Final Report for Sagarmala (Vol. VI)

Ministry of Shipping, Indian Ports Association

November 2016

Technical Notes

- A&N Combined Note
- Evaluation of Tajpur Port-R1
- Pondicherry Feeder port
- Port in Central AP_Vadarevu Naraspur Evaluation Note
- Project Report for Mechanized Fertilizer Terminal at Kandla
- Technical Note-Oil Jetties & Associated Pipelines at Kandla Port

New Ports-Techno Economic Feasibility reports

- Dugarajapatnam
- Belekeri Port
- Sagar port
- Sirkazhi Port
- Vadhavan Port
- Paradip Outer Harbour

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Prepared for

Ministry of Shipping
Government of India

Ministry of Shipping / Indian Ports Association

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Review, revisions and approvals record

Name	**Date of submission**	**Approved by**
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“In 2015 the Ministry of Shipping instructed McKinsey & Company and AECOM to provide fact-based analysis and insights from best practice around the world into [potential future trends in container shipping, options for infrastructure and potential approaches to financing ports development].

The Ministry will evaluate this advice, along with inputs and advice from a variety of internal and external experts, and determine the most appropriate strategy to give effect to the Cabinet’s decision of 25 March, 2015. McKinsey’s advice, in the form of the following confidential report, was provided in November, 2016.

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The analyses and conclusions contained in this report are based on various assumptions have been developed with the Ministry of Shipping, which are subject to uncertainty. Nothing contained herein is or shall be relied upon as a promise or a representation. Neither McKinsey nor AECOM are investment advisors, and thus do~~es~~ not provide investment advice. This is not intended to serve as investment advice, and parties should conduct their own due diligence prior to making investment decisions.

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November 2016

Development Options (FTWZ, Transhipment Hub, Bunkering, Shipbreaking/ Building Yard, Cruise Facilities) at Andaman and Nicobar Islands

Technical Note

Prepared for

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1.0 Introduction

1.1 Background

The Andaman and Nicobar Islands are strategically important to the countries security and international trade due to its close proximity to East West Shipping line and Malacca Strait. These islands act as a barrier to Chinese progress into Bay of Bengal. Thus, it is prudent to develop these islands to not only safeguard national interest but also to provide source of livelihood to locals and also to connect them islands to other parts of the country.

The present technical note has been prepared to address this aspect and evaluates various options for developments across these Islands. A detailed review had been carried of all the proposals that were suggested in the past and based on the understanding and arguments presented for each case the following options are presented in this note:

- Free Trade and Warehousing Zones (FTWZ) at Andamans
- Transshipment Hub at Nicobar
- Shipyard at Nicobar
- Bunkering Hub at Nicobar
- Cruise tourism at Nicobar

1.2 Project Site

The Andaman and Nicobar Island, one of the seven union territories of India, are a group of islands at the juncture of the Bay of Bengal and Andaman Sea.

There are 572 islands in the territory having an area of 7,950 km^2. Of these, about 34 are permanently inhabited. The islands extend from 6° to 14° North latitudes and from 92° to 94° East longitudes. The Andaman islands are separated from the Nicobar group by a channel (the Ten Degree Channel) some 150 km wide. The highest point is located in North Andaman Island (Saddle Peak at 732 m). The Andaman group has 325 islands which cover an area of 6,170 km^2 while the Nicobar group has only 24 islands with an area of 1,765 km^2.

The capital of the union territory, Port Blair, is located 1,255 km from Kolkata, 1,200 km from Visakhapatnam and 1,190 km from Chennai. The northernmost point of the Andaman and Nicobar group is 901 km away from the mouth of the Hooghly River and 190 km from Myanmar. Indira Point at 6°45’10″N and 93°49’36″E at the southern tip of the southernmost island, Great Nicobar, is the southernmost point of India and lies only 150 km from Sumatra in Indonesia. The only volcano in India, Barren Island is located in Andaman and Nicobar.

1.3 Site Conditions

1.3.1 Meteorological Conditions

Andaman & Nicobar Islands climate is a warm tropical climate, with the presence of irregular rainfall during the south-west monsoon. According to the climate data of IMD (1960 – 1991) the humidity of Port Blair was found to vary between 65% and 85%. The maximum and minimum temperature does not present much variation in the year. April was found to be the hottest month with a temperature of 32.5°C while 29.5°C was the lowest daily maximum temperature recorded during January.

The annual rainfall is about 3000 mm where June, July and August receive the maximum rainfall.

The average wind speed at Port Blair was measured to be little under 11 kmph (3 m/s), while wind was found to be as high as 19.5 kmph during monsoon months. During the months of May to August, S, SW and W is the predominant sector, months of April, September and October are transient months while N, NE and E are prominent direction for the months between November to March.

1.3.2 Tide

The tidal levels observed at the South Bay (Galatea, Close of Port Blair on North) with respect to Chart Datum of admiralty chart were observed to vary between 0.2 m to 1.6 m with a tidal range of 1.4 m.

- Mean Highest Water Spring : + 1.6 m
- Mean Highest Water Neap : + 1.1 m
- Mean Sea Level : + 0.9 m
- MLWN : + 0.7 m
- MLWS : + 0.2 m

1.3.3 Wave Conditions

Based on the analysis of the ship observed data in the previous studies carried out by Andaman and Lakshadweep Harbour Works (ALHW), 65% waves approach from the S-W quadrant and the harbour needs protection from these waves, 22% waves approach from E-NE quadrant and the bay is naturally protected from these waves. The wave rose diagram at this site is as shown in **Figure 1.1**.

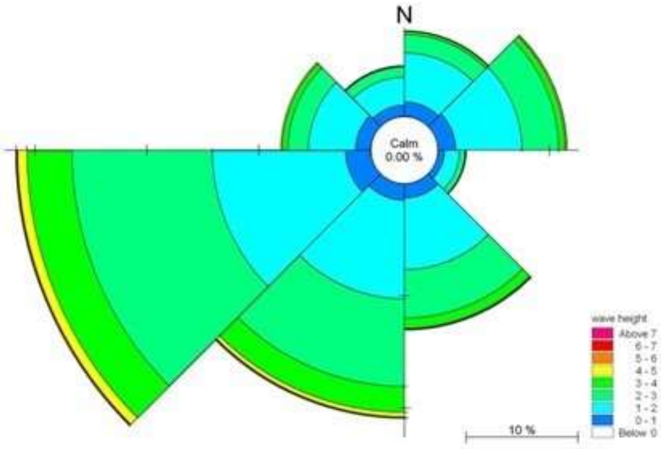


Figure 1.1 Wave Rose Diagram at South Bay, Great Nicobar Island

1.4 Environmental Setting

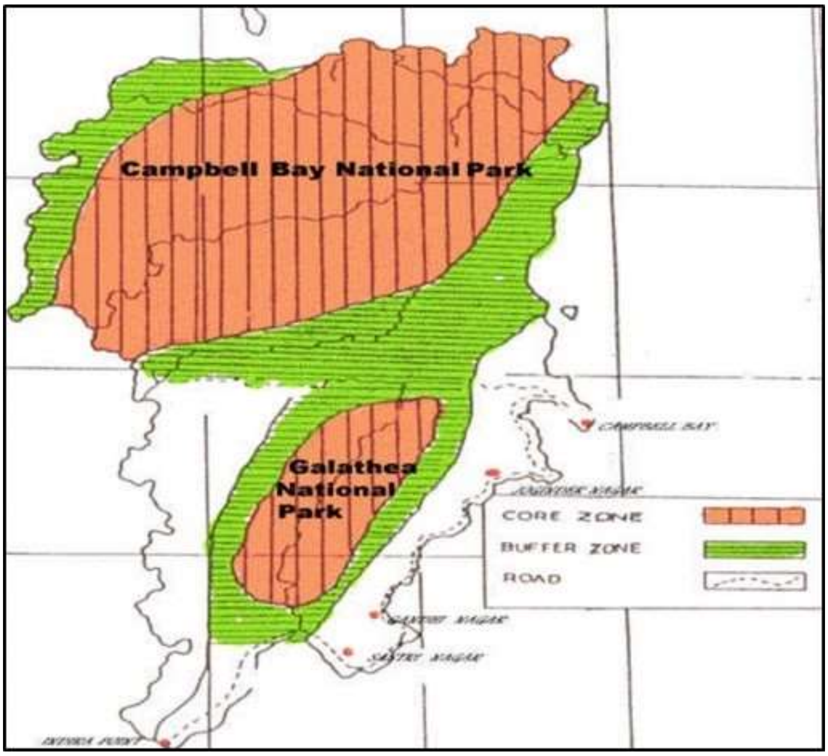
Andaman and Nicobar islands are rich in biodiversity and about 84% of the islands' geographical area is covered by Forests. These Islands have evergreen tropical rainforest canopy as well as with luxuriant mangroves and magnificent fringing coral reefs.

