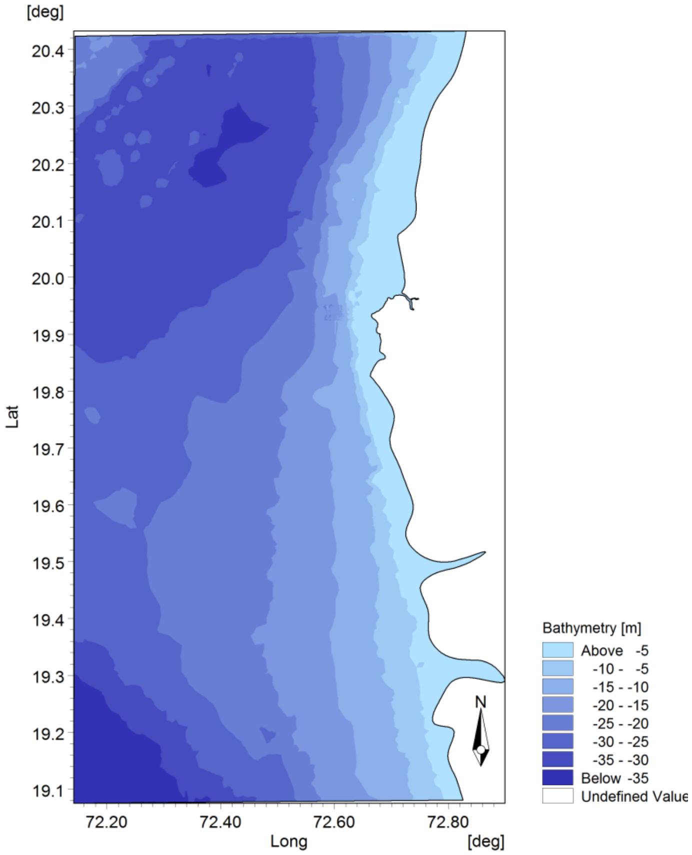


Figure 2.14 Model Domain used for Nearshore Wave Transformation Study

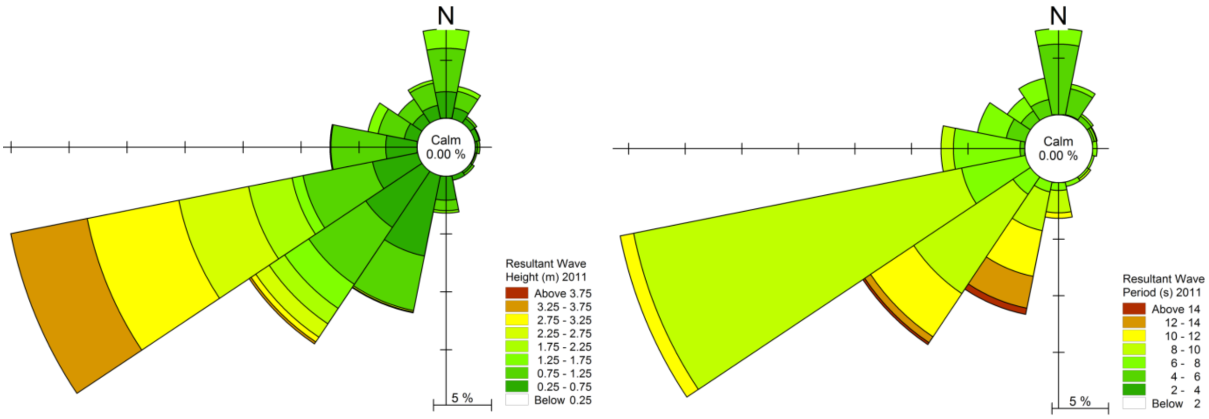


Figure 2.15 Resultant Wave height and period used as input to the model (UKMO: 2011)

The likely position of breakwater for the proposed port is at 15 m contour, therefore the detailed nearshore transformations were carried out at 5, 10 and 15 m depth (**Figure 2.16**).

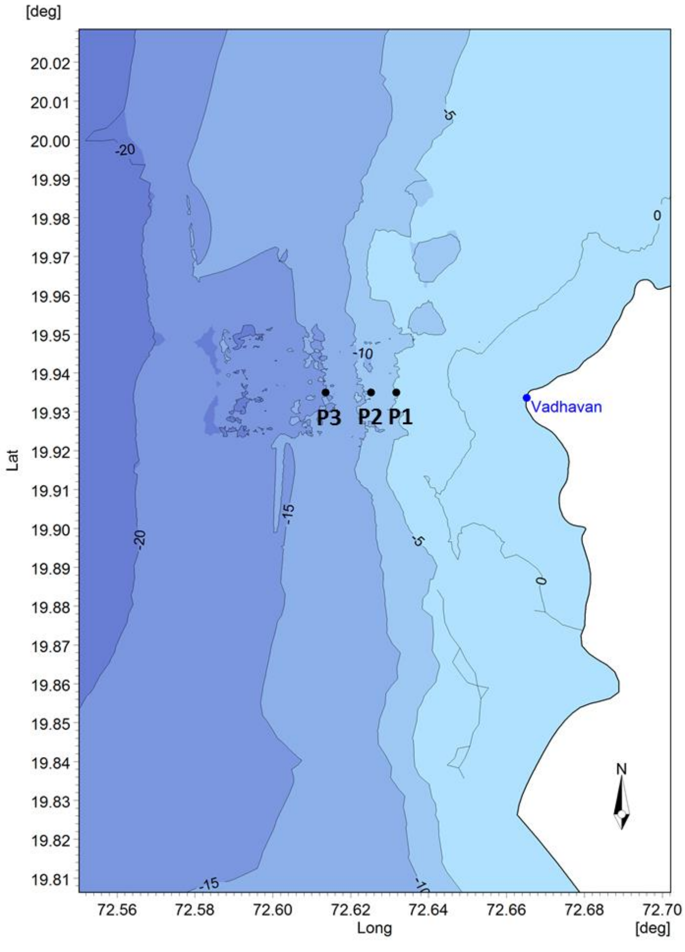


Figure 2.16 Extraction Points for near shore wave modelling at 5m (P1), 10m (P2) and 15m (P3) water depth at Vadhavan Point

The model results showed that predominant wave direction at near shore points is west (**Figure 2.17**, **Figure 2.18** and **Figure 2.19**). More than 64%, 56 % and 55% of the waves at are found to approach the shore from WSW at P1, P2 and P3 respectively (**Table 2.2**, **Table 2.3** and **Table 2.4**).

The wave height of the incoming waves at P1 is less than 1m for about 66% of the time in a year. Similarly, less than 1 m waves are encountered for about 64% and 62% at P2 and P3. The time periods for the waves at the mentioned points are less than 8s.

It is important to note that Waves from WNW, NW and NNW are also observed for more than 16% of the time at the mentioned locations. However, the wave height is less than 1.5 m at P1 and 1.75 m at P2 and P3.

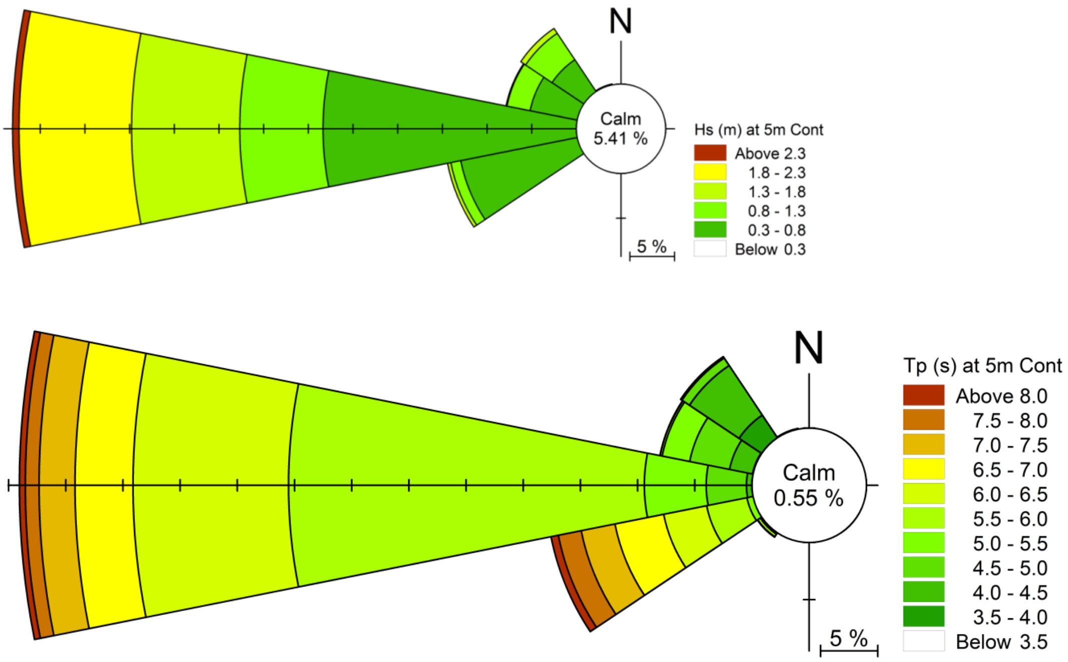


Figure 2.17 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 5m depth (P1)

Table 2.2 Annual Occurrence Probabilities (in %) of given Resultant Wave Height at 5 m contour

RWH (m)	SW	WSW	W	WNW	NW	NNW	All
0 - 0.25	0.4	3.4	1.1	0.1			5.1
0.25 - 0.5		12.5	13.0	1.3	1.4		28.3
0.5 - 0.75		0.8	15.3	4.1	3.0	0.1	23.3
0.75 - 1		0.8	4.7	2.4	2.2		10.1
1.0 - 1.25		0.3	4.7	0.2	1.4		6.6
1.25 - 1.5		0.2	5.4	0.1	0.7		6.4
1.5 - 1.75		0.2	6.7				6.8
1.75 - 2			7.2				7.2
2.0 - 2.25			5.4				5.4
2.25 - 2.5			0.7				0.7
Total	**0.4**	**18.2**	**64.2**	**8.3**	**8.8**	**0.1**	**100.0**

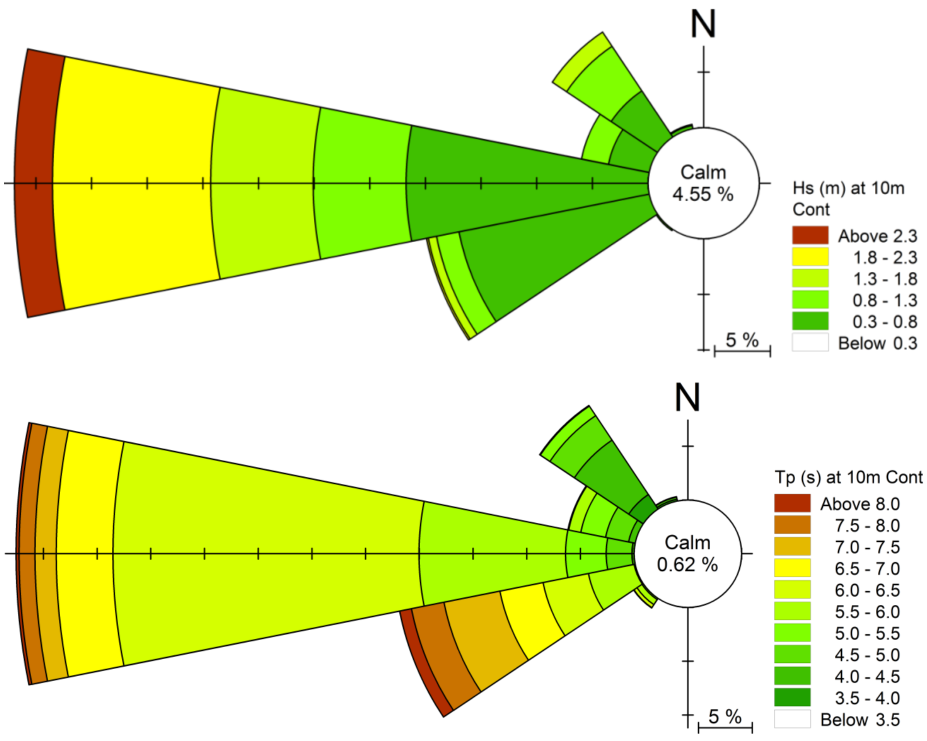
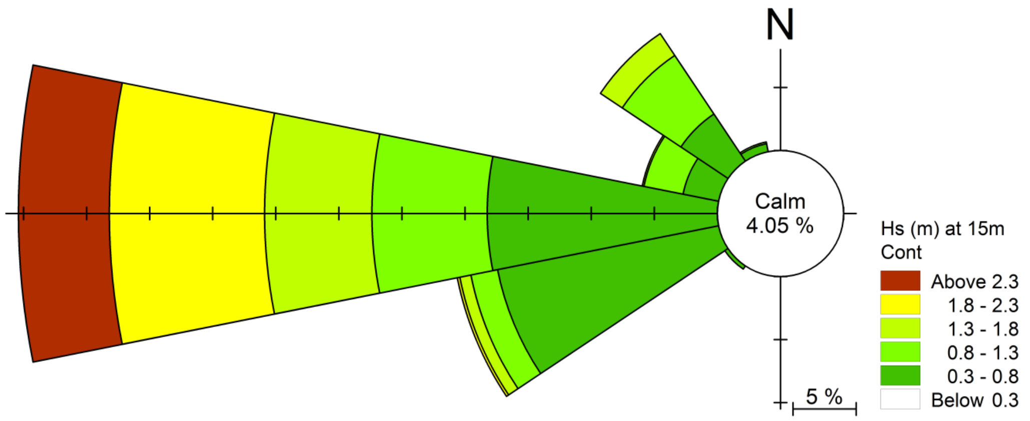


Figure 2.18 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 10 m depth (P2)

Table 2.3 Annual Occurrence Probabilities (in %) of given Resultant Wave height at 10 m contour

RWH (m)	SW	WSW	W	WNW	NW	NNW	All
0 - 0.25	0.9	3.1	0.2	0.1	0.2		4.6
0.25 - 0.5	0.1	14.8	8.6	0.9	1.0	0.1	25.5
0.5 - 0.75		2.7	13.1	2.8	4.1	0.2	22.9
0.75 - 1		1.5	5.0	2.2	3.0	0.1	11.7
1.0 - 1.25		0.6	3.4	0.3	2.0		6.2
1.25 - 1.5		0.6	5.1		1.5		7.1
1.5 - 1.75		0.2	4.1		0.1		4.4
1.75 - 2		0.2	8.0				8.2
2.0 - 2.25			6.2				6.2
2.25 - 2.5			3.1				3.1
Total	**1.1**	**23.6**	**56.8**	**6.3**	**11.8**	**0.4**	**100.0**



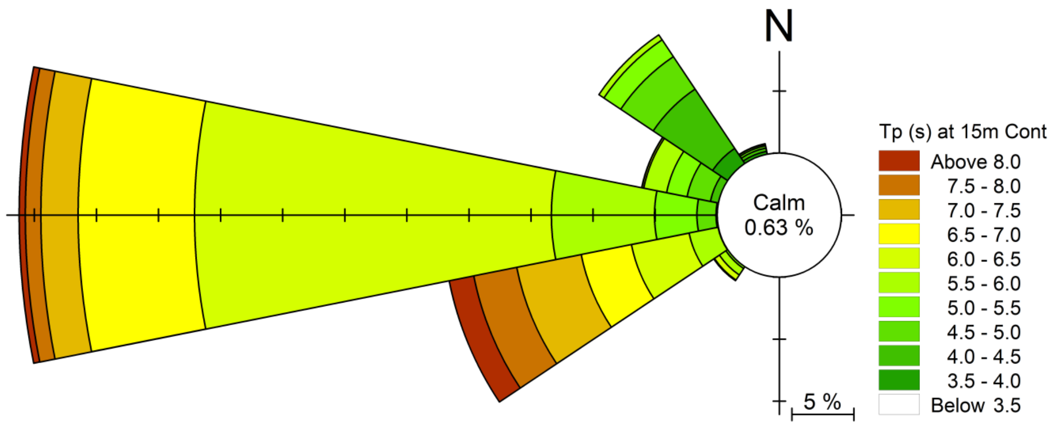


Figure 2.19 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 15 m depth (P3)

Table 2.4 Annual Occurrence Probabilities (in %) of given resultant wave height at 15 m contour

RWH (m)	SW	WSW	W	WNW	NW	NNW	All
0 - 0.25	1.0	2.4	0.1		0.2	0.1	3.9
0.25 - 0.5	0.3	14.2	6.8	0.6	0.9	0.2	23.0
0.5 - 0.75		3.6	11.4	2.3	3.8	0.4	21.5
0.75 – 1.0		1.4	6.6	2.7	3.4	0.1	14.2
1.0 - 1.25		0.8	2.5	0.5	2.2		6.0
1.25 - 1.5		0.7	4.2	0.1	1.4		6.5
1.5 - 1.75		0.2	4.3		0.7		5.1
1.75 – 2.0		0.2	5.8				6.0
2.0 - 2.25			6.5				6.5
2.25 - 2.5			5.2				5.2
2.5 - 2.75			2.0				2.0
2.75 - 3.0			0.1				0.1
Total	**1.3**	**23.5**	**55.6**	**6.2**	**12.5**	**0.9**	**100.0**

The results of the nearshore wave transformation study suggest that it is desirable to protect the proposed port location from SW, WSW and W waves. In addition protection may also be required from waves from NW direction, which may be decided based on operation and cargo handling.

2.6.3 Tides

Tide levels in the Vadhavan Port region as per the NHO Chart No. 210 Umargam to Satpati are summarised below.

Table 2.5 Tide levels in Vadhavan

Description	Tide Levels
Mean High Water Spring	+4.7m CD
Mean High Water Neap	+3.7m CD
Mean Sea Level	+2.8m CD
Mean Low Water Neap	+2.0m CD
Mean Low Water Level Spring	+1.2m CD

2.6.4 Currents

The ocean currents in the Vadhavan Port are mainly influenced by the tidal fluctuations. Flood tide current is towards North while ebb tide current direction is towards south. The magnitude of the current in general is directly proportional to the tide range. The direction of surface current is greatly influenced by the wave and wind direction during the monsoon period.

The currents during spring tide are of the order of 3 knots (1.5 m/s) which is predominantly on high tide range. The currents are in south-north direction during floods and north-south during ebb. The current magnitude during ebb tide is slightly stronger than that compared to flood tide.

2.7 Geotechnical & Geological Conditions

As per the seismic survey conducted in 1997, high reflectivity of the sonar indicates presence of rock at seabed level. The surface rock could be observed during the low water tide in the entire intertidal zone.

As per the details mentioned in the report on seismic survey, most of the rock at Vadhavan Point and off comprises rock of basaltic composition. The basaltic rock is dark grey, black and hard, tough and compact. The rock is susceptible to superficial weathering. Most part of the hard rock under the sea is weathered and degree of weathering varies from exposed rock to subsurface rock with subsurface rock more weathered than the exposed one. **Figure 2.20** below shows exposed weathered rock in Vadhavan intertidal region.

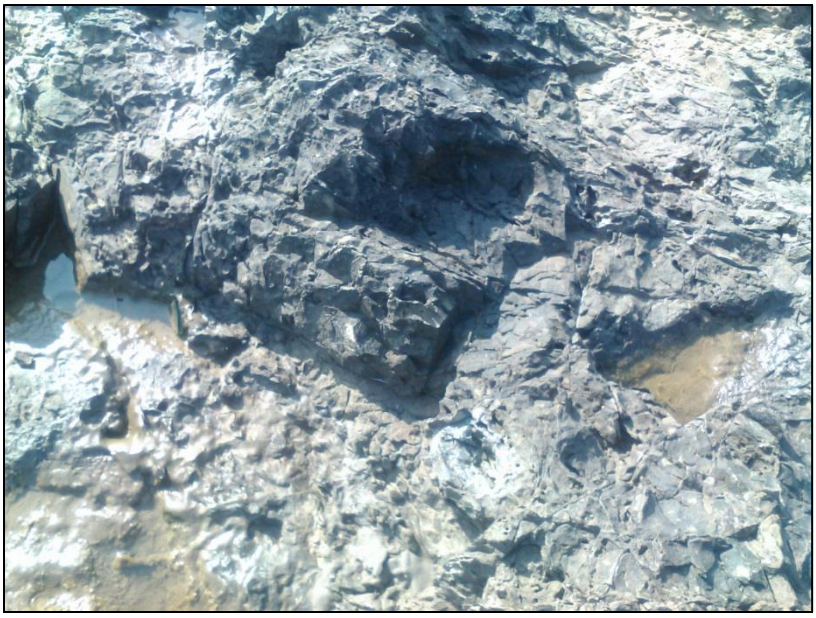


Figure 2.20 Exposed Weathered Rock in Vadhavan Intertidal Region

2.8 Topographic Information

Topography of the intertidal zone is rocky and highly undulated. Casuarina plantations are observed along the shoreline. The bed levels in inter tidal zone are sloping west. The slope varies from 1:350 to as gentle as 1:2000 in some section. The onshore area topographic details have been extracted from various like Google Earth and processed through ArcGIS software. This information has been completed using the available land charts of the region. The following **Figure 2.21** shows the result of the processing of information.

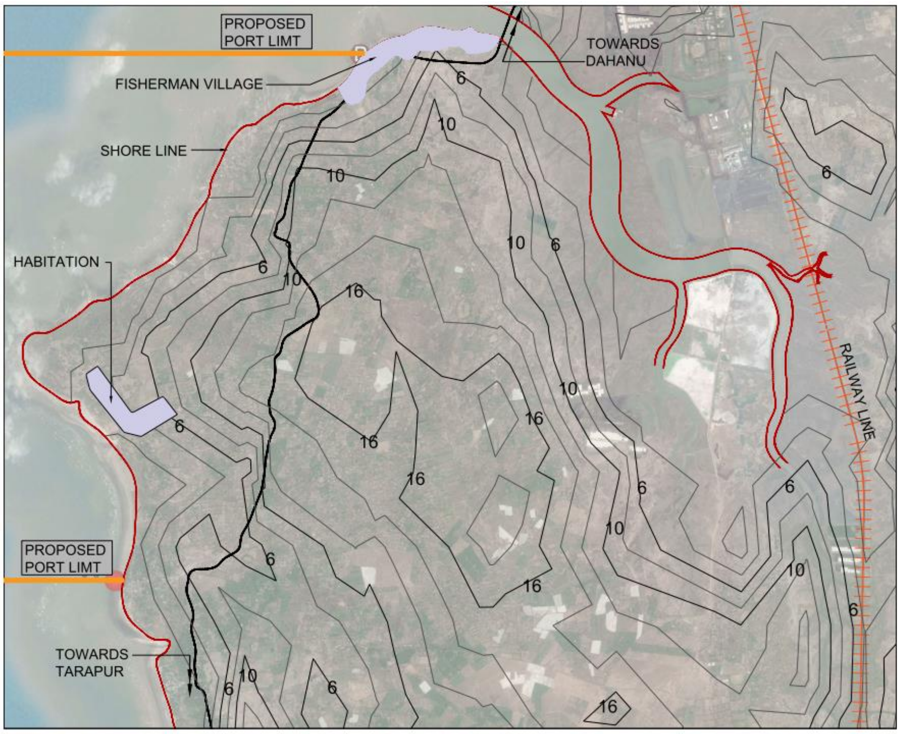


Figure 2.21 Topographic Details of the Study Area

2.9 Connectivity to Port Site

2.9.1 Rail connectivity

Existing western railway mainline is 10km away from Vadhavan Point. Nearest railway station to Vadhavan Point is Dahanu which is approximately 10.5km and Vangaon railway station is approximately 12km from Vadhavan Point.

2.9.2 Road Connectivity

NH-8, which is a 4-lane National Highway connecting Mumbai and Delhi, is approximately 28km away from the proposed port location. Vadhavan site can be reached via Boisar through Boisar road then Boisar-Tarapur road. This road passes through the dense habitation in Boisar. Other two options to reach Vadhavan are Kasa junction on NH-8 then - Dahanu-Jewhar road and Kasa Junction then – Chinchani-Vangaon road via Chinchani.

Figure 2.22 and **Figure 2.23** below show the Dahanu area road map with existing road images.

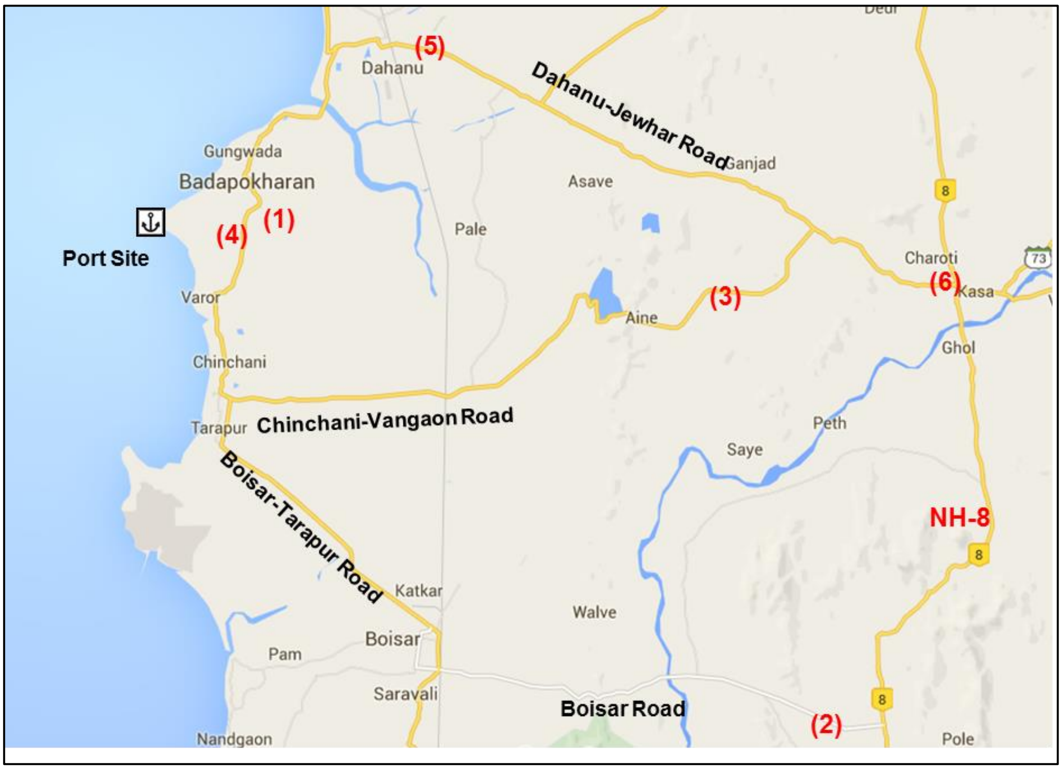


Figure 2.22 Existing Road Connectivity to Vadhavan Port

Figure 2.23 Road connecting to Vadhavan Port Site

2.10 Water supply

Sakhare dam which is the main source of water for Dahanu and Boisar is located approximately 15km away from Vadhavan site in East direction. The dam has the storage capacity of 4.07 Mcum of water.

Figure 2.24 Sakhare Dam and Location Map

2.11 Power Supply

The 220 kV substation is located in Boisar which is approximately 20km from the proposed port location. **Figure 2.25** below shows location map of Boisar sub-station.

Figure 2.25 Location of Boisar Substation

3.0 Traffic Projections for Vadhavan Port

3.1 General

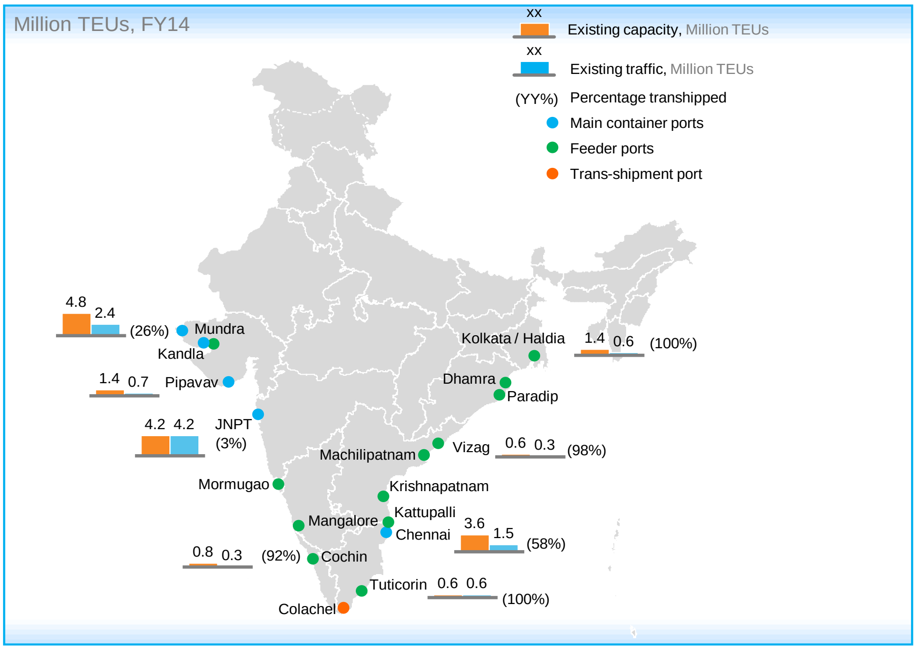
The port at Vadhavan will act as a satellite port for JNPT. JNPT currently has Maharashtra as its primary hinterland with other hinterlands including NCR, Punjab, Rajasthan and UP which it shares with Gujarat ports- Mundra and Pipavav. While Vadhavan is mainly expected to cater to container traffic, it may also have potential to handle coal mainly to cater to power plants in the region.

3.2 Hinterland Identification and Cargo Potential

Mckinsey has carried out assessment of traffic based on analysis of past traffic at JNPT, interviews with Port authorities, Maharashtra Maritime Board and Maharashtra Industrial Development Corporation (MIDC) as well as several stakeholders in the shipping and user industries.

West coast container ports handled ~7.6 MTEUs out of the 10.7 M TEUs handled in India in FY14. In the same year, JNPT operated at ~100% capacity utilization handling 4.2 MTEUs (**Figure 3.1**).

Port wise EXIM container movement in India



SOURCE: APMT; Expert interviews

Figure 3.1 Port wise EXIM container movement in India

The key hinterland of JNPT includes Maharashtra, NCR, Punjab, Uttar Pradesh, Uttaranchal, Rajasthan and Gujarat. Except for Maharashtra, which is almost solely served by JNPT, above hinterland is also served by the Gujarat Ports – mainly Mundra and Pipavav (**Figure 3.2**).

Hinterland to port mapping

Primary hinterland of port

EXIM container volumes

'000 TEUs, FY14	JNPT	Mundra	Pipavav	Kandla	
NCR+Punjab	936	1,264	329	11	
Maharashtra	2,121	54	0	2	
Tamil Nadu	0	0	0	0	
Gujarat	552	262	169	2	
Uttar Pradesh	228	274	107	4	
West Bengal	0	0	0	0	
Rajasthan	43	448	60	9	
Karnataka	94	0	0	0	
Kerala	0	0	0	0	
Andhra Pradesh	75	0	0	0	
Madhya Pradesh	43	70	14	1	
Bihar/Jharkhand	0	0	0	0	
Uttaranchal	95	0	0	0	
Orissa	0	0	0	0	
Chhatisgarh	15	18	14	0	
North East	0	0	0	0	
Port total	4,202	2,390	692	29	7,314

SOURCE: APMT; Expert interviews

Figure 3.2 Hinterland to Port mapping

Container traffic from the North and North-western parts of India (including NCR, Uttar Pradesh, Haryana, Punjab and Rajasthan) has shifted to Mundra and Pipavav over the recent years. This trend is expected to continue going forward mainly because of the shorter distance by road and rail from this hinterland to Gujarat ports as compared to JNPT (e.g. avg. rail distance of NCR from/to Mundra and Pipavav is ~350 and 250 km lesser than JNPT).

A part of the reason for the shift is due to increasing congestion at JNPT. While the completion of the 4th container terminal and other expansions will ease this situation, the rail distance advantage of Gujarat Ports will still make them more competitive for North and North-western parts of India.

Given the above context, following are the key assumptions underpinning the methodology for projecting traffic for JNPT:

– The current shared hinterland of JNPT and the Gujarat Ports will continue to evolve so that most of the traffic from the North and North-western parts is mainly handled by the Gujarat Ports

– JNPT will mainly cater to traffic from south Gujarat, Maharashtra and to a much smaller extent Madhya Pradesh, Telengana and Karnataka

– Vadhavan will also cater to the same hinterland as JNPT – however JNPT will have an advantage given its existing trade network. Historically it has been found that such infrastructure tends to be quite sticky. Therefore it has been assumed that Vadhavan will mainly cater to spill over traffic from JNPT once the latter is saturated. The total traffic capacity at JNPT has been assumed to be 10 MTEUs per annum after the ongoing expansions

– However, Vadhavan has been allocated a small share of its common hinterland with JNPT based on traffic (~20%) from its immediate hinterland of south Gujarat and north Maharashtra.

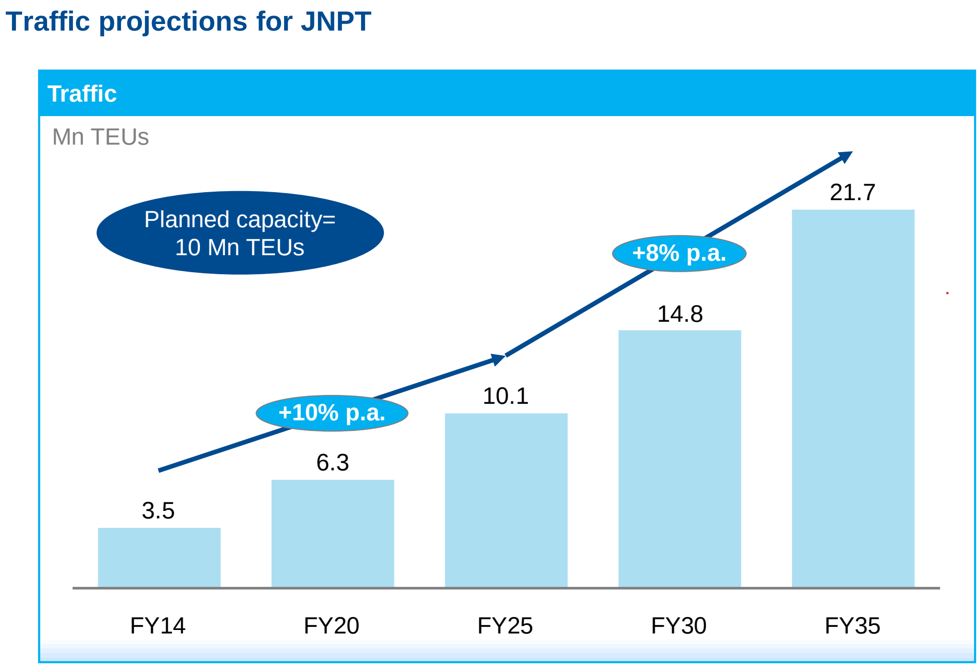
JNPT's core hinterland of Maharashtra, Karnataka, Madhya Pradesh and Chhattisgarh resulted in ~3.5 M TEUs in FY14. This is the base traffic we have taken for JNPT. Traffic projections for JNPT have been done considering:

– Historical growth in container traffic at JNPT and other ports

– Historical trends in level of containerization in India

– Forecast for manufacturing GDP of different districts including increase in demand and manufacturing from initiatives like Delhi-Mumbai Industrial Corridor (DMIC), Visakhapatnam-Chennai Industrial Corridor (VCIC), Chennai-Bangalore Industrial Corridor (CBIC), Mumbai-Bangalore Economic Corridor (MBEC), "Make in India" campaign

Based on above, container traffic at JNPT is expected to be ~ 10 M TEUs by FY25 which will be about the same as the expanded capacity at the port (**Figure 3.3**).



SOURCE: Interviews with stakeholders, McKinsey Global Institute; APMT

Figure 3.3 Container Traffic Projections for JNPT

This indicates that there is significant need for another port to handle container traffic even after the expansions ongoing at JNPT.

3.3 Final traffic potential for Vadhavan

3.3.1 Containers

The container traffic potential for Vadhavan has been calculated considering the following:

– Traffic from JNPT's core hinterland after eliminating traffic from the North and North-western states is assumed to be ~3.5 M TEUs in FY14 as above. This has been assumed to grow at 10% until 2025 and 8% thereafter until 2035.

– FY23 will be the first year of operation of port assuming 2 years for development and pre construction activities (FY17- FY18) and four years for construction (FY19- FY22)

– Vadhavan is assumed to cater to spill over traffic from JNPT port once its expanded capacity of 10 M TEUs is fully utilized

– However, Vadhavan since it is closer to South Gujarat, parts of Madhya Pradesh (e.g., Vapi, Surat, Ahmedabad, Indore) as compared to JNPT, it has been assumed that it will attract a part of the total traffic from these hinterlands even before JNPT reaches full capacity utilization. Traffic from areas that are closer to Vadhavan versus JNPT is ~30% of the total hinterland considered for JNPT. However, considering the stickiness of container traffic, only 15-20% is actually allocated to Vadhavan.

Based on the above, Vadhavan is expected to handle ~0.8 MTEUs in its first year of operation (FY23).

3.3.2 Coal

In addition, in order to cater to the power demand of state, Vadhavan might handle coal for coastal power complex of 2.5 GW to be constructed in three phases starting FY25.

3.3.3 Breakbulk cargo

The proposed port could be used as a gateway port for the import and export of cargo for Tarapur Industrial Area. The cargos that are likely to be handled at the port are steel rods, steel coils, scrap etc. In addition there could be possibility of export of oil extractions and import of cement by coastal shipping from Gujarat.

3.3.4 Summary traffic

The traffic projections for the proposed Vadhavan port are summarised in Table 3.1 below:

Table 3.1 Vadhavan Port – Traffic Projections

Cargo	Import/ Export	2023	2028	2033	2038
Dry Bulk Import					
• Coal	I	-	2.30	11.50	11.50
• Other Bulk	I	-	-	-	-
Other cargo					
• Breakbulk (machinery, project cargo)	E	1.00	1.50	2.00	2.50
• Iron and Steel	E	0.50	0.50	0.50	0.50
Containers					
• Total in TEUs	I/E	830,000	2,680,000	8,630,000	15,150,000
• Total in MT		13.11	42.34	136.35	239.37
Total Traffic (MTPA)		**14.61**	**46.64**	**150.35**	**253.87**

4.0 Design Ship Sizes

4.1 General

The size of ships that would call at any port will generally be governed by the following aspects:

- The trading route
- Availability of a suitable ship in the market
- Available facilities mainly navigational channel and manoeuvring areas including the draft
- The available facilities for loading & unloading
- Volume and type of annual traffic to be handled and the likely parcel size as per the requirements of the users.

The following main cargo commodities for the proposed Vadhavan Port have been identified:

- Dry Bulk - Coal
- Break Bulk - Steel, Non Metallic Minerals, Engineering Goods
- Containers

4.2 Dry bulk ships

Dry bulk carriers are generally classified into the following groups, viz.

Handysize	:	10,000–40,000 DWT
Handymax	:	40,000–60,000 DWT
Panamax	:	60,000–80,000 DWT
Cape	:	80,000–120,000 DWT
Super cape	:	Over 120,000 DWT with the largest carrier being 400,000 DWT

While selecting the design ship size, in addition to ascertaining the freight advantage of larger vessels, it is essential to study the origin/destination ports and the facilities available there for handling large carriers.

4.2.1 Thermal Coal

Currently the power plant is catered by thermal coal imported from Indonesia and South Africa. The coal is supplied to the power plant through rail from the nearest port.

The coastal shipping in cape size/ super cape offer cost advantage for many of the users and it would be prudent the proposed port should also have unloading facilities for cape size ships. For planning purposes 200,000 DWT is recommended as the maximum design size of ships.

4.3 Breakbulk Ships

4.3.1 General Cargo

The general cargo commodities such as non-metallic minerals, heavy machine goods etc. are likely to be imported / exported in ships, which range from 10,000 DWT to 40,000 DWT. For planning purposes 40,000 DWT is recommended as the maximum design size of general cargo ships.

4.3.2 Steel Products

Generally, steel, steel products etc. are exported mainly through general cargo ships. At the Indian ports, ship sizes carrying steel products are 20,000 DWT on an average, though there have been occasions when ships of about 40,000 DWT have also called. Considering these facts it is recommended to adopt the design ship size as 40,000 DWT.

4.4 Container Ships

4.4.1 General

The success of the container ship story is unparalleled in the history of shipping. Ever since its start in the early sixties, the idea of shipping cargo in locked containers has been widely accepted, resulting in uninterrupted growth, continuing even into the beginning of this century. Consequently, the world container fleet has the fastest growth rate than any other ship type. Economy of scale effects in container shipping have led to a rapid increase in size for all types of vessels, from feeders to the large inter-continental carriers. The trend towards larger ships has accelerated in recent years and can be observed in the increasing size of the line haul as well as feeder vessels.

4.4.2 Container Vessels – World Fleet

Since its start in the early sixties, container trade has grown exponentially worldwide, resulting in significant increase in vessel numbers and sizes.

There is a continuing trend towards larger container vessels and a number of vessels at the top end of the size range are already on order. Historically, as the mainline vessel sizes have increased, larger vessels operating in primary routes have ‘trickled down’ to the second tier routes. It is expected that vessels in the range of 10,000 TEU will ‘trickle down’ to serve secondary or feeder routes in the future.

In order to establish Vadhavan port position as a direct call port, it will need to be able to handle ships normally in the range of 8,000 to 18,000 TEUs.

4.4.3 Container Ships Dimension

Container ships are classified into six broad categories viz. Feeder, Feeder Max, Handy, Sub-Panamax, Panamax and Post-Panamax. The following table, which has been compiled through data from the Shipping Register of Lloyds Fairplay database, gives a broad outline of the principal dimensions of the ships under the different categories. The **Table 4.1** gives the dimensions of the smallest and the largest ship in each category. This will help in planning the layout of the container terminal and the other facilities.

Table 4.1 Dimensions of the Smallest and Largest Ship

Parameters	1000 TEU	2000 TEU	4000 TEU	6000 TEU	9000 TEU	14500 TEU	16000 TEU	Triple E	18300 TEU
Nominal Capacity	1000	2000	4000	6000	9000	14500	16000	18000	18300
LOA (m)	160	200	290	320	350	365	400	400	400
Beam (m)	22	32	32	42	45	50	54	59	59
Loaded Draft (m)	10.0	11.0	13.5	14.0	15.0	16.0	15.5	15.0	15.5

[Source: Lloyds Fairplay Database]

However, it is understood that the future vessels of up to 22k to 24k TEUs are under discussion, and the dimension of these could increase from the current value to 430 m LOA, 62-64 m beam and about 17 m draft.

4.5 Design Ship Sizes

Since the dimensions for any class vary between designs, there are no definitive dimensions for any particular vessel capacity. The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed Vadhavan port are presented in **Table 4.2** below:

Table 4.2 Parameters of Ship Sizes

Commodity	Design Ship Sizes (DWT)	Maximum Parcel Size (T)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Coal	80,000	72,000	240	32	14.5
	120,000	110,000	260	40	16.5
	200,000	**180,000**	**300**	**50**	**18.3**
Break Bulk	10,000	9,000	125	19	8.1
	20,000	18,000	160	25	10.0
	40,000	36,000	200	28	11.3
Containers	1,000 TEUs	700 TEUs	160	22	10.0
	18,000 TEUs	**3,500 TEUs**	**400**	**59**	**16.0**

5.0 Port Facility Requirements

5.1 General

The layout of any port will be based on the requirements in terms of number of berths, navigational requirements, material handling equipment, storage area for each type of cargo, road and rail access for the receipt and evacuation of cargo, and other utilities and service facilities. These requirements have to be worked out for development in a phased manner to enable preparation of the port's master plan.

The vessel size for Phase 1 needs to carefully chosen so that the capital investment commensurate with the traffic forecast. Considering that the containers would be the key commodity for the proposed port, it is important that phase 1 port facilities are able to handle the largest container ships plying currently i.e. 16 m draft. Also the option of handling cape size vessels of 200,000 DWT in Phase 1 itself should also be explored.

Accordingly it is proposed to consider the following options for phasing of depths in approach channel and harbour basin:

1. Design depths to be based on the largest container vessel with 400 m LOA, 59 m beam and 16 m draft.

2. Design depths to be based on the largest coal vessel of 200,000 DWT with 300 m LOA, 50 m beam and 18.3 m draft.

The above two options would be evaluated taking in account the navigation of design ships with and without tidal advantage.

5.2 Berth Requirements

5.2.1 General

The required number of berths depends mainly on the cargo volumes and the handling rates. While considering the handling rates for various commodities it must be ensured that they are at par or better as compared to the competing facilities so as to be able to attract more cargo. Allowable berth occupancy, the number of operational days in a year and the parcel sizes of ships are other main factors that influence the number of berths.

5.2.2 Cargo Handling Systems

Considering the project throughput and the competiveness requirements, the handling systems assumed for various commodities are described below:

5.2.2.1 Containers

Considering the projected traffic for containers, it is proposed to provide state of the art equipment as well as the best international operational practice. It is proposed to equip the container terminal with Rail Mounted Quay Gantry Cranes (RMQC) on berths which will capable of handling container ships with 23 container wide beam. For handling at the container yard suitable number of Rubber Tyred

Gantry Cranes (RTGCs) shall be provided. At the railway yard Rail Mounted Gantry Cranes (RMGCs) shall be provided to enable faster turnaround of rakes.

5.2.2.2 Dry Bulk Import

The fully mechanised system of Dry bulk import of cargo like thermal and coking coal, ore, FRM etc. comprises of gantry type unloaders at berth, connected conveyor system from berth to yard, stacker and reclaimer at yard and wagon loading system.

However, in the initial phase, considering the limited traffic of coal, it is proposed to handle this cargo at the multipurpose berths using mobile harbour cranes.

5.2.2.3 Breakbulk Cargo

The forecast of other dry bulk cargoes at Vadhavan Port comprise of iron and steel, non-metallic goods etc. Mostly geared ships are used for carrying these cargos. However, it is proposed to provide two mobile harbour cranes at each berth to achieve higher handling rates. Support dumpers/ trailers shall be provided to match the handling rates at berth. At storage areas adequate number of front end loaders, mobiles cranes would be provided.

5.2.3 Cargo Handling Rates

The following cargo handling rates have been assumed as mentioned in **Table 5.1** below:

Table 5.1 Cargo Handling Rates

S. No.	Commodity	Average Handling Rate (tonnes per day per berth)			
		2023	2028	2033	2038
1.	Coal	12,000	45,000	60,000	60,000
2.	Other Bulk	12,000	35,000	35,000	35,000
3.	Break bulk	8,000	8,000	8,000	8,000
4.	Iron and Steel	8,000	8,000	8,000	8,000
5.	Containers (TEUs per day per Berth)	2,500	3,000	3,000	3,500

It may be noted that the increased handling rate for bulk cargo is on account of providing fully mechanised bulk import system in Phase 2 development of port.

5.2.4 Operational Time

Considering that the port is planned as all-weather port, the effective number of working days is taken as 350 days per year, allowing for 15 non-operational days due to weather. Further, it is assumed that the port will operate round the clock i.e. three shifts of eight hours each. This results in an effective working of 20 hours a day.

5.2.5 Time required for Peripheral Activities

Apart from the time involved in loading / unloading of cargo, additional time is required for peripheral activities such as berthing and de-berthing of the vessels, customs clearance, cargo surveys, positioning and hook up of equipment, waiting for clearance to sail, etc. An average of 4 hours per vessel call has been assumed for these activities.

5.2.6 Allowable Levels of Berth Occupancy

Berth occupancy is expressed as the ratio of the total number of days per year that a berth is occupied by a vessel (including the time spent in peripheral activities) to the number of port operational days in a year. High levels of berth occupancy will result in bunching of ships resulting in undesirable pre-berthing detention.

In order to be competitive, it is important that the ships calling at the port should have minimal pre-berthing detention. At the same time the investment at the port infrastructure has to be kept at optimal level. Keeping these in consideration it is proposed to limit berth occupancy of 60% for 1 berth and that 65% for 2 berths for similar commodity. This shall reduce the pre-berthing detention of ships and offer reduced logistics cost to the shippers.

5.2.7 Berths Requirements for the Master Plan

Based on the above criteria, the berth requirements for different cargo have been worked out. A summary of the estimated berths over master plan horizon is presented in **Table 5.2** below:

Table 5.2 Estimated Berths at the Vadhavan Port Based on Traffic Forecast

S. No.	Commodity	Total Berths Needed			
		2023	2028	2033	2038
1	Bulk	0	1	1	1
2	Multipurpose Berth	2	2	2	2
3	Containers	2	7	13	20
	Total Berths	**4**	**10**	**16**	**23**

5.2.8 Port Crafts Berth

For the initial stage development, the port would require 5 tugs (4 operational + 1 standby) with a capacity of 50 T bollard pull, 2 pilot launches and 2 mooring launches.

It is proposed to utilise one end of the main berths for berthing of port crafts initially. An exclusive berth for the port crafts could be provided in the later phases.

5.2.9 Length of the Berths

Length of a single berth for a commodity depends on the LOA of the largest vessel of that commodity expected to use that berth. However in case of multiple berths of a same commodity it is possible to optimise the total length based on the average LOA of the ships visiting that berth.

Based on site conditions a continuous quay is proposed for all commodities which enable optimal utilisation of total berth length. It may be noted that due to contiguity of berths, flexibility is provided to utilise any berth for loading/unloading operations based on its availability.

The proposed berth lengths for various phases of port development are presented in **Table 5.3** below.

Table 5.3 Total Berth Length

Berth Type	Design Ship Size	Design Ship's LOA	Minimum Berth Length
Coal Berths	80,000 DWT	240 m	290 m
	120,000 DWT	260 m	310 m
	200,000 DWT	300 m	350 m
Multipurpose Berths	10,000 DWT	125 m	160 m
	80,000 DWT	240 m	290 m
Container berths	8000 TEUs	350 m	400 m
	18000 TEUs	400 m	460 m

5.3 Storage Requirements

The storage requirement at port for a particular commodity is mainly determined by the dwell time of the cargo at port. It is a common practice to assume a dwell time of;

- 30 days for imported bulk cargo,
- 30 days for Break bulk cargo,
- 5 days for containers on an average.

It should also be ensured that the storage capacity at the port for a particular cargo is at least 1.5 times the parcel size so as to allow faster turnaround of the ship.

Other factors to be taken into account in determining the size of the storage areas are stacked densities, angle of repose, maximum and average stacking height, aisle space, reserve capacity factor, peaking factor, etc.

Based on the above criteria the storage areas have been worked out for various cargos. The Phase 1 storage area works out to about 21 Ha increasing to 386 Ha over the master plan horizon.

5.4 Buildings

Sufficient buildings as per their functional requirements shall be provided in the port area. The following buildings are generally envisaged:

5.4.1 Terminal Administration Building

It will be a 4 storied building housing the following:

- Administrative offices of various operational departments including documentation space
- Canteen
- First aid post
- Central control room for terminal operations
- A VIP floor on top floor to have an overall view of the terminal

5.4.2 Signal Station

A signal station with radar and VHF communication facilities will be provided at a suitable location near the water front to communicate with the ships calling at the port and control their movements.

5.4.3 Customs Office

An office building inside the port area at an appropriate location to accommodate the customs officials who are required to inspect the ships and give clearance for movement of cargo in and out of the bonded area.

5.4.4 Gate Complex

This will be a single storied building for security personnel and shall be provided near the port entrance.

5.4.5 Substations

Two substations are envisaged to be provided, one each for container and coal terminals, apart from the main receiving substation at the terminal boundary.

5.4.6 Worker's Amenities Building

This shall provide locker and store rooms. It will also include bath and lavatory facilities. Separate buildings for container and bulk terminals are envisaged.

5.4.7 Maintenance Workshops

This shall comprise of a workshop plus store room, and an annex building to provide space for offices of the workshop foremen, mechanics, electricians, technicians and the storekeepers and rooms for off duty operational personnel and maintenance labour.

5.4.8 Other Miscellaneous Buildings

The following miscellaneous buildings shall also be provided in the port area:

- Fire Station to house firefighting equipment, fire tenders, etc.
- Dispensary buildings to be located near the operational areas and provide minimum first aid services.
- Other miscellaneous utility sheds as per requirements of a particular terminal
- Port Users Building for allocation to Banking, C&F Agents' offices
- A fuelling station shall be provided to cater to the requirements of ITV's and other vehicles used.

5.5 Receipt and Evacuation of Cargo

5.5.1 General

For the efficient functioning of a port, the essential pre-requisite is the rail and road connectivity for the effective movement of cargo in and out of the port.

Based on the market assessment and the infrastructure constraints, it is envisaged that the key cargo shall follow the evacuation pattern from Vadhavan port, as shown in **Table 5.4**:

Table 5.4 Evacuation Pattern for Various Cargo

S. No.	Commodity	2023		2028		2033		2038	
		Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share
		%	%	%	%	%	%	%	%
1.	Thermal Coal	100%	0%	100%	0%	10%	90%	10%	90%
2.	Other Bulk	70%	30%	50%	50%	5%	95%	5%	95%
3.	Fertilizer	70%	30%	70%	30%	70%	30%	70%	30%
4.	Iron and Steel	80%	20%	80%	20%	80%	20%	80%	20%
5.	Containers	80%	20%	75%	25%	70%	30%	60%	40%

5.5.2 Port Access Road

The port would need to be connected to national highway for evacuation of the cargo by at least a 4 land road initially. The width of the road shall be increased with new connectivity provided once the throughput picks up.

5.5.3 Rail Connectivity

The port shall be connected to the nearest rail link for effective evacuation of cargo particularly containers. The provision to handle DFCC rakes shall be provided while planning the terminals.

5.6 Water Requirements

Water would be needed at the port for use of port personnel, dust suppression, firefighting and miscellaneous uses.

It is estimated that the average water requirement for the initial phase development will be around 0.2 MLD increasing to about 1.7 MLD in the master plan phase.

5.7 Power requirements

HT and LT power supply at the port would be required for Handling Equipment, Reefer stacks, Lighting of the Port Area, Offices and Transit Sheds etc.

The electrical load demand for the proposed port for the initial phase development is about 13 MVA increasing to about 81 MW in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at various berths and reefers.

5.8 Land area requirement for Vadhavan Port

Large backup area has always been a prime requirement for major port development anywhere in the world. Therefore, especially in the case of a completely new port it will be prudent if a large area is specifically reserved for the long term development of the port, so that the port facilities which are so vital to the growth of the Nation can be developed easily to cater to its growing needs.

The minimum land area required for the purpose of cargo handling, storage, port operations, rail and road connectivity, greenery etc. has been worked out as shown in **Table 5.5** below:

Table 5.5 Minimum Land Area Requirement for Vadhavan Port

S. No.	Commodity	Land Allocation over Master Plan Horizon (sqm)			
		2023	**2028**	**2033**	**2038**
1.	Storage Space for various Cargoes	322,814	933,964	1,808,282	2,347,454
2.	Internal Roads and Circulation Space in Storage areas @ 25%	80,703	233,491	452,071	586,864
3.	Rail and Road Corridor	500,000	600,000	700,000	800,000
4.	Port Building Complexes including parking	20,000	30,000	40,000	50,000
5.	Landscaping, Green belt and other for Expansion	150,000	180,000	210,000	240,000
	Minimum Land Area (Sqm)	**1,073,517**	**1,977,455**	**3,210,353**	**4,024,318**
	Minimum Land Area (Hectares)	**107**	**198**	**321**	**402**

The master plan details have been worked out based on traffic studies only up to 2038. However, ports are normally planned for 50 to 70 years of growth and hence there is need to provide at least another 100% excess over the area requirement assessed for the year 2038.

6.0 Preparation of Vadhavan Port Layout

6.1 Layout development

The key considerations that are relevant for the establishment of a Greenfield port and its layout are given below:

- Potential Traffic;
- Techno-economic Feasibility;
    - Design ship size
    - Geotechnical Characteristics at site
    - Protection from waves and swell to create tranquillity at berths
    - Availability of material for Reclamation and Breakwater construction
    - Adequate manoeuvring area and Channel for the design ships
    - Scope for expansion beyond the initial development
    - Suitability for development in stages
    - Optimum capital cost of overall development and especially of initial phase
    - Flexibility to Expand Beyond Master Plan Horizon
- Land Availability;
    - Availability of adequate back-up land for storage of cargo and port operations
    - Rail and Road Connectivity to the Hinterland
- Environmental issues related to development.

6.2 Brief Descriptions of Key Considerations

The following sub-sections briefly discuss the relative importance and implication of each of the above factors in relation to the Greenfield port development at Vadhavan.

6.2.1 Potential Traffic

The potential traffic that a new port could attract forms the first and foremost requirement of the project. Considering the site conditions and initial investment needed for creation of the basic port infrastructure, the projected traffic for the initial phases of development would govern the viability of Vadhavan port.

6.2.2 Techno-Economic Feasibility

6.2.2.1 Design Ship Size

The selection of design ship size is a key input for the port development as the required depths and the size of the navigational and manoeuvring area of the harbour as well as the cargo handling infrastructure are dependent on this. The ship size has direct implication on the cost of the port development and therefore has impact on the viability. In the present case the proposed port has to be established as a mega port for handling containers and therefore it is prudent that the design draft of the vessel for Phase 1 be at least 16 m i.e. the draft of the largest container ships plying currently. Depending upon the cost economics providing the deeper draft of 18.3 m for 200,000 DWT cape size coal carriers shall also be examined.

6.2.2.2 Geotechnical Characteristics of the Site

The geotechnical characteristics of the site could be a key factor in capital cost of port development. The rock levels at the site will impact the selection of marine layout because of the potentially very high cost of dredging in rock. Similarly very soft soil at the location would also have impact on capital cost as ground improvement works will have to be resorted to support the structures. Based on the site information rock is observed to be at or very close to the bed levels. It would therefore be important to develop a layout that has minimum rock dredging.

6.2.2.3 Protection from Waves and Swell

The location of the port has to be evaluated in terms of the shelter available from the direct attack of waves. The locations which are in naturally protected zones do not require expensive breakwaters for protection from waves for round the year operations. As per the analysis of wave conditions at Vadhavan Port site it is observed that during monsoon period the wave heights exceed the limiting wave conditions for cargo handling operations and therefore it would be required to provide protection to the berths from direct attack of waves.

6.2.2.4 Availability of Construction Material

Transportation cost of the borrowed fill and rock from longer distance forms the major component of the overall cost of reclamation. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. At Vadhavan there is likely to be significant requirement of rock for the breakwater construction. The same has to be brought to the port site from quarries located about 35 km from port site. Considering significant requirements many quarry sites would need to be operated at the same time and also bringing the rock through coastal shipping may also need to be explored during the implementation phase.

6.2.2.5 Adequate Manoeuvring Area and Channel for Design Ships

This consideration requires provision of adequate channel width, stopping distance and the manoeuvring area for the design ship, as per the best international practices. The potential of marine accidents of the ships hitting the berth structure and approach trestle should be eliminated. The width of the channel would be based on the design ship size as well as requirement for one way or two way channel.

6.2.2.6 Scope for Expansion over the Initial Development

With the costly basic infrastructure like dredged basin, channel, hinterland connectivity in place, addition of more berths will not be so capital intensive. This is a likely incentive for investors to create additional cargo handling capacity by building new berths/ terminals in future. Therefore the port location and layout should allow for the flexibility for expansion to allow additional berths, storage and evacuation.

6.2.2.7 Flexibility for Development in Stages

The site should allow a development plan such that it is capable of being developed in stages, if needed for phase wise induction of cargo handling facilities.

6.2.2.8 Optimum Capital Cost of Overall Development and especially for the Initial Phase

Capital cost is clearly the primary consideration while evaluating a port location. The cost of development of initial phase takes precedence. This aspect shall be duly kept into consideration while deciding the design ship size for Phase 1 development so as to minimise the cost of capital dredging.

6.2.2.9 Flexibility for Expansion beyond Master Plan Horizon

An important and sometimes forgotten aspect of Master Planning is to consider what may happen after the end of the immediate time horizon of the Master Plan study. The traffic projections for a 20 year period inevitably have more inbuilt uncertainty than the more immediate 5 year projections. Therefore the requirements in 2038 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing in 2038. Therefore in comparing the merits of different alternatives for Master Plan layout, preference should be given to those that allow space for further development.

6.2.3 Land Availability

6.2.3.1 Availability of Backup Area for Storage of Cargo and Port Operations

Adequate land must be available along the waterfront for an efficient cargo storage and port operations. Acquiring the land for this purpose may lead to protests from local residents resulting in abandoning of the project or involving significant cost towards land acquisition. At Vadhavan, it is therefore proposed that backup area of cargo storage and port operations be planned on reclaimed area in the intertidal zone. Substantial area of reclaimed land can be formed over the rocky inter-tidal area, which will be at relatively low cost and have a good foundation.

6.2.3.2 Provision for Rail and Road Connectivity

The onshore cargo storage area should have good connectivity to the external rail and road linkages for faster evacuation of cargoes with minimum capital investment and minimum rehabilitation and resettlement. Considering the historical background on the agitations by local population about two decades ago when this site was selected for port development, it shall be ensured that the road and rail alignment be selected in such a manner so as to minimise the need for any land acquisition.

6.2.4 Environmental Issues related to Development

The environmental issues such as deforestation, rehabilitation and resettlement would need special consideration while arriving at the suitable port location or suitable layout of port.

6.3 Planning criteria

6.3.1 Limiting wave conditions for port operations

6.3.1.1 Pilot boarding

Ships arriving at the port will take on a pilot to guide it to the designated berth inside the port. The pilot will normally board the ship at the outer anchorage. Since the pilot has to board the vessel in the open sea through rope ladder along the ship side, the limiting condition is that the significant wave height

(H_s) should not exceed 2.5 m. As in the present case the pilots shall be boarding at Vadhavan Roads and then take the ship to the port location through Vadhavan Channel.

6.3.1.2 Tug fastening & tug operations

The tugs, which assist the ship while stopping, turning in the basin and manoeuvring to the berth, normally meet the vessel in protected water, just inside the breakwaters. The limiting wave condition for tugs to fasten to a ship and effectively assist and control the ship varies from Hs=1.0m to Hs=1.5m depending the type of tugs used.

6.3.1.3 Tranquillity requirements for cargo handling operations

For carrying out cargo handling operations at the berths, it has to be ensured that there are no excessive movements of the ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for the different types of cargoes. Hence, the breakwater configuration and the overall port layout should ensure adequate tranquillity at the berths so that cargo handling may continue even when the offshore wave climate exceeds the limit for ships' movement in and out of the harbour.

The maximum acceptable wave conditions for cargo handling operations at the berth are dependent on ship size, the type and method of cargo handling and the direction of the wave attack. Beam waves cause the vessel to roll and affect the cargo handling operations more than head waves. The limiting wave height (H_s) from different wave directions for cargo handling operations are stipulated in PIANC bulletin - "Criteria *for movements of moored ships in Harbours – a Practical Guide (1995)".* An extract is summarised in **Table 6.1** below:

Table 6.1 Limiting Wave Heights for Cargo Handling

Type of Ship	**Limiting Wave Height (H_s)**	
	Head or Stern (0°)	**Quadrant (45°- 90°)**
Dry bulk Carriers		
- loading	1.5 – 2.0 m	1.0 – 1.5 m
- unloading	1.0 –1.5 m	0.5 - 1.0 m
Break-bulk Ships	1.0 m	0.8 m
Liquid Carriers	1.5 m	1.0 m
Containers	0.5 m	0.5 m

6.3.2 Breakwaters

The purpose of breakwater is to provide tranquil conditions inside the port in operating conditions. South breakwater is to be planned for predominant waves coming from South-West direction. For the initial phase, an offshore North breakwater can be planned to protect harbour from the waves coming from North-West direction. The length of North Breakwater shall be sufficient enough to cover the berthing area and manoeuvring in the shadow zone. Final layout and alignment of the breakwater to be decided based on the harbour tranquillity study and the length shall be kept minimum to limit the overall capital expenditure.

6.3.3 Berths

The estimated berths and the total quay length for the various phases of development have been worked out and are presented in the **Table 6.2** below.

Table 6.2 Berth Requirement as per Traffic Forecast

S. No.	Commodity	Total Berths Required			
		2020	2025	2030	2035
1.	Bulk	0	1	1	1
2.	Multipurpose Berth	2	2	2	2
3.	Containers	2	7	13	20
Total Berths		**4**	**10**	**16**	**23**

It may be noted that the above only indicates the number of berths needed as per the traffic projections. The actual number of berths provided in different phases would be governed by the physical and financial constraints of the proposed port site. Further it may be noted that for containers, it is the total quay length rather than the number of berths are important for \handling operations.

6.3.4 Navigational Channel Dimensions

The dimensions of the navigation channel to the terminal are dependent on the vessel size, the behaviour of the vessel when sailing through the channel, required tidal access, the environmental maritime conditions (winds, waves, currents) and the channel bottom conditions.

6.3.4.1 Channel Width and Length

The channel width has been calculated from the latest PIANC Guidelines "Harbour Approach Channels – Design Guidelines: Report No. 121 – 2014". The detailed calculations are shown in attached **Table 6.3**.

Table 6.3 Assessment of Channel Width

PIANC Recommendations						
					Channel	
Basic Lane Width W_{bm} (multiple of ship beam B)		Vessel Speed	Outer Channel Exposed to Open Water	Inner Channel Protected Water	outer	inner
vessel manoeuvrability						
	- good	all	1.3	1.3	1.3	1.3
	- moderate	all	1.5	1.5		
	- poor	all	1.8	1.8		
				TOTAL BASIC MANOEUVRING LANE W_{bm}	**1.3**	**1.3**
PIANC table 5.2 - Additional Width for Straight Channel Sections (multiple of ship beam B)						
(a)	**vessel Speed (knots)**					
	- fast >12		0.1	0.1		
	- moderate >8 - 12		0.0	0.0	0.0	0.0
	- slow 5 - 8		0.0	0.0		
(b)	**Prevailing cross wind (knots)**					
	- mild ≤ 15 (≤ Beaufort 4)	all	0.0	0.0		
	- moderate > 15 - 33	fast	0.3	-		
	(> Beaufort 4 - Beaufort 7)	mod	0.4	0.4	0.4	0.4
		slow	0.5	0.5		
	- severe >33 - 48	fast	0.6	-		
	(> Beaufort 7 - Beaufort 9)	mod	0.8	0.8		
		slow	1.0	1.0		
(c)	**Prevailing cross current (knots)**					
	- negligible < 0.2	all	0.0	0.0		
	- low 0.2 - 0.5	fast	0.1	-		
		mod	0.2	0.1	0.2	0.1
		slow	0.3	0.2		
	- moderate >0.5 - 1.5	fast	0.5	-		
		mod	0.7	0.5		
		slow	1.0	0.8		
	- strong > 1.5 - 2.0	fast	0.7	-		
		mod	1.0	-		
		slow	1.3	-		
(d)	**Prevailing longitudinal current (knots)**					
	- low ≤ 1.5	all	0.0	0.0	0.0	0.0
	- moderate > 1.5 - 3	fast	0.0	-		
		mod	0.1	0.1		
		slow	0.2	0.2		
	- strong > 3	fast	0.1	-		
		mod	0.2	0.2		
		slow	0.4	0.4		
(e)	**Significant wave height H_s and length l (m)**					
	- Hs ≥ 1 and l ≥ L	all	0.0			0.0
	- 3> H_s > 1 and l = L	fast	2.0			
		mod	1.0	1.0	1.0	
		slow	0.5			
	- H_s > 3 and l > L	fast	3.0			
		mod	2.2			
		slow	1.5			
(f)	**Aids to Navigation**					
	- excellent with shore traffic control		0.0	0.0		
	- good		0.2	0.1	0.2	0.1
	- moderate with infrequent poor visibility		0.5	0.2		
	- moderate with frequent poor visibility		0.5	0.5		
(g)	**Bottom Surface**					
	- if depth ≥ 1.5T		0.0	0.0		
	- if depth < 1.5T then					
	- smooth and soft		0.1	0.1		
	- smooth or sloping and hard		0.1	0.1		
	- rough and hard		0.2	0.2	0.2	0.2
(h)	**Depth of Waterway**					
	- ≥ 1.5T (inner and outer waterway)		0.0	0.0		
	- 1.5T - 1.25T (outer waterway)		0.1			
	- < 1.25T (outer waterway)		0.2			
	- < 1.5T - 1.15T (outer waterway)			0.2		
	- < 1.15T (inner waterway)			0.4	0.4	0.4
(i)	**Cargo Hazard Level**					
	- low		0.0	0.0	0.0	0.0
	- medium		0.5	0.4		
	- high		1.0	0.8		
				TOTAL ADDITIONAL MANOEUVRING WIDTH FACTOR W_i	**2.4**	**1.2**

PIANC Recommendations					
Basic Lane Width W_{bm} (multiple of ship beam B)	Vessel Speed	Outer Channel Exposed to Open Water	Inner Channel Protected Water	Channel outer	Channel inner
PIANC Table 5.4 - Additional Width for Bank Clearance					
- sloping channel edges and shoals	fast	-			
	mod	0.5		0.5	0.5
	slow	0.3			
- steep and hard embankments and structures	fast	-			
	mod	1.0			
	slow	0.5			
TOTAL BANK CLEARANCE FACTOR W_{br} or W_{bg}				**0.5**	**0.5**
PIANC Table 5.3 - Additional Width for Passing Distance for Two-Way Traffic					
additional width for traffic speed	fast	2.0	-		
	mod	1.6	1.4	1.6	1.4
	slow	1.2	1.0		
additional width for traffic encounter density					
- light	all	0.0	0.0	0.0	0.0
- moderate	all	0.2	0.2		
- heavy	all	0.5	0.4		
TOTAL EXTRA FOR STRAIGHT CHANNEL TWO-WAY TRAFFIC W_p				**1.6**	**1.4**
Curved Channel Width Factor W_c - PIANC Figure 5.9					
assume rudder angle 20 deg, W/D ratio 1.1, therefore Ws/B = 1.18	all	0.18	0.18	**0.18**	**0.18**

Required channel width

ship beam (m)		Channel Width outer	Channel Width Inner
Container 18000 TEU	59		
Bulk Carrier	50		
one way straight channel			
Container 18000 TEU		**277**	**207**
Bulk Carrier		**235**	**175**
one way curved channel			
Container 18000 TEU		**288**	**217**
Bulk Carrier		**244**	**184**
two way straight channel			
Container 18000 TEU+Bulk Carrier		538	397
two Bulk Carrier		500	370
two way curved channel			
Container 18000 TEU+Bulk Carrier		**557**	**417**
two Bulk Carrier		**518**	**388**

The calculated channel width for various design ship sizes is summarised below in **Table 6.4**.

Table 6.4 Particulars of Navigational Channel for Design Ships

Design Ship Size	Beam (m)	Outer Channel Width (m)		Inner Channel width (m)	
		One way Channel	Two way Channel	One way Channel	Two way Channel
200,000 DWT – Capesize Bulk Carrier	50	250	500	180	370
18,000 - TEUs Container Carrier	59	290	590	215	440

The transit time in the channel for 200,000 DWT ships will be about 0.30 hours at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1 hour, maximum of 18 ship movements per day (8 in and 8 out) could be accommodated with one set of tugs. Taking an average of about 15 ship movements per day in the channel, a one way channel can handle about 2500 ship calls per year using one set of tugs. Comparing this with the projected ship movements in the master plan stage it is considered that one way channel would be adequate. In case of additional ship movements than projected above additional set of tugs could be procured to manage with one way channel.

6.3.4.2 Dredged Depths

The depth in the channel is determined by the vessel’s loaded draught; trim or tilt due to loads within the holds; ship’s motion due to waves, such as pitch, roll and heave; character of the sea-bottom, soft or hard; wind; influence of water level and tidal variations; and the sinkage of the vessel due to squat or bottom suction. In this particular case the bed level comprises of rock and hence additional underkeel clearance of 0.5 m is considered.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship. The dredged depths that are required to be provided at different parts of the harbour for the design ships have been worked out for two scenarios i.e. with tidal advantage and without tidal advantage. The calculated values are given in **Table 6.5** below:

Table 6.5 Dredged Levels at Port for the Design Ships

A. With Tidal Advantage

Ship Size	Draft (m)	Tidal Advantage (m)	Approach channel outside breakwater (m CD)	Inner channel and manoeuvring area (m CD)	At Berths (m CD)
80,000 DWT	14.5	2.8	14.4	13.7	16.5
18,000 TEUs	16.0	2.8	16.1	15.3	18.1
200,000 DWT	18.3	2.8	18.7	17.8	20.6

As the mean sea level is about +2.8 m CD and the channel is short, it is possible to take the tidal advantage of minimum +2.8 m during the traversing of the design ship through the channel and manoeuvring area, at least during the initial phase of the port development. This is unlikely to result in any significant waiting time. Taking advantage of tide while entering and leaving the port is a normal practice in major ports.

B. Without Tidal Advantage

However in case it is desired that there should not be any waiting time for the ships on account of tide levels the minimum dredged levels to be provided at the port are given below:

Ship Size	Draft (m)	Tidal Advantage (m)	Approach channel outside breakwater (m CD)	Inner channel and manoeuvring area (m CD)	At Berths (m CD)
80,000 DWT	14.5	0	17.1	16.5	16.5
18,000 TEUs	16.0	0	18.9	18.1	18.1
200,000 DWT	18.3	0	21.5	20.6	20.6

6.3.5 Elevations of backup area and berths

Considering the mean high water springs as +4.7 m CD and allowing for the operational wave height of 1.0 m and thus crest height of 0.7 m and height of the structure as 1.5 m, the deck elevation of berths is arrived at +8.0 m CD. However, the finished levels of onshore areas will be kept at around +7.5 m CD.

6.4 Alternative Marine Layouts

Various alternative layouts for the development of the Vadhavan Port have been prepared keeping in view various considerations as discussed above.

Alternative Layout 1 is a coastal harbour option with most of the berths located close to the shore. This would result in shorter breakwater length but higher dredging quantities, including that of rock dredging. The berths are located at the middle of the long intertidal zone. This alternative is shown in **Drawing DELD15005-DRG-10-0000-CP-VAD1001** and **VAD1002**.

Alternative Layout 2 involves offshore harbour option where the harbour area is located away from the shore. As compared to Alternative 1, this alternative is envisaged to involve longer time and more cost for breakwater but less for dredging. The basic concept of developing this alternative is to minimise the quantity of costly rock dredging. Though the reclamation costs would be higher but the back area created would be useful for port operations. The channel orientation is similar to as that of Alternative 1. This alternative is shown in **Drawing DELD15005-DRG-10-0000-CP-VAD1003** and **VAD1004**.

Alternative Layout 3

This layout is developed with the same objective as Alternative 2 i.e. to minimise the quantity of capital dredging. In this layout it is envisaged that all berths are located beyond 10 m natural water depth below chart datum. The layout of breakwaters as well as the orientation of approach is similar to that in Alternative 2. This alternative is shown in **Drawing DELD15005-DRG-10-0000-CP-VAD1005** and **VAD1006**.

6.5 Evaluation of the alternative port layouts

6.5.1 Cost Aspects

One of the key considerations for the layouts evaluation is that it should be able to handle the project throughput in phased manner keeping the capital cost of development especially that of Phase 1 development as optimum. It is to be noted that the items such as Berths and Equipment, Stacking areas, Internal Roads and Railway, Port Crafts, Navaids, Utilities, Buildings etc. are of negligible cost difference for all the alternative layouts. Therefore, for cost comparison for various alternative port layouts, items of major cost difference need to be considered, as presented in **Table 6.6** hereunder:

Table 6.6 Cost Differential (Rs. in Crores) of Phase 1 Development for Alternative Layouts

Item Description	**Cost (Rs. in crores)**		
	Alternative 1	**Alternative 2**	**Alternative 3**
Breakwaters, Reclamation Bund & Revetment	1,466	2,646	2,649
Reclamation	1,177	3,525	3,176
Dredging **(Design Ship 18,000 TEU Vessel)**	4,114	515	494
Cost of Items of Major Cost Differentials in Phase 1 (Rs. in crores)	**6,757**	**6,686**	**6,319**

It could be seen from the above table that rock levels would be critical in deciding upon the cost effective port layout for Phase 1 development.

It is observed that Alternative 3 looks optimum in terms of cost of development as the berths in this case are at deeper waters, which results in minimal cost of rock dredging. This alternative however offers limited number of berths as compared to the other alternatives.

6.5.2 Fast track implementation of phase 1

It is anticipated that the breakwaters construction would be on the critical path for the port development. The quantities of rock in the breakwaters and the estimated breakwater construction time are calculated approximately as given **Table 6.7** below:

Table 6.7 Estimated Rock Quantity and Construction time of Breakwater and Approach Bund

Alternative	**Estimated Rock Quantity (million tonnes)**	**Estimated Construction Time (months)**
Alternative 1	9.0	41
Alternative 2	16.3	68
Alternative 3	16.3	68

6.5.3 Available Land for Phased Development

The selected port layout should be able to expand in a phased manner to meet the market demand. The minimum required land area is 107 Ha for Phase 1 development and that 402 Ha for master plan development as mentioned in para 5.8. For the alternative layouts 2 and 3, the required land for the storage and port operations could be created after reclaiming the large intertidal zone and still there would be additional land available for setting up the port related industries.

6.5.4 Expansion Potential

The master plan development envisaged 23 berths. However the maximum possible berths that could be built in alternative 3 are only 11 as compared to 21 that could be built in alternative 2.

6.6 Multi Criteria Analysis of Alternative Port Layouts

The above alternative port layouts were evaluated using a Multi-Criteria-Analysis. The comparison of these layouts is presented in the **Table 6.8**.

Table 6.8 Multi-Criteria Analysis of Alternative Layouts

S. No.	Factor Description	General	Alternative 1	Alternative 2	Alternative 3
1.	**Rock Levels and Estimate of Rock Dredging**	The weather rock is present very close to the bed level.	The marine facilities are relatively onshore resulting in higher quantity of rock dredging	The marine facilities are relatively offshore resulting in lesser quantity of rock dredging	Least quantity of rock dredging.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	Optimal use of the dredged material, part of which can be dumped in lee of the south breakwater	Dredged material is limited and thus significant borrowed fill material would be needed	Higher borrowed fill material needed for reclamation
3.	**Protection to the berths from waves and swell**	The predominant wave direction is from SW and WSW during the SW monsoons	The berths are well protected from direct attack of waves	Same as Alternative 1.	Same as Alternative 1.
4.	**Suitable location of back-up land for storage of cargo and port operations**	The storage area should located close to the berths so as to provide faster evacuation of cargo and also provide separation between dirty and clean cargo	Provides clear separation of clean and dirty cargo.	Same as Alternative 1.	The coal and container stackyard are relatively closer
5.	**Provision for Rail and Road Connectivity**	The port layout should be such so as to be able to be connected to the main road and rail networks	Same for all alternatives	Same for all alternatives	Same for all alternatives

S. No.	Factor Description	General	Alternative 1	Alternative 2	Alternative 3
6.	**Environmental issues related to development**	Blockage of sediment movement should not result in choking of the river mouth.	Same for all alternatives	Same for all alternatives	Same for all alternatives
7.	**Potential Reclamation Area**	The higher reclamation area could be used to establish industries for which the port could act a gateway	507Ha	951 Ha	979 Ha
8.	**Capital Cost of Phase 1 Development**	Optimized capital cost for the initial phase development so as to increase the project viability	Base case	Lower than alternative 1	least of all alternatives
9.	**Expansion Potential**	Maximum number of berths possible in the harbour so as to meet the demand at least for master plan horizon	Total Quay length of 5660 m possible within the harbour	Total Quay length of 5870 m possible within the harbour	Total Quay length of 3220 m possible within the harbour

6.7 Recommended Master Plan Layout

It could be observed from above that while alternative layout 3 appears to be the best in terms of minimal investment for Phase 1 development, it does not offer adequate expansion potential to meet the demand for the master plan horizon or even closer to that. On the other hand the alternative 2 offers additional 3400 m of quay length over the alternative 3 but the cost of Phase 1 development is higher.

Considering the above a new alternative layout i.e. Recommended Layout has been developed which is a combination of alternatives 2 and 3. The key features of this layout are given below:

1. Phase 1 of the recommended scheme is same as that of alternative 3.
2. The recommended scheme is basically similar to alternative 2 and provides about 4500 m of quay length for container handling. Apart from that it also offers flexibility in providing liquid berths and coastal cargo berths in the lee of North Breakwater to enable handling any liquid and coastal cargo traffic the need for which may arise in future.
3. The berths provided in each phase of development are to cater to the traffic projections for that phase with some allowance for handling incremental traffic before the next phase facilities are ready.

The recommended master plan layout of the Vadhavan Port is shown in **Drawing DELD15005-DRG-10-0000-CP-VAD1007**.

6.8 Phasing of the port development

The development of port shall be taken up in phases. The key port facilities that shall be developed in the phased manner over the master plan horizon are indicated in **Table 6.9** below.