These islands are reported to have 2200 varieties of plants, which include 200 endemic species. About 50 varieties of forest mammals are found to occur in A&N Islands. Rat is the largest group having 26 species followed by 14 species of bats. These islands have about 225 species of butterflies and moths due to its pollution free and pristine environment.

Here it is important to mention that about 85% of the Nicobar Island was declared as Biosphere Reserve earlier in January, 1989 by India, which further was recognized as a World Biosphere Reserve by the United Nations Education, Scientific and Cultural Organization (UNESCO) in a convention held in Paris on 30 May, 2013.

The Great Nicobar Biosphere Reserve has a total core area of approximately 885 km2, surrounded by a 12 km wide "forest buffer zone". It also encompasses two National parks of India, which were gazette in 1992: the larger Campbell Bay National Park and Galathea National Park.

A limited area of about 6 km between Indira Point and boundary of Galathea National Park towards South Bay is left out of reserves boundary for any development. However, any new development will require permission from National Board for Wild life (NBWL) as entire region falls within 10 km radius.



Source: http://forest.and.nic.in/frst-greatnicobarbiospherereserve1.htm

Core and Buffer Zone of Great Nicobar Biosphere Reserve

The A&N Islands are not only significant from environmental point of view but also have indigenous population, thus any development should have limited foot print. Any proposed maritime related development on this island must address that Nicobar Island is strategically important for Nations security and must have least impact on the ecological diversity.

2.0 Free Trade Warehousing Zone at Andaman

2.1 Introduction

FTWZ is the policy of the Government of India announced in the Foreign Trade Policy 2004-09 to setup Free Trade and Warehousing Zones. The objective of the policy is to create trade related infrastructure to facilitate EXIM of good and services with freedom to carry out trade transactions in free currency. On June 23, 2005, the Parliament of India passed the Special Economic Zones Act 2005 and on February 10, 2006 Government of India notified Special Economic Zone Rules 2006. The Free Trade and Warehousing Zones (FTWZ) is a special category of Special Economic Zone and is governed by the provisions of the SEZ Act and the Rules.

A FTWZ is designated as a deemed foreign territory and is envisaged to be an integrated zone for use as an international trading hub. It would have fully integrated mega-trading hubs integrated with state-of-the-art warehouse and storage infrastructure, CFSs, rail connectivity with hinterland, commercial complexes for offices, etc. The Free Trade & Warehousing Zones are deemed foreign territory in India and enjoy tax benefits of the goods handled there. Apart from tax exemption, there are a number of benefits from FTWZ.

- Custom Duty exemption of re-export of imported goods as duty is not applicable till the goods exit FTWZ to a location within a domestic tariff area in India.
- Income tax (section 80IA) and Service Tax exemptions for developers and users of the zone.
- No service tax is applied on the activities carried out in FTWZ.
- Excise duty exemption for products sourced from the domestic markets, including goods, spares, DG sets, packing materials, etc.
- Foreign exchange transaction capability.
- Allows for a storage time of 2 years as against 90 days at CFS and ICD
- Assist in meeting specific warehousing requirement for each product category.
- Cost effective shared warehousing and handling equipment.
- Duties are to be paid on good leaving the FTWZ only hence a bulk inventory may be stored at FTWZ and taxes may be paid as when material is taken out to save immediate cost.
- Availability of temporary storage facilities to enable users to meet short term demand without incurring significant costs (e.g. leasing space for a year to meet 2/3 months demand)
- Benefits to Region / State, i.e., export facilitation, FDI inflow, Employment generation.

These zones are strategically located and offer quicker regulatory clearances, tax and duty incentives, flexibility, visibility and reduced working capital expenses.

Proposals for setting up FTWZs may be made by public sector undertakings, public limited companies or by joint ventures in technical collaboration with experienced infrastructure developers. The FTWZ scheme envisages duty free import of all goods for warehousing. Such goods shall be permitted to be re-sold/re-invoiced or re-exported. Packing or re-packing without processing and labelling as per customer requirement could be undertaken within the FTWZ. FTWZ would be a key link in the global supply chain servicing both India and the world.

2.2 Demand Drivers

The concept of FTWZ is very promising but it requires some of the following drivers for its success (**Figure 2.1**).

- Cargo in the hinterland
- Cargo growth potential in future
- Good connectivity to hinterland and ports
- Proximity to international gateway
- Availability of manpower and services

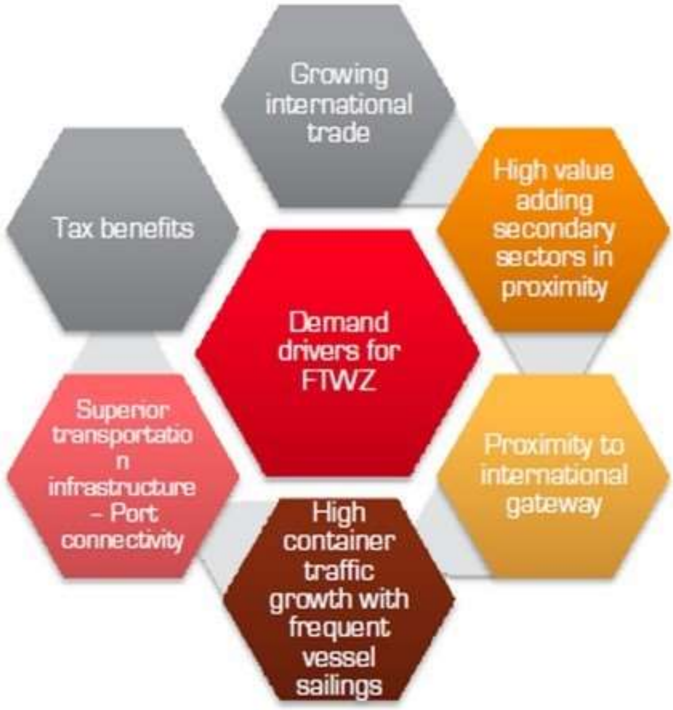


Figure 2.1 Demand drivers for FTWZ

2.3 Potential of FTWZ at Andaman Islands

Port Blair city is the capital of Andaman and Nicobar Islands and is governed by Municipal Corporation. The total urban population of the city is 108,058 as per the Census of 2011. Total males and female population is 57,761 and 50,297 respectively, where about 93% males and 87% females are literate. Total working population is 44,006, where 34,879 males and 9,127 females are working. As such limited manpower is available.

A&N Islands had container traffic of ~32,000 TEUs in 2013-14. Considering a 5% CAGR, the container cargo traffic is expected to reach ~45,000 TEUs by 2020. In addition to this, other break bulk cargo traffic was ~490,000 T in 2013-14 which is expected to reach ~690,000 T by 2020 (assuming a CAGR of 5%). Considering the limited export oriented cargo generated in A&N hinterlands, potential for development of FTWZ is limited. Other locations in India with sufficient existing infrastructure and access to cargo generating hinterlands might be better candidates for development of FTWZ as compared to Andaman.

3.0 Development Options at Nicobar Islands

3.1 General

The Great Nicobar Island is situated south of the neighbouring Andaman Islands archipelago, and is located about 170 km northwest of the Indonesian island of Sumatra. The Great Nicobar is the largest of the Nicobar Islands of India.

The Great Nicobar Island is strategically located equidistant from Colombo, Port Klang and Singapore and is also very close to the East – West international shipping corridor. The location map of Great Nicobar with respect to international shipping line is shown in **Figure 3.1**.

Figure 3.1 Internation Shipping Route vis a vis Great Nicobar Island

In order to take advantage of the proximity of Great Nicobar Island to the international shipping route, possibilities have been evaluated to develop the following port related activity on this island.

- Transshipment Hub
- Shipyard, Dry Dock and Ship Repair (Navy and others)
- Bunkering Hub
- Cruise tourism
- Tourism/Cruise facilities

3.2 Potential for Potential of Transshipment Hub at Great Nicobar

3.2.1 General

Transhipment is the shipment of containers to an intermediate destination where they are transhipped onto another vessel before being sent to the final destination. Globally, there are two models of transhipment – hub and spoke transhipment and relay transhipment.

- Hub and spoke involves transhipment from a smaller "feeder" vessel into a larger "mainline" vessel.
- Relay involves transhipment between two large mainline vessels.

A successful transhipment port must satisfy the following key requirements:

- Minimum deviation from the east–west trade route followed by international liners so that it is cost-effective and does not disrupt their network planning
- Improved operating environment
  - Operating efficiency and turnaround times on par with the best transhipment ports such as Singapore
  - Potential to spread the infrastructure cost for creating the transhipment port over additional traffic items (e.g., bulk)
- Adequate physical infrastructure
  - Deep draft to allow large vessels to call on the port
  - Adequate handling capacity in the port
- Supporting legal framework

3.2.2 Traffic

Container traffic in India has grown by more than 10% in the last decade and is expected to reach ~25 MTEUs by 2025. However, ~25% of the container traffic destined for India in 2013-14 was transshipped at international ports like Colombo, Singapore, Klang, etc. which fall on the east-west trade route. This results both in additional cost for trade in India and the Indian ports losing out on potential revenue.

Deviation from the main sailing route is the key determinant for the transshipment hub location. Other important factors include domestic cargo traffic, presence of deep draft, efficiency of operations and linkages to cost-efficient feeder networks.

Great Nicobar is one of the contending locations amongst others like Vizhinjam, Enayam, Cochin, etc. for being developed as the transshipment hub. Great Nicobar's detour from the east-west trade route (which accounts for 80% of India's current container transshipment cargo) is comparable to that of other potential locations like Vizhinjam and Enayam (30 nm for Great Nicobar as compared to 10 nm for Vizhinjam and 8 nm for Enayam). Campbell Bay is the non-major port in Great Nicobar which handled 66,000 T of cargo in 2013-14 majority of which was coastally moved to the hinterland.

However, the major disadvantage for Great Nicobar as a potential transshipment hub is the scale of domestic cargo. All the ports in A&N Islands combined had container traffic of only ~32,000 TEUs in 2013-14 (0.3% of the total EXIM container traffic in India). Clearly, the domestic cargo traffic is miniscule as compared to that in other contending locations like Vizhinjam and Enayam. Enayam, located on the south-west coast of India at about 14 nautical mile deviation from the east-west trade route and has the advantage of attracting traffic from container generating hinterlands of Tamil Nadu, Kerala and southern Andhra Pradesh and Karnataka. Substantial transshipment cargo originating in the hinterland and the possibility of converting the present transshipment cargo to gateway cargo is the major advantage that works in favor of transshipment hubs in southern tip of India than Nicobar Island.

3.2.3 Locations

Many alternative locations along the coast of Great Nicobar, as shown in **Figure 3.2,** were considered in the previous prefeasibility studies for transhipment port.

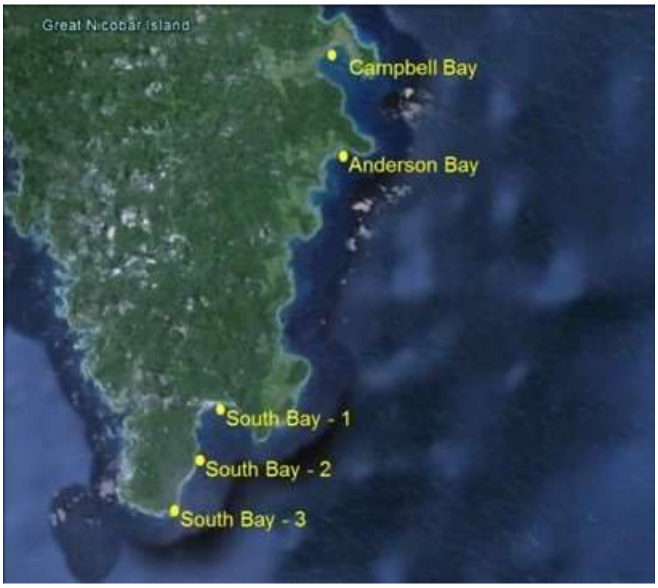


Figure 3.2 Alternative Locations for Citing of Port

The key challenge for developing a port are mainly identified as restricted area, proximity to naval facilities, poor connectivity and environmental issues.

3.3 Potential of Shipyard at Great Nicobar

India currently accounts for only ~0.45 per cent of the global shipbuilding market. Shipbuilding is a cyclical industry and is currently on a downturn with excess capacities globally. After the peak in deliveries in 2011, the industry's output is decreasing and reached 91.2 MDWT in 2014. However, strong demand is expected in the long term, driven by shipping companies' move towards ultra-large vessels, demolition of old vessels fleet and growth in global exports. India, supported by the recent policies and initiatives instituted by the Union Government for the development of the shipbuilding sector could target 3-4 MDWT shipbuilding industry by 2025. Opportunity in defence sector, growth in coastal shipping and replacement of existing vessel fleet could be the drivers of growth of the shipbuilding industry in India.

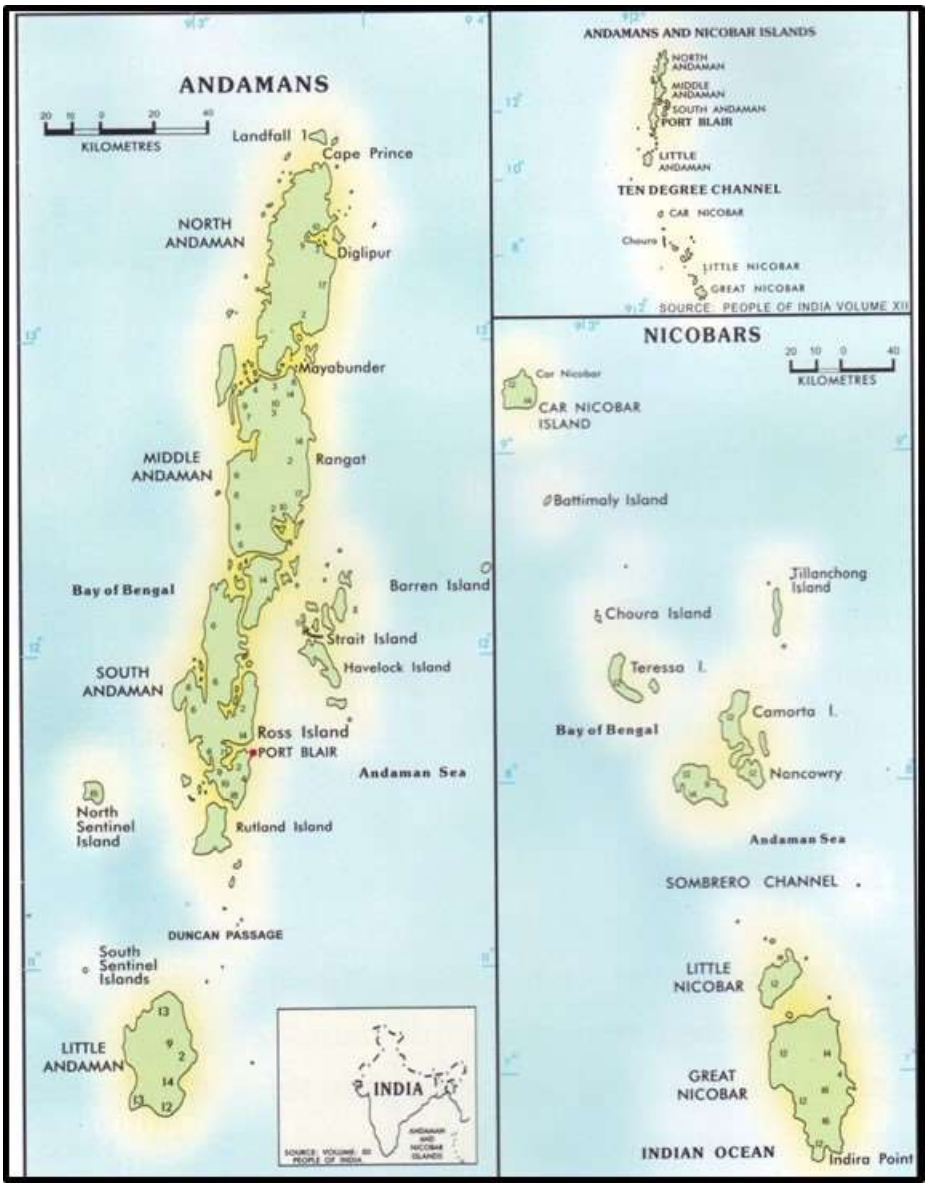
Great Nicobar can be one of the potential locations that can be evaluated for the development of shipbuilding yard along with other contending locations like Gujarat and Tamil Nadu. Amongst the different factors required for the development of a marine cluster, the most important ones are presence of ancillary units, availability of skilled labour and proximity to sources of materials like steel. As compared to other contending locations, Great Nicobar is at a disadvantage as is does not have an established base of ancillary units and steel manufacturing unit/s. Gujarat already has shipyards linked to ports of Pipavav, Dahej and Hazira while Tamil Nadu has a large shipyard in Katupalli. The marine clusters at locations like Gujarat and Tamil Nadu can leverage the existing ecosystem for shipbuilding. Hazira steel plant and proposed steel cluster in Northern Tamil Nadu can make these locations much more competitive as compared to Great Nicobar by saving on the logistics cost of moving steel. Consequently, ship repair also has limited potential for development in Great Nicobar.