Table 6.9 Phasewise Port Development over Master Plan Horizon

Description	Total Port Facilities in Each Phase			
	Phase 1 - Year 2023	Phase 2 - Year 2028	Phase 3 - Year 2033	Master Plan - Year 2038
Maximum Ship Size				
• *Dry Bulk (DWT)*	*80,000*	*80,000*	*2,00,000*	*2,00,000*
• *Containers (TEUs)*	*18,000*	*18,000*	*18,000*	*18,000*
Approach Bund				
• *Northern Bund (m)*	*0*	*0*	*0*	*3450*
• *Southern Bund (m)*	*1960*	*1960*	*1960*	*1960*
Breakwater				
• *Northern Breakwater (m)*	1760	1760	3600	4650
• *Southern Breakwater (m)*	*6440*	*6440*	*6440*	*6440*
Number of berths (Total length of berths in meters)				
• *Mechanized Bulk Berths*	*0*	*1(300)*	*1(300)*	*1(300)*
• *Multipurpose berths*	*2(590m)*	*2(590m)*	*2(590m)*	*2(590m)*
• *Container berths*	*2(800m)*	*9(3150m)*	*10(3500m)*	*13(4500m)*
Navigational Areas				
• *Length of Approach Channel (m)*	*1500*	*1500*	*1500*	*1500*
• *Width of Approach Channel (m)*	*290*	*290*	*290*	*290*
• *Diameter of Turning Circle (m)*	*800*	*800*	*800*	*800*
Design Draft of the Ship (m) for Channel	16.0 m	16.0m	18.3m	18.3m
Dredged Depths at Port (m below CD)				
• *Approach Channel*	*-16.1m*	*-16.1m*	*-18.7m*	*-18.7m*
• *Manoeuvring Areas*	*-15.3m*	*-15.3m*	*-17.8m*	*-17.8m*
• *Berths*				
○ *Breakbulk*	*-16.5m*	*-16.5m*	*-16.5m*	*-16.5m*
○ *Container*	*-18.1m*	*-18.1m*	*-18.1m*	*-18.1m*
○ *Bulk*	*-16.5m*	*-16.5m*	*-20.6m*	*-20.6m*
Incremental Dredging Quantity (million cum)	*1.2*	*3.9*	*6.8*	*3.3*
Incremental Reclamation Quantity (million cum)	*30.3*	*22.6*	*14.7*	*2.2*
Total Reclamation Area to be Developed (Ha)	*245*	*414*	*553*	*567*

The phase wise development plan of the Vadhavan port is indicated in **Drawings DELD15005-DRG-10-0000-CP-VAD1007** to **VAD1010**.

7.0 Engineering Details

7.1 Mathematical Model Studies on Marine Layout

7.1.1 General

The mathematical model studies on the preferred marine layout shall be carried out. The purpose of the study, our approach and findings of model study are presented in following paragraphs.

7.1.2 Hydrodynamics/ Flow Modelling and Sedimentation Studies

MIKE 21 FM is a modelling system for 2D free-surface flows suitable for environments such as lakes, estuaries, bays, coastal areas and seas. It is based on Flexible Mesh approach.

The HD module is the basic module in the MIKE 21 Flow Model and it provides the hydrodynamic basis for the computations of all other modules such as sedimentation. The inputs to the model, apart from the bathymetry, are water level or wave conditions along the boundaries of the model, bottom roughness etc. MIKE 21 HD simulation was aimed at computing hydrodynamics around the proposed port location for the present flow pattern as well as after the construction of the facilities.

7.1.2.1 Bathymetry

The bathymetry prepared for the HD and sedimentation study based on the depth information from the survey carried out for the present study and Naval Hydrographic Chart No MAH 210 and BA 211 along with data from earlier study carried out by P&O in 1997 (**Figure 7.1**). While, modified mesh is prepared to include the layout of the proposed port and the channel (**Figure 7.2**).

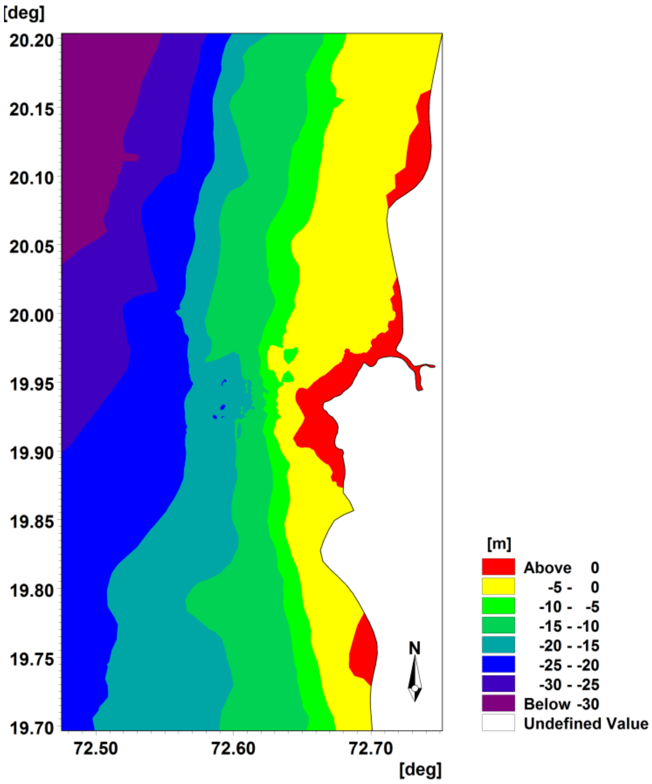


Figure 7.1 Bathymetry of the study area w.r.t. chart datum

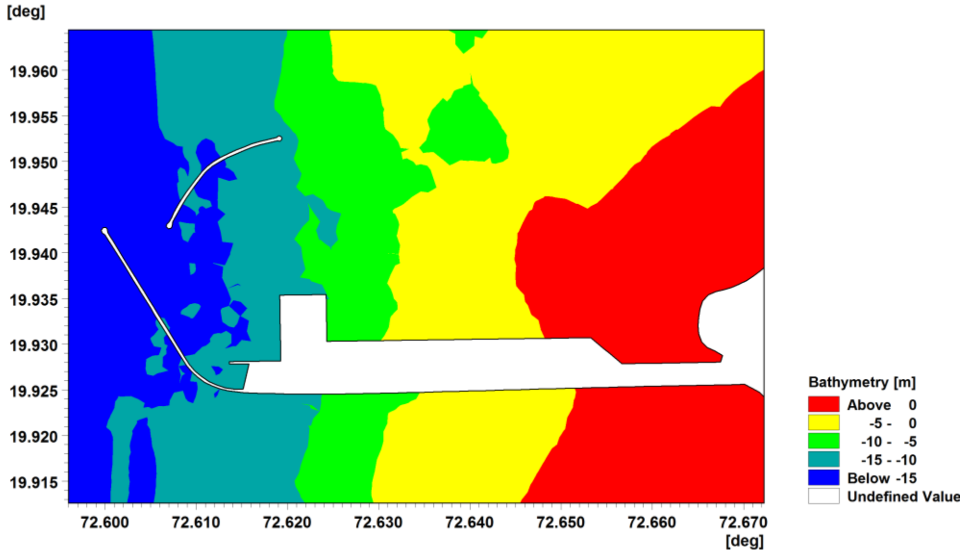


Figure 7.2 Bathymetry including Proposed Layout w.r.t. Chart Datum

7.1.2.2 Boundary Conditions

The tidal information for location called Umbergaon has been taken from International Hydrographic Organisation (www.iho.int) to be used as Northern Boundary, while Satapati tide has been used at Southern boundary also with appropriate phase lag and water level adjustments. The tide was found to vary between 0 to 5.5 m (**Figure 7.3**). Discharge of 30 m^3/s has been considered from the River.

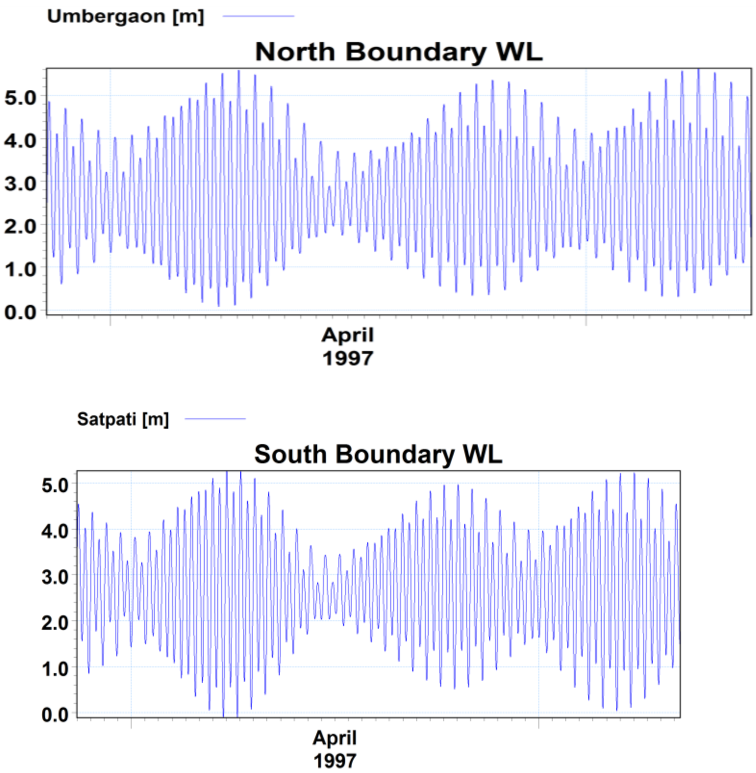


Figure 7.3 Water levels used as Northern Boundary and Southern Boundary

7.1.2.3 Model Calibration

The model was calibrated in order to compare the model results with the observed tidal levels and currents at Vadhavan. The modelled results and observed data presented very good match (**Figure 7.4).**

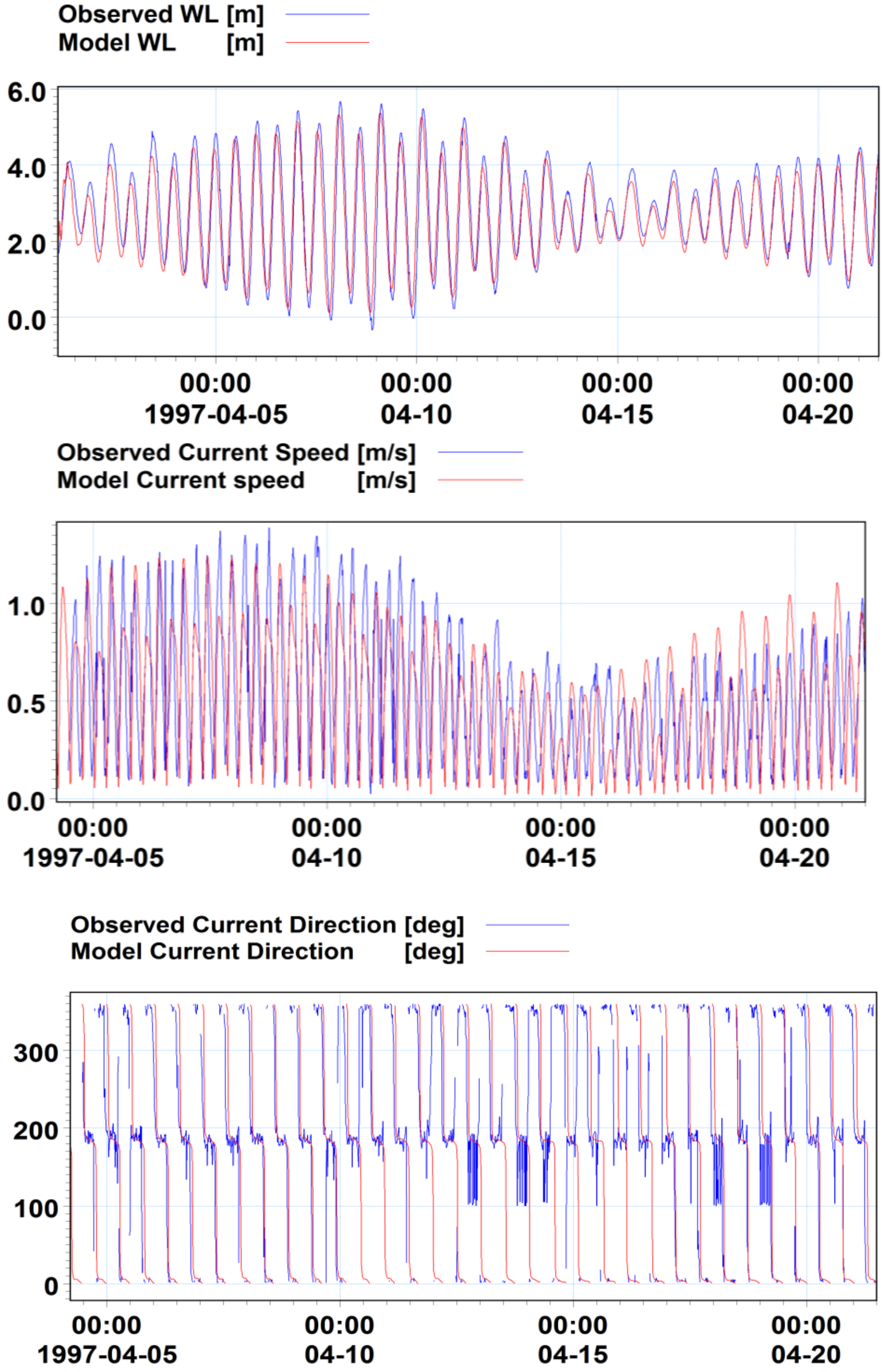


Figure 7.4 Model Calibration: Comparison of Measured (Red) and Modelled Tidal Levels (Blue) at Vadhavan

7.1.2.4 Model Results

The results of hydrodynamic studies are discussed in this section. The surface elevation during flood and ebb tides are as shown in **Figure 7.5** and **Figure 7.6**

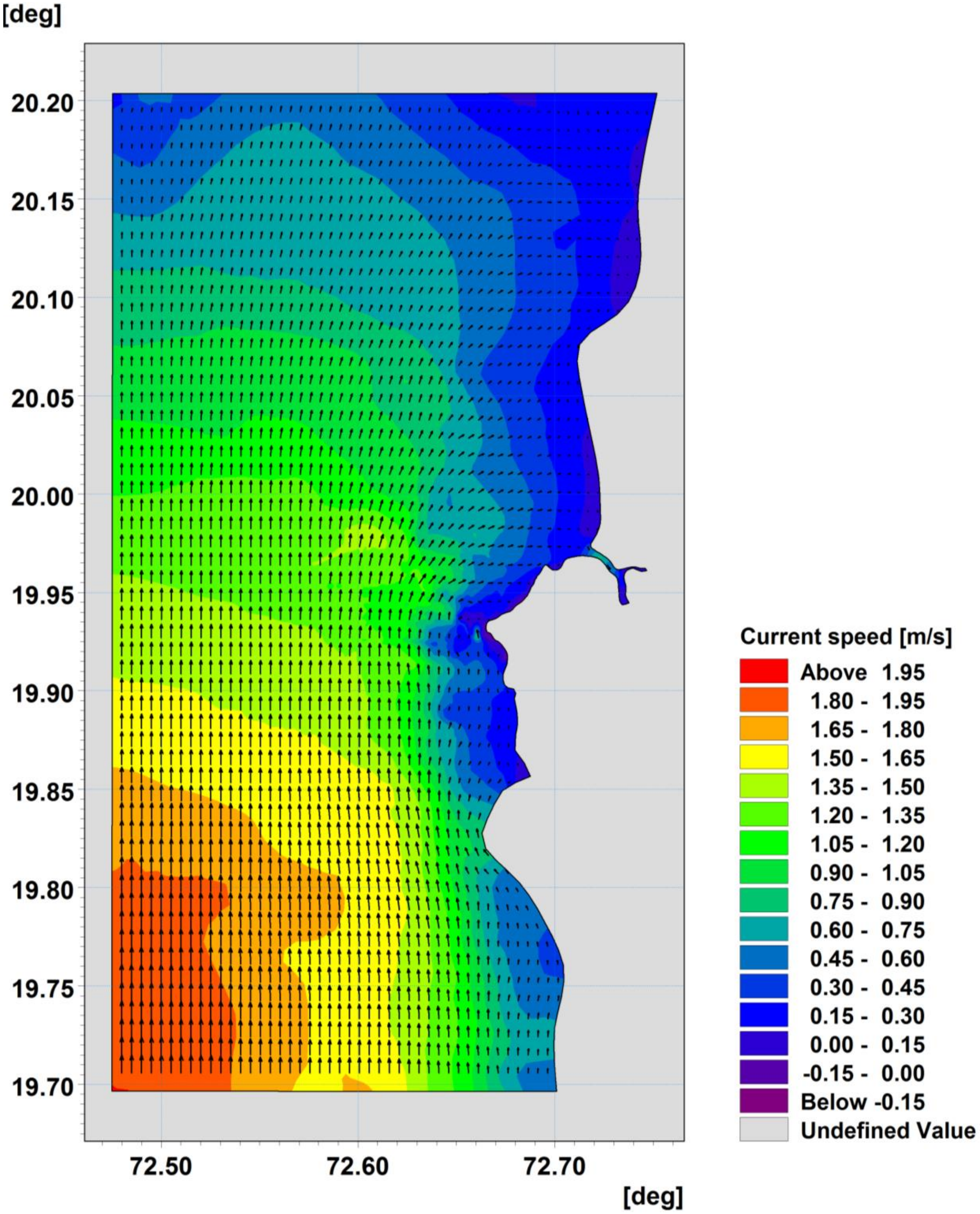


Figure 7.5 Surface Elevation in the entire region during Flood Tide

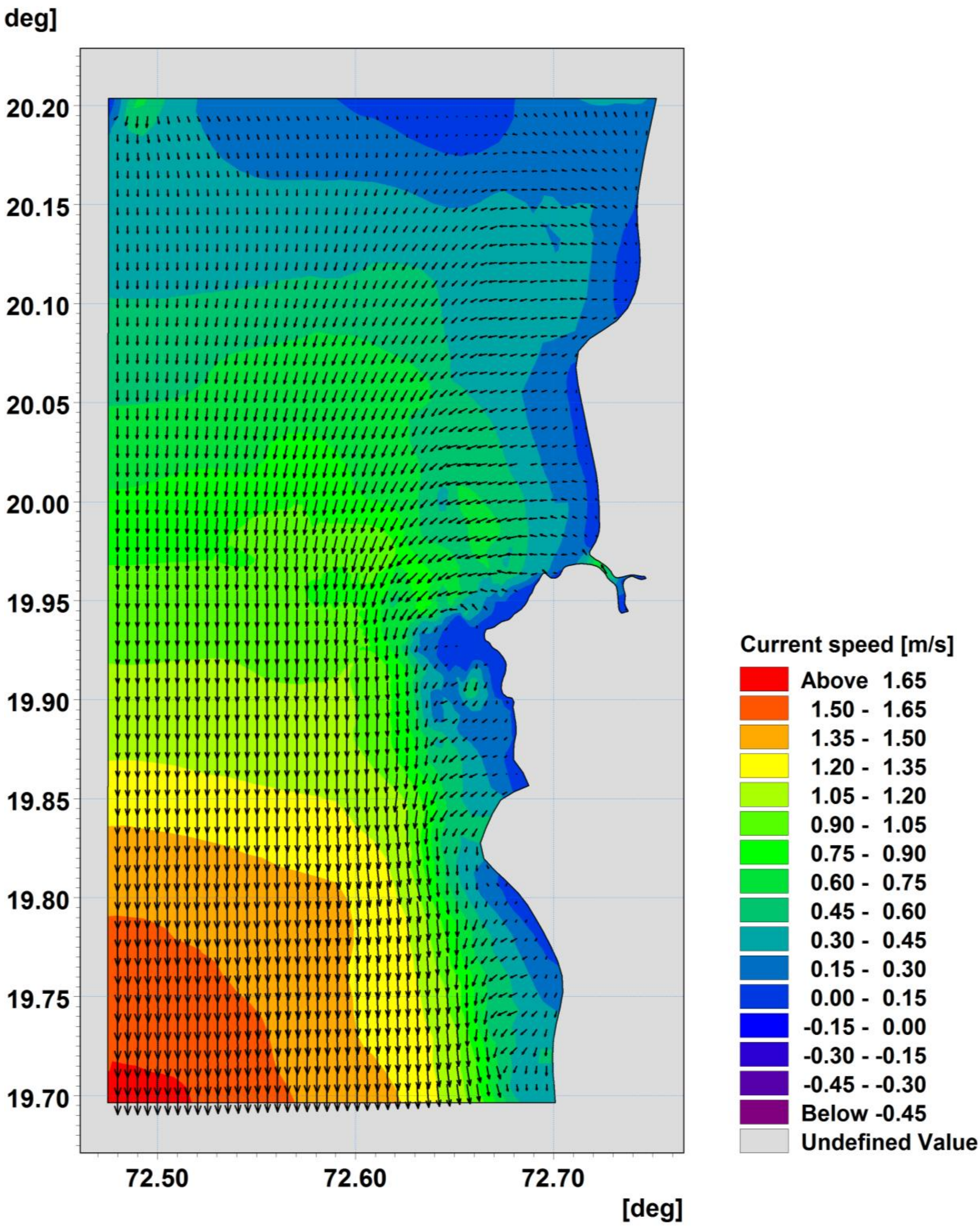


Figure 7.6 Surface elevation in the entire region during Ebb Tide

The velocities are important parameters as these will have direct impact on the sedimentation profile of the port. To have a clear understanding on the velocity variation near bank velocity time-series are extracted at the locations shown in the **Figure 7.7.** The velocities for existing conditions are presented in **Figure 7.8**. The velocities were found to vary between 0.1 to 1.2 m/s.

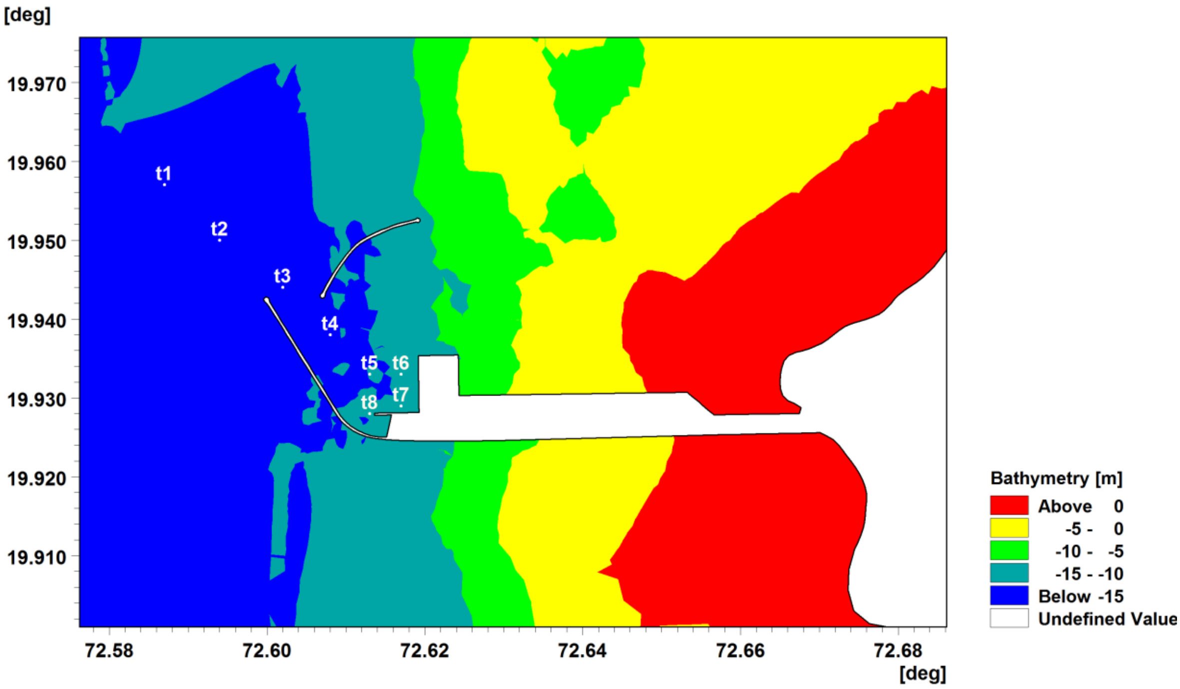


Figure 7.7 **Location of Current Time-Series – Existing Conditions**

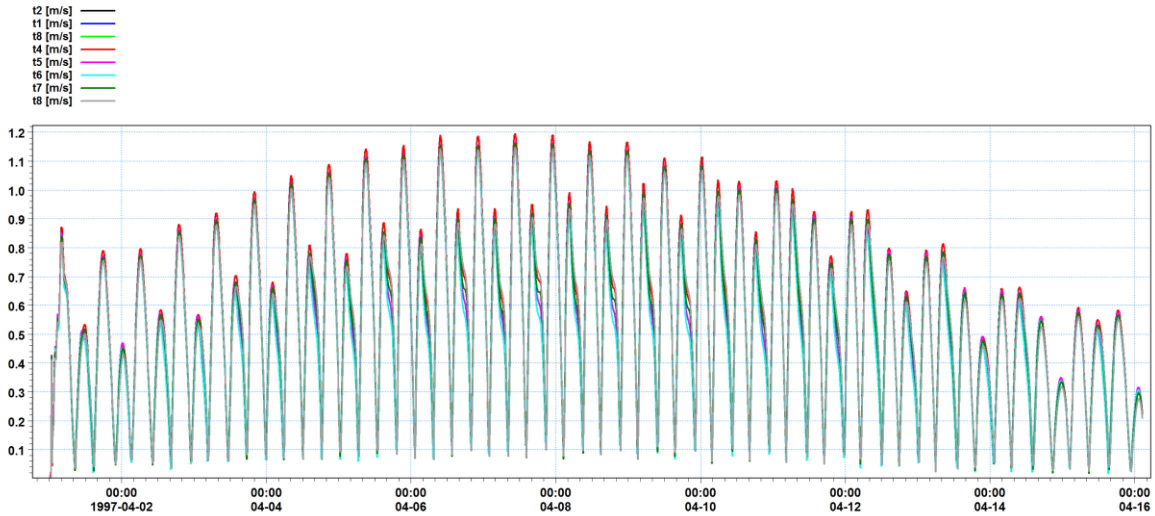


Figure 7.8 **Current Time-Series at various location in the Port and Channel for Existing Conditions**

Similarly velocities were extracted with the proposed layout and the new channel (**Figure 7.9**). It is important to note that velocities at the port location have reduced significantly due to the flow restriction, while at offshore marginal increase in velocities are observed.

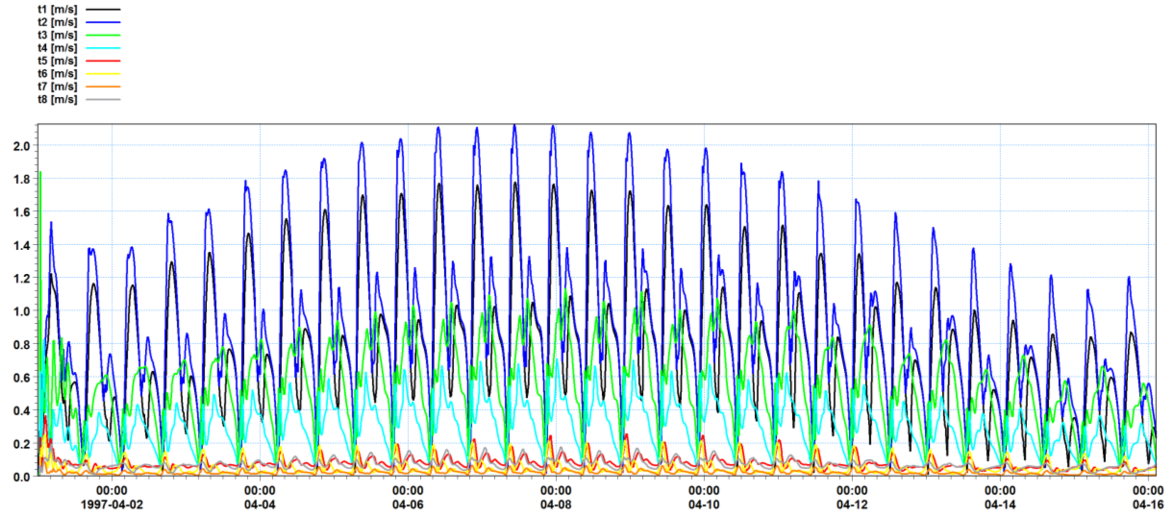


Figure 7.9 **Current time-series at various location in the Port and Channel with Proposed Layout**

7.1.3 Sediment Transport Model – MIKE MT

The MIKE 21 Mud Transport Module (MT) describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents and waves. In the MT-module, the settling velocity varies, according to the salinity, if included, and the concentration taking into account flocculation in the water column. Furthermore, hindered settling and consolidation in the fluid mud and under consolidated bed are included in the model. Bed erosion can be either non-uniform, i.e. the erosion of soft and partly consolidated bed, or uniform, i.e., the erosion of a dense and consolidated bed. The bed is described as layered and characterised by the density and shear strength.

Once the HD model is calibrated, sediment model was setup for proposed layout. **Figure 7.10** presents sedimentation for the region with construction of outer harbour.

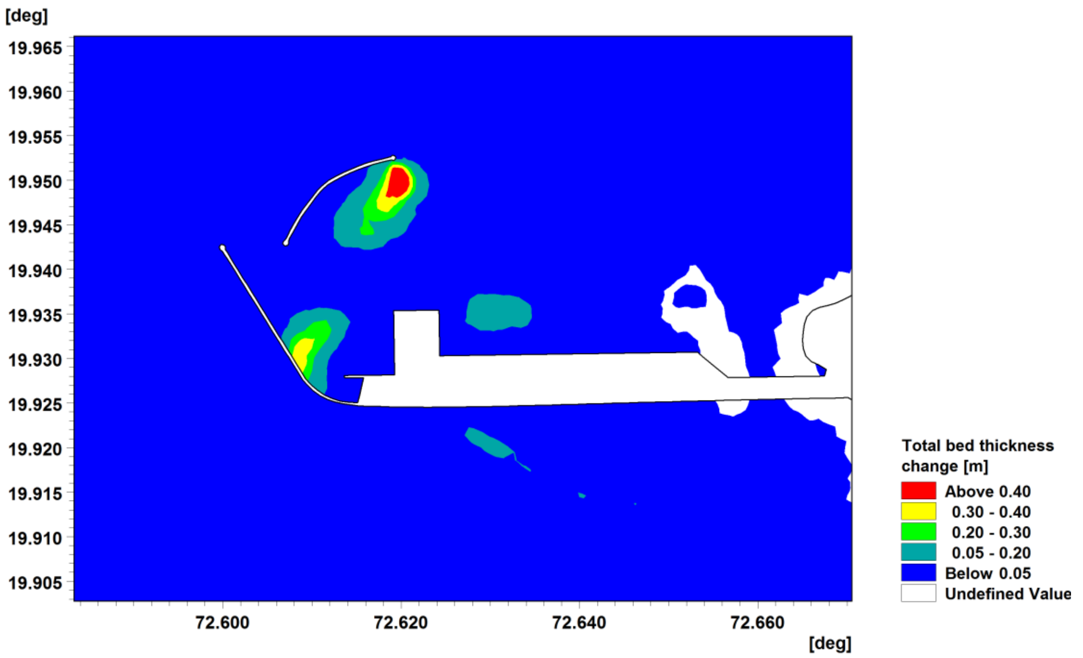


Figure 7.10 **Annual Bed level Change – with Proposed Layout**

Based on the model results, annual maintenance dredging for the new port is assessed as about 1.4 Mcum (**Table 7.1**).

Table 7.1 Annual Sedimentation within harbour and the channel – Proposed Layout

S. No.	Description	Estimated Annual Sedimentation (Mcum)
1.	Harbour Basin	*0.13*
2.	Approach Channel	*0.004*
	Total	**0.137**

7.1.4 Wave Tranquillity inside Harbour - Mike 21BW

MIKE 21 BW based on the Boussinesq's equation is applied to carry out the wave agitation study, which determines the tranquillity inside the harbour. MIKE 21 BW is a non-linear wave model and it simulates in the time domain the propagation of irregular, directional waves into the harbour taking into account all important effects like shoaling, depth refraction, diffraction, bottom friction, partial and full reflection, and transmission through porous structures.

7.1.4.1 Model Inputs

The model bathymetry was created using the breakwater configuration and the approach channel as shown **in Figure 7.11**. All the numerical simulations of the wave agitation were carried out with a water level corresponding to the Chart Datum (CD).

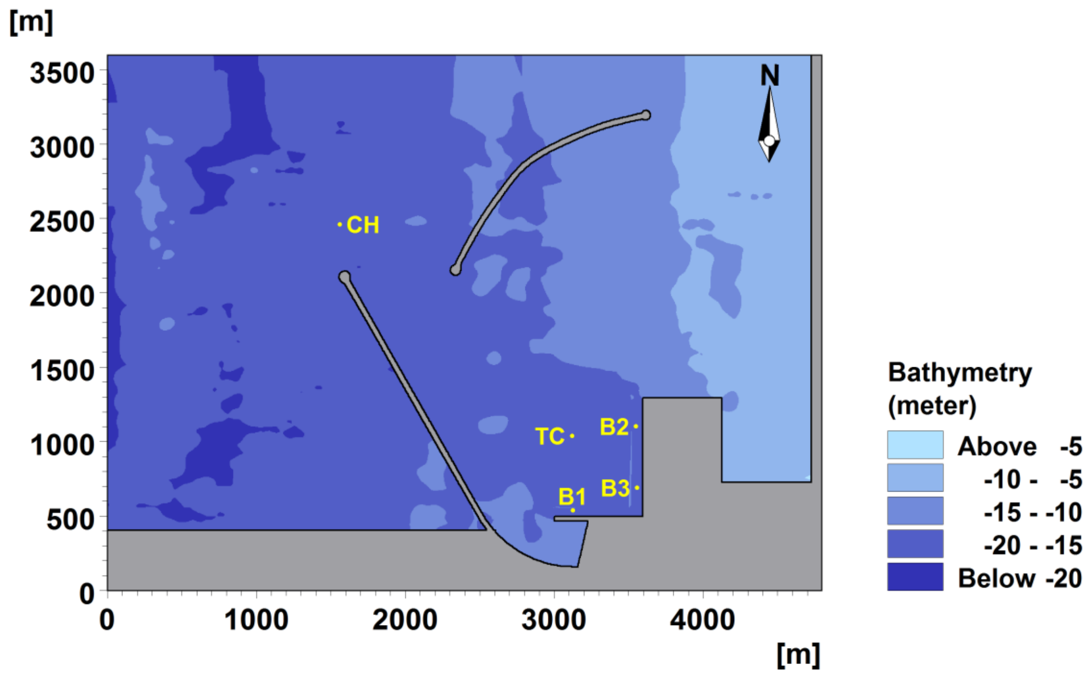


Figure 7.11 Bathymetry used for the BW

The waves in the numerical model were generated along the open boundaries and to avoid reflection on the boundaries of the model thus so-called sponge layers (layers which smoothly absorb all wave energy entering the layers) were introduced along the open boundaries of the model. Sponge layers were also introduced at the land and boundaries (**Figure 7.12**).

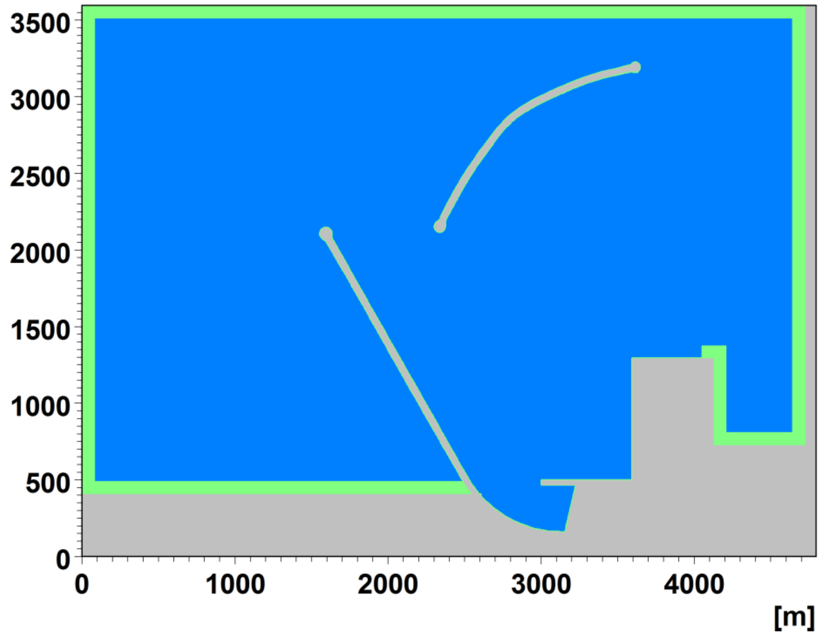


Figure 7.12 Sponge layers (in Green) along the non-reflecting boundaries

Various structural components of the port like Breakwaters, riveted banks, sheet piles, and vertical block works etc. have their own wave absorption capacity and reflectivity. In order to reproduce the structures in the model, different reflection and absorption coefficients are provided in the model as porosity layers (**Figure 7.13**). For the present study, the porosity coefficient for the breakwater has been taken as 0.5 while that for berths a value of 0.9 has been considered.

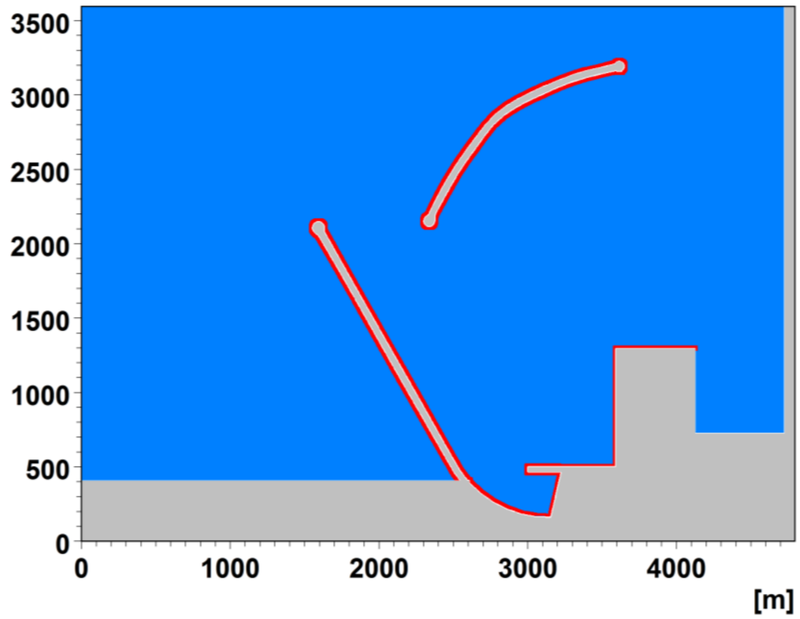


Figure 7.13 Porosity layers (in Red) along the port structures

The proposed layout provides effective protection from SW, WSW and partially from the W and WNW. Thus the partially protected directions were chosen to carry out wave agitation simulations. The input wave heights were taken as 1.0 m with peak wave period of 10 s.

7.1.4.2 Model Results

Figure 7.14 to **Figure 7.16** provides wave height that may be encountered within the harbor under the impact of 1 m waves from WNW, W and WSW directions respectively. It may be observed that the wave entering the harbour form WNW have maximum impact at the berth locations and turning circle, while W and WSW waves are attenuated at the breakwater.