3.4 Potential of Bunkering Hub at Great Nicobar

Great Nicobar would not make for an ideal bunkering hub considering both the demand and supply side factors. There would be less demand considering the limited number of stoppages of vessels at the location owing to small scale of domestic cargo. It would also not be cost effective for transit vessels to call at the port only for bunkering. Supply side factors are also not very favourable since establishment of a bunkering hub would involve setting up of infrastructure and additional logistics of bunker fuel from other refineries as Great Nicobar does not have any refining capacity of its own.

4.0 Tourism/Cruise facilities

At present most of the tourism activities are concentrated on Andaman Islands. Tourist reach Port Blair by air and from there travel by boats to other nearby islands like Havelock Island, Long Island, Neil Island etc.



Map of andaman and Nicobar Islands

Islands of Nicobar are still unexplored and large distances discourage the tourist to explore these exotic locations. Thus, it is prudent to provide some mode to cover long distance and yet making the journey enjoyable and comfortable. In this case, cruise tourism could be preferred choices for the following reasons:

- The Islands of Andaman and Nicobar are scattered over a large distance of 1000 km.
- Weather is favorable most of the year for year round cruise operations.
- A number of suitable itineraries and packages may be planned where tourist may not only sightsee magnificent scenic beauty but also enjoy activities like Beach-combing, sunbathing, scuba diving, sea walk, snorkeling, watersports, surf riding, swimming, game fishing, watching the sunset or sunrise, elephant ride, bird-watching, trekking, sailing, kayaking at various locations.
- There is a market for yachting around tropical islands. Phuket (which is actually close by) has much of this market today. This would need a decent international airport working though in the islands, so needs to be part of a broader plan.

It is suggested to develop cruise terminals along the route starting from Port Blair and ending at Great Nicobar (distance of 500 -600 km). The islands could also be positioned as an exotic stopover for cruises from/around Thailand. As against any other development, tourism is permitted within the buffer zone of Great Nicobar Biosphere Reserve and excursions may be planned for tourists to explore the rich biodiversity of the island.

Most basic facilities required for any cruise terminal are berthing facilities, customs and immigration counters, luggage counter, public address system, drinking water and modern toilets. A medium term target for a dedicated cruise terminal with separate Customs and Immigration set-ups is to be explored to expedite cruise journeys and make it a hassle free experience for the passengers as well as operators. While good berthing and ultramodern cruise terminals of international standards can remarkably enhance the cruise experience, it is the simplification of procedures for entry and exit of passengers, Customs, and CISF security checks that can truly make these trips enjoyable. This is something that the government does not have to invest much on. A review of the current processes can eliminate redundant practices making it easier and faster to reach at the same outcome without compromising on security.

A helipad may also be developed at Great Nicobar Island so as to provide greater flexibility to the tourists to transport people to either Port Blair or to any other Indian port while their return journey.

Making it happen

Infrastructure	➤ Development of world-class cruise terminals ➤ Development of supporting infrastructure in and around terminals for a comfortable tourist experience
Simplified processes	➤ Simplification of entry and exit process of passengers ➤ Hassle free customs and CISF security checks
Technology support	➤ Improvement in efficiency of information dissemination and management within and across ports ➤ Use of tools such as RFID, Advance passenger information system and PCS
Fiscal impetus	➤ Reasonable tax rates and duties ➤ Reasonable port charges arrived at by international benchmarking

5.0 Conclusions

This technical note evaluated many options that could be considered for development at Andaman and Nicobar Islands. Development of FTWZ and transhipment hub may not be a favourable option due to the insufficient hinterland demand and supply. While bunkering is also a non-starter as it would involve setting up of fuel supply infrastructure from refineries form mainland of India as Great Nicobar does not have any refining capacity of its own.

Setting up of cruise facilities is the only feasible option that look promising at these islands as it will require minimal infrastructure and the exotic locations combined with many water related activities makes it a favourite tourism destination.

Brief Note for Evaluation of Proposed Tajpur Port

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1.0 Background

Kolkata Port which is one of the major port of India has two docks i.e. Kolkata Dock System and Haldia Dock Complex. Haldia and Kolkata ports have following constraints:

- These ports are not able to handle deep draft vessels due to presence of shallow water patches (sand bars) along the approach channel.
- Part of cargo from ships has to be unloaded at other ports or at anchorage, to reduce the ship's draft to permissible levels. This results in higher shipping costs and low operational efficiency.
- Excessive maintenance dredging with significant annual cost needs to be carried out even to handle partly loaded panamax ships. Central government is providing an annual subsidy of Rs. 275 crores to KoPT for dredging.

There has been an increased emphasis on the developing a deep draft port in West Bengal where efficient and cost economic cargo handling operations could be undertaken overcoming the above constraints.

In this connection, Bhor Sagar port has been proposed for development. Ministry of Shipping has initiated the process for development of Bhor Sagar Port including the connectivity of Sagar Island with mainland.

Meanwhile state government has announced development of a Greenfield port at Tajpur located --- Km east of Digha. It has been reported that a prefeasibility report has been prepared by CRISIL though the copy of the report is not available.

In this connection KoPT has approached AECOM for their views on the comparative analysis of the proposed ports at Tajpur and Bhor Sagar and also the possible impact of Tajpur port on the Haldia port.

In the absence of the prefeasibility report this brief note has been prepared based on the inhouse available information with AECOM, in a very short time frame.

2.0 Alternative Locations for Citing of Port

For locating a suitable deep water port in the state of west Bengal, various sites have been considered in the past. These site locations along with Tajpur site are shown in **Figure 2.1**.

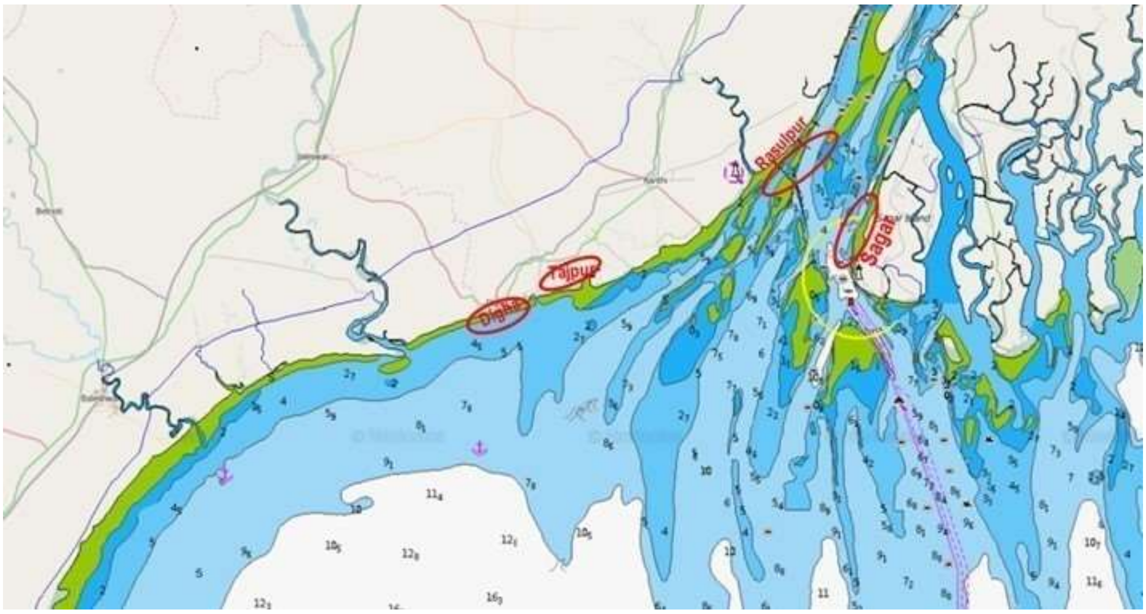

Figure 2.1 Alternative Port Locations

The TEFR for Bhor Sagar Port has already been prepared as part of the Sagarmala assignment. At the possible port location at Digha, there are tourist beaches and therefore this port site is likely to have R&R and environmental issues. The port site at Rasulpur was awarded to a private developer and the matter is sub-judice and therefore this site is not being considered further in the present evaluation.

3.0 Port at Tajpur

3.1 Location of Port

Tajpur is approached through a single lane road from NH 116A by travelling about 5 km. The onshore area behind the beach is utilised for aqua culture, salt pans. Some Beach resorts are located to the north of the river mouth. Therefore it seems that the land area towards south of the river mouth could be utilised as waterfront for the port as shown in **Figure 3.1**.

Figure 3.1 Onshore Area Details of Proposed Tajpur Site

3.2 Environmental and Social Settings

Tajpur has emerged as a recent tourist destination owing to presence of wide beaches and also its location between already established tourist centers, i.e., Digha and Mandarmani. However, the location has very few hotels or resorts as compared to Digha and Mandarmani.

A large land area around the site is used for aquaculture practices and a number of bheris or fish ponds may be seen in the area (**Figure 3.2**).

The selected port location is fronted by Casuarina tress, which may be planted under government initiatives either for social forestry or as a coastal protection measure (**Figure 3.3**). The site appears to be free from any erosion and about 200 m wide beaches are observed near the site. Numerous red crabs are reported to be present on this location.

Figure 3.2 Location showing habitation (yellow) and aqua culture practices (blue)

Figure 3.3 Beach and Casuarina plantation near the selected location

Small habitations have been noted on the West of the site but no rehabilitation or resettlement issue are envisaged as the port is proposed entirely on the reclaimed land. Land would only be required for rail and road connectivity.

3.3 Connectivity to Port Site

The proposed site for Tajpur port is connected to the hinterland through east coast railways connecting Panksura and Digha. Three railway stations are located near the proposed Tajpur Port site. Out of these, Badalpur railway Station is approximately 8 km from the port site.

NH 116A connecting Contai and Jaleshwar is 5 km from the proposed port site.

The road and rail connectivity to the proposed port site at Tajpur port is shown in **Figure 3.4** below:

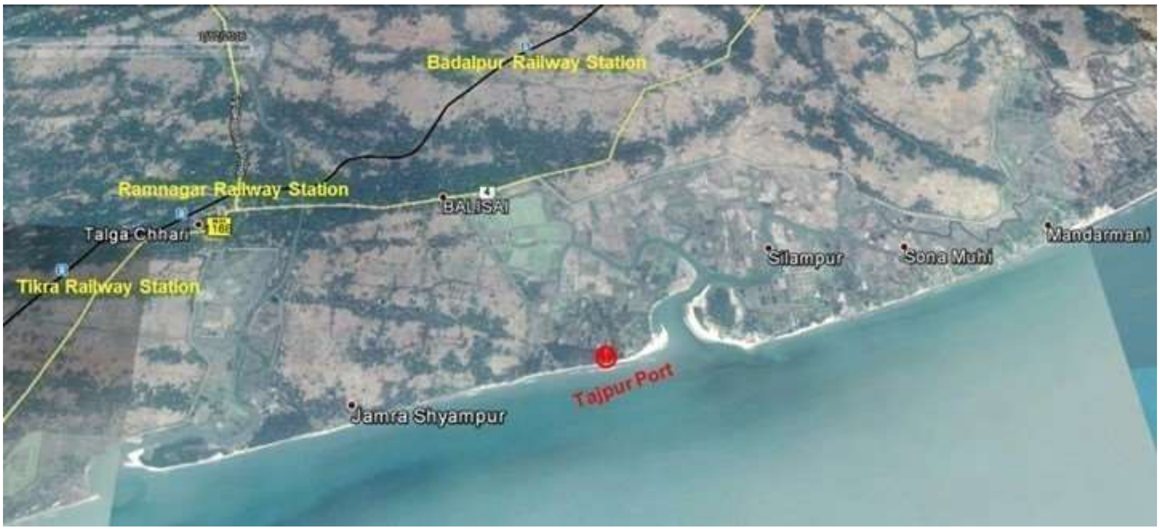

Figure 3.4 Rail and Road Connectivity to Proposed Tajpur Site

3.4 Draft Availability and Morphological Details

Based on the available bathymetric information, 10 m contour is about 22 km and 20 m contour is about 60 km from the shoreline. The bathymetry details at the location of port site alongwith the Eden Channel and Eastern channel are shown in **Figure 3.5**.

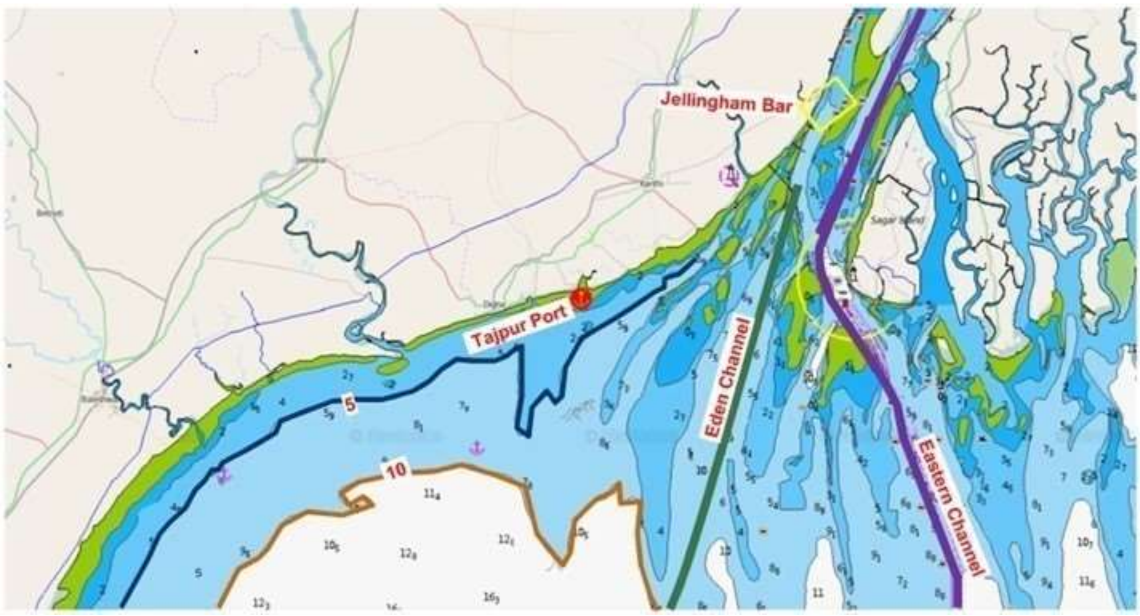

Figure 3.5 Bathymetric Details of Tajpur Site

There are many shoals nearby the proposed port site for which detailed model studies would need to be carried out for the possible impact in the short and long term.

4.0 Assessment of Port Site at Tajpur

4.1 Parameters for Evaluation

AECOM carried out desktop study to evaluate the proposed site for development of port at Tajpur. The following are the key parameters that would dictate the development of deep water port at the selected location.