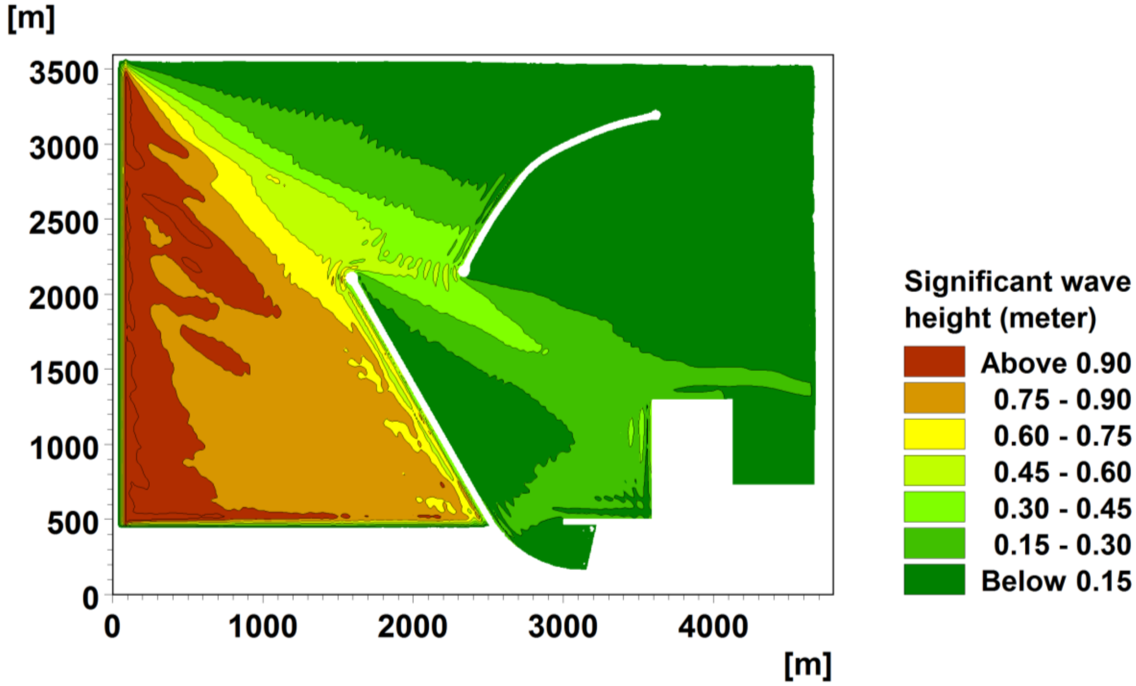


Figure 7.14 Wave Tranquililty Assessment for Waves from WNW Direction

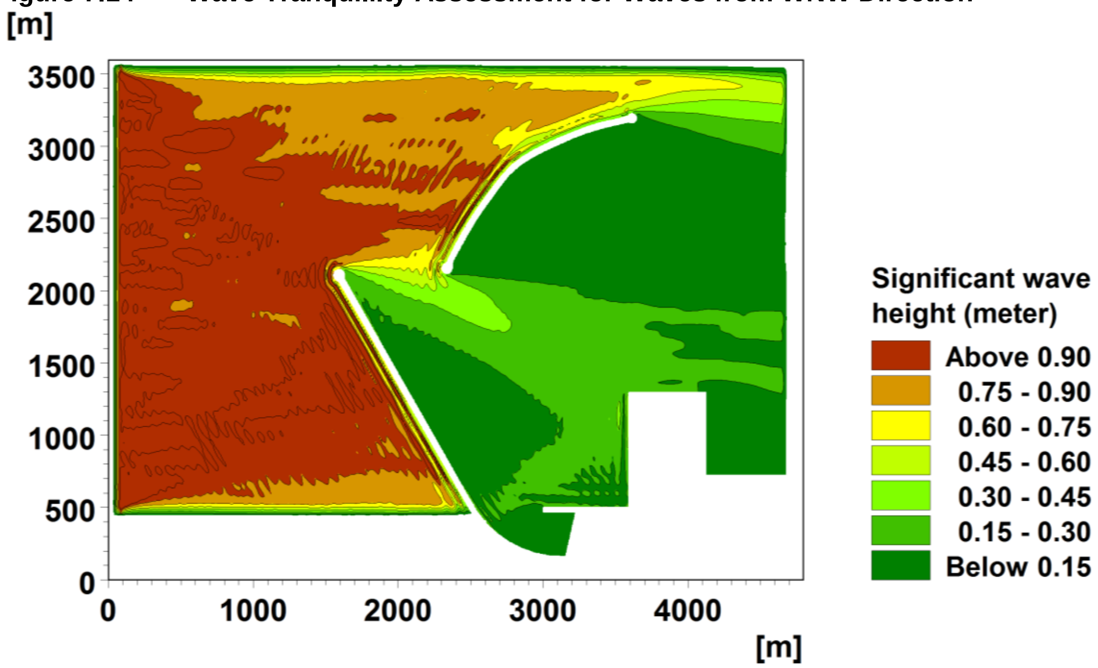


Figure 7.15 Wave Tranquililty Assessment for Waves from W Direction

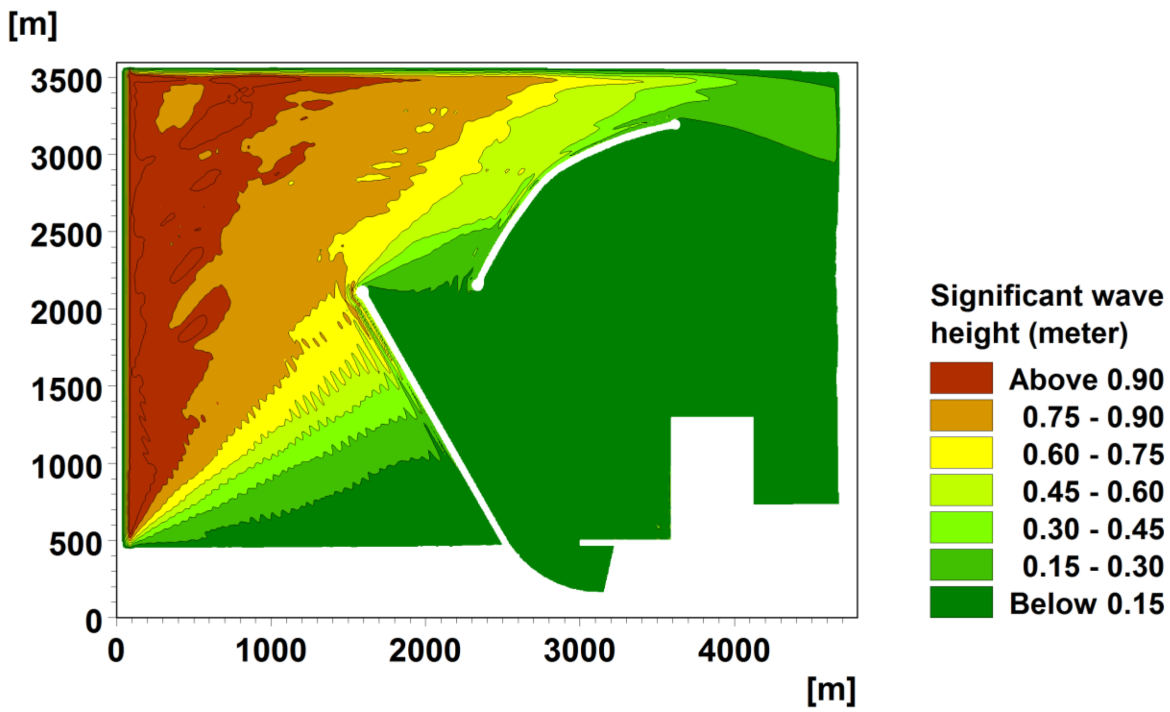


Figure 7.16 Wave Tranquililty Assessment for Waves from WSW Direction

Based on the model runs carried out for the above conditions the wave disturbance coefficients i.e., ratio of Hmo (Site)/Hmo (incoming), are calculated at the locations of proposed berths and turning circle (**Table 7.2)**.

Table 7.2 Wave Disturbance Coefficients

Location	WNW	W	WSW
Channel (CH)	0.249	0.201	0.109
Turning Circle (TC)	0.164	0.146	0.089
Berth 1 (B1)	0.147	0.126	0.075
Berth 2 (B2)	0.198	0.157	0.048
Berth 3 (B3)	0.086	0.070	0.062

Using these coefficients, a representative mean significant wave height (Hm0, mean) can be estimated by multiplication of the wave disturbance coefficient of the area with the incident significant wave height (Hm0) outside. As may be seen from the **Table 7.2** above, wave of only 0.16 m and 0.2 m reaches location B2 if incident wave of 1 m approach the port from W and WNW directions respectively.

Considering that the berths under consideration are for handling containers, the significant wave height allowed for effective handling should be less than 0.5 m. This concludes that offshore incident wave height of more than 3.0 m and 2.5 m from W and WNW respectively, are critical.

On further accessing the percentage exceedance of waves at 15 m contour (Table 2.4), it may be noted that wave height from all the direction is less than 2.5 m except W which is also contained within 3.0 m under normal conditions. Hence, the downtime at the port with proposed layout is practically nil under the normal wave conditions.

7.2 Onshore Facilities

The main consideration, in locating the facilities has been to have segregation of operation/ handling areas. The buildings catering to port users, amenities etc. are placed close to the gate. They shall be planned as a single complex because of their inter-related functions.

While arriving at the layout of approach road and the storage areas due consideration has been given to the fact that the main berthing area are located about 5 km offshore of the shore and connected by about 100 m wide approach corridor on lee of the southern breakwater.

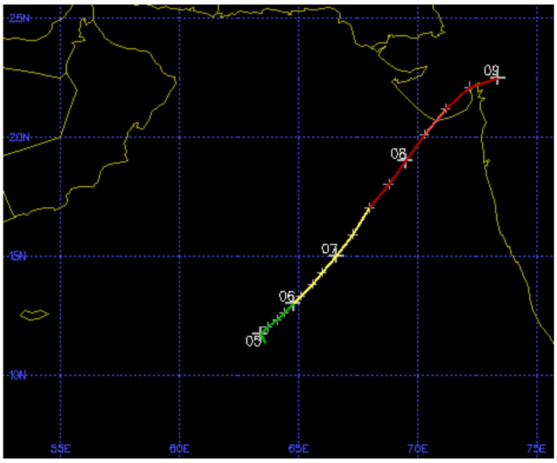
7.3 Breakwaters

7.3.1 Basic data for breakwaters design

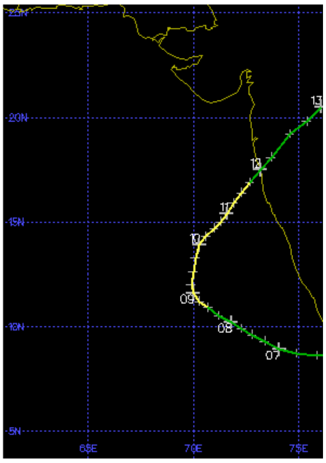
7.3.1.1 Cyclonic Storms and Extreme Wave Conditions

Cyclonic data from the IMD was collected in the form of storm tracks, and synoptic charts (pressure charts) along the tracks of the cyclones. Data for almost 33 years starting from 1978 to 2011 was analysed and 10 cyclones that passed near the proposed port location.

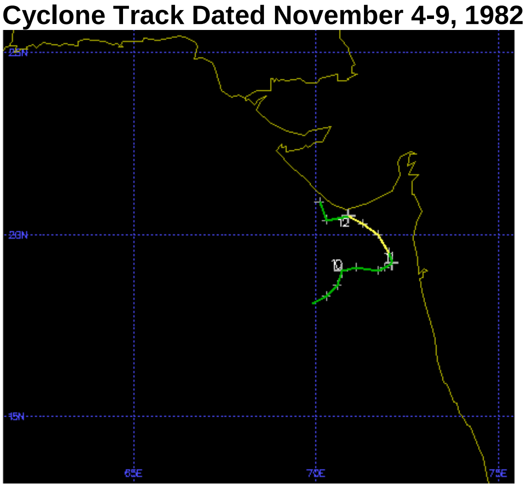
Figure 7.17 shows storm tracks used in the analysis for the some of the cyclones.



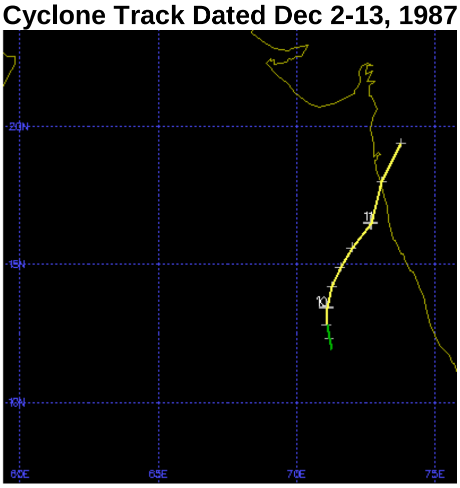
Cyclone Track Dated November 4-9, 1982



Cyclone Track Dated Dec 2-13, 1987



Cyclone Track Dated June 9-12, 2011



Cyclone Track Dated June 9-11, 2009

Figure 7.17 Cyclone tracks used for the study (Source: weather.unisys.com)

The MIKE 21 SW, model developed by DHI, was used to simulate the cyclone generated waves. The fully spectral formulation, which can simulate waves generated by complex wind fields during storms, was used for the wave hindcast study.

Figure 7.18 and **Figure 7.19** provide the wind speed and significant wave height near the port location due to the 1982 cyclone.

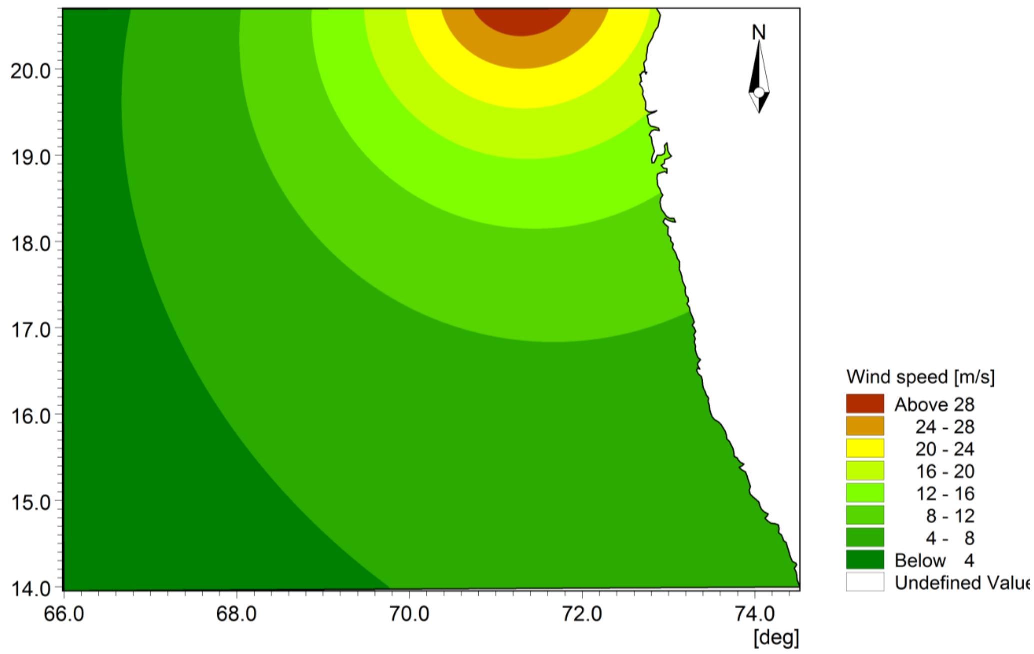


Figure 7.18 Wind Speed for cyclone of 1982

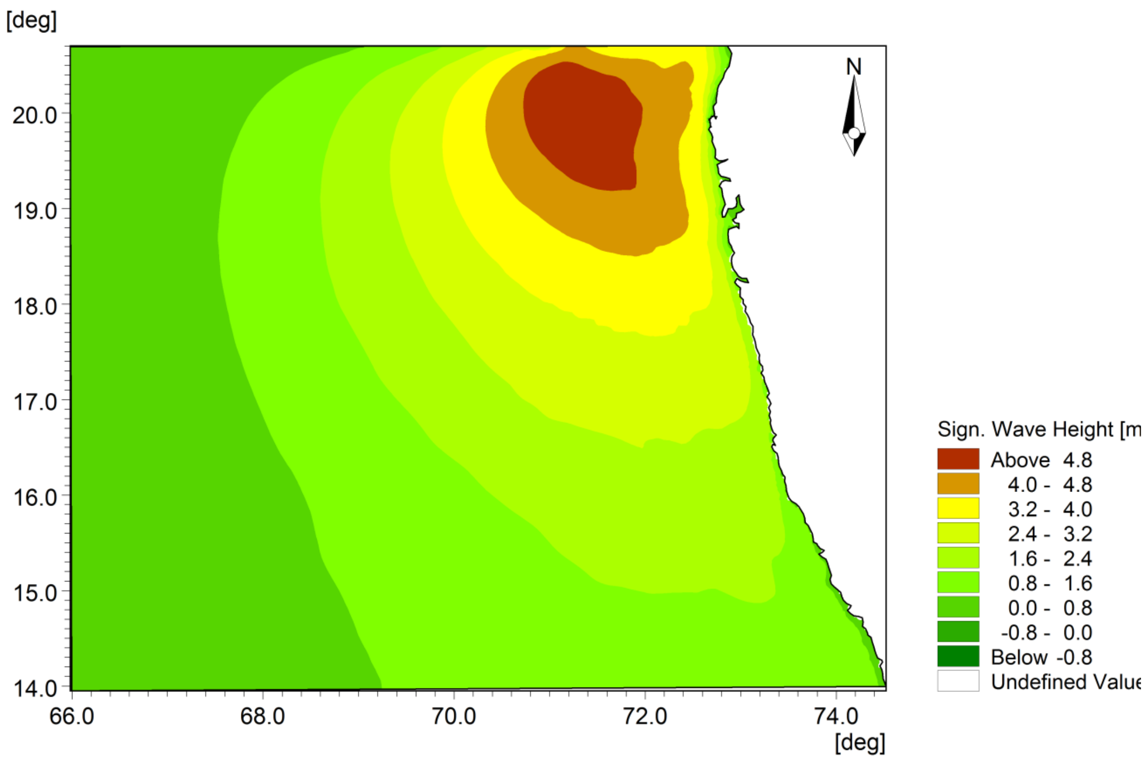


Figure 7.19 Maximum Wave height for cyclone of 1982

The outcome of the study provides the significant wave height during extreme or cyclonic events that could be expected at the project site during the cyclonic storm conditions at 5, 10, 15 and 20 m depths.

The most server cyclone during 1982 provided maximum wave height of 3.7 m at 20 m depth, which is slightly deeper than at the outer end of the probable location of the development of breakwater (**Table 7.3**).

Table 7.3 Maximum Wave height due to the selected cyclone near the proposed port location

S. No.	Cyclone Year	Significant Wave Height (m) at various water depths			
		5m	10m	15m	20 m
1	**1978**	0.55	0.57	0.61	0.76
2	**1982**	2.54	2.80	3.04	3.70
3	**1987**	0.34	0.36	0.37	0.47
4	**1985**	0.90	1.10	1.20	1.50
5	**1996**	1.42	1.58	1.70	2.00
6	**1998**	0.34	0.36	0.37	0.47
7	**1999**	1.34	1.39	1.47	1.82
8	**2001**	1.09	1.13	1.18	1.50
9	**2009**	0.31	0.33	0.37	0.42
10	**2011**	1.23	1.33	1.47	1.96

7.3.1.2 Extreme Value Analysis of Waves due to Cyclones

An extreme value analysis was done for the waves due to cyclones from the results of the simulations as tabulated in **Table 7.3**. The purpose of the analysis was to find the wave associated with various return period that is required to design the breakwaters.

The results of the EVA are provided in **Table 7.4**. It may be noted that significant wave height of 5.9, 4.6m, 4 m and 3.8 m were estimated for 5, 10, 15 and 20 m depth respectively, for 100 years return period.

Table 7.4 Cyclone waves associated with different Return Periods

Return Period	Significant Wave Height (m) at various water depths			
	5m	10m	15m	20 m
50	3.0	3.2	3.9	5.0
100	3.8	4.0	4.6	5.9
200	4.5	4.8	5.4	6.6

7.3.1.3 Design Water Levels

Since, no historic cyclones are reported to have cross the coast at this location, the effect of the surge heights are likely to be low. On the other hand, since the cyclonic paths are highly unpredictable, enough care must be taken to predict the accurate wave and surge heights. With storm surges the meteorological conditions causing the rise in water levels are sometimes but not always the same as those causing maximum wave attacks. In some cases the two conditions will be independent variables; in others they can be positively or negatively related. The combined probability of the storm causing design wave height at structure along with maximum storm surge (both arrived at after carrying out extreme value analysis on the modified storm tracks) is considered to be negligible. It is therefore proposed to use Mean High Water Springs i.e. +4.7 m CD, as the design water level for the breakwater design.

- Other Design Assumptions
- Stones upto 5.0 T are economically available with density of 2.6 T/m^3
- The minimum density of concrete armour units will be 2.4 T/m^3
- Concrete slab with a parapet will be provided at the crest of the breakwater
- The design life of the breakwater is 100 years.
- The breakwater construction will be by end-on dumping method and that there will be no restriction/ limitations of crane for laying armour units. However where ever possible construction shall by carried out by Barge dumping also.
- Both the breakwaters would be constructed simultaneously.

7.3.1.4 Design Wave Height

The extreme wave conditions at the project site are given in **Table 7.4** above. The wave heights to be considered for the breakwaters design would depend upon the extreme wave conditions for 1 in 10 years and 1 in 50 year return periods for the respective depths in which breakwaters are located from considerations of over topping and section design respectively.

Considering the extreme wave heights, their return periods, depths in which the breakwaters are located, the importance of the breakwaters (i.e. functional requirements) and the judgment for allowing the risk factor, the following design conditions are adopted for the south as well as north breakwaters:

- No damage for actual predicted wave heights as mentioned in para 7.3.1.1

  or
- Corresponding breaking wave height in that water depth, whichever is critical

7.3.1.5 Crest Width and Elevation

The primary purpose of the breakwaters at the port is to provide the required tranquillity conditions in the manoeuvring areas and berths. The required minimum crest height of the breakwater is determined by the allowable wave penetration by overtopping during extreme conditions.

The crest level has been decided based on the limiting the overtopping discharge to 50 l/s/m. The crest width is determined after allowing a 2 way roadway for the maintenance of breakwater.

7.3.1.6 Armour Units

For the armour units following options have been considered:

- Rock as armour layer
- Accropodes as Concrete Armour Units

While evaluating the above options the major factor under consideration will be the cost of breakwaters and the implementation schedule. It is expected that at the present site conditions, the placement of rock for breakwater construction, will be limited on an average to about 10,000 T/day by end on dumping method. An additional 3,000 to 5,000 T/day of rock could be placed by using the barge dumping also.

Wherever possible, rock would be utilised as armour layer. However concrete armour units would be used once the rock size increases beyond 5 T. The present base case design has been undertaken considering accropodes as armour units but during detailed engineering a decision could be taken to adopt other armour units such as Coreloc or Xblock.

7.3.2 Breakwater Cross Sections

Hudson formula is used for calculating the weight of armour unit.

$$W = \frac{e_s H^3}{K_D \left(\frac{e_s}{e_w} - 1 \right)^3 \times \cot \alpha}$$

where	W	=	weight of armour unit
	e_s	=	Mass density of armour unit
	H	=	Design Wave height
	K_D	=	Stability Coefficient
	e_w	=	Mass density of water
	cot α	=	Armour slope (H/V)

The design wave height is taken as follows:

- 1 in 100 year return period significant wave height at the corresponding location or the breaking wave height at that location, whichever is severe, when using the concrete armour units.
- $H_{1/10}$ (i.e. 1.27 times Hs) for 100 year return period at the corresponding location or the breaking wave height at that location, whichever is severe, when using rock as armour unit.

The values for K_D considered (under non breaking conditions) are as follows:

Stones (in double layer) K_D = 2.8 for head portion
K_D = 4.0 for trunk portion

Table 7.5 K_D Values for Breakwater

Breakwater Portion	K_D values for Accropodes
Trunk	15
Head	12

The typical cross sections of the breakwaters are presented in **Drawing DELD15005-DRG-10-0000-CP-VAD1011**.

7.3.3 Geotechnical Assessment of Breakwaters

The seabed level at the breakwaters increases from +2.0 m CD near shore to a maximum of –18.0 m CD. The crest level of breakwater is assumed at the maximum depth is about +9.5 m CD.

The stability of the breakwater foundation needs to be analysed for the subsoil conditions at the locations. In the present case the breakwaters are supported by basalt rock below, which is a very good bearing stratum for the breakwater structure and therefore geotechnical stable.

7.3.4 Rock Quarrying and Transportation

7.3.4.1 Location of Quarries

Existing quarry sites are located at Nagzari Village which is around 35km away from the proposed port location.

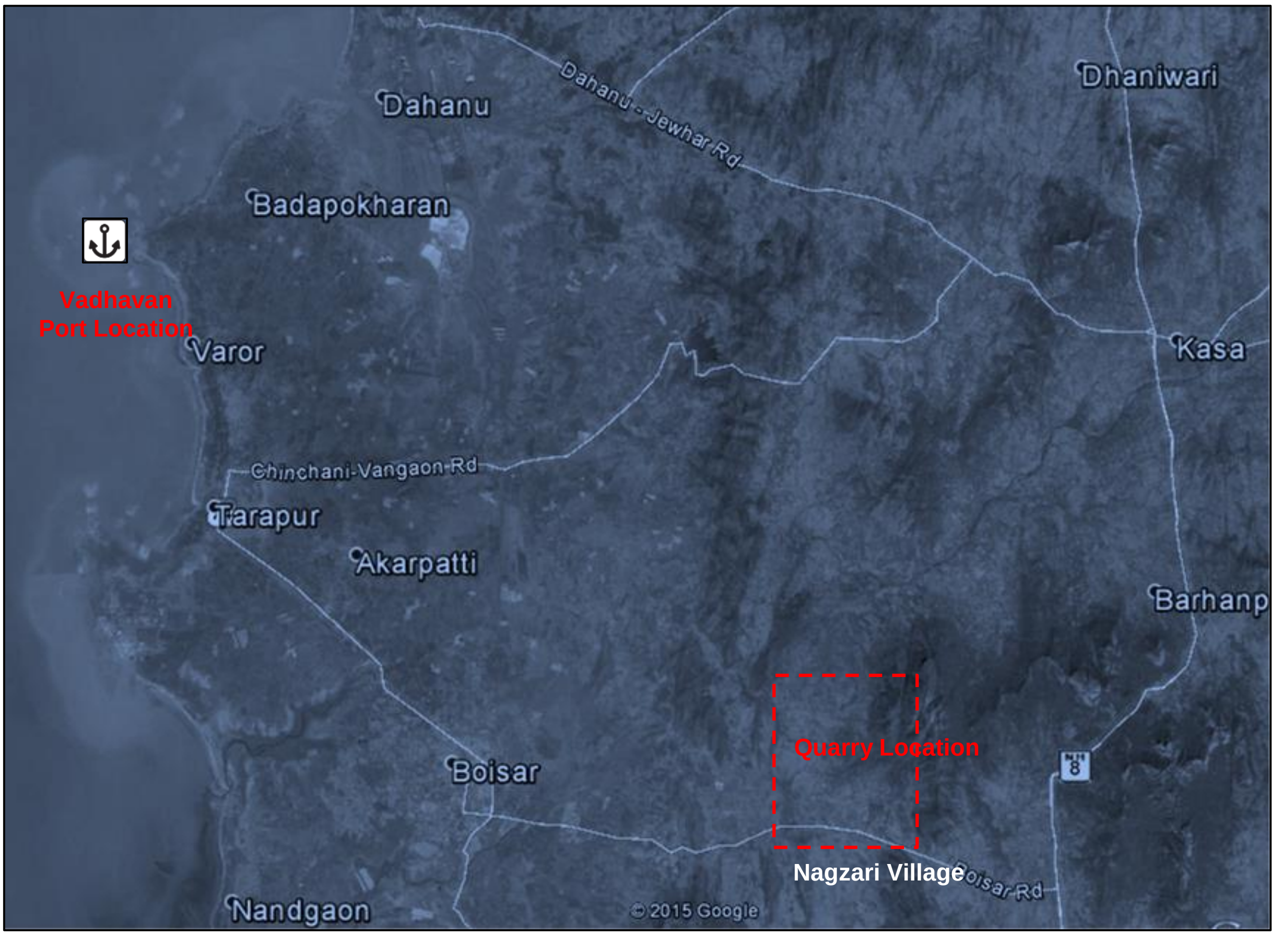


Figure 7.20 Quarry Location with respect to Vadhavan Port

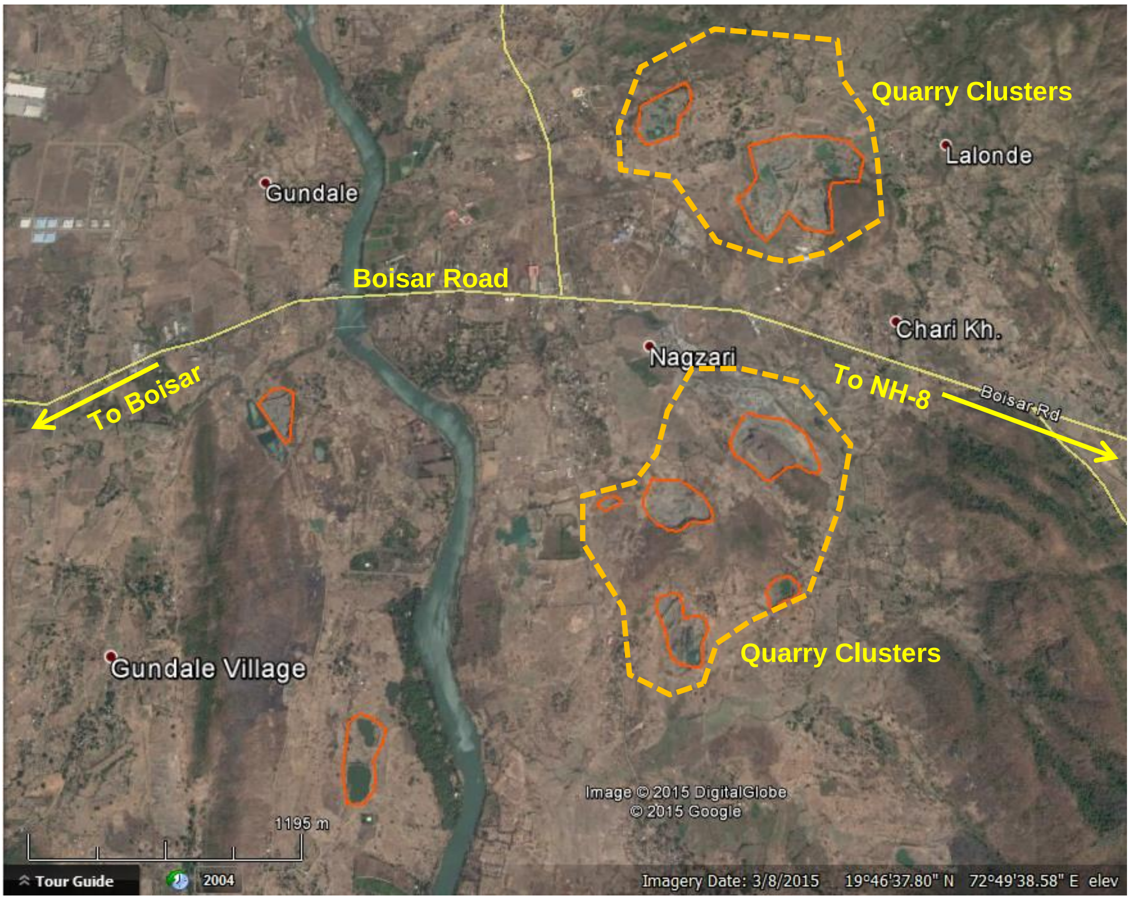


Figure 7.21 Quarry Sites in Nagzari Village

Figure 7.22 Existing Quarry site in Nagzari Village

7.3.4.2 Transport to Site

The viable option for rock quarrying and transportation which is socially acceptable, environmentally and technically feasible, and economical is transportation of rocks to the site through trucks/ dumpers.

The proposed quarry site is located at about 30-35 km from port location. The quarry material will have to be transported in through dumpers.

7.4 Berthing Facilities

7.4.1 Location and Orientation

The location and orientation of the proposed berths is shown **Drawing DELD15005-DRG-10-0000-CP-VAD1008**. Ideally the Container and Multipurpose berths should be built contiguous to the land for ease of handling operations, whereas the bulk berths could be located away and connected to shore by means of an approach trestle.

Considering the rock level at the berth locations at about the existing bed level, it is found that a steeper rock slope of about 1:1.75 would be stable and therefore it is proposed to provide contiguous multipurpose and container berths.

However, the bulk berths shall be located away from backup area to which the connection shall be by approach trestle.

7.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +8.0 m CD. This deck elevation will prevent the waves slamming the deck during cyclones. This deck level will also ensure adequate clearance to the deck during operational wave conditions.

7.4.3 Design Criteria

7.4.3.1 Design Ships

The structural design of the multipurpose berths shall be carried out for the maximum size of the ships expected to be handled at these berths at the ultimate phase. The details of design ship sizes are given in **Table 7.6** below:

Table 7.6 Characteristics of Design Ships

Commodity	Design Ship Size (DWT)
Coal	200,000
Multipurpose	80,000
Containers	18,000 TEUs

7.4.3.2 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -20.6 m CD for bulk berths, -18.3m CD for container berths and -16.1m CD for multipurpose berth.

7.4.3.3 Design Loads

- **Dead loads** comprising the self-weight of the structure plus superimposed loads of permanent nature shall be considered as per IS: 875 (Part-I) 1987.

- **Live load** on the deck slab shall be 5 T/m^2

- **Vehicle and Crane loads** as per details below
  - *Mobile Harbour Cranes LMH500 or equivalent on Multipurpose berth*
  - *Single train of IRC class AA vehicle or Loads due to mobile crane of 70 T lifting capacity*
  - *Loads due to Container Gantry cranes with rail centres at 30 m c/c on container berth*
  - *Loads due to Coal unloaders with rail centres at 20 m c/c on coal berth*

- **Seismic loads** on the structures shall be computed in accordance with the seismic code of India IS: 1893.

- **Wind loads** on the structures shall be calculated using a basic wind speed of 50 m/s as per the Indian standards. However, wind speed during the operational conditions shall be limited to 20 m/s only.

- **Current loads** on the structure shall be applied on the submerged parts of the structure considering the maximum current velocity as 1.0 m/s.

- **Wave loads** shall be computed considering maximum wave height of 4.5 m (~ 1.8*2.5m) for the design of the berths on a conservative side.

- **Mooring *loads*** shall be calculated considering 200 T bollard pull.

- **Berthing loads**
  The berthing loads have been calculated as per relevant Indian standards. Considering the tidal range at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the ship and the fender face is ensured at all tidal levels, for all possible size of ships expected to be berthed at the jetty. Based on these criteria it is proposed to use fenders with a frontal frame reaching down to the lowest water level at all the berths.

  It is observed that the berthing energy of the fully loaded 200,000 DWT ships would govern the design. Basis this selection of suitable fender has been made has been and the corresponding design reaction force has been worked out based on the standard fender design catalogues. The details are provided in **Table 7.7** below:

Table 7.7 Details of Berthing Energy, Fender and Berthing Force applied at Berths

Parameters	Value
Berthing Energy	3275 kNm
Fender	Trellborg Cell Type Fenders SCK 2500H 1.3 or equivalent
Rated Berthing Force	2983 kN

In addition a longitudinal force equal to the 25% of above transverse berthing force is also applied simultaneously on the fender point to account for the friction between the ship's hull and the fender. The parameters of the fender need to be confirmed after getting the exact details from the supplier during the detailed engineering stage.

7.4.3.4 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4) shall be applied on the different components of the berths.

7.4.3.5 Materials and Material Grades

Concrete of minimum grade M40 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

7.4.4 Proposed Structural Arrangement of Berths

7.4.4.1 Dry Bulk Berth

As the transfer of dry bulk between berths and stackyard is through conveyors, these berths do not require contiguity with land. The access to the shore for operations and maintenance is provided through an approach trestle connecting the berths to the shore.

The berth shall be provided with a conveyor system which will carry the coal from the berth and transfer to the conveyor provided over the approach trestle. **Drawing DELD15005-DWG-10-0000-CP-VAD1017** presents the cross section of dry bulk import berth and approach trestle.

The minimum width of the berth, keeping in view the rail span of the coal unloaders, service ducts and the end clearances should be about 25m. The total length of each dry bulk berth is taken as 300m.

In view of the above arrangement of berth and its location, founding strata, piled foundation is considered as best option for the structural system. The proposed structural scheme consists of four rows of vertical bored cast-in-situ RCC piles of 1.2 m diameter, spaced at 8 m c/c in the longitudinal direction. The piles will be socketed 6 m into hard rock and the expected founding levels shall be about -23 m CD to -28 m CD.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front row and the fourth row, are designed for loads due to ship unloaders. A 450 mm thick deck slab will be provided supported over the intermediate longitudinal beams.

Bollards and rubber fenders will be provided @ 24 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities. The crane rails are provided at a spacing of 20 m c/c to match the rail span of the ship unloaders. The conveyor supports are provided in the rear side of the berth at a spacing not exceeding 25 m.

7.4.4.2 Container and Multipurpose Berths

The container berths are proposed to be contiguous to the backup area. Considering the rail span of 30 m the minimum width of the container berths is taken as 41 m. The berth shall be made contiguous to the land by means of the revetment underneath the berth from dredged level till top of the backup area.

The proposed scheme consists of seven rows of vertical bored cast-in-situ piles of 1.2 m diameter, spaced at 8 m c/c in the longitudinal direction. The piles will be socketed 6 m into hard rock and the expected founding levels shall be about -23 m CD to -28 m CD.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front row and the fifth row, are designed for crane loads. A 500 mm thick deck slab will be provided supported over the intermediate longitudinal beams.

Bollards and rubber fenders will be provided @ 24 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities.

Considering the apparently excellent foundation material, alternative forms of construction based on gravity walls (caissons, blockwork) may also be considered during the detailed engineering stage.

Drawing DELD15005-DWG-10-0000-CP-VAD1014 presents the cross section of container berths.

7.5 Dredging and Disposal

7.5.1 Capital Dredging

The capital dredging for Phase 1 of the port development is estimated to be around **1.3 million cum**. Based on the information from geophysical surveys it is estimated that entire volume consists of rock dredging.

The overburden from the approach channel and harbour basin shall be dredged using the cutter suction dredger of suitable power to dredge rock upto compressive strength of 20 MPa. The remaining dredging of material shall be resorted to drill and blast technique.

The rock dredged using cutter suction dredger shall be mostly in the pulverised form and could be pumped ashore for the purpose of reclamation. The rock removed by the drill and blast technique shall either be removed by backhoe dredger or used for breakwater core or for onshore works.

7.5.2 Maintenance Dredging

Considering the rocky strata and harbour area in deeper waters the annual maintenance dredging volumes are estimated to be very low and limited to about 200,000 cum only. The better estimate shall be arrived on completion of the ongoing model studies on siltation.

7.6 Reclamation

7.6.1 Areas to be Reclaimed

Reclamation would be needed for the access corridor from mainland and stacking areas for containers and break bulk cargo. The reclamation level is proposed to be +7.5 m CD and the total quantity of reclamation fill is estimated as 30 Mcum.

7.6.2 Reclamation Process

The reclamation process comprise of creating bunds in the reclamation areas of suitable heights to receive the dredged material. Considering that most of the fill will be placed under water, the bunds will need to be formed of Rock/ boulders. Thereafter the reclamation levels within the bunds are raised in suitable stages, to prevent overloading of the underlying subsoil. Placement of the reclamation fill will be mostly Sub-aqueous i.e. in the water body, considering that the tidal levels in the area vary between (+) 0 to (+) 5 m CD. Between the elevations (+) 5 to (+) 7.5 m, the placement will be sub-aerial, i.e. in the air. The reclamation sequence should be such that there is no accumulation of silt/clay at one place. The fill material shall be placed in layers with height of each layer limited to 2 m.

As the reclamation quantity is much higher than the suitable material available from dredging, borrowed fill would be needed.

7.7 Material Handling System

7.7.1 Bulk Import System

7.7.1.1 General system description

A fully mechanized ship unloading system is planned at the coal berth. The system is designed for a rated capacity of 4,000 TPH to ensure faster turnaround of vessels at berth. The system shall be planned such that it could be upgraded later to rated capacity of 6000 TPH by way of adding additional ship unloader and increasing the speed of conveyor belt.

The major components of the mechanized bulk import system are:

- Ship unloaders
- Stacker cum Reclaimer units at stackyard
- Wagon Loading System (if needed)
- Connected Conveyor system

7.7.1.2 Ship Unloaders

The coal berth shall be provided with two numbers rail mounted gantry type Grab Unloaders of designed capacity of 2,200 TPH each. This shall enable average total unloading capacity of about 2500 TPH throughout the ship discharge operation. However, the actual unloading capacity could be lower while unloading a partly loaded panama ship due to higher proportion of bottom cargo.

The material from the grab of the ship unloaders is discharged into a central hopper integral with each unloader which is mounted on the gantry frame fitted with load cells. From the hopper a VVVF driven belt feeder shall transfer the material at an adjustable rate via a chute into the elevated jetty conveyor provided on the rear side of the rear crane rail.

Figure 7.23 Typical Ship Unloader

Unloaders on the jetty shall have adequate under clearance to allow movement of general purpose cargo handling equipment for operation / maintenance requirement.

7.7.1.3 Conveyor System

The material unloaded from the ship will need to be conveyed to the stackyard. The ship-unloading rate typically peaks during initial operation of a ship, when the cargo holds are full and conditions are favourable for “cream digging”. The conveying system will be rated for such operations and short-term surges, as anticipated. However, the required conveying capacity will reduce as the ship is progressively emptied. The designed capacity of the connected conveyor is 4400 TPH.

The conveyor galleries will be covered, for environmental protection. At road crossings, the conveyor galleries will have a clear height of at least 6 m.

7.7.1.4 Stacking and Reclaiming

It is proposed to provide two stacker-cum-reclaimer units at the stackyard. This equipment shall be used to receive coal from the ship and stacking in the yard. The same equipment shall also be utilised to reclaim the coal from stackyard for further transportation by cross-country conveyor or to Wagon loader. The Stacker cum Reclaimer units will travel on ballasted tracks and slew through the requisite angles. The rated capacity of stacker cum reclaimer is 4400 TPH.