1. Traffic Potential
2. Connectivity to the cargo centres
3. Capital Cost of Development and O&M Costs
4. Scope for future expansion
5. Environmental and Social Issues

These parameters are discussed in the subsequent paragraphs:

4.2 Traffic Potential

If this port site could be developed to handle deeper draft ships as compared Kolkata and Haldia ports, there is a possibility to attract some traffic for the Haldia port, which is about 150 Km away from the proposed and has limitation of handling ships with loaded draft of 8 to 9 m only.

Even proposed Bhor Sagar port is proposed for handling ships with loaded draft limited to 9.5 m only. While the traffic projection for the Bhor Sagar Port is mainly based on the spill over container traffic of Kolkata port and only minor spill over traffic from Haldia port. The total traffic considered for phase 1 development for Bhor Sagar port is initially only 3.5 MTPA increasing to 7.5 MTPA.

While making a comparative assessment, it is fair to limit the initial traffic at proposed Tajpur port also at 7.5 MTPA though it composition may be little different form that at Bhor Sagar port.

4.3 Connectivity to the Cargo Centres

As could be seen from Figure 3.4 the link for connecting the main railway network is only 7 km away and that for the connecting to the main road network (national highway) is only 5 km. While a detailed assessment is still needed in terms of the capacities of the existing rail and road network, it is considered that this site has a significant advantage over Bhor Sagar Port where not only a significant cost has to be incurred in connectivity of Sagar Island with mainland, but also the existing road and rail networks have to be significantly improved.

At the same time it should also be noted that there is no captive cargo for this port i.e. a power/steel plant/refinery etc. The cargo generated at this port would be purely the traffic diverted from the competing ports i.e. KoPT & Dhamra, subject to its competitiveness.

4.4 Capital Cost of Development and O&M Costs

4.4.1 Technical Issues

The following technical issues need to be considered while planning a port at Tajpur:

1. The proposed site at Tajpur is along the open coast and therefore would need breakwaters to provide tranquility for round the year operations.

2. The 10 m contour is about 22 km and 20 m contour is about 60 Km from the coast. This means a very long outer channel would be needed.

3. In view of the distant deep water contours, a two way channel would be needed for effective functioning of the port.

4. The estimated capital dredging for the proposed port is worked out as below:

   a. To handle ships with draft limited to 9.5 m - 36 Mcum
   b. To handle ships with draft limited to 14.5 m - 160 Mcum
   c. To handle ships with draft of 18.5 m - 350 Mcum

   In view of significantly high quantity of capital dredging, it is unlikely that the port could be developed even for handling fully loaded panamax size ships. Hence for the purpose of present evaluation, the limiting draft of ships is taken as 9.5 m only that is comparable to the proposed Bhor Sagar Port.

5. The approach channel passes very close to the shoals and sand bars for which a detailed mathematical model studies would be needed to decide whether the proposed channel, developed by significant dredging, would be stable in this region or not. However for the purpose of this initial assessment it is assumed that a dredged channel is possible.

6. The availability of the backup land for the purpose of port operations and storage of cargo can not be confirmed at this stage and therefore it is assumed that for this purpose most of the land needed for port would need to be reclaimed.

4.4.2 Capital Cost Estimates

The indicative order of magnitude capital cost estimates for development of an all-weather Greenfield port at Tajpur, for the draft limited to 9.5 m, are given below:

S. No.	Component	Estimated CAPEX INR in crores
1.	Breakwater	750
2.	Dredging & Reclamation	1600
3.	Port Infrastructure[1]	725
4.	Rail and Road Connectivity to main network	225
	Estimated Capital Cost for Phase 1 development	**3300**

[1] The cost of port infrastructure is taken same as that for phase 1 development of Bhor Sagar port for Comparison purposes, though it would vary depending upon the profile of cargo to be handled.

[2] The above cost estimates are based on the best engineering judgement and to be considered as indicative only

4.4.3 O&M Cost Estimates

The order of magnitude O&M cost estimates for the port infrastructure created are estimated to be Rs. 225 crores per annum.

4.5 Scope for Expansion

Most of the capital expenditure in phase 1 development would be for construction of breakwaters and capital dredging of the channel. This would form the basic infrastructure utilising which additional cargo terminals could be built at a cost comparable to the similar development any other port.

5.0 Conclusions

While at the initial assessment Tajpur appears to be good location for port development in terms of its proximity to the hinterland, the following are the key factors that need consideration:

1. The initial cost of development, even with limiting the draft of the ships to 9.5 m, is too high vis a vis the projected traffic. Further the traffic built-up would be slower in the absence of any captive cargo for the port.

2. Due to the presence of shoals and sand bars close to the port location, the stability of the outer channel needs to be examined in detail by way of model studies. This would also decide whether it would be possible to develop this port for cape size ships or even fully loaded panamax size ships. In any case due to the maintenance dredging is likely to be very high, as is the case for any port in this region.

3. There are places of tourist attraction both towards north and south of the proposed port site. Further the land availability close to the shore is limited. It is likely that comprehensive EIA studies would need to be carried out and the site would have to pass through rigorous process of getting the environmental clearance involving significant time.

4. Meanwhile large investments are already planned at the competing ports like KoPT and Dhamra. Also the ports like Gopalpur (construction nearing completion) and Subernrekha (MoEF Clearance already obtained) may also come up, denting further the viability of the proposed Tajpur Port.

As per TEFR for Bhor Sagar port, the traffic projected there mainly spill over container traffic from Kolkata port. Further the Bhor Sagar Port is anyway not financially viable without VGF/grant and additional expenditure on providing connectivity to Sagar Island and improving the hinterland connectivity. The development of proposed Tajpur port and that too for handling ships with limited draft of about 9.5 m, is unlikely to affect much the limited traffic projected for Bhor Sagar port and thus its financial assessment.

Development & Operation of Pondicherry Port as a Feeder Port

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AECOM

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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.

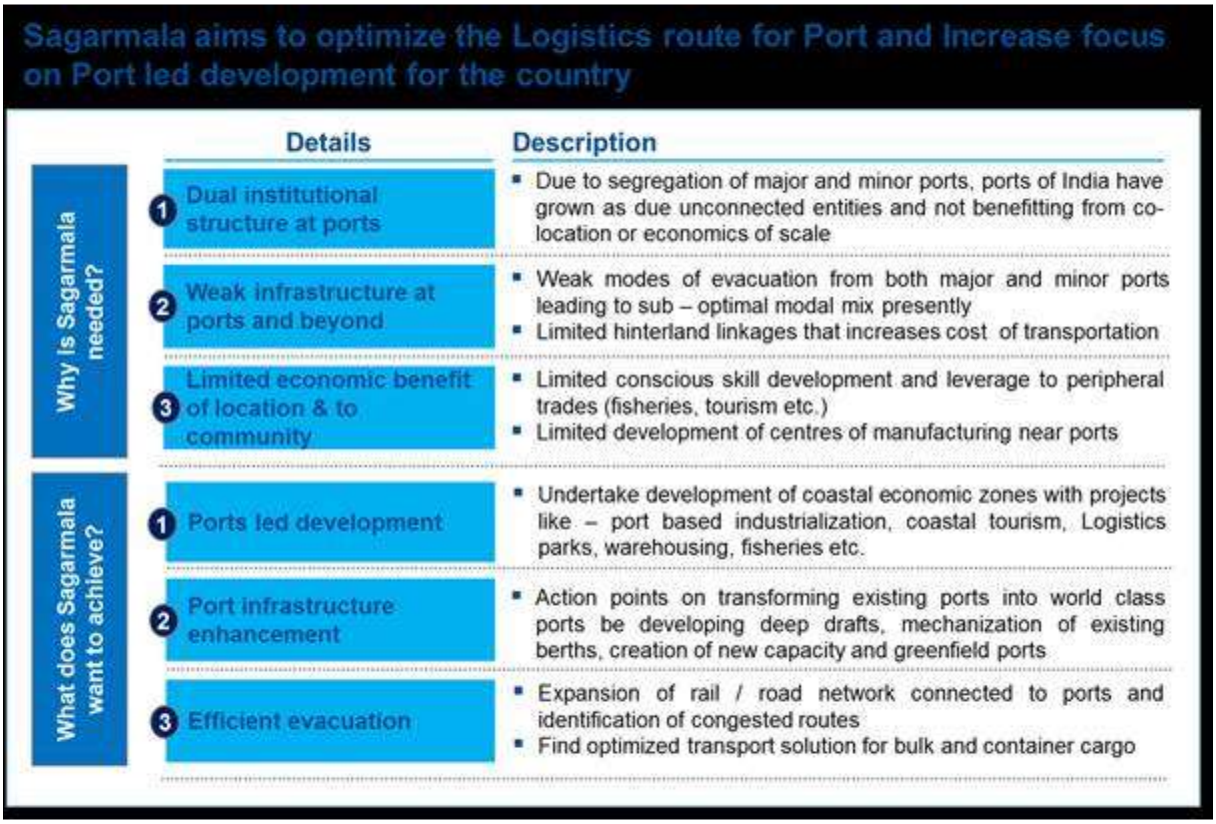

Figure 1.1 Aim of Sagarmala Development

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.