The stacker cum reclaimer will have limit switches and controls to restrict the stockpiles to their planned boundaries. The equipment shall be used to stack coal to 15 m height.

7.7.2 Container Handling System

7.7.2.1 Ship-to-Shore handling facility (Rail Mounted Quay Cranes - RMQCs)

These are rail mounted travelling cranes on quay provided as a ship-to-shore handling facility. They will have an outreach of up to 65 m for handling 18,000 TEUs vessels. It is not envisaged to stack any containers on the quay except in emergency situations. The cranes will be provided with telescopic twin lift spreaders. Typical details of RMQCs are shown in **Figure 7.24**.

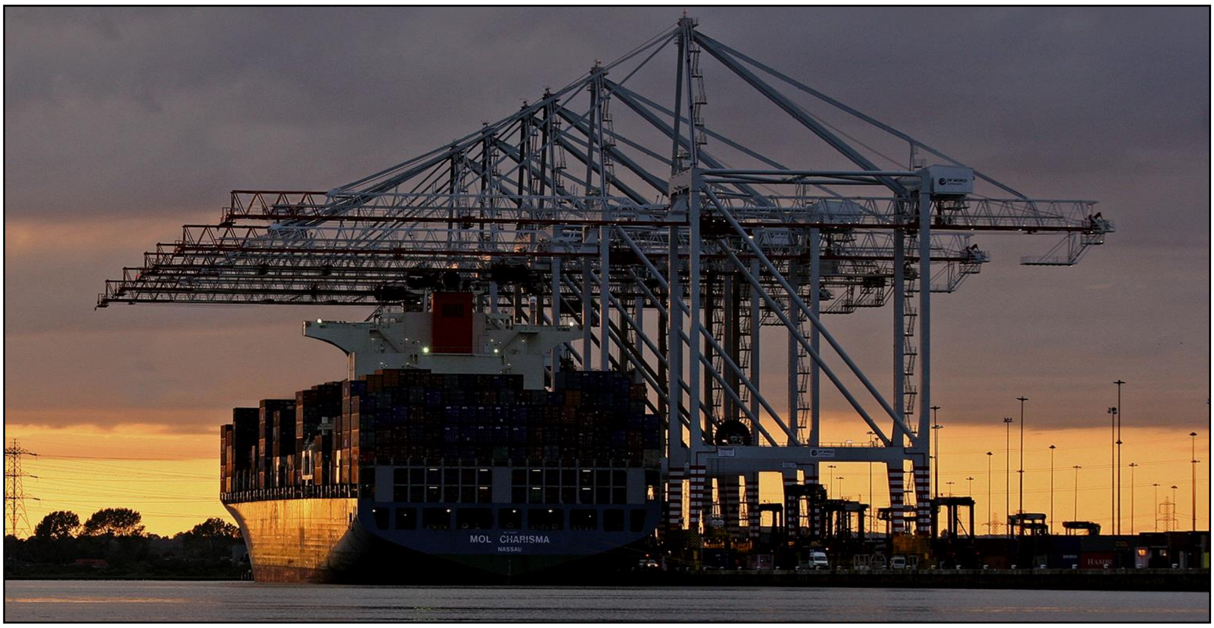


Figure 7.24 Typical RMQCs Operating at Berth

7.7.2.2 RTGs (Rubber Tired Gantry Cranes)

RTG cranes have long been the most common mode of operating worldwide in a container yard. As the name implies, these machines operate on rubber tires and can roam anywhere in the container yard. They typically run on reinforced concrete runways to minimize the rutting that can take place along the RTG travel paths.

Although, RTGs have traditionally been diesel powered, there is a major trend in the container handling industry to shift to electrically powered RTGs. RTGs can be powered from a cable reel but the most common electrical solution is an above ground bus bar power system.

Taking due care of the green nature of the proposed port, spatial provisions are provided in the planned development for E-RTGs (Electric RTGs) for container yard handling. It will run with zero emission compared to a diesel-powered RTG, a greenhouse gas emission free container yard operation and saving in energy costs on long run. Local NOX, PM, CO emissions can be reduced at greater level with use of E-RTGs**. Figure 7.25** shows an E-RTG in operation.

Figure 7.25 Typical E-RTG for Yard Operation

Figure 7.26 Typical Details of Electric Buss Bar Arrangement for E-RTG

7.7.2.3 RMGCs (Rail mounted gantry Cranes)

RMGCs are deployed at the rail yard for loading unloading the rakes. They move on a straight rail track slightly longer than the length of the rake. These equipment have cantilevers at both end through which the containers are lifted from trailers and then loaded to wagons and vice versa.

7.7.2.4 Reefer load container storage

The reefers will be stored for access via multi-level reefer racks, stacked to a maximum of five containers high. The racks will provide power and maintenance access. Reefers will be delivered and retrieved by ITVs.

Figure 7.27 Typical Details of Reefer Stacks

Reefer racks provide grounded storage for reefers. Multi-level reefer racks are provided to allow mechanics access to plug and unplug units, to check reefer machinery status, and to perform low level maintenance and repair. Refrigerated loads are plugged into power receptacles, located on the reefer racks, to maintain temperature while stored in the container yard.

7.7.2.5 Empty container handlers

Empty containers will be block-stowed in grounded rows with containers stacked up to eleven-wide by six to seven high. Empty Container Handlers (ECHs) will service these rows.

Figure 7.28 Snapshot of Typical Side-pick Handling

Containers will be transported between the quay and the empty storage areas by ITVs.

7.7.2.6 Reach stackers

Reach Stacker is the equipment used for handling containers within container yard and intermodal operation of the containers. It is able to transport containers for short distances and stack them in various rows depending on its access. In small to mid-size ports reach stackers are also used in the yard operation for stacking containers. Reach stacker has gained ground in container handling in rail yard because of its flexibility and ability to stack across rail tracks.

Figure 7.29 Snapshot of Typical Reach Stacker Handling

7.7.2.7 Internal transfer vehicles (ITVs)

These are the vehicles used for cargo movement within the terminal area from berth to storage area and storage area to rail yard or vice-versa. Generally trucks with a forty feet long trailer are used for container handling and dumper trucks are used for bulk cargo.

Figure 7.30 Typical ITV for Handling Containers

7.7.3 Break Bulk Handling System

7.7.3.1 Steel Products

Major share of steel products is likely to be steel coils each weighing about 25 T. Other steel products for export shall be in the category of rods, pipes, angles, channels, beams etc. of various sections. All such cargo shall be in bunches, duly tied and slinged. Such steel products in the storage area shall be loaded on to trailers by heavy duty Fork Lift Trucks (FLT) or Mobile Cranes of adequate capacity. At the berth MHCr shall lift the pre-slinged cargo directly from trailers with the help of cargo beam/hooks for loading on to the vessel at planned sequence.

Terminal facilities and equipment required for handling the aforesaid cargo for aggregation, transfer and loading on the vessel are:

- Open storage area/covered storage shed of adequate capacity for the purpose of cargo aggregation.
- Fleet of trailers for cargo transfer from storage area to the berth.
- Heavy Duty FLTs (35 T) and a Mobile Crane.
- MH Cranes at berth for vessel loading
- Cargo loading accessories like cargo beam, wire rope net slings of adequate capacity and size

7.7.3.2 General Cargo

General cargo shall be aggregated in covered storage shed before arrival of vessel. The terminal facilities and handling equipment required for handling general cargo are as follows:

- Dumpers / trucks for cargo transfer from shed to the jetty during vessel operation.
- Sufficient numbers of net slings of proper size and capacity to ensure cargo loading in the hatches with the help of MHCr or ship’s derrick in case of geared vessels.

7.7.3.3 Other Dry Bulk Cargo

The fully mechanized handling system for bulk import shall be provided only in the second phase once sizeable dry bulk import is anticipated. Initially the small quantities of the dry bulk cargo shall be handled at the multipurpose terminal using mobile harbour cranes. While unloading the material shall be unloaded onto the mobile hoppers through which it shall be transferred to the dumpers underneath, which shall move to the bulk stackyard for dumping the cargo in allocated stockpile.

7.8 Road Connectivity

7.8.1 External Road Connectivity

7.8.1.1 Alignment Options Study

A desk study was carried out to prepare a comparative analysis of the different possible New Alignment alternatives. In the subsequent section the different possible alternatives are discussed. To verify the alignments, AECOM carried out the site visit to find out the various options for road and rail connectivity from the port site.

In this report the various options has been proposed for the connectivity in between Vadhavan port to National Highway 8.

7.8.1.2 Methodology for Selection of Alignment

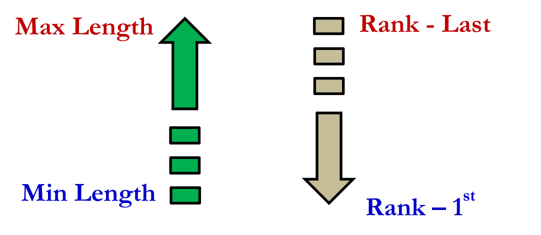
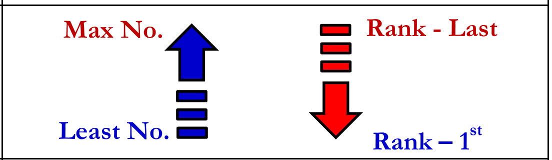
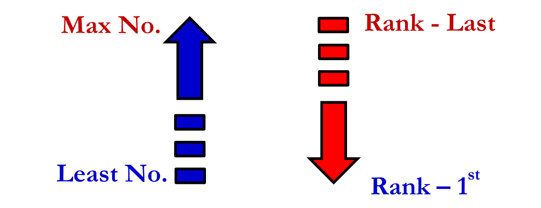
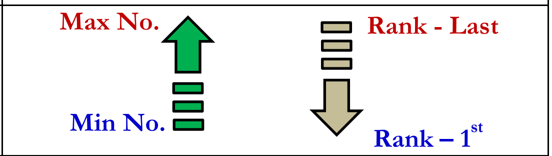
Techno-Economic Parameters
After the options are prepared, following salient techno-economic parameters were evaluated and the Options were compared against each individual parameter:

- Length of New Alignment (km)
- Horizontal Geometry
- Difference in Elevation
- No of structures
- Social Effect (Length of Built up sections affected)

Based on the comparisons of the above parameters by subjective analysis, a ranking and a weightage system is adopted to evaluate each option quantitatively.

Ranking System

Ranking system adopted for each techno-economic parameter is described in the table below:

Sl. No.	Parameter	Ranking System	
1	Length of New / Existing Alignment (km)	Option with the minimum length of New Alignment will have Rank -1 while the one with the maximum length will rank last	
2	ROB	Option having least no. of ROB will Rank-1 and one with maximum structures will rank last	
3	No. of Bridges / ROB/Flyovers	Option having least no. of Major Bridges will rank 1st while the option having maximum Major Bridges will rank last	
4	Social Effect	Lesser the no. of structures affected, better is the rank	

Weightage System

As it is difficult to judiciously weigh separately each of the above parameters, hence for evaluation purpose all were given equal weightage with individual score of 10. Hence each alignment option is evaluated on a scale of 100 (10no. of parameters x 10 points). The weight of each parameter for each option is evaluated by the following formula presented in **Equation 1**:

<u>Equation 1:</u>

$$\text{Score of Parameter}_i \text{for Option: X} = 100\text{x}\left(1 - \frac{\text{Rank of Parameter}_i \text{for Option: X} - 1}{\text{Last Rank} - 1}\right)$$

Hence from the above it is evident that for an individual parameter the option having Rank-1st will score 10, while the option with last rank will score 0. Other intermediate options will have intermediate score calculated using Eq. (1).

<u>Equation 2:</u>

$$\text{Total Score of Option: X} = \sum_{i=1}^{i=100} \text{Score of Parameter}_i \text{ for Option: X}$$

The total score of each option is then estimated by summation of score of all the parameters following Eq. (2). above. The option having maximum score will Rank-1st and is recommended to be adopted for further study.

7.8.1.3 Alignment options

During the study, it is observed that there exist few existing roads which can provide the connectivity in between port and national Highways. The details of existing routes are as following

- Dahanu – Jewhar Roads (SH 30)
- Chinchini – Vangaon Road
- Tarapur – Boisar Road SH 74
- State Highway 34

AECOM team travelled on these roads and the existing conditions are given in the following photographs:

Photographs on State Highway 34

It originates from SH 30 (Ashagarh Junction) and traverse to northwest before meeting with NH 8.






Photographs on Dahanu – Jewhar Road

Photographs on Tarapur - Boisar Road

Photographs on Chinchini – Vangaon Road

Road from Vangaon Road connecting SH 30

After having the site visit, we understand that it will not be advisable to follow one route for the connectivity. In case of following one existing road will attract R&R issues. AECOM has proposed the following alternative routes. The merits and demerits for all the possible alignments have been discussed hereunder and route prefeasibility is given below:

- **Alternative 1:** A1- A2- A3 - A4 - A5 - A6: **Length: 36.5 km (Existing Length 24.5 km and Greenfield Alignment 12 km)**
- **Alternative 2:** B1- B2- B3 - B4 - B5 - B6 – B7: **Length 46.5 km (Existing Length 38.5 km and Greenfield Alignment 7.5 km)**
- **Alternative 3:** C1- C2- C3 - C4 - C5 : **Length: 36 km (Existing Length 24 km and Greenfield Alignment 12 km)**
- **Alternative 4:** D1- D2- D3 - D4 - D5 – D6 : **Length:38 km (Entire Greenfield)**
- **Alternative 5:** E1- E2- E3 - E4: **Length:35 km (Entire Green field)**

Alternative 1:

It takes off from NH 8 (near Dhundalwadi) and follows SH 74 and meets with SH 30 at Ashagad Junction for a length of 17 km and follow SH 30 for a length of about 1.5km. Then it takes southward direction and follows Dahanu Vangaon Road for a length of about 6.0km where it takes western turn and follows the Greenfield Alignment to reach the Port. It will pass through Badapokhran and Gung Wada before reaching port. The length of the Greenfield Alignment is 12.0km. It will have 6 major bridges. Out of which 2 bridges will need rehabilitation and 4 will be new. It will also have one new ROB over the Boisar – Vangaon track. It is also proposed to have 1.5 km of flyover over SH 30.

Alternative 2:

It takes off from NH 8 (Near Dhundalwadi) and follows SH 74 and meets with SH 30 at Asha gad Junction for a length of 17 km and follow SH 30 for a length of about 1.5km. Then it takes South ward direction and follows Dahanu Vangaon Road for a length of about 12.5km. After that it has to move towards west through via Chinchini- Vangaon Road for a length of 8.1 km. After that it is proposed to have a Green field alignment of about 7.5 km. It will have nine major bridges. Out of this 5 will be required widening and rest will be new. It will also have I ROB (widening) over the Boisar – Vangaon railway track. It is also proposed to have 1.5 km of flyover over SH 30.

Alternative 3:

It takes off from NH 8 (Kasa Junction) and follows SH 30 for a length of 18 km. Then it takes South ward direction and follows Dahanu Vangaon Road for a length of about 6.0km.Then it takes Western turn and follows the Greenfield Alignment to reach Port. It will pass through Badapokhran and Gung Wada before reaching port. The length of the Green field Alignment is 12.0 km. It will have 6 major bridges. Out of which 2 bridges will need rehabilitation and 4 will be new. It will also have 1 new ROB over the Boisar – Vangaon track. It is also proposed to have 1.5 km of flyover over SH 30.

Alternative 4:

This alignment is proposed to be entirely Greenfield alignment and will run almost parallel with Tarapur-Boisar Road. This proposed road will take off from near the existing junction of NH 8 and Boisar Road. It will run almost parallel for about 20 km before crossing the Boisar Road. It will have another crossing with the existing road after traversing about 3 km. Further it move towards North for about 5km and moved further Northwest direction for about 5 km to reach the proposed port location. It is proposed to have 5 major bridges, 2 flyovers on Boisar Road and one ROB.

Alternative 5:

This alignment is proposed to be entirely Greenfield alignment. This proposed road will take off from near the existing Kasa junction of NH 8. It will have about 5 km of viaduct portion. Viaduct will take off after the alignment cross Dahanu – Vangaon Road before Railway line. The viaduct will also include the ROB in this section. Apart from significant higher cost this alternative will have also have environmental and LA issues.

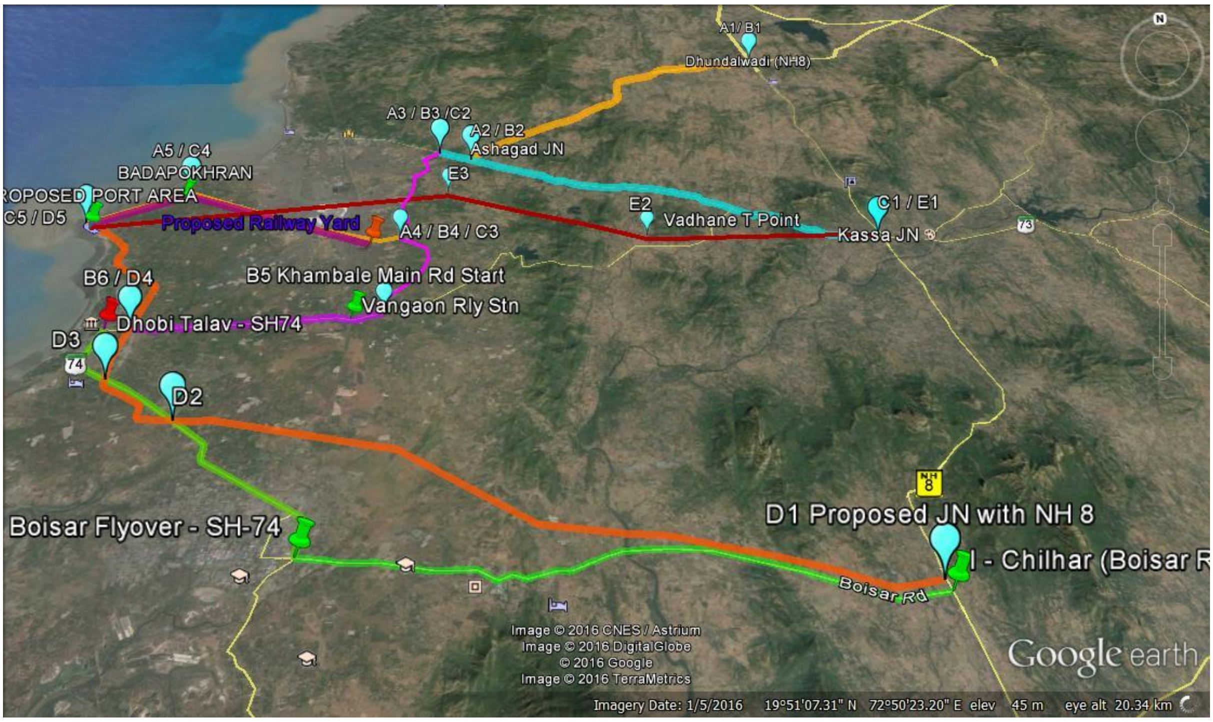


Figure 7.31 **Road Alignment Options**

7.8.1.4 AECOM's proposal for road connectivity

From the decision matrix it is observed that alignment in **Alternative 3** is the most preferred alignment considering both technical and financial aspects.

In future, if warrants, two separate connectivity from Northern and Southern side of the port may be considered to connect NH 8. Alternative 3 will satisfy the requirement for the connectivity from NH 8 while alternative alignment 4 will satisfy the connectivity from the Southern side of the port.

7.8.2 Internal roads

The main approach road to the port shall be located parallel to the rear of the backup area. The road leading to container terminal shall widen out near the terminal gates where security checks will be undertaken and to provide queuing space for trucks. Within the terminals internal roads shall be planned based on the cargo handling and storage plans with 1 way circulations to avoid any criss crossings.

Table 7.8 Alternative Alignment Options Analysis

WADHAVAN PORT ROAD CONNECTIVITY WITH NH 8 - ALIGNMENT OPTIONS																					
Alignment	Length, Km	Relative Marking	Existing Road length (km)	Relative Marking	New Road length /Greenfield Length	Relative Marking	At Grade / Interchanges	Relative Marking	ROB	Relative Marking	New Major Bridges	Relative Marking	Widening of existing bridge	Relative Marking	Flyover	Relative Marking	Elevated Corridor length (km)	Relative Marking	Block Cost	Relative Marking	**Total Markings**	**Rank**
Alternative 1: A1- A2- A3 - A4 - A5 - A6	36.5	96	24.5	98	12	63	1	100	1	100	4	50	2	90	1	60	0	100	₹ 7,71,00,00,000	62	719	III
Alternative 2: B1- B2- B3 - B4 - B5 - B6 – B7	46.5	75	38.5	85	7.5	100	1	100	1	100	4	50	5	70	1	50	0	100	₹ 9,05,12,50,000	53	683	V
Alternative 3: C1- C2- C3 - C4 - C5	36.0	97	24	96	12	63	1	100	1	100	4	50	2	90	0	100	0	100	₹ 4,80,25,00,000	100	796	I
Alternative 4: D1- D2- D3 - D4 - D5 – D6	38	92	0	100	38	20	1	100	1	100	5	40	0	100	2	40	0	100	₹ 4,82,50,00,000	100	691	IV
Alternative 5: E1- E2- E3 – E4	35	100	0	100	38	20	1	100	1	100	2	100	0	100	0	100	5	0	₹ 6,87,50,00,000	70	790	II

7.9 Rail Connectivity

7.9.1 External Rail Connectivity

In the project vicinity, there exist three stations namely Dahanu, Boisar and Vangaon. The railway line for the Vadhavan port shall take off from near the Vangaon station. The proposed alignment will run almost parallel to the road connectivity as shown in **Figure 7.31**.

7.9.2 Internal Rail Links

The internal rail lines will be developed to the various cargo terminals. It shall be ensured that their location does not obstruct the movement of port vehicles. For containers the rail sidings shall be taken till the rear of the container yard. At the bulk import yard two rail sidings shall be provided including one engine escape line. The exchange yard is proposed in the reclamation area just before the entry gate to the container terminal.

7.10 Port Infrastructure

7.10.1 Electrical Distribution System

7.10.1.1 Introduction

The handling systems for containers are power intensive and hence require considerable high tension electrical power for their operation. The terminal development will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

Similarly the mechanised coal unloading, conveying and stock piling system would also need considerable electrical power. This apart the illumination of the terminal areas, stacking areas, storage sheds, roads and auxiliary services viz., dust suppression system, firefighting system and port buildings would all require considerable HT and LT power.

7.10.1.2 Estimation of Electrical Load

Based on the proposed port facilities the total installed power load for the proposed Phase 1 development are estimated to be around 13 MVA. This is expected to go up to 81 MVA over the proposed master plan horizon.

7.10.1.3 Source of Power Supply

Power supply to Vadhavan can be brought through transmission lines from Boiser, located about 20 Km from the port site. Alternatively the power supply from Dahanu power plant can also be explored during detailed engineering stage.

7.10.1.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the port boundary, where the main receiving substation shall be located. This outdoor switch yard will have two numbers of 33 KV transformers with 15 MVA rating and convert the power at the secondary voltage of 11 KV. Of the two transformers, one will be main and the second will be a stand by and each transformer is designed is to cater to 100% of the maximum demand of the port.

7.10.1.5 Distribution of Power

11 KV feeders from main receiving substation will feed to two secondary substations; one for breakbulk terminal and other for container terminal. The distribution of power in the respective terminals shall be through these secondary substations.

Both the substations will be equipped with 11KV /0.415 KV transformer of suitable capacity to cater to LT loads of different buildings for illuminations, area lighting, street/road lighting, firefighting, water supply system, etc.

7.10.1.6 Standby Power Supply

It is proposed to install one diesel generator of 2 MVA in container handling substation. This would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

7.10.1.7 Illumination

The illumination level in various areas will be maintained as per the industry standards and shall generally be as in **Table 7.5** below:

Table 7.5 Illumination Level

Area	Lux Level
Gate houses, Buildings	50
Transfer House	150
Substation, pump houses and fire houses	250
Workshops	200-300
External illumination (Road Lightings), Parking	15-20
Stock pile areas and open storage areas	20-30
Berths	50
Conveyor galleries	50

For transfer house, high-pressure sodium vapour fixtures (SON) will be provided. For illumination of street, road, and conveyor galleries poles of suitable height with HPSV fittings will be installed. Power supply will be made available from suitably located feeder pillars. For illumination of roads 9 metre high steel tubular type pole with 250 W HPSV street light fixtures shall be provided. For stackyard area high mast (30 m) and for berth area high mast (40 m) with HPSV (SON) will be installed.

7.10.1.8 Cables

To meet the HT load requirement 11 KV XLPE aluminium armoured cables will be used. Cables will be laid on cable trays, ducts, directly buried in ground and in trenches, etc. as per site requirement.

LT power distribution to various services such as illumination, firefighting, air conditioning water supply etc. will be done through 1.1 kV grade PVC insulated aluminium armoured power cables. Laying of cables will be done as per site requirement.

Internal wiring to be done in recessed UPVC conduit or on surface with GI conduit and single core PVC insulated FRLS copper wire to be done in case of transfer towers, conveyors, workshops, substations, pump house, fire house, etc.

7.10.1.9 Earthing & Lighting Protection

Suitable lightning protection system will be installed as per the guide lines of the IS: 2309. An efficient earthing and lightning protection system will be designed to ensure protection of men & material in worst of the weather conditions.

7.10.1.10 Power Factor Improvement

Suitable rating HT capacitors with automatic power factor correction arrangement will be installed to maintain the overall power factor correction to 0.95.

7.10.2 Communication System

7.10.2.1 General

The Communication system comprising Radio Communication units, Telephone System and PA system of suitable capacities will be provided to suit the port operation requirement.

7.10.2.2 Telephone System

To meet the total port requirements, an EPABX of 200 lines capacity will be installed. Suitable telephone instruments to suit the site requirement with adequate protection will be provided.

7.10.2.3 Radio Communication

A radio communication system will be installed for transfer of information between various operational areas of port like mobile harbour cranes, shore side duties, control room, terminal engineering services, operational management, supervision etc.

7.10.2.4 Public Address System

The public address system will supplement the above two systems. The central control for the system will be kept with the control room located at top floor of the administrative building.

Distribution type public address system will provide a comprehensive paging system for oral communication and announcement by loud speakers and handset stations with built-in amplifiers covering all working areas of the port terminal. The loud speakers will be mounted on purpose built supports provided on permanent structures. The exterior speakers will be weather proof. One number master control station with microphone to zone selection and all call facility will also be provided at control room.

7.10.3 Computerized Information System

7.10.3.1 Overall Objectives

The computerised information system proposed for Vadhavan Port will have the following objectives:

- Establish one common IT infrastructure that is based on large scale operations in order to deliver services of high quality.
- Enable centralized control of the Infrastructure to ensure effective management and security.
- Ensure mobility of users located at different office premises by providing the necessary services to ensure connectivity from anywhere.
- Utilize best practices for technology selection and implementation.

7.10.3.2 Terminal Operating System

Terminal handling equipment will have control systems to maintain and manage bulk terminal operations. These control systems will be interfaced with BI systems for reporting and MIS. Terminal Operating systems will be deployed for handling the following processes:

- Berth Planning
- Terminal Planning, Monitoring and Execution processes
- Stowage planning
- Operations Equipment Control (OEC)
- Cargo Control (CC)
- Yard Planning, gate delivery and receipt control
- Landside planning processes
- Enterprise Resource Planning

7.10.3.3 Technology Infrastructure

The IT Infrastructure of Vadhavan Port like hardware, software, network etc. will be implemented according to a long-term strategic plan. The capacity plan includes the necessary infrastructure for the IT strategy development as well as to support the general day-to-day IT requirements (anticipated capacity growth etc.)

7.10.4 Water Supply

7.10.4.1 Water Demand

The water demand for the Vadhavan Port has been worked out in the **Table 7.9** below:

Table 7.9 Estimated Water Demand at Vadhavan Port

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	97	1,193
2.	Potable Water (KLD)	56	417
Total Water Demand at Port (KLD)		**153**	**1671**

7.10.4.2 Sources of Water Supply

The water requirement for the Vadhavan shall be sourced from the will be sourced from the Sakhare Dam located about 15 km from the port. Alternatively the option of providing dedicated desalination plant could also be examined at the detailed engineering stage.

7.10.4.3 Storage of Water

The water supply from the main header shall be fed to the underground water tank of 500 cum located at the port boundary which is equivalent to two days consumption. Water from this tank shall be treated in the water treatment plant, consisting of chlorination, filtration and softening units (depends on the water quality test). Potable water shall be stored in the underground domestic water tank of 100 cum capacity for potable use. For this purpose a small filtration plant is provided at this place. This treated water will be stored in a sump adjoining the main sump for the raw water. The water treatment plant must ensure that it produces water of acceptable quality as per the provisions of IS 10500: 1991.

The water from the main sump would be pumped to secondary sumps of 300 cum capacity each located near the multipurpose terminal and container terminal. The secondary sump at multipurpose terminal shall be split into three compartments of 100 cum, 100 cum and 100 cum. The compartment of 100 cum will retain water permanently for firefighting; the compartment of 100 cum will be used for water supply to buildings and greenery. The third compartment of 100 cum will provide water for dust suppression system in the bulk import terminal. The secondary sump for the container terminal shall be split into two compartments i.e. one to retain water permanently for firefighting and other for water supply to buildings and greenery.

7.10.5 Drainage and Sewerage System

7.10.5.1 Drainage System

Storm Water Drainage at the port will be through a system of underground covered drains provided to discharge the collected runoff. At the bulk import stackyard, the drainage system would comprise of open drains for taking the discharge to the settling pond. Before discharging the collected storm water into the main drainage system of the port it would be passed through the necessary filters for further reduction of PPM.

Surface drainage system shall be provided in the container yard through which water shall be diverted to the secondary covered drains, which shall ultimately discharge to the main drain.

7.10.5.2 Solid Waste Management

For the buildings complex having administration building and port user buildings, a small sewage treatment plant of 18 KLD capacity is proposed. The treated sewage shall be discharged to the main drainage network. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

For the isolated buildings where the quantity is negligible, it is proposed to construct septic tanks and connect the septic tank outlets to soak pits for disposal.

There will be very little sewage water generated at the quay walls and hence separate treatment proposals are not contemplated.

7.10.6 Floating Crafts for Marine Operations

7.10.6.1 Tugs

For berthing / un-berthing of the design coal carriers a minimum of four harbour tugs of 50 T bollard pull capacity are required initially. In addition one tug for standby/ emergency shall be provided. One of the tugs shall be equipped with firefighting facilities.

7.10.6.2 Pilot cum Security Vessels

These vessels are required for the pilots to travel to and fro between the port and boarding point, where the port's pilot will embark/disembark the ship. It is proposed to provide two pilot vessels including one standby vessel.

7.10.6.3 Mooring Boats

These boats will be required to carry the lines from the ships and pass it to the required points during berthing and un-berthing operations. Two boats are required per vessel for berthing and un-berthing operations. Considering the frequency of the ships, two mooring boats are considered adequate for Phase 1.

7.10.6.4 Harbour Crafts

The requirements of Harbour Crafts for the first phase of the Vadhavan Port development are given in **Table 7.10** below.

Table 7.10 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 50 T bollard pull	5
2.	Pilot cum Security Vessels	2
3.	Mooring Boats	2

7.10.7 Navigational Aids

7.10.7.1 General

It is envisaged that navigation will be carried out throughout the year, by day and night, except during cyclonic weather, when rough seas, high wind speeds, and negative storm surge may result in low/inadequate draft. Navigation aids are required for ensuring safe navigation of ships entering and leaving the port through the approach channel as well as berthing / un-berthing requirements inside the docks. These aids are such as fairway buoys, port and starboard buoys, leading / transit lights, beacons and Vessel Traffic Management Information System (VTMIS) etc., which are installed on land or in water for guidance to all vessels for safe and regulated navigation in channels, anchorages, berths and docks. VTMIS will have the requisite communication, Radar system integrated into it.

7.10.7.2 Buoys

The approach channel is short but for the safe navigation and pilotage it is necessary to mark the channel with suitable number of navigational buoys by following the IALA zone ‘A’ code. Considering the need to provide adequate assistance for safe navigation of the ships, it is recommended to provide paired buoys at a spacing of 1 Nautical miles. In addition some buoys are proposed in the respective harbour basins as well. IALA maritime buoyage system as per region A, in which Vadhavan Port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

7.10.7.3 Leading / Transit lights

Considering the channel being straight and very short and being adequately marked with navigational buoys, it is not proposed to install any leading / transit lights to guide the ships through the channel.

7.10.7.4 Beacons / Mole lights

One Beacon at each breakwater head would be provided.

7.10.7.5 Vessel Traffic Management System (VTMS)

The purpose of the VTMS is to provide a clear and concise real time portrayal of vessel movements and interaction in the Vessel Traffic Service (VTS) area. In Vadhavan Port case, the service area will be the approach channel, the anchorage area, the harbour basin etc. This system will be used for marine operations and will also be linked to the PMIS (Port Management and Information System). The information provided by VTMS system allows the operator or user of the system to:

- Provide the required level of VTS: Information, Assistance or Organisation
- Enhance safety of life and property
- Reduce risks associated with marine operations
- Enhance efficiency of vessel movements and port marine resources
- Distribute VTS related information
- Provide Search and rescue assistance
- Provide VTS data for administrative purposes, analysis of incidents and planning

The VTS in recent years has changed from Traffic Monitoring to Traffic Planning by introduction and interconnection of databases and expert systems. It allows access of static and dynamic information about ships, their cargo and port service requirements. Together with an automatic update of traffic information the VTMS provides a powerful tool for programming of traffic movement within the surveillance area. Operators can associate tracked targets with vessels registered in the database, which makes the data readily available and allows the system to automatically provide pertinent voyage information to other port service providers.

7.10.8 Security System Complying with ISPS

Security system of the port is required to provide sufficient protection against:

- Sabotage
- pilferage and thefts
- encroachments by unauthorised persons
- trespassers and antisocial elements

The security system must comply with the requirements of ISPS Code.

Keeping in view the importance of various areas in the port, the following proposals are made:

- The custom bound area will be provided with a rubble masonry wall 2.4 m high with barbed wire fencing of 1 m high over the wall.
- A security office and check post at the entrance to the terminals.
- Provision of watch towers at suitable intervals for manual monitoring with night vision binoculars for use during nights.
- Adequate isolated area would be allocated for storage of dangerous goods
- The lighting in the port area shall be to the acceptable standards
- Close circuit Television system (CCTV) to capture activities at all vantage, vulnerable and sensitive locations.

The security arrangements proposed would have to be to the approval of the Director General of Shipping who is the designated authority under the ISPS code.

7.10.9 Firefighting System

7.10.9.1 General

The firefighting system shall be designed to be capable of both controlling and extinguishing fires. The firefighting system for berths and terminal areas will be a fresh water system with a separate pump house with pumps which will draw water from the respective fresh water tanks.

A centralised fire station will be provided for attending to all calls which will house two mobile fire tenders. One fire tender will be provided with snorkel attachment. Alarm system should cover all buildings and have central monitoring/control as well as local.

7.10.9.2 Dry bulk berths and stackyard

It is proposed to install Fire Hydrant System, which shall be designed to give adequate fire protection for the facility based on Indian Standard or equivalent and shall conform to the provisions of the Tariff Advisory Committee's fire protection Manual.

Fire hydrant system is proposed at the following areas, which are classified as ordinary hazard areas.

- Berths
- Stackyards
- Wagon Loading Station
- All galleries of Coal Conveyors

The fire hydrant system shall be designed to ensure that adequate quantity of water is available at all times, at all areas of the facility where a potential fire hazard exists. Each hydrant connection shall be provided with suitable length of hoses and nozzles to permit effective operation.

7.10.9.3 Container and multipurpose terminal

The firefighting system shall be designed to give suitable fire protection for the containerised/breakbulk cargo and container handling facilities in the terminal and shall conform to the provision of Tariff Advisory Committee’s fire protection manual. The firefighting system shall be a combination of water hydrants, fire alarm system and fire extinguishers.

7.10.10 Pollution Control

7.10.10.1 General

One of the essential regulatory functions of a Port Authority is to ensure that the port waters are free from pollution. To this end, pollution control assumes a significant role in any port operations. The main sources of pollution during operations in the port are:

- Discharge of oil by ships / crafts.
- Discharge of bilge by ships / crafts.
- Discharge of dirty / contaminated ballast by ships.
- Discharge of cargo overboard.
- Spillage of cargo during unloading / loading operations.
- Discharge of garbage, sweepings, sewage, etc.
- Discharge of industrial effluents.
- Municipal sewage and drainage.
- Dust from cargo.
- Smoke from ships, vehicles.
- Noise from vehicles, machinery.
- Accidents

7.10.10.2 Dust suppression

Dust control equipment is proposed for efficient control of dust pollution to the environment during storage and handling of coking coal / thermal coal at the berth and stackyard. An efficient dust suppression system will contain dust particles before it becomes airborne.

A system consisting of pumps, storage tank, nozzles for dust suppression at discharge / feeding points of belt conveyors have been proposed at each transfer tower for efficient dust control. In addition to above suitable spray system shall also be provided at ship unloader, coal stackyard and wagon loading station.

Each unit of the proposed dust control system shall consist of plain water tank to store the plain water, chemical tank for chemical storage, plain water pump, metering pump sprinklers & nozzles and piping network. Both the tanks shall be provided with low level and high level switches for control and safety of the pumps. This makes the pump fully automatic and does not require manual monitoring.

The water pumping system shall be designed to operate only when it is required thus saving energy. The spray in dust generation area shall operate only when material is being handled in that location.

8.0 Environmental Settings and Impact Evaluation

8.1 Introduction

This section presents environmental conditions in and around the proposed port location at Vadhavan. It briefly describes general environmental conditions of the project area, i.e., physical environment, flora and fauna; identifies environmental issue that may arise due to the considered project and its components, suggests mitigation measures to minimise adverse impacts. This section also details environmental policies and legislation to highlight the permissions and clearances required for the project.

The section is largely based on the review of literature, available secondary data and information gathered during the site visits.

8.2 General

Vadhavan is located in Dahanu taluka of Palgarh district in the state of Maharashtra. Vadhavan is a coastal village and as Census of India 2011 it has total population of 1278 from 296 households. Equal population of 639 has been reported for both males and females. The literacy rate is more than 83.4% where 87% of males and 80% of females are literate among their respective populations.

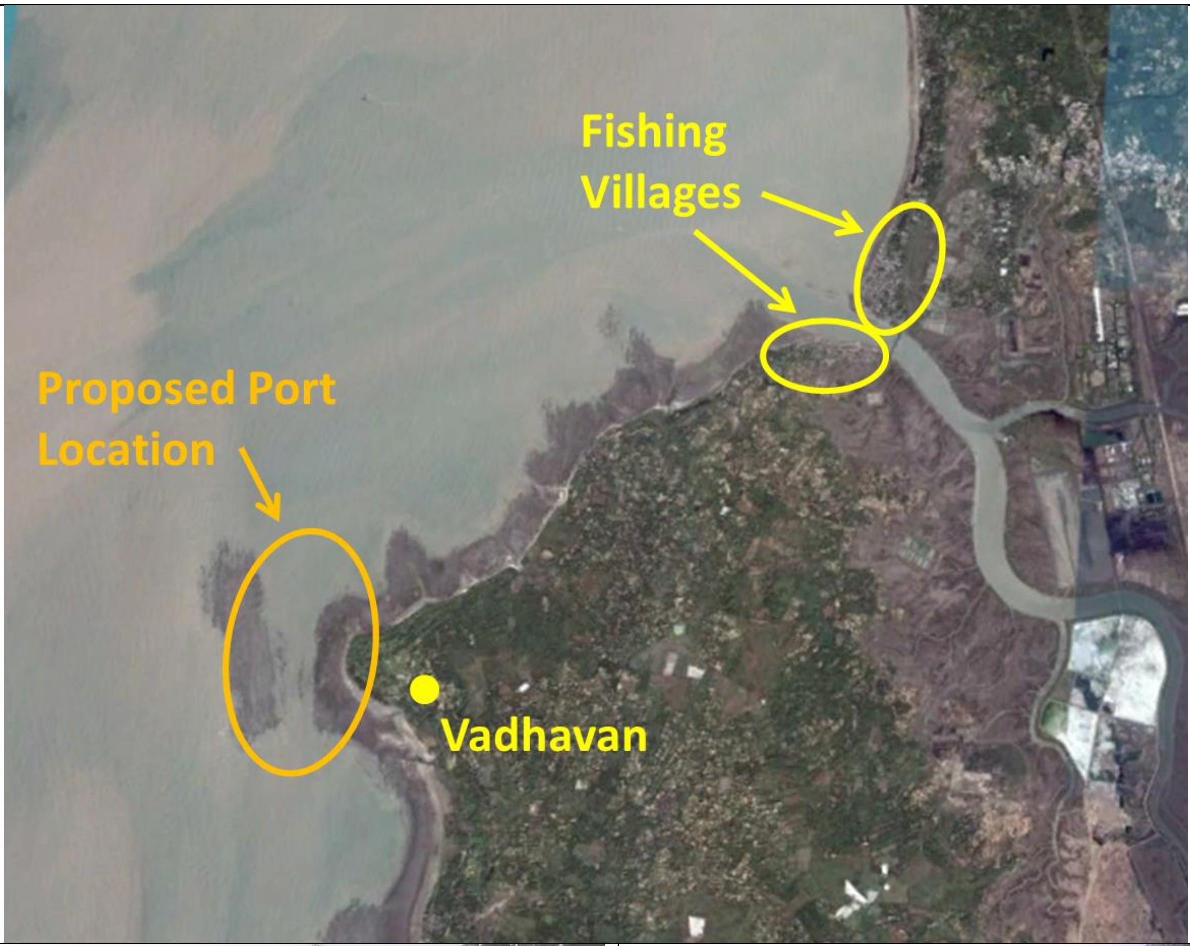
Dahanu Taluka has been designated as an ecologically fragile area and restriction had been imposed on setting up any polluting industries. Thus this region has never witnessed any industrial development and agriculture, animal husbandry, fishing, small scale units and farming are the only industries where expansion can take place.

A variety of crops are grown in Dahanu Taluka including Vadhavan village, such as chickoo, mango, coconuts, guava and papaya. Rice is also widely cultivated in this region along with moong dal, chilies and other spices.

8.3 Site setting

A Greenfield port is planned to be developed on the coast near the Vadhavan village. The shore is fronted by the rocks which are scantily covered with mangroves. On the shoreline Casuarina plantation was observed which was reported to be under afforestation program.

About 8 km north, fishing hamlets are located. The area sustains hundreds of families primarily dependent on fishing. There are three main communities among fishermen’s, i.e., Kohlis, Mitnas and Mangelas.



Tidal flat and Casurina plantation

Mangrove on the shore

Exposed rock

Fishing Village

8.4 Environmental Policies and Legislation

Table 8.1 presents Environmental regulations and legislations relevant to this project, along with the details of the competent authority for implementation.

Table 8.1 Summary of Relevant Environmental Legislations

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
1.	Environment Impact Assessment Notification and amendments made thereafter, 2006	For environmental clearance to new development activities following environmental impact assessment	Yes, Category A. For port having cargo more than 5MTPA.	MoEF&CC
2.	Indian Forest Act, 1927 Forest (Conservation) Act, 1980	• Conservation of Forests, Judicious use of forestland for non-forestry purposes; and to replenish the loss of forest cover by Compensatory Afforestation on degraded forestland and non-forest land • Permission for tree felling	No. No forest land is involved in the project	MoEF&CC; Department of Forest, GoM
3.	Wild Life (Protection) Act, 1972	• To protect wildlife in general and National Parks and Sanctuaries in particular • Permission for working inside or diversion of sanctuary land	No.	Chief Conservator of Wildlife, Wildlife Wing, Forest Department, GoM; National/State Board for Wildlife
4.	The Water (Prevention and Control of Pollution) Act, 1974	• CPCB/ SPCB to establish water quality and effluent standard; monitor water quality; prosecute offenders • Issuance of Consent to Establish (CTO) and Consent to Operate (CTP)	Yes, Consent required to establish and not to pollute water during construction and operation	Maharashtra Pollution Control Board
5.	The Air (Prevention and Control of Pollution) Act, 1981	• CPCB/ SPCB to establish air quality and emission standard; monitor air quality; prosecute offenders • Issuance of Consent to Establish (CTO) and Consent to Operate (CTP)	Yes, Consent required to establish and not to pollute air during construction and operation	Maharashtra Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Maharashtra Pollution Control Board

7.	The Motor Vehicle Act, 1988 Central Motor Vehicle Rules, 1989	• Licensing of driving of motor vehicles, registration of motor vehicles, with emphasis on road safety standards and pollution control measures, standards for transportation of hazardous and explosive materials. • Issuance of Pollution Under Control (PUC) certificate to vehicles used in	Yes, all vehicles shall comply with these provisions	State Motor Vehicle Department
8.	The Explosive Act (& Rules), 1884	• Regulations with regard to the usage of explosives and suggests precautionary measures while blasting and quarrying	Yes, If new quarrying activity needs to be undertaken for construction material	Chief Controller of Explosives.
9.	Public Liability and Insurance Act, 1991	• Protection to general public from the accidents due to hazardous material	Yes, Any hazardous material used as raw material or waste for activities	District Collector
10.	Hazardous Wastes (Management and Handling Rules), 1989	• Guidelines for generation, storage, transport and disposal of Hazardous waste • Issuance of authorisation for all above mentioned activities.	Yes, NOC to handle any hazardous waste, i.e., waste oil from machineries etc.	Maharashtra Pollution Control Board
11.	Mines and Minerals (Regulation and Development), Act, 1952, 1996	• Permission of mining of aggregates and sand	Yes, mining of borrow material to be undertaken.	Department of Mines, GoM
12.	The building and other construction workers (regulation of employment and conditions of services) Act, 1996	• Employing labour/ workers	Yes, as construction workers will be appointed	District Labour Commissioner

Apart from the environmental stipulations mentioned above, other acts applicable for the project are Child Labour (Prohibition and Regulation) Act, 1986; The Factories Act, 1948 and The Minimum Wages Act, 1948.

8.5 Anticipated Environmental Impacts and Mitigation Measures

Potential impacts on environment due to the proposed port project have been summarized in **Table 8.2**. The impacts due to the project location are generally irreversible and cannot be mitigated through environmental enhancement measures. However, impacts related to construction are normally short term, which can be off-set to a large extent by observing a set of precautionary measures. The impacts during operation phase are permanent and can be mitigated following environment management plan provided in next section strictly.

Table 8.2 Potential Environmental Impacts

Environmental aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	**Potential Impacts**	**Activities**	**Potential Impacts**
Impact on Land & Soil Environment	• Quarrying for fill material • Construction of road and rail • Clearing of site and land levelling • Dumping of liquid and solid waste from labour camps, stack yards, workshops etc.	• Change in land use • Loss of trees/vegetative cover hence increase in soil erosion • Soil contamination due to dumping of solid waste (municipal and construction) and spillage of hazardous waste, i.e., oil or other chemicals	• Construction of breakwater • Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• Shoreline changes • Contamination due to spillage
Impact on Water Environment	• Construction of road and rail • Setting up of Labour camps • Dredging and construction	• Change in natural drainage • Water Pollution from labour camps • Increase in turbidity due to dredging and construction activities	• Handling and Storage of cargo such as coal, iron ore etc. • Sewage generation • Oily effluent from maintenance area • Discharge of bilge and ballast water • Maintenance dredging	• Change in marine water quality due to wastewater from stack yards, sewage, bilge and ballast. • Oil spill from vessels serving port • Increase in turbidity
Impact on Air Environment	• Operation of vehicles and construction machinery • Fuel burning at labour camps	• Dust emissions due to construction activities and vehicle movement • Emissions from labour camps, vehicles, machinery and DG sets	• Vehicle movement • Cargo Handling	• Vehicular pollution • Emission from ore and coal handling
Impact on Noise Environment	• Rock Blasting and dredging • Operation of vehicles and construction machinery • Quarrying and transportation of material to the site.	• Vibrations may be felt in the areas closer to the coast • Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery Including stand-by generators Plus klaxons	• Increase in noise Both airborne and through the water

Environmental aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	Potential Impacts	Activities	Potential Impacts
Impact on Ecology	• Quarrying for fill material • Construction of road and rail • Clearing of site and land levelling • Reclamation and dredging	• Loss of vegetation due to site clearing including mangroves • Loss of habitat to birds and small animals • Impact of dredging and dumping of dredged material on marine flora and fauna	• Cargo Handling • Maintenance dredging	• Impact of dredging and dumping of dredged material on marine flora and fauna.
Impact on Socio-economic	• Construction activities • Traffic Movement	• Hindrance in the fishing activities • Discomfort to nearby communities due to noise, air and water pollution • Loss of land/ livelihood in case of rail and road development • Relocation of CPR and utilities for rail and road development • Increased traffic movement • Occupation health issues	• Operations • Traffic movement	**<u>Negative Impacts</u>** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **<u>Positive Impacts</u>** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

8.6 Impacts during Construction Phase

The construction phase, in general, has adverse influence on all the components of environment. Most of these impacts are short lived and reversible in nature, hence proper care is must to minimize the disturbance so as to the restoration of natural and ecological services.

8.6.1 Impacts on Land and Soil

The Dahanu Taluka has rich floral diversity and sea shore also has a thick patch of Casuarina vegetation. The Casuarina plantation in the areas acts as wind-breaker and as a shield during cyclonic conditions. Moreover, this plantation also protects erosion of the shoreline.

The proposed port is planned on reclaimed land between shoreline to 15 m depth. Thus, no land is required for port development and only activities that require land are road and railway connectivity development. Thus, vegetation clearing will be kept to the minimum.

The anticipated impact of the project are soil contamination that may be caused from roadside litter, oil spillage form machinery, sanitation and waste disposal, spillage of hazardous chemicals etc. Any soil contamination will also impact marine water as the site is located in the intertidal region.

Mitigation Measures

Considering the activities and their impact on land and soil the following mitigation measures are discussed below.

- Vegetation clearance shall be confined to the minimum area required for the project.
- Re-plantation shall be taken up followed by construction in another identified area.
- All the waste has to be collected and nothing to be dumped on land or water.
- The contractor will be held responsible to clean all debris before leaving the construction site and also to make necessary arrangements with scrap dealers to sell off the waste scraps.
- The waste from labour camps and administrative activities during construction will all be disposed off through municipal facility.

8.6.2 Impacts on Water Quality

Impacts on water resource are two-fold, one increased water demand and disposal of waste water.

Additional water demand due to this project is anticipated towards construction activities and drinking water needs for labours and employees. The water will be sourced from the Sakhare dam which is located about 15 km from the proposed site. All the required permissions from the state authorities will be sought from withdrawal of water.

It is generally assumed that 80% of the domestic consumption is generated as sewage, which if discharged untreated will act as a source of water pollution. During construction phase, sewage of 20 m^3/day is expected to be generated.

Other sources of contamination are accidental disposal of construction debris and spillage of oil and grease from the vehicles and construction machineries.

The construction activities have potential influence on the water resources within the activity area. The pile driving, rock cutting and dredging will cause high turbidity, removal of nutrient due to dredging, which would ultimately affect the marine flora and fauna.

Natural drainage may be impacted due to the provision of the road network and hence it needs careful planning.

Mitigation Measures

In order to mitigate negative impacts on water that are expected from the projects, the following measures will be implemented:

- Bore wells, if required to source water for construction phase will be drilled after an exhaustive historical study of the region and after obtaining necessary permission and approvals from the state water board or Central Ground water Authority. Water cess shall also be paid to relevant authority;
- The embankments of any surface water bodies will be raised to prevent contamination from run-off;
- Workers shall be provided proper sanitation facilities including mobile toilets or 10 ‘Sulabh Shauchalayas’ (community toilets).
- All the waste water will be collected and treated using soak pits and sludge from soak pits will be cleaned.

- The construction site and camp will be provided with temporary drainage; Avoid water stagnation/ ponding near work and camp sites to curb vector borne diseases;
- Fuel/ oil storage will be sited away from any watercourses; leakage of oil wastes from oil storage and vehicles shall be avoided in order to prevent potential contamination of streams or ground water;
- Surface runoff from machine operations, oil handling areas/devices will be treated for oil separation before being discharged into the river;
- Waste Oil/ grease/ lubricants are categorized by MoEF as Hazardous Wastes. All such waste will be collected and stored at a protected place and sold to a vendor authorized by MPCB or MoEF.
- No construction activity will be undertaken during monsoon period.
- Use of silt curtains is recommended to confine areas of high turbidity during dredging and pile driving.
- To avoid impacts from dumping of dredged material the following measures shall be adopted:
    - Most of the quantity of dredged material and rock will be used as reclamation material and for revetments.
    - Limited material, which will not be suitable for reclamation, will be disposed off at an identified site beyond 20 m depths in the sea.
    - Areas with high fish yield or used by locals for fishing shall be avoided.
    - Dumping activity shall not be carried out during monsoon season.
    - To reduce the potential for error on the part of the contractor, efforts should be made to monitor regularly the activities during dredging and disposal of spoils.
    - Where appropriate, disposal vessels should be equipped with accurate positioning systems. Disposal vessels and operations should be inspected regularly to ensure that the conditions of the disposal permit are being complied with and that the crews are aware of their responsibilities under the permit.

8.6.3 Impact of Air Quality

Air emissions due to construction activities, fuel burning, vehicle movement, machinery and DG sets are the most significant sources of air pollution during construction phase.

Air pollution can cause significant impacts on the environment, and subsequently on humans, animals, vegetation and materials. It primarily affects the respiratory, circulatory and olfactory systems in humans. In most cases, air pollution aggravates pre-existing diseases or degrades health status, making people more susceptible to other infections or the development of chronic respiratory and cardiovascular diseases.

Mitigation Measures

- Power supply from State Electricity Board shall be sourced for electrically operated construction machinery/equipment.
- The use of DG set would be limited to backup during power failure;
- Dust suppression systems (water spray) will be used near the earth handling sites, asphalt mixing sites and other excavation areas to reduce the wind-blown fugitive dust emissions.
- Earth moving equipment, such as bulldozer with a grader blade and ripper will be used for excavation work.
- Excess idling of construction equipment as well as vehicles to be prohibited.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.
- Vehicles and construction equipment will be fitted with internal devices i.e. catalytic converters to reduce CO and HC emissions.

- All stationary machines/ DG sets / construction equipment emitting the pollutants will be inspected weekly for maintenance and shall be fitted with exhaust pollution control devices;
- Vehicles and machineries will be regularly maintained to conform to the emission standards stipulated under Environment (Protection), Rules 1986.
- “No Objection Certificate (NoC)” for setting up of crusher, hot-mix plant and DGs will be obtained from Maharashtra Pollution Control Board;
- Ensure that all vehicles must possess Pollution under Control (PUC) Certificate and shall be renewed accordingly;
- All the roads in the vicinity of Port site and the roads connecting quarry sites to construction sites will be paved to minimize the fugitive emissions.
- If any of the road stretches are not paved due to some reason, then adequate arrangements will be made to spray water on such stretches of the road.

8.6.4 Impacts on Noise Quality

During construction phase, there could be high noise levels due to operation of various construction equipment and increased number of vehicles supplying man and material to the site. It is known that continuous exposure to high noise levels above 90 dBA affects the hearing acuity of the workers/operators or residents and hence, require mitigation planning.

Another impact for the proposed port is anticipated due to the rock blasting due to which communities residing near the coat may feel the vibrations.

Mitigation Measures

- Controlled blasting techniques such as Noiseless Trunk Delay (NTD) technique etc. to be adopted to reduce vibrations.
- The established time for blasting will be notified and displayed in the project area at strategic places such as main gate, project office, project roads, near blasting site etc.
- The construction works will be carried out during the day time. The work hours should be limited depending on convenience of the local people.
- Noise levels of machineries used shall conform to relevant standards prescribed in Environment (Protection) Rules, 1986. Workers shall not be exposed to noise level more than permitted for industrial premises, i.e. 90 dBA (Leq) for 8 hours;
- 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.
- Labour camps shall be established away from high noise generating area. Workers exposed to high noise level shall use ear plugs or ear muffs;
- Regular maintenance of all vehicles and machinery shall be made mandatory to keep noise under check;
- Nearby communities will be notified of the construction schedule and construction works shall be structured to daylight working hours;
- Any ‘High Noise Area’ shall be posted with warning signs and will have restricted access.
- Noise from air compressors could be reduced by fitting exhaust mufflers and intake mufflers.
- Chassis and engine structural vibration noise can be dealt with by isolating the engine from the chassis and by covering various sections of the engines.
- Crushers, if any, will be fitted with rock lining to act as natural sound insulator during the crushing process;
- Noise levels from the construction equipment can be reduced by fitting of exhaust mufflers and the provision of damping on the steel tool.
- It is proposed to develop a greenbelt within the port premises including along the road stretches.

- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- Regular monitoring and maintenance of all the equipment and DG sets shall be taken up to keep a note on noise levels and to take corrective actions.

8.6.5 Impacts on Ecology

Vadhavan is located in Dahanu Taluka, which had been declared as an eco-sensitive zone via a notification of 20th June 1991. As mentioned earlier, the proposed project is planned on a reclaimed area in an offshore location and do not fall in the purview of the notification. However, it is important to note that development of support infrastructure like road and railway development would be planned in Dahanu Taluka. The proposed location is about 50 km away from the Western Ghat boundary (**Figure 8.1**).

Dahanu Taluka also reported to have rich marine biodiversity and supports hundreds of families primarily dependent on fishing. On the coast line, mangrove vegetation was found to be present covering exposed rock area.

Although the land requirement for port development is not envisaged but any development to provide for rail and road connectivity will require careful planning to avoid sensitive locations (habitation, vegetation etc.). Tree cutting is inevitable at this location for infrastructure development.

Pile driving, deposition of rubble, sand compaction and other construction work in water may cause increase in sediment concentration, which may also reduce sunlight penetration. Disturbance from construction activities may cause displacement of fishery resources and other mobile bottom biota.

Due to the rock dredging and development port at an offshore location, marine life will be impacted, however, damage to marine life would be minor and localized, which is reversible except the port location.

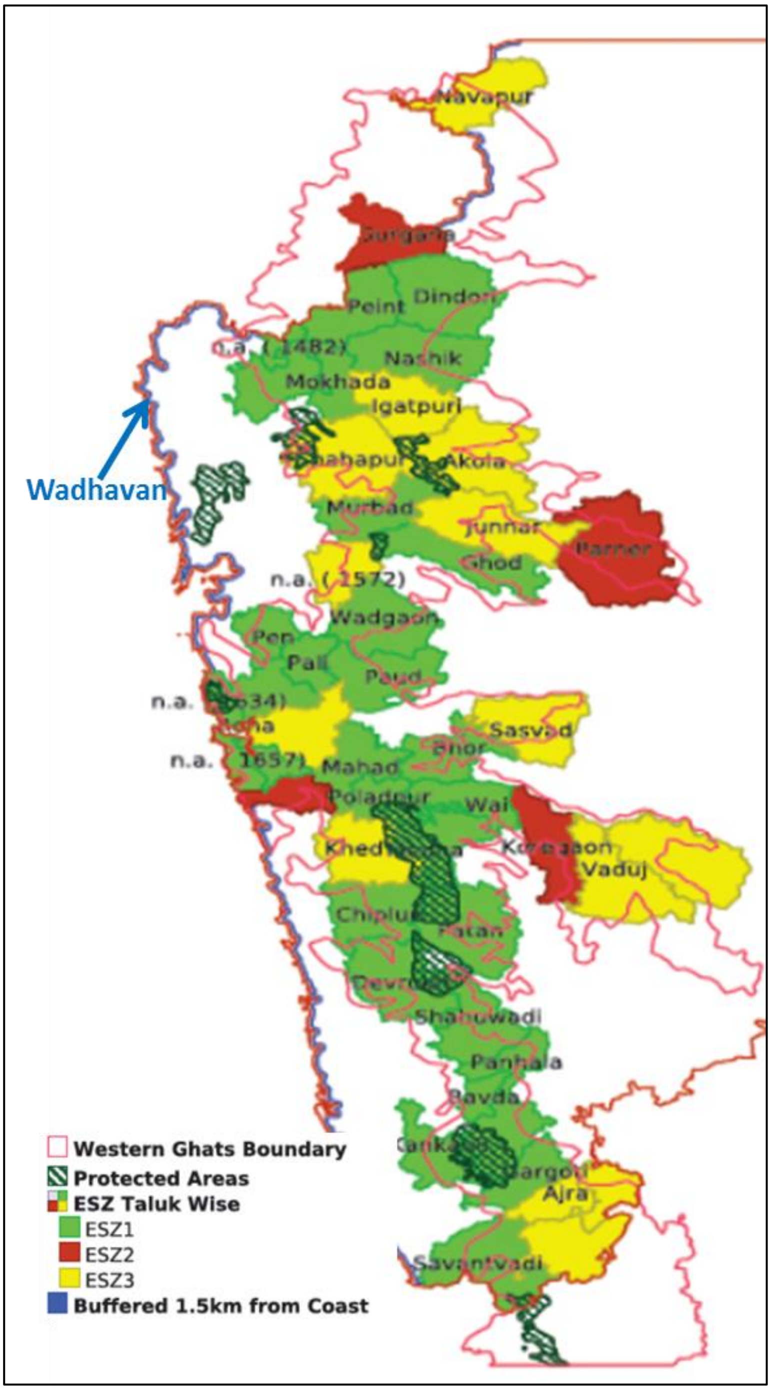


Figure 8.1 Location of Western Ghat and Vadhavan

Mitigation Measures

- All care shall be taken that trees shall be protected as far as possible while site clearing and infrastructure development.
- In consultation with Forest Department, more than twice number of the trees will be planted in lieu of trees removed.
- Detailed ecological survey shall be conducted during detailed EIA study to assess the impacts.
- No construction activity will be allowed during the monsoon season so as to avoid breeding period of fishes.

- Use of silt curtains is recommended to confine areas of high turbidity during dredging and pile diving.
- Controlled dumping of the dredged material will be carried out beyond 20 m depths in the sea as a designated site.
- Areas with high fish yield or used by locals for fishing shall be avoided.
- All care shall be taken to avoid mangroves vegetation while construction activity. It is also proposed to plan and develop mangroves in the area identified and suggested by Forest Development.

8.6.6 Impact on Social Conditions

During the site visit no major settlement were seen at the proposed site. In addition, no major social impacts associated with the proposed port like loss of land and associated lively hood activities is anticipated as proposed port will be developed utilising wide intertidal plain.

However, limited acquisition of land and loss of livelihood is anticipated for the provision of rail and road connectivity.

Mitigation Measures

- It is proposed that existing roads will be strengthened wherever possible and as far as possible government land will be used for rail and road alignment.
- Detail survey of the land will be undertaken to ascertain land losers, properties etc. falling within the area. Each stakeholder will be adequately compensated as per government regulations.
- A Rehabilitation and Resettlement (R&R) plan has also been put forth to take up activities for well-being of affected families and panchayats.

8.7 Impacts during Operation Phase

8.7.1 Impact on Water Quality

The most likely impacts from the operation phase of the project will be on the marine water, primarily due to (a) effluent from coal stack yard; (b) oily wastes such as bilge water, washing water, lubricant oil and other residues from vessels and machineries (c) sewage; (d) cargo spillage. All these may lead to odour and degradation of water quality.

Mitigation Measures

- An aerated lagoon is proposed to be provided for treatment of effluent from domestic sources and the settled sludge will be dried in sludge drying beds and then used as manure for local use.
- Effluent generated from coal stackyard will be treated in a settling tank. The sludge produced will be mainly coal dust, which will be dried on sludge drying beds.
- The effluent from workshops, oil storage, etc. will contain oil and grease particles which shall be treated in an oil skimmer. The collected oily matter is stored in cans and disposed of at through authorised waster recycler.
- To combat oil pollution near the port, inflatable type containment boom with oil skimmers will be provided at the berth. A clean sweep oil recovery unit consisting of a power pack and the recovery unit mounted on a system will also be deployed for this purpose.

- Any kind of spill, release and other pollution incidents is to be reported promptly to the nearby port authorities and coastguard personnel are informed to take appropriate actions.
- Strom water drain shall be made to collect run off from rain but care shall be taken that it is not contaminated.
- The ships will not be allowed to discharge their sewage in the port complex. As per MARPOL convention, the ships are now required to have STP on board.
- The International Convention Guidelines for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL, 73/78) will be strictly adhered to at Vadhavan Port area for prevention of marine pollution.

8.7.2 Impact on Air Quality

Vehicle traffic to service cargo at the port, emissions from port equipment, cargo handling (Coal, iron ore, etc.) and fuel burning at labour camps are the major source of air pollution during operation phase.

The coal stock pile is another potential source for entrainment of fugitive coal dust.

Mitigation Measures

- As such, a system consisting of pumps, storage tank, nozzles for dust suppression at discharge feeding points of belt conveyors will be provided at each transfer tower for efficient dust control.
- In addition to above, a suitable spray system will also be provided at ship unloader, coal stackyard & wagon loading station. The effluent generated by washing from coal terminal will be treated in a settling tank and sludge so produced dried on sludge drying beds.
- All vehicles shall have a valid PUC certificate and regular maintenance shall be mandated.
- All the roads in the vicinity of the project site will be paved or black topped to minimize the entrainment of fugitive emissions.
- If any of the road stretches cannot be blacktopped or paved due to some reason or the other, then adequate arrangements will be made to spray water on such stretches of the road.
- For wind generated dust, a windshield with a wire mesh fencing with fast growing creepers up to a height of 10 m around the stockyard shall be installed.
- In addition to all the above measures, a 10 m wide greenbelt will be developed for dust arresting proposes.
- No unauthorized labour settlement shall be allowed in the vicinity of the port.
- It will be a responsibility of labour contractors to provide for clean fuel to the labours.

8.7.3 Impact on Noise Quality

As discussed in construction phase, noise due to equipment and vehicles and human activities will be chief sources. Noise from vehicles can be attributed to the engine, vibration, friction between tyres and the road, and horns. Increased levels of noise depend upon volume of traffic, road condition, vehicle condition, vehicle speed, congestion of traffic and the distance of the receptor from the source.

Mitigation Measures

- Noise levels of port equipment used shall conform to relevant standards prescribed in Environment (Protection) Rules, 1986. Workers shall not be exposed to noise level more than permitted for industrial premises, i.e. 90 dBA (Leq) for 8 hours;
- 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.

- Labour camps shall be established away from high noise generating area. Workers exposed to high noise level shall use ear plugs or ear muffs;
- Regular maintenance of all vehicles and machinery shall be made mandatory to keep noise under check;
- Any ‘High Noise Area’ shall be posted with warning signs and will have restricted access.
- It is proposed to develop a greenbelt within the port premises including along the road stretches.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- Regular monitoring and maintenance of all the equipment and DG sets shall be taken up to keep a note on noise levels and to take corrective actions.

8.7.4 Impact on Ecology

Once port is in operation, major impacts are anticipated from vessel movement, cargo handling, waste water discharge and disturbance due to maintenance dredging.

Release of heavy metals and other chemicals and compounds from the spilled cargo in long run may cause bioaccumulation of these substances in sediment as well as marine flora and fauna.

The constituents of oil are toxic to marine life and release of oil contents on to water will result in formation of a shining film on the surface of water which prevents dissolution of oxygen across the surface of water. Moreover, oil gets accumulated on the body of the small species of fish or invertebrates and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures.

The proposed port is located at a depth of 15 m and beyond, which saves a lots of maintenance dredging. Hence, only limited quantity of dredged disposal is anticipated.

Once the project is operation, a green belt will be developed around the ports site and shoreline.

Mitigation Measures

The following actions shall be taken to avoid any major damage due to oil spill:

- Indian Coast Guard (CG) is the Central Coordinating Authority for Oil Spill Response, so in case of any such event CG shall be informed immediately.
- All the measures shall be taken according to the “Guidelines and Policy for use of OSD in Indian Waters” issued in 2002 and in consent with CG.
- Booms, skimmers and dispersant inventory shall be maintained to contain spill at the port location.
- All recovered oily material shall be disposed-off properly. Either to waste oil dealers or dumped in secured landfill sites.
- Role and responsibility of personnel taking part in oil spill emergency shall be clearly spelled out.
- Regular drill for oil spill containment shall be conducted and any lag shall be recorded and corrected.

8.7.5 Impact on Socio-Economic Conditions

It is envisaged that during operation stage impacts are mostly positive in nature. Once the project is operational, the project has several benefits to the immediate affected community and society in large. The following positive impacts envisaged from the project:

- Employment generation for locals
- Development of road and rail connectivity
- Business opportunity due to ware-housing, cargo handling (stevedoring), transport requirements.

In addition, under Corporate Social Responsibility initiatives will be undertaken in consultation with the local administration and local population to benefit local population and environment. The key thrust areas for CSR activities will be:

- Environment
- Primary Education
- Health Care
- Employment Skill & Job Trainings
- Environmental Services and climate resilience.

8.8 Environmental Monitoring Plan

This section presents the environmental monitoring framework for the project where parameters, frequency and locations for the environmental monitoring are suggested (**Table 8.3**).

Table 8.3 Environmental Monitoring Plan

Environmental Components	Parameters	Frequency of Monitoring	Location
Air	PM2.5, PM10,SO2,NOx,CO, HC	Continuous monitoring, 2 times a week for 24 hours	3 - 4
Surface water / Marine water	pH, DO, BOD, O&G, Salinity, Electrical Conductivity, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides and heavy metals (Zinc, Lead, Cadmium, Mercury)	Once every months	3 - 4
Ground water	Comprehensive monitoring as per IS : 10,500:2012	Once every months	5 – 8
Noise	Leq (Night), Leq (day), Leq (24 hourly)	Once every month	8 – 10
Ecological Environment (Coastal)	No. of species and density: • Phytoplankton • Zooplankton • Benthos • Fisheries • Mangroves Invasion of new plant species and plant communities, increased habitat diversity, invasion of new species.	Once a year	3 – 4
Bed Sediment	Texture, size, O&G, Heavy Metals (Zinc, Lead, Cadmium, Mercury)	Once every six months	4 - 5

8.9 Environmental Management Cost

A site specific Environmental Management Plan (EMP) shall be prepared for avoiding, mitigating, monitoring the adverse impacts envisaged on various environmental components during construction and operational phase of the project. About 1% of the project cost is estimated to be earmarked for environmental management activities.

In addition about 1% of average net profits of last 3 years will be spent on Corporate Social Responsibility (CSR) activities each year during operational phase (Companies Act, 2013). The CSR activities may be formulated to deal with hunger and poverty; promoting public health; supporting education; addressing gender inequality; protecting the environment; and funding cultural initiatives and the arts.

9.0 Cost Estimates and Implementation Schedule

9.1 Capital Cost Estimates

9.1.1 General

The capital cost estimates prepared for the project are based on the project descriptions and drawings given under the relevant sections of the present report. The drawings were prepared after carrying out basic engineering of various components of the project. The quantities have been calculated from the drawings for cost estimation purpose. The basis of the costing is as follows:

- The cost estimates of civil works have been prepared on the basis of current rates for various items of work prevailing in the region and also on the past costs for similar works elsewhere.
- The costs of equipment and machinery are based on budgetary quotations and discussions held with the manufacturers and also in-house data. The costs include all taxes, duties, insurance freight etc.
- The price level used for the estimates is as of the third quarter of 2015.
- All costs towards overheads, labour, tools, materials, insurance, financing costs, etc., are covered in the rates for individual items.
- The costs towards plant and machinery include manufacture, supply, transport, installation and commissioning of the respective items.
- The exchange rate has been assumed as 1 US $ = Rs. 65/-
- Provision towards contingencies, engineering and establishment has been included separately.

These site information and assumptions are subject to many factors that are beyond the control of the consultants; and the consultants thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.

9.1.2 Capital Cost Estimates for Phased Development

The capital cost of phased development of port, as per the proposed phasing as per **Table 6.9** has been worked out as furnished below in **Table 9.1**. The costs given for each phase are for the facilities created during that particular phase only.

Table 9.1 Block Capital Cost Estimates (Rs. in crores)

S. No.	Item	2023	2028	2033	2038
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	25	11	6	16
2.	DREDGING AND RECLAMATION	2,826	3,030	3,272	1,207
3.	BREAKWATER AND BUND	2,930	202	477	540
4.	BERTHS	448	883	122	544
5.	BUILDINGS	84	41	23	18
6.	STACKYARD AND OTHER BACKUP AREA	160	206	160	80
7.	ROADS AND RAILWAY	627	73	189	85
8.	EQUIPMENTS	796	2,861	1,664	1,988
9.	UTILITIES AND OTHERS	177	91	50	44
10.	NAVIGATIONAL AIDS	12	-	0	0
11.	Total (1+2+3+4+5+6+7+8+9+10)	**8,084**	**7,396**	**5,963**	**4,522**
12.	Contingencies @ 10%	808	740	596	452
13.	Engineering and Project Management @ 5%	404	370	298	226
Incremental Capital Cost (Rs. In Crores)		**9,297**	**8,506**	**6,857**	**5,200**

These capital cost estimates do not include the following:

- Cost of land acquisition for rail/road corridors
- Port crafts, as these are proposed to be leased out
- Financing and Interest Costs

9.2 Operation and Maintenance Costs

9.2.1 General

Operation and maintenance costs have been calculated under various heads as described in the subsequent paras.

These costs do not include the following items:

- Lease rent to the state government
- Maintenance of Infrastructure outside the port boundary

9.2.2 Repair and Maintenance Costs

The following norms have been used for estimating the annual maintenance and repair costs:

- 3% of Quay Cranes and Gantries
- 7% of ITVs, Reach Stackers and FLTs
- 5% of other Mechanical equipment and Electrical Works
- 1% of Civil Works
- 3% of Utilities and Other Works

For dredging, the actual cost based on the maintenance dredging volume estimated from model studies is taken into account.

9.2.3 Manpower Costs

The estimated manpower for the initial phase of development is about 500 increasing to about 2000 in the ultimate stage of development. The manpower costs have accordingly been calculated considering the number and types of personnel deployed.

9.2.4 Operation Costs

The operation costs include the fuel, water and power costs. These have been considered as below:

- Power - INR 4.50 per unit plus INR 225 per kVA of demand rate per month
- Water Charges - INR 50 per kilolitre
- Diesel - INR 50 per litre

The operation costs for the equipment run by electrical power have been calculated based on the maximum throughput and utilisation of the equipment. Similarly the operation cost of major equipment like ITVs run by diesel has been worked out based on the utilisation level for the annual throughput. Further the operation costs of the following items have been estimated as a percentage of their capital cost, as given below:

- Diesel Driven Equipment (minor) - 5% per annum
- Other Works such as Fire fighting & Pollution Control - 3% per annum

9.2.5 Annual Incremental Operation and Maintenance Costs

Based on the various criteria discussed above, the annual operation and maintenance cost for various phases of development of Vadhavan Port are summarised below in **Table 9.2** below:

Table 9.2 Annual Operation and Maintenance Costs (Rs. in crores)

S. No.	Item	2023	2028	2033	2038
1.	REPAIR AND MAINTENANCE COSTS	98.2	193.4	108.2	125.5
2.	OPERATION COSTS	66.2	117.8	54.0	61.3
3.	**TOTAL**	**164.4**	**311.2**	**162.2**	**186.8**
4.	Contingencies @ 10%	16.4	31.1	16.2	18.7
5.	Administrative Expenses @ 5%	8.2	15.6	8.1	9.3
Incremental O & M Costs (Rs. In Crores) per annum		**189**	**358**	**186**	**215**

9.3 Implementation Schedule for Phase 1 port development

9.3.1 General

The main components for the Development of Vadhavan Port comprises of construction of breakwaters, capital dredging for approach channel and manoeuvring basin, reclamation of the terminal areas, construction of berths, supply and installation of material handling equipment, onshore infrastructure and marine support systems. The implementation schedule of the critical project items is discussed below.

9.3.2 Construction of Breakwater

The construction of the breakwaters is considered as the most critical item in the project implementation schedule, as the other marine works like berths construction and the dredging have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 16 million tonnes of rock is required for the construction of breakwaters. The major quantity of rock required for armour and sub armour layers would be obtained from identified quarry sites located about 35 km from site.

It is proposed to construct the breakwaters by end on dumping method as well as using the marine equipment viz. self-propelled side dumping and/or bottom opening barges of approximately 500 T to 1000 T capacity.

The floating equipment shall be used for dumping of filter and core, as well the Accropodes of greater than 5 m^3 size upto about -4m CD. The cross section above -4m CD will be constructed by end on method. It is envisaged that using the end on dumping and the floating equipment, about 10,000 T stones can be placed per day. Upon completion of the Accropode armour / stone armour to full length, the mass concrete capping shall be commenced from the root. This would mean that the construction of shore protection bund and the breakwater could be completed in a period of about 60 months duly accounting for weather downtime and establishing the quarry and rock sizing.

9.3.3 Dredging and Reclamation

Though the overall dredging quantity is limited to only 1.3 Mcum and mainly comprise of rock dredging to be undertaken using drill and blast technique which is time consuming process. The overall duration of the dredging is expected to be 30 months. Considering that the dredging at the berth location needs to be completed before start of berth construction, the programme of dredging shall be accordingly planned.

The reclamation activity will commence once the breakwater construction has reached 12 m contour. Since the major quantity of reclaimed fill i.e. 30 Mcum shall be borrowed fill, the reclamation activity shall be almost independent of the dredging activity.

9.3.4 Berths

The construction of berths sites would commence after the dredging in the berth pockets has been completed and adequate shelter to the berth area is provided by the completed portion of breakwater. It would also follow the construction of the long approach bund in the lee of the south breakwater so as to ease the construction material supply. The berth piling would be commenced using piling gantries installed from the reclaimed areas near berths. The superstructure would be mainly built using precast concrete elements to avoid soffit shuttering. This would also enable the construction of superstructure on the piles already completed. The construction of berths is expected to take about 30 months.

9.3.5 Equipment and Onshore Development

It is envisaged that the delivery and installation of equipment and the development of onshore works can be carried out to match the implementation schedule of the project.

9.3.6 Implementation Schedule

The construction time of Phase 1 development of the Vadhavan port is likely to take over 60 months. This has been worked out taking into account all the items of the project, the various activities involved and the duration of each activity. The project implementation schedule for the Phase 1 Development of the Vadhavan Port is shown in **Table 9.3**.

Table 9.3 Implementation Schedule for Development of Port at Vadhavan

S.No.	Task Description
A	**Appointment of Cosultant for DPR Preparation** Zero Date
1	Preparation of DPR
2	Prepration of Tender Documents
3	Prepration of EIA Report and Approvals
B	**Tendering Activity of Common Infrastructure to be developed by JNPT**
1	Tendering Period
2	Evaluation, Negotiations and Award of Contracts
3	Financial Closure
C	**Construction Activity of Common Infrastructure**
1	Establishment at Site by Contractor
2	Appraoch Roads
3	Breakwaters
4	Dredging
5	Reclamation Bund
6	Reclamation
7	Rail and road connectivity
D	**Terminal Construction by BOT Operator(s)**
1	RFP to selected bidders, Evaluation and Selection of Concessioner for Terminals
2	Detailed Engineering By Concessionaire
3	Tendering and Selection of Contractor by Concessionaire
4	Financial Closure
5	Berths
6	Yard and Pavement
7	Supply and Installation of Mechanical Equipment
8	Buildings
9	Onshore Infrastructure
10	Commissioning of Port Facilities

10.0 Financial Analysis

10.1 Introduction

A profitability analysis for the proposed development has been carried out with the following objectives:

- To establish a realistic and reasonable tariff, comparable to those available for similar cargoes at nearby ports, that provide adequate returns after meeting all the costs
- To assess the viability of the project in terms of Financial Internal Rate of Return (FIRR) considering the revenue generated at the proposed tariff and the costs of operations including the investments costs and debt service charges.

A profitability analysis for the proposed development has been carried out with the objective of assessing the viability of the project in terms of Financial Internal Rate of Return (FIRR).

10.2 Capital Expenditure Plan

The capex spending has been planned over 4 phases. First phase is spread over 5 years and subsequent phases over three years. The total project capex is around INR 29,860 crores (at current prices. For the master plan phase the capacity expansion of the port for handling containers is restricted to ~9.87 M TEUs.

The operations and maintenance cost estimates as indicated in section 9 have been considered.

10.3 Tariff

For the purpose of this preliminary analysis, it has been assumed that Vadhavan port charges ~INR 7500 per TEU (current prices), which is benchmarked with the applicable port charges at JNPT and other competing ports.

10.4 Financial Viability

The pre-tax IRR for the project on the basis of the above assumptions comes out to be 17.8%.