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.

1.2 Scope of Work

Based on the experience in port-led development, the major engagement challenge to develop a set of governing principles for our approach is shown in **Figure 1.2**.

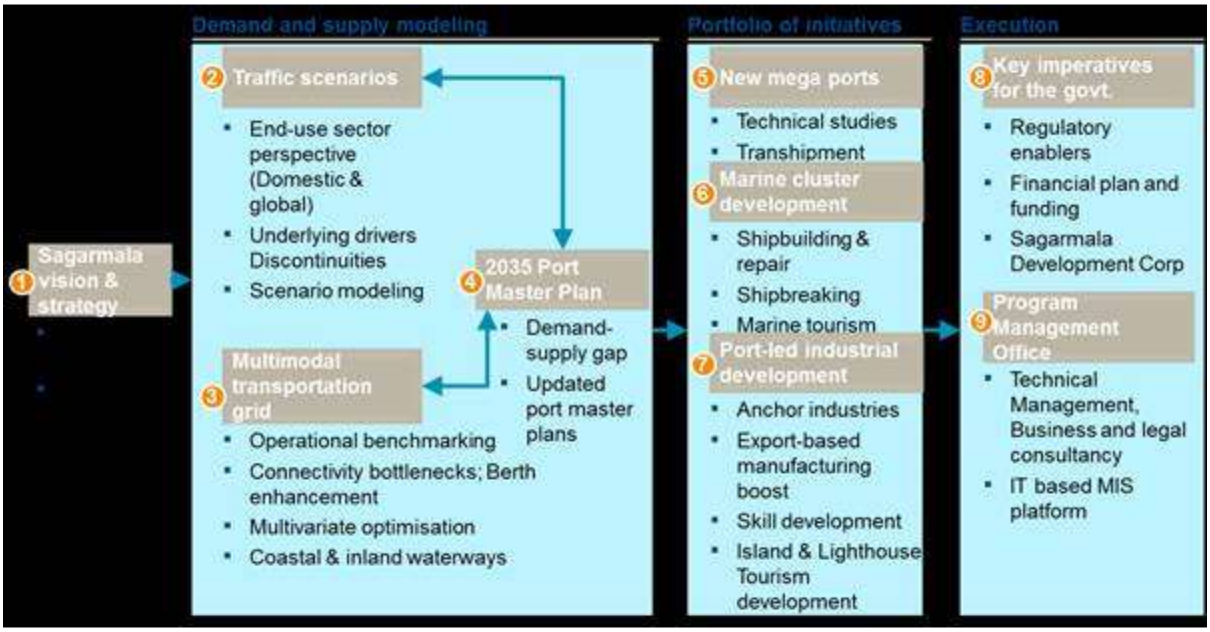

Figure 1.2 Governing Principles of our Approach

1.3 Background

1.3.1 Chennai Port

Chennai Port Trust has been facing stiff competition in the recent past due to development of new Ports along the coast viz. Kamarajar Port, Kattupalli Port and Krishnapatnam Port. Kamarajar Port has started operations of their Ro-Ro/ General cargo berth and their Container Terminal is to be commissioned later this year. Krishnapatnam Port and Kattupalli Port have also started container handling operations. As these ports are private/corporate ports, they have the advantage of modern handling facilities, lesser cost and absence of congestion. They are also not under the TAMP regime and can take decisions on charging users on case to case basis very quickly.

Chennai Port, due to ban on coal handling based on the order of High Court, has lost about 10 MTPA of coal to other Ports. This has resulted severe financial stress to the Port. Due to all these adverse developments, the Consultants, under MoS Sagarmala Programme, have recommended various measures to improve the performance of the port including reduction in port tariff for certain cargoes in order to keep Chennai Port competitive and attractive. Accordingly during 2015-16, Chennai Port announced various concessions to different categories of cargoes especially containers to the tune of about Rs.80 crores per annum with a view to retain/attract cargo.

1.3.2 Pondicherry Port

As an additional initiative, Chennai Port has explored the possibility of having tied up with the neighbouring ports to act as satellite/feeder port for Chennai Port. A team of officers from Chennai Port including Chairman, Traffic Manager and Chief Engineer visited Pondicherry Port and found that Pondicherry Port has all basic infrastructure facilities to operate as a Port.

The Port is located near the mouth of the Ariyankuppam River. The entrance is prone to siltation and requires dredging continuously to maintain the required depths For the past few years the dredging has not been carried out and consequently the present available depth all along the channel is around 2 to 2.5 m depth and close to the wharf and the depth are less than a meter. Because of this, there is no operation at the Port and the existing facilities such as berth, handling equipment's, sheds and back-up areas are idling without generating revenue.

After site visit, the Port Officers visited the offices of Pondicherry Port as well as Pondicherry Government including Chief Secretary and had detailed discussions in this regard. After discussion, Pondicherry Port has expressed its desire to have a tie up with Chennai Port to revive the port operations. It was proposed to make Pondicherry Port operational throughout the year by suitable maintenance dredging of entrance and channel ensuring that the existing facilities are gainfully utilised.

It was agreed in principle that Pondicherry Port will carry out the first year Capital Dredging and Chennai Port should take the responsibility of carrying out annual maintenance dredging thereafter in addition to consultancy support in marketing, tariff, dredging and other engineering issues. On their part Pondicherry Port is willing to share the revenue at the ratio of 50:50 to meet with the expenditure of maintenance dredging.

It was also intended to develop Pondicherry Port as Satellite/Hub Port of Chennai Port, for container cargo - Exports and Imports from and to Pondicherry and its hinterland extending to Cuddalore / Nagapattinam in South East; Trichy / Villupuram in South; Salem/Namakkal in West.

1.3.3 Obligations of Chennai Port

Based on the discussions, a list of obligations of Chennai Port was drawn up. The significant obligations are presented hereunder:

- Technical Assistance to Pondicherry Port for dredging of mouth/ channel/ berth area during the first year to achieve a draft of 3.7 m
- Maintenance Dredging of Mouth/Channel/Berth area of Pondicherry Port from 2nd year onwards till the agreed period.
- Maintenance of the draft at the mouth and the channel, and manage handling of cargo on priority basis from second year onwards:
- Assistance to Pondicherry port in administration of the port to handle 0.2 to 0.3 MTPA in the first phase and further capable of expanding to another 1 MTPA for future.
- Assistance for establishing Shipping connectivity between Chennai Port and Pondicherry Port immediately after initial dredging is completed.
- Assistance to promote Transportation of Container Cargo by sea in Pondicherry/ Chennai/ Pondicherry Sector.
- Technical assistance to market the proposed service between Chennai and Pondicherry by taking up appropriate initiatives including Promotional Incentives/Preferential Tariff for Ships/ Container Cargo from and to Pondicherry/Chennai Ports.
- Suitable berths for Container Ships under priority berthing in Chennai Port to enable immediate onward Mother Ship connectivity for Exports from Pondicherry Port and immediate clearance and shipment of Imports from Chennai Port to Pondicherry Port.