FINANCIAL ANALYSIS

Assumptions

Capex

? Rs. 29,860 (current prices)

? Capex schedule: Phase 1 from FY18-22, Phase 2 from FY25-27, Phase 3 from FY30-32 and Phase 4 from FY35-37

Viability Gap Funding

? NA

Opex

? Rs. 189 cr in year 1 of operation (Current prices)

? Increment of Rs. 360 in FY28, Rs. 186 in FY33 and Rs. 215 in FY38

? 5% annual growth

Traffic

? Overflow traffic from JNPT port will be catered by Wadhavan port but container capacity at master plan Stage is capped at 9.4 MTEUs

? Coal for coastal power complex will be handled by Wadhavan

? Natural growth of container traffic: 10% (y-o-y) till FY25; 8% from FY35 till FY25; 5% subsequently

Port charges

? Rs. 6,000 per TEU in year 1 of operation (Current prices)

? 5% annual growth subsequently

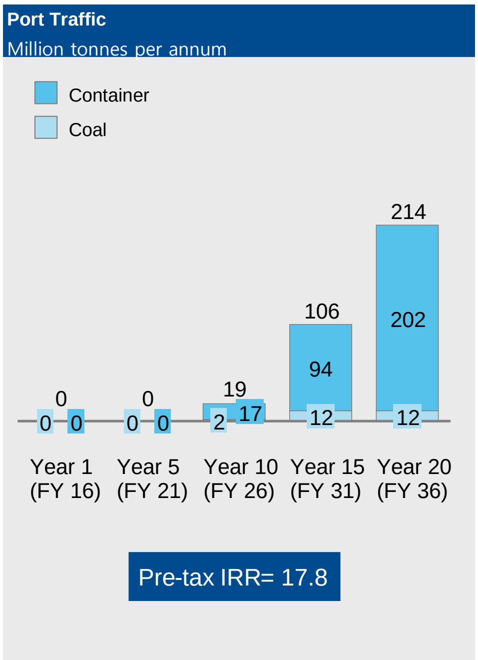


Figure 10.1 Financial Analysis

10.5 Sensitivity Analysis

The following sensitivity scenarios have been worked out for Vadhavan Port:

- **Slow traffic growth:** Assuming the traffic growth is reduced to 6.5% until FY 25 and 4.5% from FY 26 to FY 35 and 1.5% thereafter, the IRR drops to 6.7%
- **Increase in capex**: Increase in capex by 20% in all phases results in IRR dropping to 14.3%
- **Lower tariff:** Assuming that tariff is 20% lower than JNPT – or INR 6,000/TEU versus INR 7,500/TEU in the base case – causes the IRR to drop to 15.4%

Therefore the IRR appears comfortable even under negative assumptions.

11.0 Conclusions and Recommendations

11.1 Project Assessment

The proposed port site at Vadhavan is technically suitable for the deep water port development. Considering its advantageous position in terms of offer deep draft to ships, it has a potential to attract customers.

Considering the long breakwaters needed for the port, the construction period for the port development is relatively longer at about 60 months. Further the significant investment needed in creating the basic port infrastructure and the gradual traffic built up impacts the financial viability of the project.

11.2 Alternative means of Project Development

11.2.1 Option 1 – SPV Model

In this option the project shall be executed by the public sector entity i.e. (JNPT and MMB), who shall also arrange funds for the project financing. The SPV shall also operate and maintain the cargo handling terminals.

11.2.2 Option 2 – Full-fledged Concession to Private Operator

In this option the entire project is allocated to a private developer like in case of Mundra, Gangavaram, Krishnapatnam ports on revenue share basis.

While the port is suitable for development under this model from a financial point of view, there could be potential competitive issues in a situation where JNPT is fully saturated. The advantage would be that the government's investment in the project would be minimal.

11.2.3 Option 3 – Landlord Model

In this option the basic infrastructure in terms of Breakwater capital dredging, reclamation, access rail and road, water and power connection to port, harbour crafts etc. shall be arranged by the Government agency. The cargo terminal facilities would be leased out to the various operators who shall be responsible for its construction, operations and maintenance. However government agency will still be directly responsible for:

- Appointing a Harbour - Master and conservator of the port.
- Navigation in the port by having qualified and licensed pilots to pilot ships with aids like tugs etc., attending to berthing and de-berthing of ships calling at the port.
- Providing and maintaining the basic infrastructure.
- Payment of lease-rent for areas leased to it and other payments to the State Government as may be contained in the agreement.
- Furnishing management information to the appropriate authority on port operations including cargo-handling activities at the various marine terminals, whether operated directed by it or by subleased to others.

- Co-ordinating with the Collectorate of customs within whose jurisdiction the port falls, for proper accounting of ships entering the port and cargo unloaded or loaded into them.
- Administering subleases for the various marine terminals leased to users, terminal operators as applicable.
- Co-ordinating all port activities, monitoring port performance by individual terminal operators and ensuring optimal performance and collecting necessary management information and furnishing the same to the Government authorities as required.
- Safety and security, pollution control and environmental protection, water supply, power supply.

11.2.4 Recommended Option

Considering the long construction time for port development, it is recommended that this project is taken up as landlord model, where in the basic infrastructure such as breakwaters, dredging, reclamation and navigational aids shall be developed by the project proponents i.e. JNPT and MMB. The project proponents shall also be responsible for the following:

1. Environmental Clearance for the Port including the terminals
2. Land acquisition for providing the rail and road connectivity to port
3. Onshore infrastructure such as linkage to water, power sources, communication, drainage network etc.

The individual terminals can be given to private players through competitive bidding where they will be investing in berths, equipment, utilities etc. This could foster greater competition but since the cost of the marine infrastructure is significant, substantial upfront government investment would be needed.

In the proposed implementation model the cost split between the project proponents and the terminal operators is estimated as below in **Table 11.1**:

Table 11.1 Estimated Cost Split (Rs. In Crores)

S. No.	Item	Project Proponents	BOT Operator
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	18	7
2.	DREDGING AND RECLAMATION	1,626	1,201
3.	BREAKWATER AND BUND	2,805	125
4.	BERTHS	-	448
5.	BUILDINGS	31	52
6.	STACKYARD AND OTHER BACKUP AREA	-	160
7.	ROADS AND RAILWAY	603	24
8.	EQUIPMENTS	-	796
9.	UTILITIES AND OTHERS	107	70
10.	NAVIGATIONAL AIDS	12	-
11.	Total (1+2+3+4+5+6+7+8+9+10)	**5,201**	**2,883**
12.	Contingencies @ 10%	520	288
13.	Engineering and Project Management @ 5%	260	144
Capital Cost (Rs. In Crores)		**5,981**	**3,316**
O & M Costs (Rs. In Crores) per annum		**89**	**100**

The process of Vadhavan port development is outlined in **Figure 11.1** attached.

11.3 Way Forward

The action plans for the project development are as follows:

1. Preparation of the Detailed project Report for the Project
2. Preparation of EIA report and approval of MoEF
3. Financial closure of the project
4. Preparation of tender documents for
    a. Selection of contractors for the works to be undertaken by project proponents
    b. Selection of private entity for development of port.
5. Simultaneously award the work for construction of rail and road connectivity to the port site from the NH/ Main Rail network
6. Start the construction of Breakwaters, reclamation, dredging and basic onshore infrastructure
7. Tendering and selection of operator(s) for the terminal development
8. Terminal development works by the BOT operators
9. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

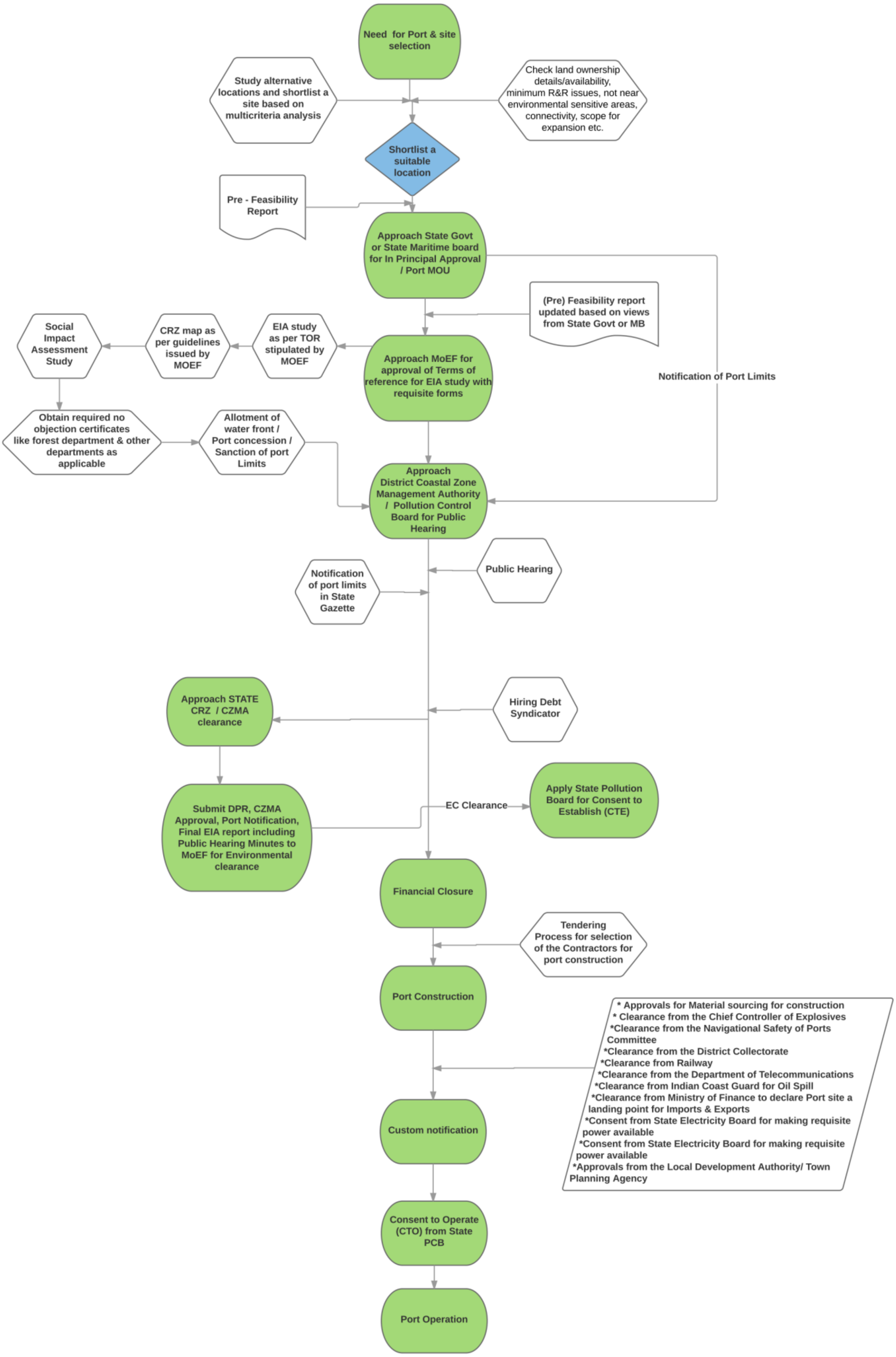
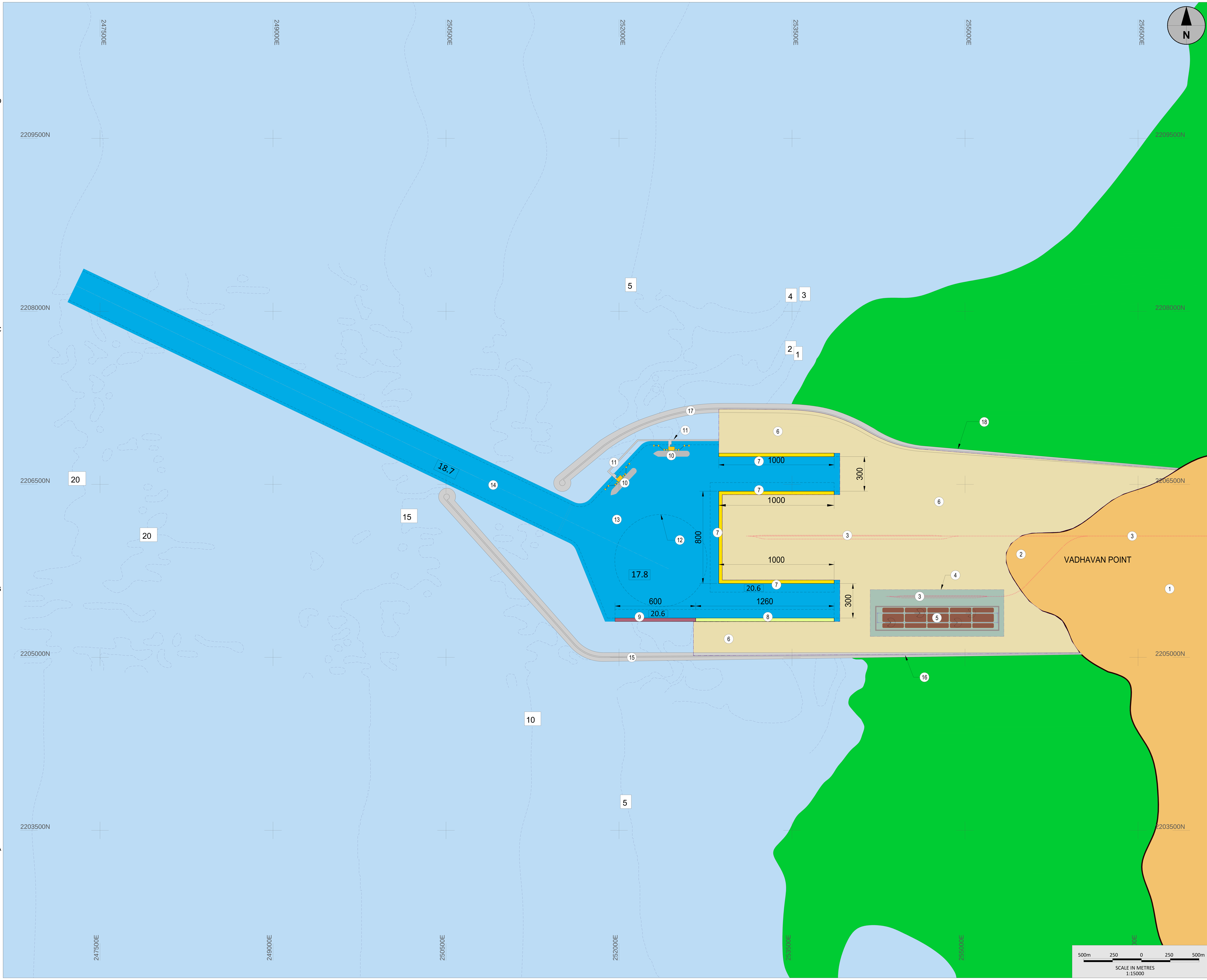


Figure 11.1 Process for the Greenfield Port Development

Drawings



KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. CONTAINER BERTHS 3800m LONG
8. MULTIPURPOSE BERTHS 1260m LONG
9. COAL BERTHS 600m LONG
10. LIQUID BERTHS
11. APPROACH TRUSTLE FOR LIQUID BERTH
12. TURNING CIRCLE
13. BASIN
14. APPROACH CHANNEL 280m WIDE
15. SOUTHERN BREAKWATER 4135m LONG
16. SOUTHERN BUND 1985m LONG
17. NORTHERN BREAKWATER 2275m LONG
18. NOTHERN BUNG 3425m LONG

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

NOTES:-

1 ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.

3 ALL COORDINATES ARE IN WGS84

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REVISION DETAILS

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PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: ALTERNATIVE LAYOUT OPTION-1 MASTER PLAN

SHEET 1 OF 1

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Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1001

REV.: 0

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ISO A1 594mm x 841mm Approved: SG Checked: AM Designer: SV Project Management Initials:

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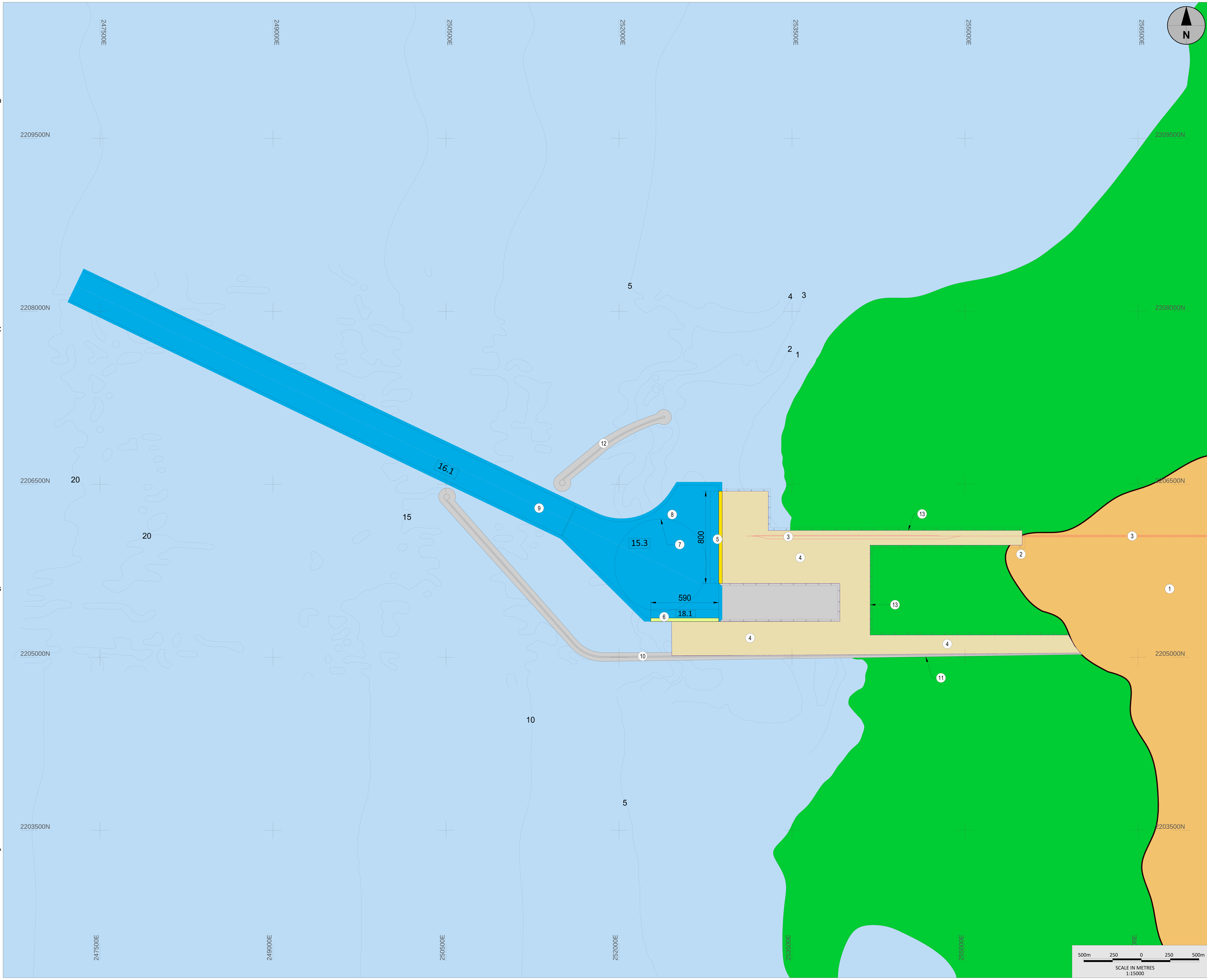

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. PORT BACKUP AREA
5. CONTAINER BERTHS 800m LONG
6. MULTIPURPOSE BERTHS 590m LONG
7. TURNING CIRCLE
8. BASIN
9. APPROACH CHANNEL 280m WIDE
10. SOUTHERN BREAKWATER 4135m LONG
11. SOUTHERN BUND 1985m LONG
12. NORTHERN BREAKWATER 1100m LONG
13. REVETMENT WORK

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- PORT BACKUP AREA

NOTES:-

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REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; INDIAN PORTS ASSOCIATION

PROJECT:
SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

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DIMENSIONS ARE IN: METRES

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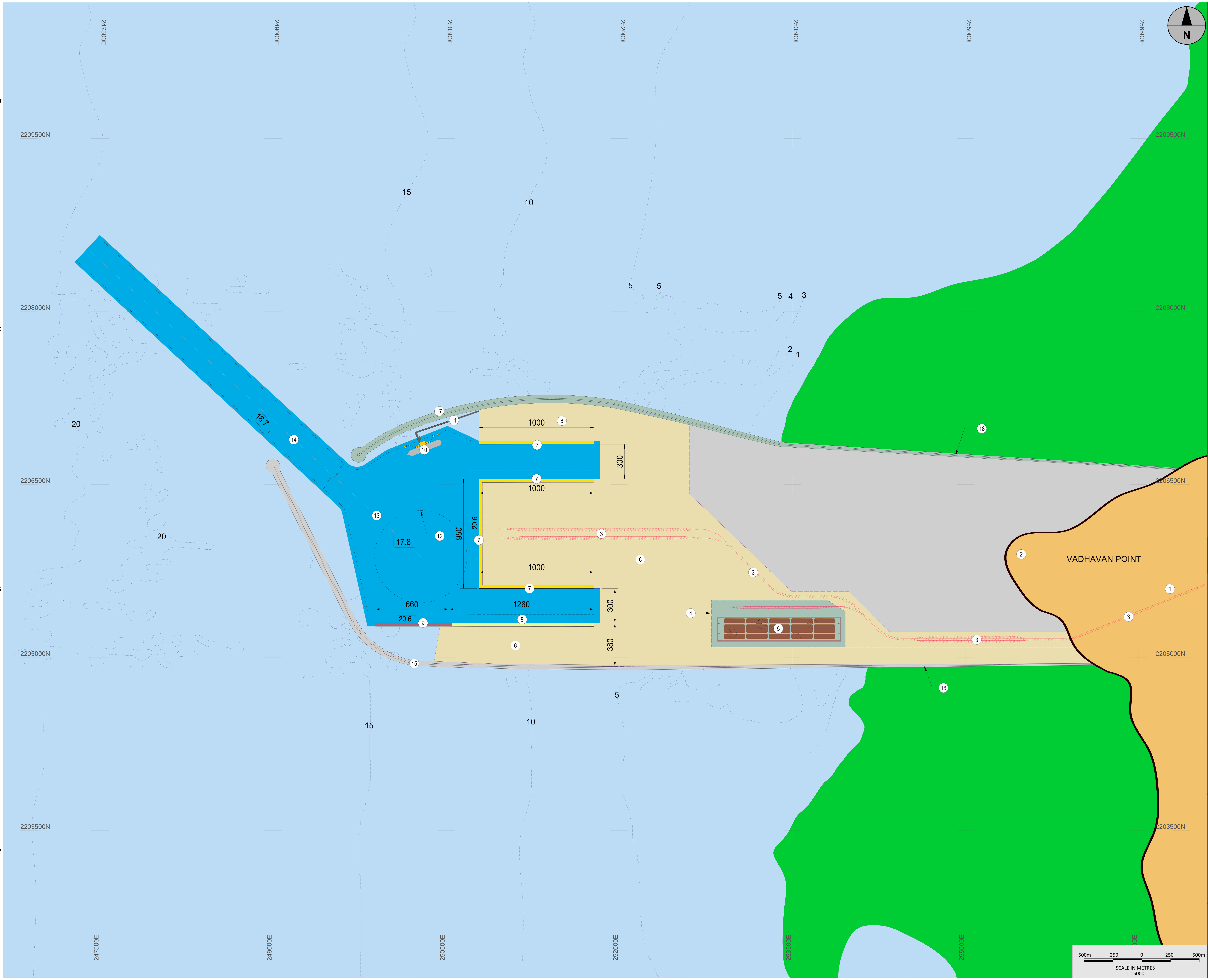

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. CONTAINER BERTHS 3950m LONG
8. MULTIPURPOSE BERTHS 1260m LONG
9. COAL BERTHS 600m LONG
10. LIQUID BERTHS
11. APPROACH TRUSTLE FOR LIQUID BERTH
12. TURNING CIRCLE
13. BASIN
14. APPROACH CHANNEL 280m WIDE
15. SOUTHERN BREAKWATER 6140m LONG
16. SOUTHERN BUND 1960m LONG
17. NORTHERN BREAKWATER 3855m LONG
18. NOTHERN BUNG 3445m LONG

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

NOTES:-

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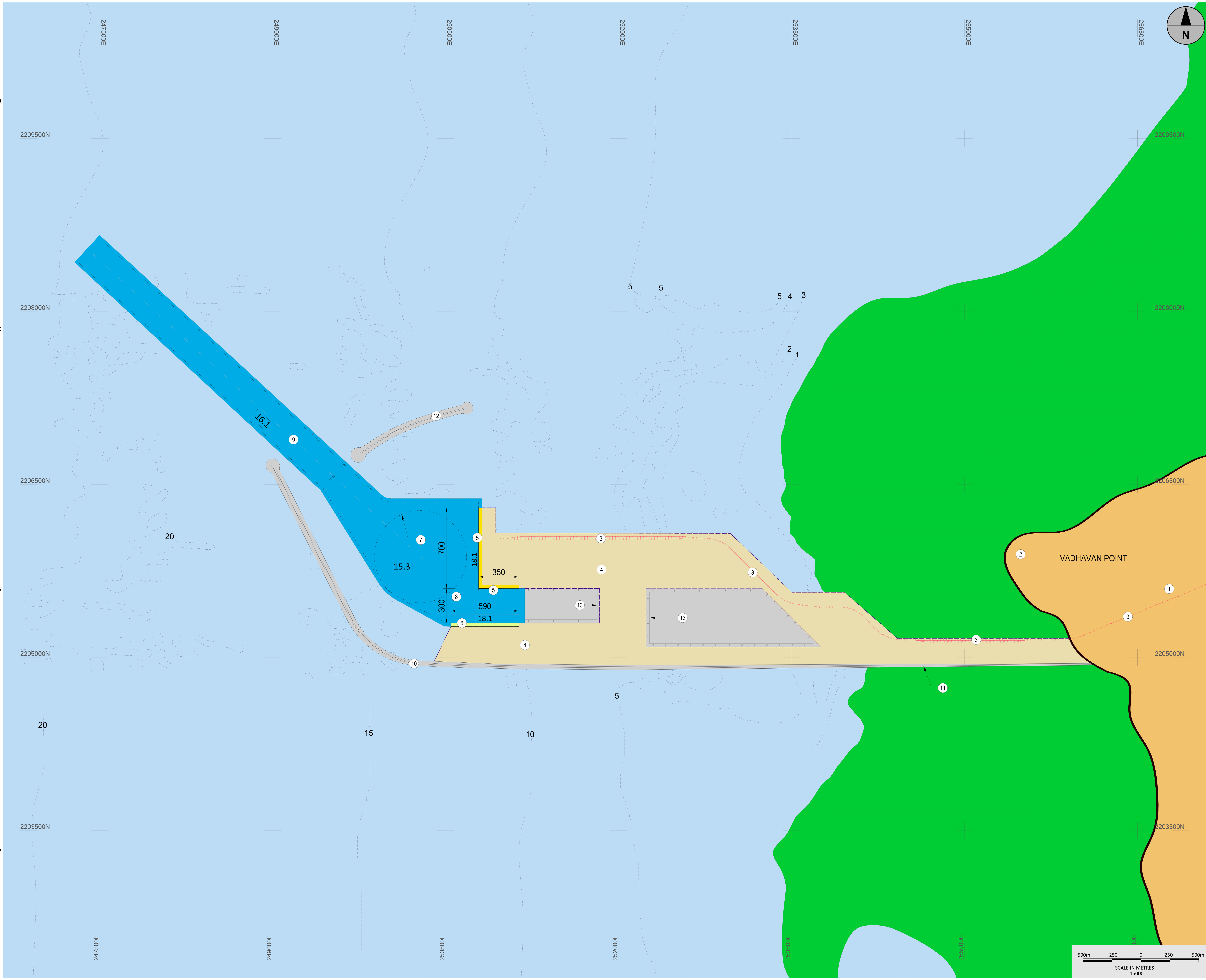

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. PORT BACKUP AREA
5. CONTAINER BERTHS 1050m LONG
6. MULTIPURPOSE BERTHS 590m LONG
7. TURNING CIRCLE
8. BASIN
9. APPROACH CHANNEL 280m WIDE
10. SOUTHERN BREAKWATER 6140m LONG
11. SOUTHERN BUND 1960m LONG
12. NORTHERN BREAKWATER 1200m LONG
13. REVETMENT WORK

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- PORT BACKUP AREA

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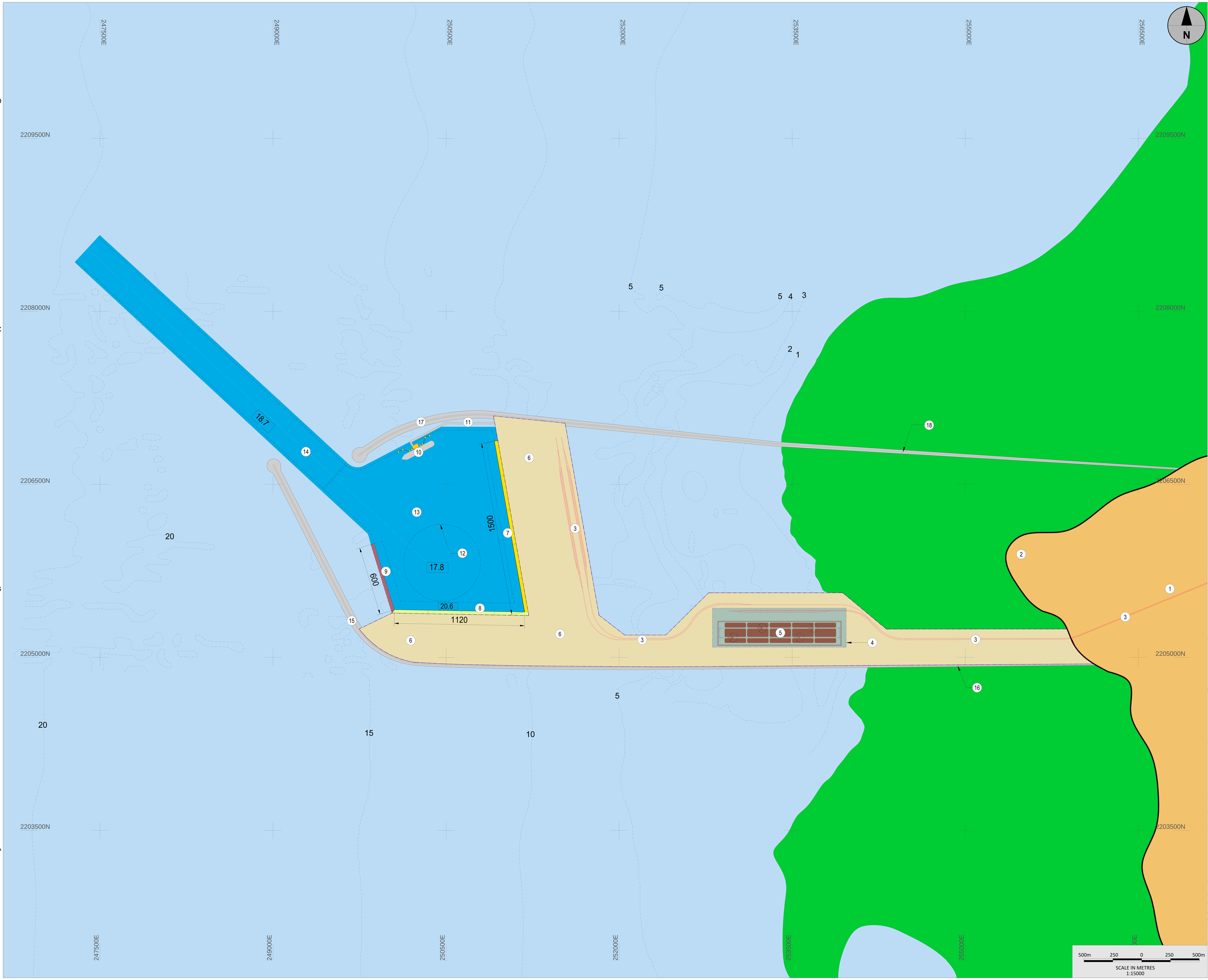

KEYNOTES

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2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. CONTAINER BERTHS 1500m LONG
8. MULTIPURPOSE BERTHS 1120m LONG
9. COAL BERTHS 600m LONG
10. LIQUID BERTHS
11. APPROACH TRUSTLE FOR LIQUID BERTH
12. TURNING CIRCLE
13. BASIN
14. APPROACH CHANNEL 280m WIDE
15. SOUTHERN BREAKWATER 6140m LONG
16. SOUTHERN BUND 1960m LONG
17. NORTHERN BREAKWATER 3780m LONG
18. NOTHERN BUNG 3450m LONG

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

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REVISION DETAILS

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SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

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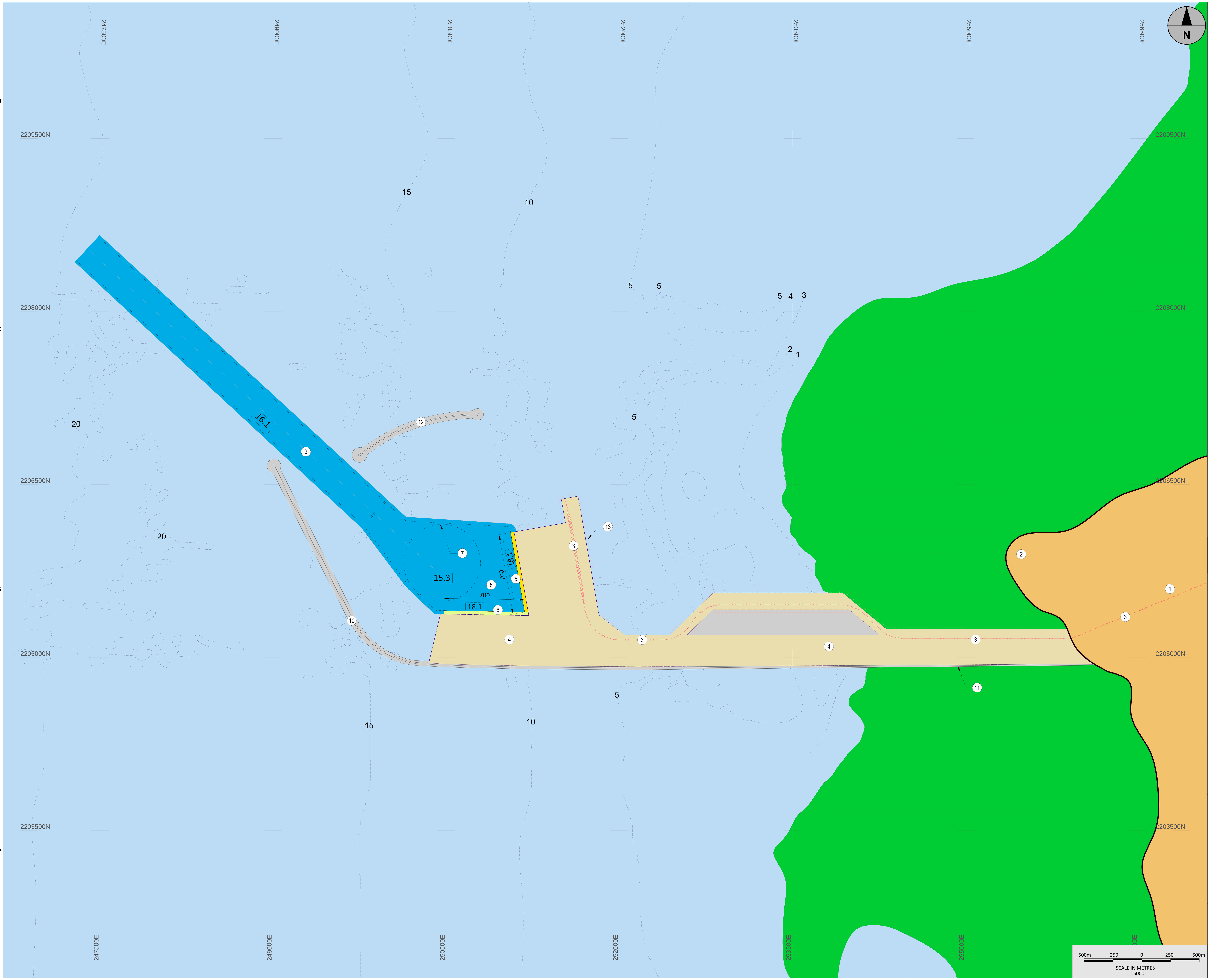

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. PORT BACKUP AREA
5. CONTAINER BERTHS 700m LONG
6. MULTIPURPOSE BERTHS 700m LONG
7. TURNING CIRCLE
8. BASIN
9. APPROACH CHANNEL 280m WIDE
10. SOUTHERN BREAKWATER 6140m LONG
11. SOUTHERN BUND 1960m LONG
12. NORTHERN BREAKWATER 1200m LONG
13. REVETMENT WORK

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- PORT BACKUP AREA

NOTES:-

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KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. ENTRY / EXIT GATE CANOPY
8. RECIEVING STATION
9. COVERED SHEDS FOR BULK HANDLING
10. CONTAINER TERMINAL OPERATION BULDING
11. CONTAINER ADMIN. BUILDING
12. CONTAINER TERMINAL SUBSTATION
13. RTG WASHING AREA
14. CONTAINER WORKSHOP
15. BULK ADMIN. BUILDING
16. BULK CANTEEN / WORKSHOP
17. PARKING AREA
18. BULK STOCKPILES
19. CONTAINER STACKING AREA
20. CONTAINER BERTHS 4500m LONG
21. MULTIPURPOSE BERTHS 590m LONG
22. COAL BERTHS 300m LONG
23. LIQUID BERTHS
24. COASTAL BERTH 400m LONG
25. TURNING CIRCLE 800Ø
26. APPROACH CHANNEL 280m WIDE
27. SOUTHERN BREAKWATER 6440m LONG
28. SOUTHERN BUND 1960m LONG
29. NORTHERN BREAKWATER 4650m LONG
30. NOTHERN BUND 3450m LONG

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

RECOMMENDED LAYOUT MASTER PLAN

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1007 REV. 0

SCALE IN METRES 1:15000

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm

Project Management Initials: Designer: SV Checked: AM Approved: SG

Last saved by: BHANOTV(2016-02-04) Last Plotted: 2015-10-29
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ISO A1 594mm x 841mm
Approved: SG
Checked: AM
Designer: SV
Project Management Initials:

Last saved by: BHANOTV(2016-02-04) Last Plotted: 2015-10-29
Filename: F:\PROJECTS\2015\05-PORTS\DELD15005 SAGARMALA\06_CAD (O)\20-SHEETS\DHANU_VADHVAN\DELD15005-DRG-10-0000-CP-VAD1008.DWG

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. PARKING
5. REVETMENT WORK
6. PORT BACKUP AREA
7. ENTRY / EXIT GATE CANOPY
8. RECIEVING STATION
9. COVERED SHEDS FOR BULK HANDLING
10. CONTAINER TERMINAL OPERATION BULDING
11. CONTAINER ADMIN. BUILDING
12. CONTAINER TERMINAL SUBSTATION
13. RTG WASHING AREA
14. CONTAINER WORKSHOP
15. BULK ADMIN. BUILDING
16. BULK CANTEEN / WORKSHOP
17. BULK STOCKPILES
18. CONTAINER STACKING AREA
19. CONTAINER BERTHS 3150m LONG
20. MULTIPURPOSE BERTHS 590m LONG
21. TURNING CIRCLE 800Ø
22. APPROACH CHANNEL 280m WIDE
23. SOUTHERN BREAKWATER 6440m LONG
24. SOUTHERN BUND 1960m LONG
25. NORTHERN BREAKWATER 1760m LONG

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- PORT BACKUP AREA

NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; INDIAN PORTS ASSOCIATION

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: RECOMMENDED LAYOUT PHASE 1

SHEET 1 OF 1

Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1008 REV. 0

SCALE IN METRES 1:15000 (500m 250 0 250 500m)

AECOM India Pvt. Ltd.

KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. ENTRY / EXIT GATE CANOPY
8. RECIEVING STATION
9. COVERED SHEDS FOR BULK HANDLING
10. CONTAINER TERMINAL OPERATION BULDING
11. CONTAINER ADMIN. BUILDING
12. CONTAINER TERMINAL SUBSTATION
13. RTG WASHING AREA
14. CONTAINER WORKSHOP
15. BULK ADMIN. BUILDING
16. BULK CANTEEN / WORKSHOP
17. PARKING AREA
18. BULK STOCKPILES
19. CONTAINER STACKING AREA
20. CONTAINER BERTHS 3150m LONG
21. MULTIPURPOSE BERTHS 590m LONG
22. COAL BERTHS 300m LONG
23. TURNING CIRCLE 800Ø
24. APPROACH CHANNEL 280m WIDE
25. SOUTHERN BREAKWATER 6440m LONG
26. SOUTHERN BUND 1960m LONG
27. NORTHERN BREAKWATER 1760m LONG
28. REVETMENT WORK

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

RECOMMENDED LAYOUT PHASE 2

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1009

REV. 0

AECOM

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm

Approved: SG

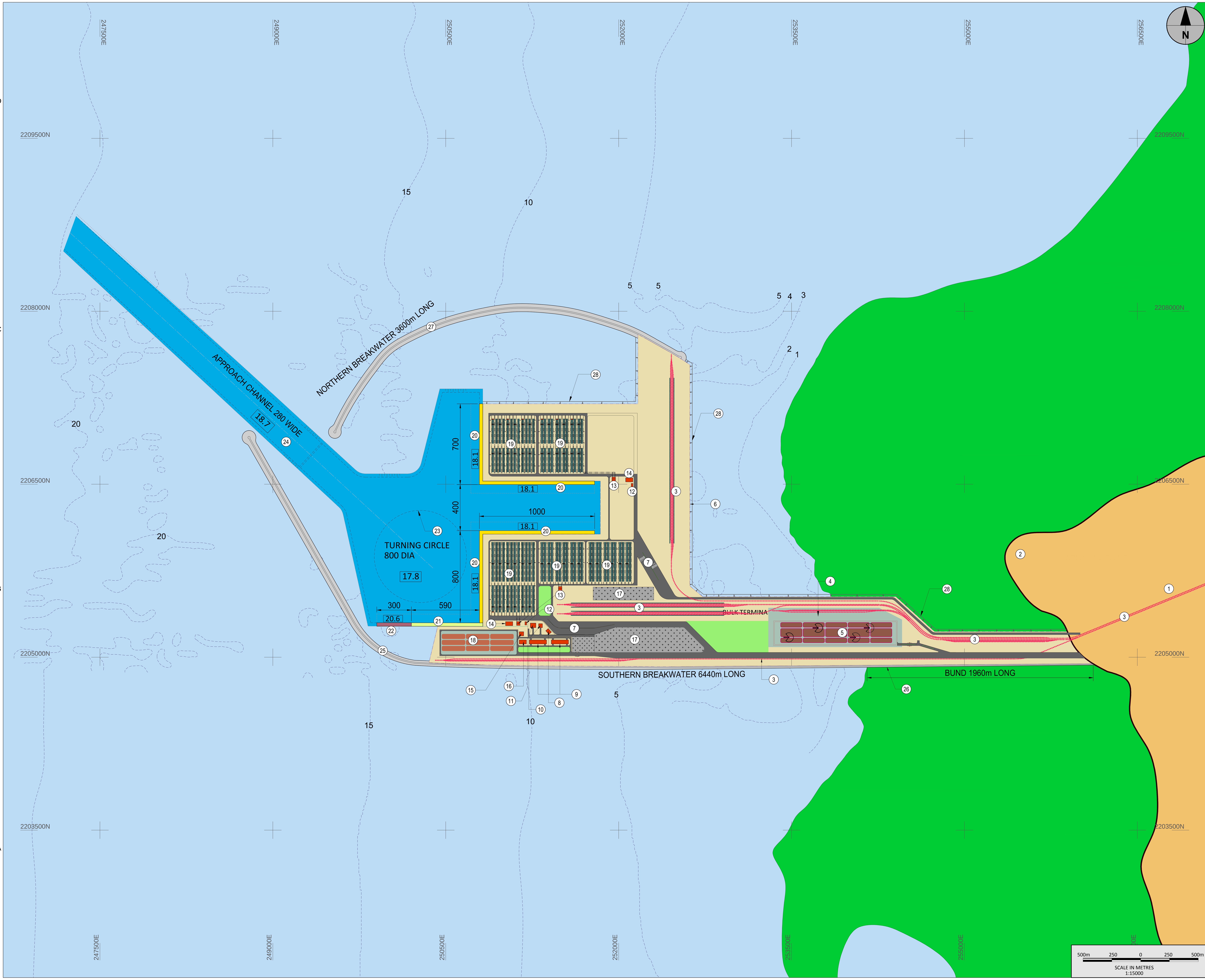
Checked: AM

Designer: SV

Project Management Initials:

Last saved by: BHANOTV(2016-02-03) Last Plotted: 2015-10-29

Filename: F:\PROJECTS\2015\05-PORTS\DELD15005 SAGARMALA\06_CAD (O)\20-SHEETS\DHANU_VADHVAN\DELD15005-DRG-10-0000-CP-VAD1009.DWG



KEYNOTES

1. DAHANU TOWN
2. VADHAVAN POINT
3. PROPOSED RAILWAY LINE
4. COAL HANDLING BACKUP AREA
5. COAL STOCKPILES
6. PORT BACKUP AREA
7. ENTRY / EXIT GATE CANOPY
8. RECIEVING STATION
9. COVERED SHEDS FOR BULK HANDLING
10. CONTAINER TERMINAL OPERATION BULDING
11. CONTAINER ADMIN. BUILDING
12. CONTAINER TERMINAL SUBSTATION
13. RTG WASHING AREA
14. CONTAINER WORKSHOP
15. BULK ADMIN. BUILDING
16. BULK CANTEEN / WORKSHOP
17. PARKING AREA
18. BULK STOCKPILES
19. CONTAINER STACKING AREA
20. CONTAINER BERTHS 3500m LONG
21. MULTIPURPOSE BERTHS 590m LONG
22. COAL BERTHS 300m LONG
23. TURNING CIRCLE 800Ø
24. APPROACH CHANNEL 280m WIDE
25. SOUTHERN BREAKWATER 6440m LONG
26. SOUTHERN BUND 1960m LONG
27. NORTHERN BREAKWATER 3600m LONG
28. REVETMENT WORK

LEGENDS:

- CONTAINER BERTHS
- MULTIPURPOSE BERTHS
- COAL BERTHS
- COAL BACKUP AREA
- PORT BACKUP AREA

NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

RECOMMENDED LAYOUT PHASE 3

SHEET 1 OF 1

Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1010

REV. 0

AECOM

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm

Approved: SG

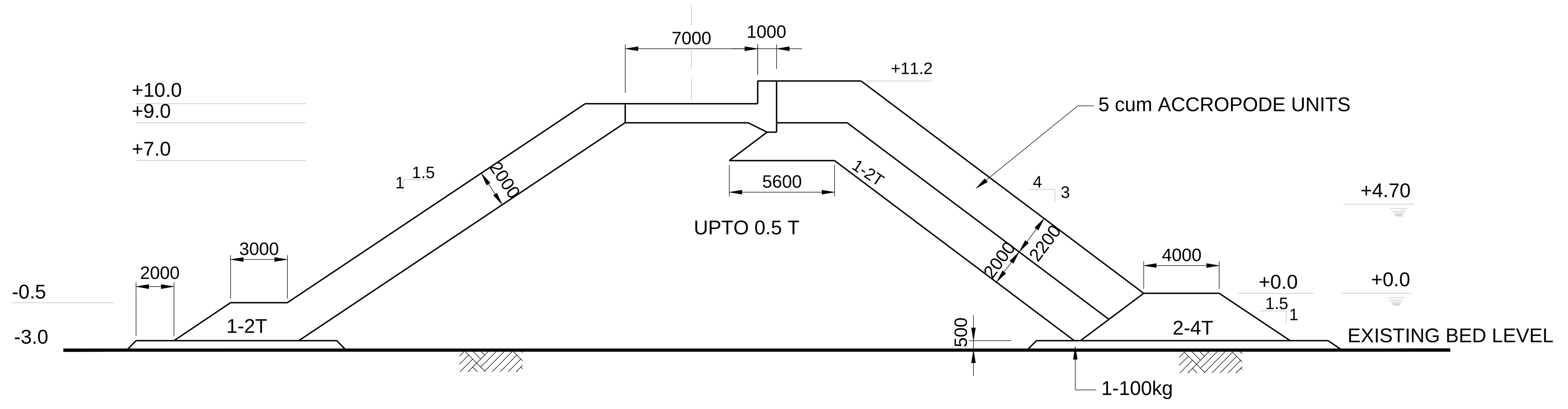
Checked: AM

Designer: SV

Project Management Initials:

Last saved by: BHANOTV(2016-02-04) Last Plotted: 2015-10-29

Filename: F:\PROJECTS\2015\05-PORTS\DELD15005 SAGARMALA\06_CAD (O)\20-SHEETS\DHANU_VADHAN\DELD15005-DRG-10-0000-CP-VAD1010.DWG



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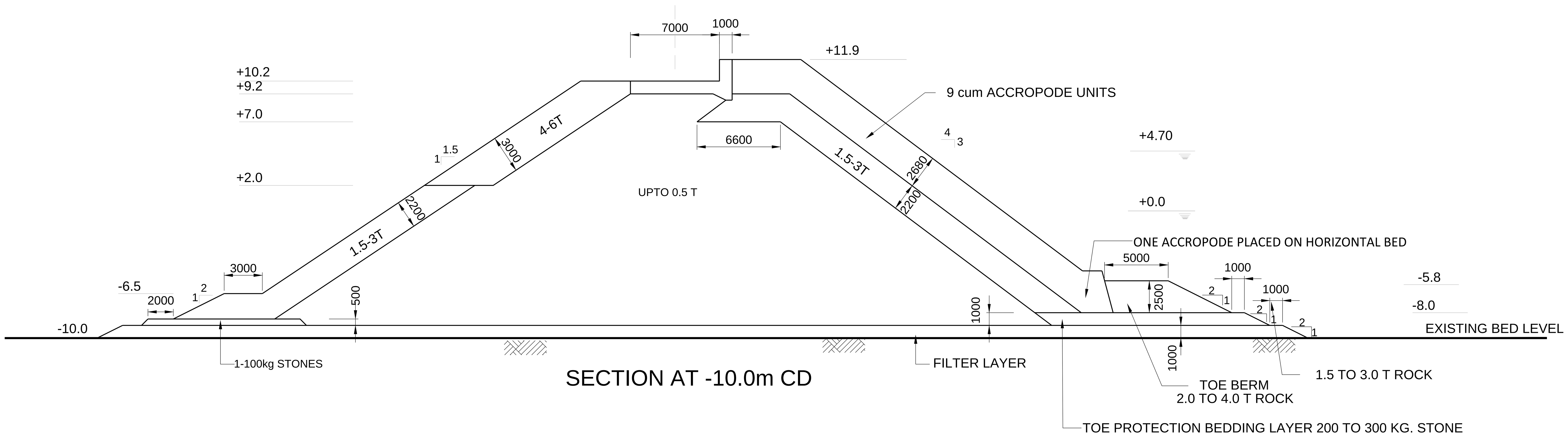

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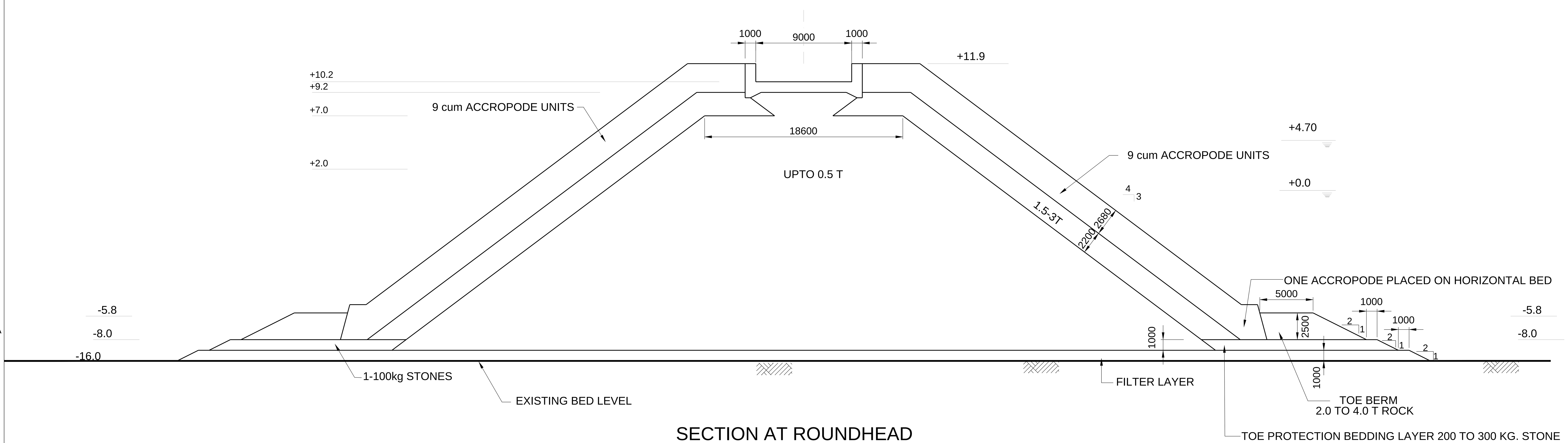


SECTION AT ROUNDHEAD

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

DETAILS OF BREAKWATER

SHEET 1 OF 1

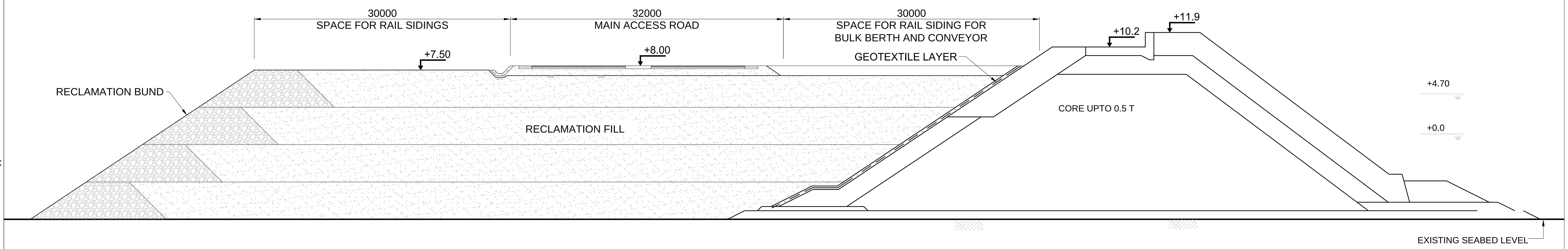
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1011

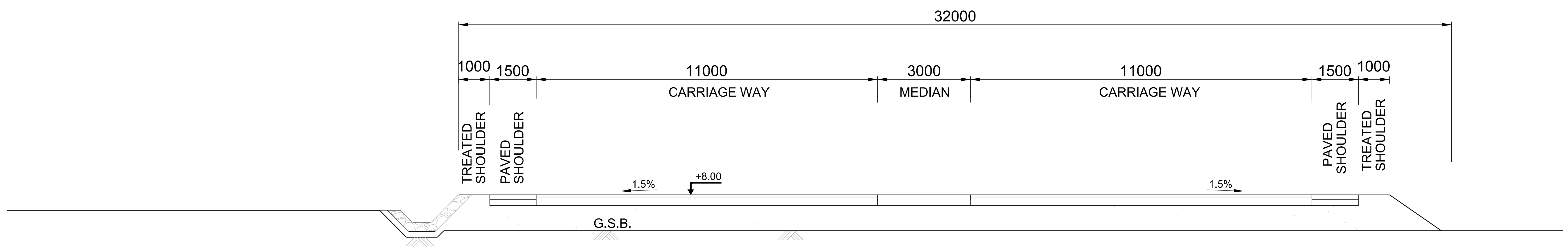
REV. 0

AECOM

AECOM India Pvt. Ltd.



TYPICAL CROSS SECTION MAIN PORT ACCESS CORRIDOR



TYPICAL SECTION OF MAIN ACCESS ROAD TO PORT

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping
Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF PORT ACCESS CORRIDOR

SHEET 1 OF 1

Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1012

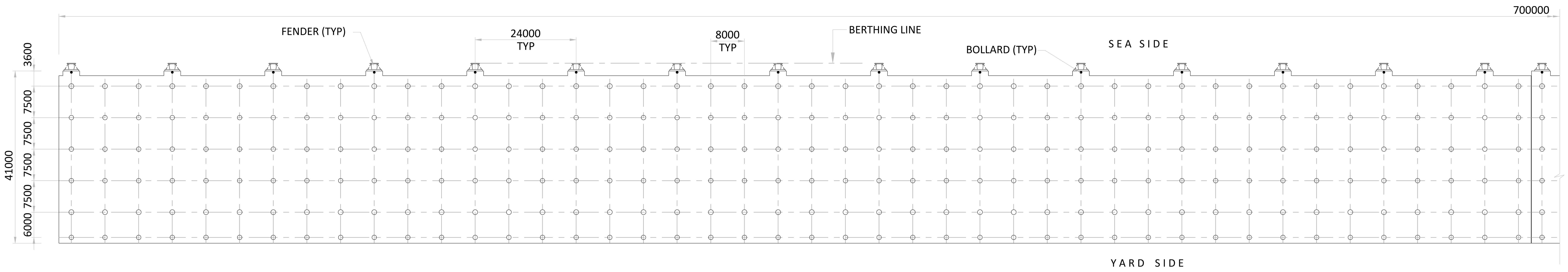
REV.: 0

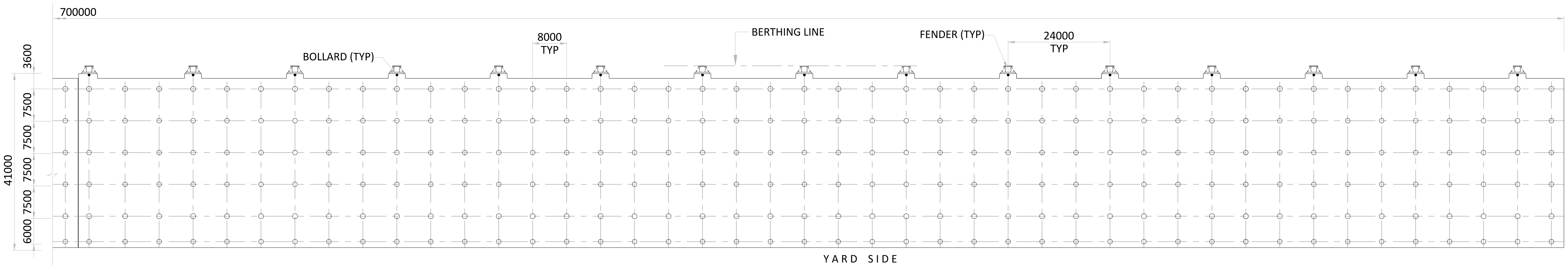
AECOM India Pvt. Ltd.

NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.





REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

PILE LAYOUT OF CONTAINER BERTH

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1013

REV. 0

AECOM

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm

Approved: SG Checked: AM Designer: SV Project Management Initials:

Last saved by: VERMAS2(2015-12-01) Last Plotted: 2015-10-29
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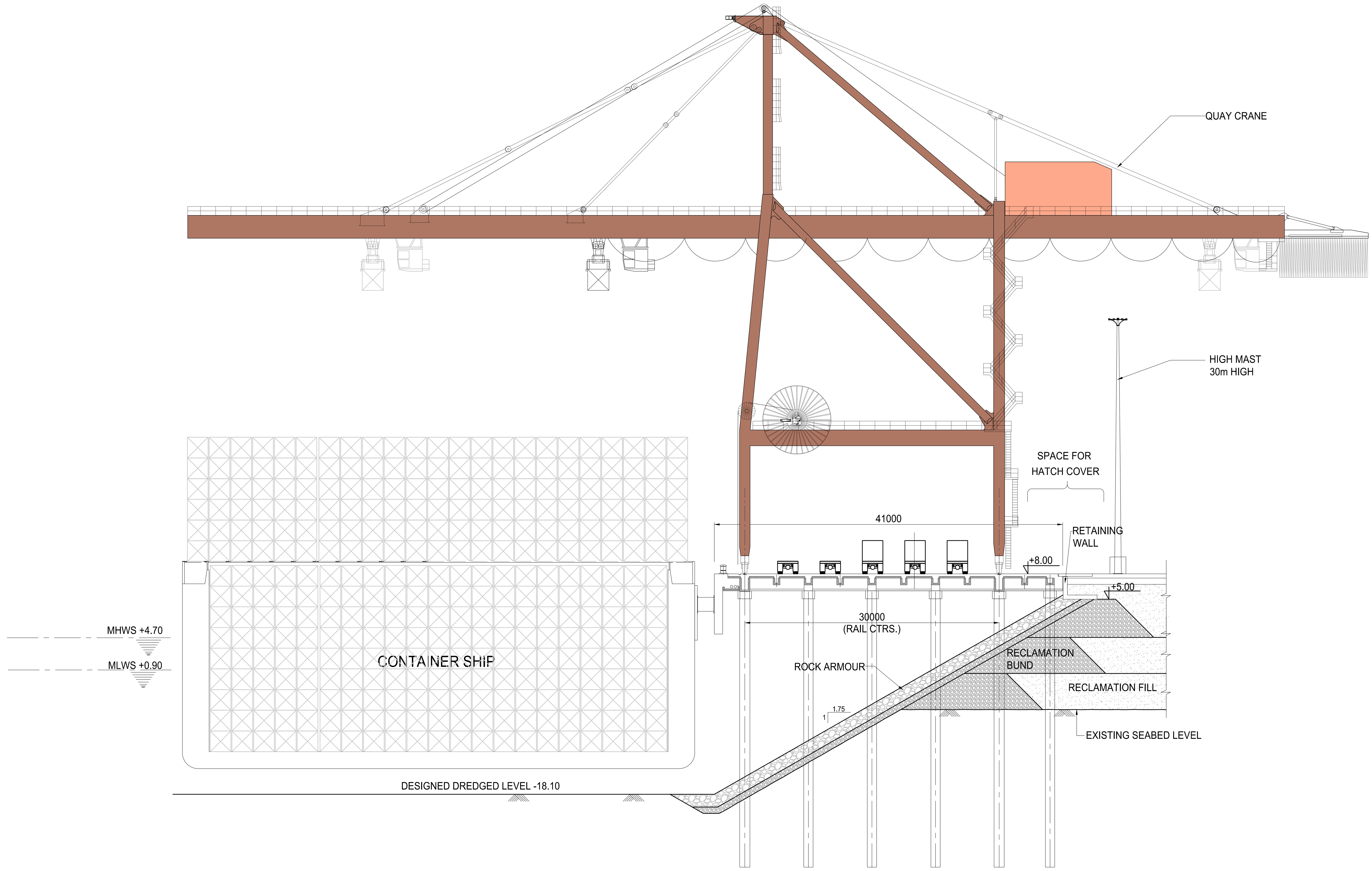

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF CONTAINER BERTH

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1014 REV. 0

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm
Project Management Initials: Designer: SV Checked: AM Approved: SG
Last saved by: VERMAS2(2016-02-07) Last Plotted: 2015-10-29
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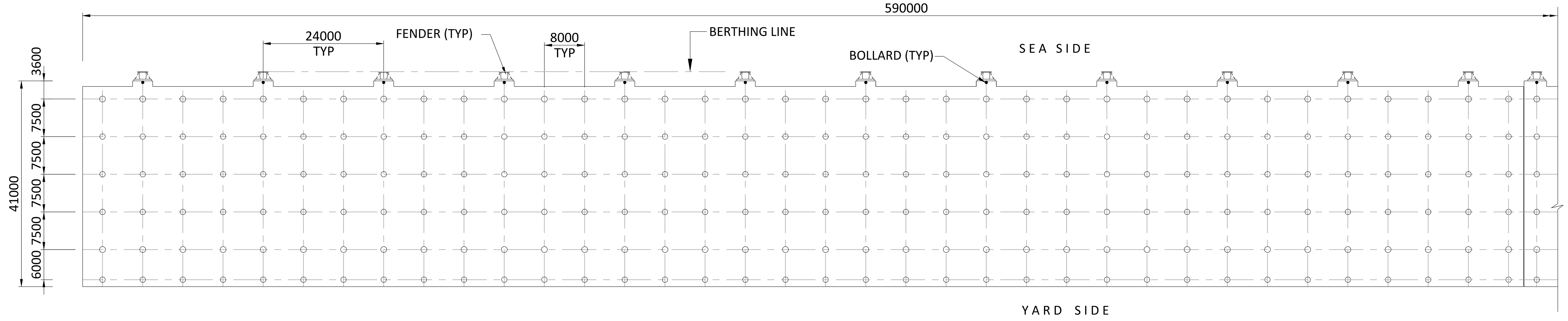

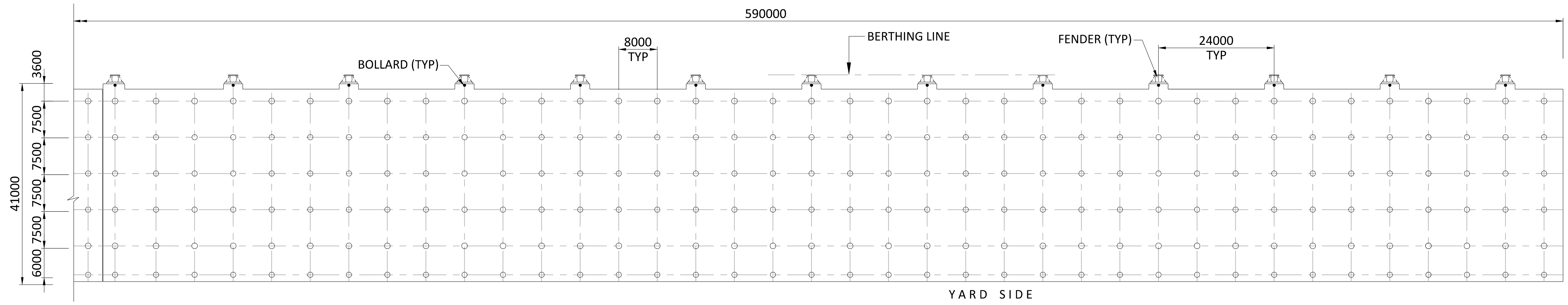

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping
Government of India

PROJECT:
SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:
PILE LAYOUT OF MULTIPURPOSE BERTH

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1015

REV. 0

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm
Approved: SG
Checked: AM
Designer: SV
Project Management Initials:

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Project Management Initials: Designer: SV Checked: AM Approved: SG ISO A1 594mm x 841mm

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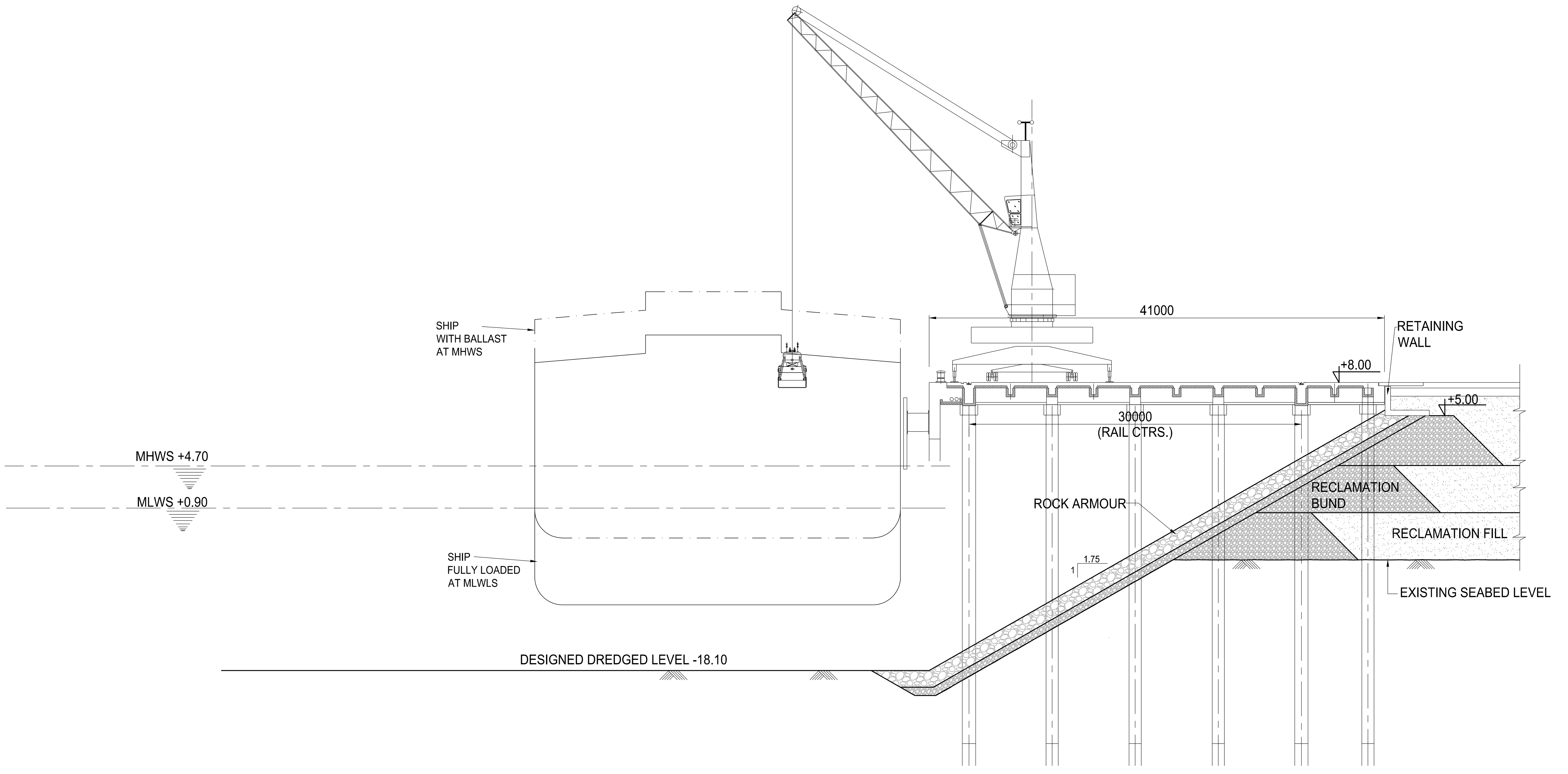
Filename: D:\PROJECTS\DHANU_VADHVAN\DELD15005-DRG-10-0000-CP-VAD1016.DWG

NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.



REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF MULTIPURPOSE BERTH

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1016

REV. 0

AECOM India Pvt. Ltd.

NOTES:-

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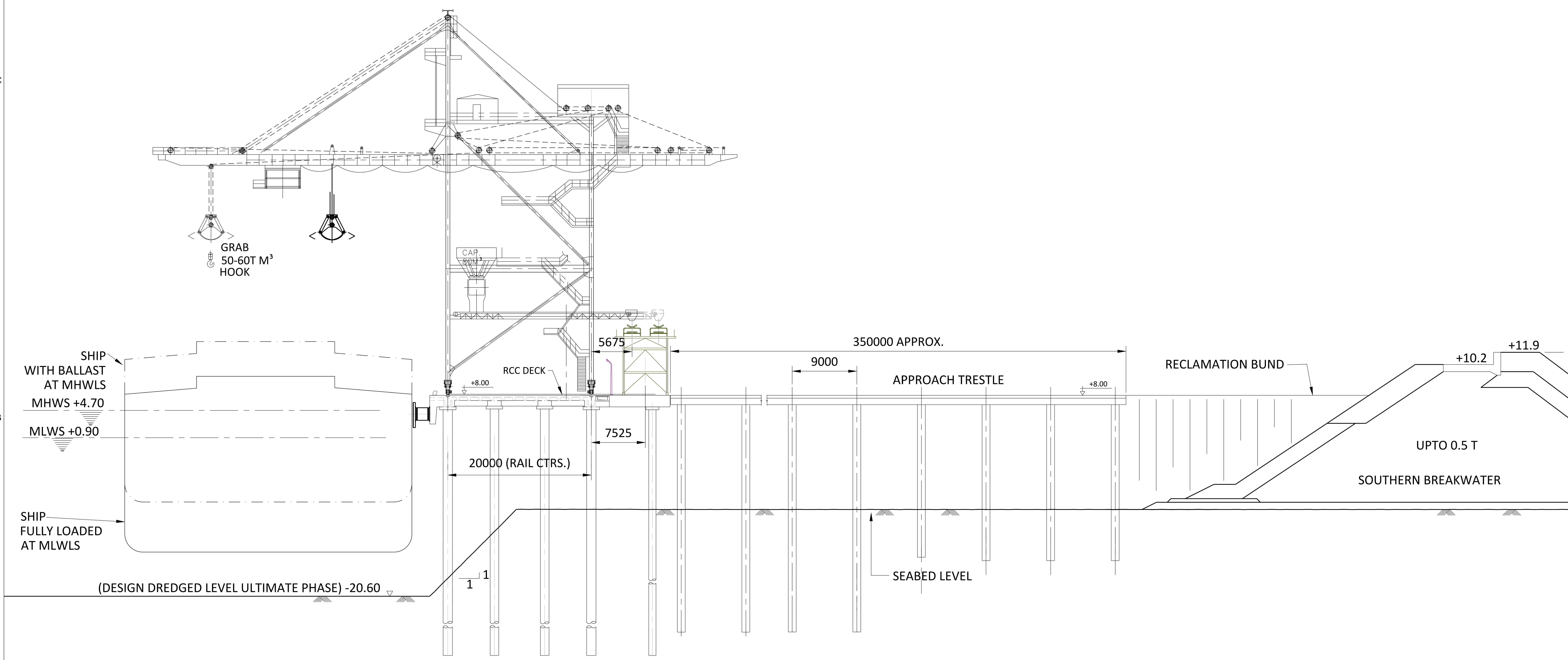
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.



REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF FUTURE BULK BERTH

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1017

REV.: 0

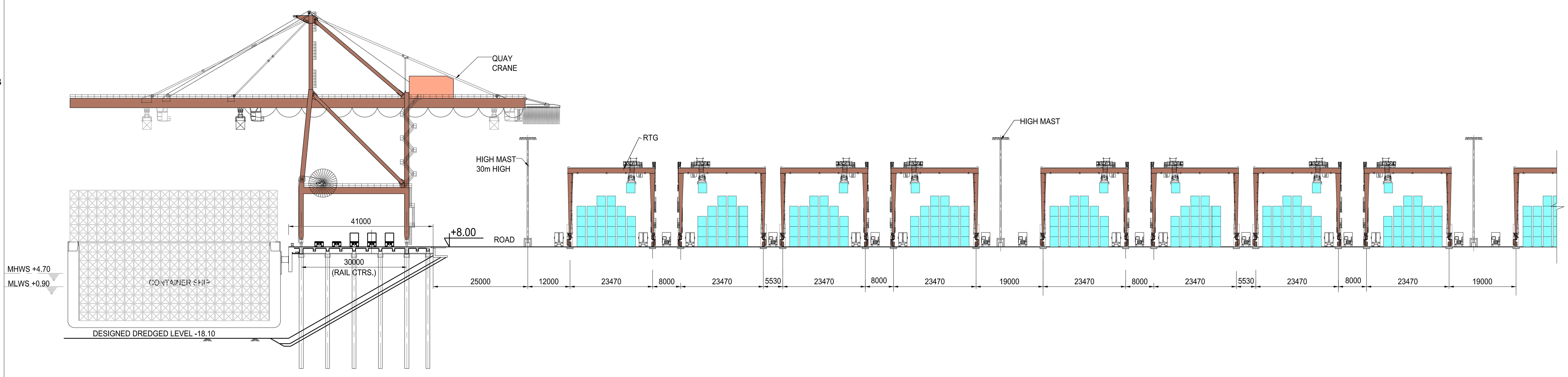
AECOM

AECOM India Pvt. Ltd.

NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.



REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF CONTAINER YARD

SHEET 1 OF 1

Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1018

REV. 0

AECOM

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm

Project Management Initials: Designer: SV Checked: AM Approved: SG

Last saved by: VERMAS2(2016-02-07) Last Plotted: 2015-10-29
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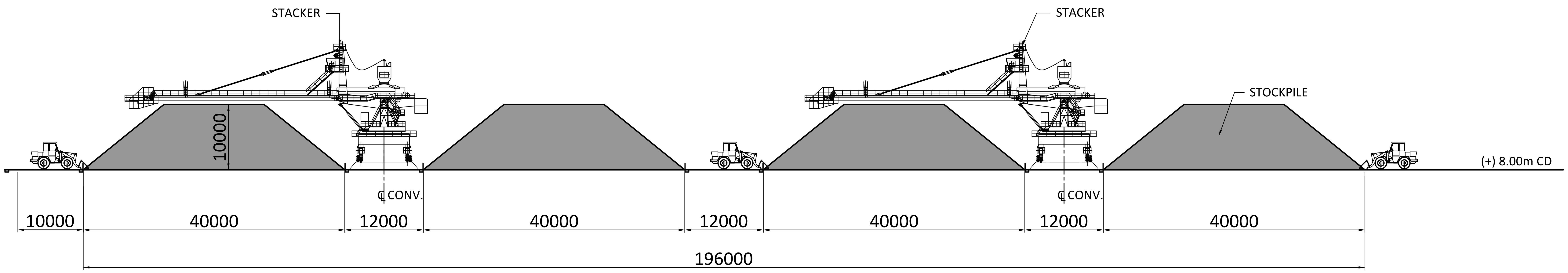


NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping
Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF COAL STACKYARD

SHEET 1 OF 1

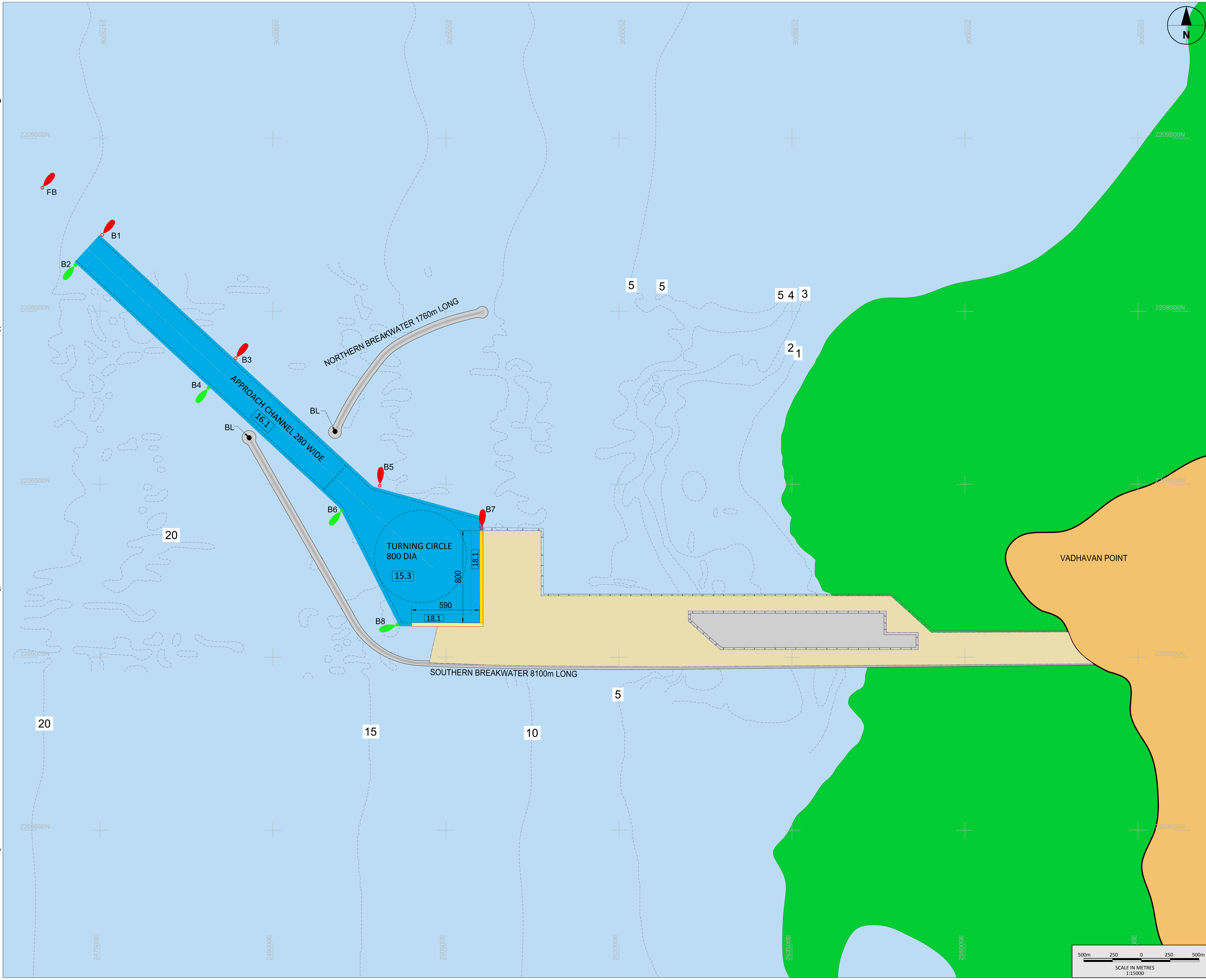
Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1019

REV. 0

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm
Project Management Initials: Designer: SV Checked: AM Approved: SG
Last saved by: VERMAS2(2015-12-01) Last Plotted: 2015-10-29
Filename: D:\PROJECTS\DHANU_VADHVAN\DELD15005-DRG-10-0000-CP-VAD1019.DWG



LEGEND:

- B1... CHANNEL MARKING BUOY
- FB FAIRWAY BUOY
- BL BEACON LIGHT

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1		ORIGINAL ISSUE			

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; INDIAN PORTS ASSOCIATION

PROJECT:
SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT VADHAVAN

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:
LAYOUT OF AIDS TO NAVIGATION

SHEET 1 OF 1

Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-11-2015	Date: 30-11-2015	Date: 30-11-2015
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-VAD1020

REV. 0

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