1.3.4 Obligations Pondicherry Port

The corresponding significant obligations of Pondicherry Port are presented hereunder:

- Dredging of Mouth and the shallow patch of Channel to enable commencement of commercial Shipping operation during the first year immediately.
- Sharing a mutually agreed percentage of their Gross Revenue from port operations with the Chennai Port on an annual basis in order to meet the maintenance dredging cost.
- The Pondicherry Port will ensure that the export cargo meant for foreign destinations should be routed through Chennai Port only similarly overseas imports if not coming directly to Pondicherry Port should be routed through Chennai Port only provided such vessel services are available at Chennai Port. In the absence of such service through Chennai Port, the export and import through other Ports shall be permissible
- The Pondicherry Port will frame Port tariff as per the policy of the Govt of Puducherry and will collect the revenue. However, CHPT will provide assistance to fix tariff for Pondicherry Port

activities and have preference in service provided by Pondicherry Port for utilizing these yards, Sheds and other developed facilities, etc.

- Ensure seamless Road and Rail connectivity to Pondicherry Port.
- Liaise with Indian Customs to ensure currency of Custom notification to enable EXIM activities

1.4 Techno-Economic Feasibility Report

With this background, Chennai Port requested Ministry of Shipping (MoS), GoI to consider including the proposal of developing Pondicherry Port as a feeder port of Chennai Port under Sagarmala programme. In order to take up the proposal forward, they also requested MoS to get this done through AECOM who are already drawing up the Master Plan of Chennai Port as Sagarmala Consultant. (Chairman, ChPT letter no. NP2/873/2016/E dt. 6th June, 2016).

For this purpose, Chennai Port shared with AECOM the draft Memorandum of Understanding and their internal assessment of expected traffic and the possible revenue accrual to Pondicherry Port.

This report, accordingly, has been prepared. The report focuses on the following key issues:

- Pondicherry port as existing at present with all infrastructure & service facilities
- The working arrangement between Chennai and Pondicherry Ports
- Understanding the issue of siltation at the entrance and in the channel based on CWPRS Specific Note No. 1758 dt. 17th June 1978
- Validating the expected traffic to be handled at Pondicherry Port
- Evaluating the financial aspects of the commitment of Chennai Port including identifying the risks involved.
- Conclusion and Recommendations.

1.5 Present Submission

The present submission is the Techno-economic Feasibility Report for "Development and Operation of Pondicherry Port as a Feeder Port to Chennai Port", Tamil Nadu. This report is organised in the following sections:

Section 1 : Introduction

Section 2 : Pondicherry Port

Section 3 : Key Issues in the Ports' Obligations

Section 4 : CWPRS Specific Note No.1758 dt. 17^{th} June, 1978

Section 5 : Assessment of Maintenance Dredging

Section 6 : Assessment of Traffic Potential

Section 7 : Assessment of Gross Revenue

Section 8 : Conclusions and Recommendation

2.0 PONDICHERRY PORT

2.1 Overview

The Union Territory of Pondicherry comprises of four regions namely Pondicherry, Karaikal, Mahe and Yanam. Pondicherry Port is situated at Latitude 11º56’ N & Longitude 79º50’ E. It is an open roadstead anchorage port situated about 150 kms south of Chennai. Its location is shown in the **Figure 2.1**.

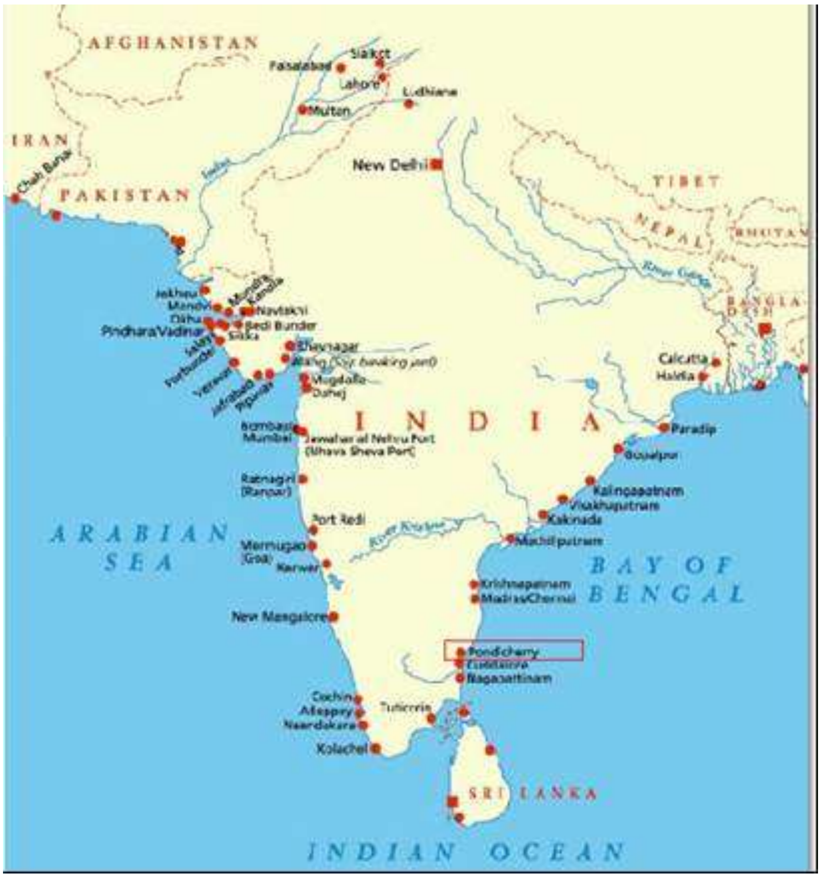

Figure 2.1 Location of Pondicherry Port

It is an intermediate port and is located on the branch of the Ariyankuppam River Canal. The port is suitable for lighterage operations during fair weather months (February to September). It consists of an old port, the new port and a fishing harbour. These are shown in the **Figure 2.2**.

Figure 2.2 Relative Locations of Old Port, New Port & Fishing Harbour

2.2 Old Port

In 1962, a new pier and port was built south of the town and about 3.5 km north of the mouth of Ariyankuppam River. The satellite picture of the old port is shown in the **Figure 2.3** and a view of the jetty with the Light House is shown in the **Figure 2.4**.

Figure 2.3 Layout of the Old Port

Figure 2.4 View of the Piled Jetty & Light House

The berthing facility is a reinforced concrete jetty positioned at right angle to the shoreline extending into the sea upto a depth of 6 m below CD. It is 286 m long with a working head of 102 m x 15 m. The draft alongside ranged from 4.5 m to 6.0 m. On the landside an associated 11 acre waller port land was used to accommodate the infrastructure required for port operations. There were 7 warehouses, Port & Customs offices, tractor shed and repair yard, weigh bridge, signal station, stores, canteen and limited class IV staff quarters. There were three railway sidings leading to the warehouses.

Cargo handling was done through cranes provided on the jetty. The ships lie at anchors in the open sea at about 1.5 km from the shore and country crafts ply between the ships and the jetty for transportation of cargo. During rough weather, when storms occur in the area, the crafts were normally beached along the shoreline in the vicinity of the jetty. These crafts were normally stationed at the nearby Cuddalore Port and are brought to this port whenever required for loading and unloading operations.

However, this old port is not operational. The support works to the pier are now severely corroded making the pier unsafe for heavy loadings. The port area is also therefore largely unused.

2.3 New Port

The new port is located on the branch of the Ariyankuppam River Canal at about 3 km south of the old port. This was conceptualised during the late seventies as there was a proposal for setting up a thermal power station with a need to handle coal transported from Haldia. Consultants were appointed and their recommendations were sent to CWPRS, Pune for model studies. The depth at the entrance is prone to siltation and requires dredging continuously to maintain the depth. Hence there was a need to stabilise the river mouth. CWPRS had suggested various measures to ensure that the river opening is maintained with the required water depth for barge operations. But the power station never came up and there was no port development till during the early 1990's when the present facilities were created.

For stabilising the river mouth, the facilities created are:

- 250 m long offshore groyne connected to the shore by a trestle south of the mouth
- 150 m longshore based groyne on the northern side
- 25 m long groyne on the southern side
- 240 long submarine tunnel with 2 x 16” dia pipelines for sand by-passing
- Sand trap of 140,000 m^3 capacity south of the mouth

The facilities as constructed are shown in the satellite picture presented in the **Figure 2.5**.

Figure 2.5 Structures at the River Mouth

At the Port area, there is a wharf of 150 m long and 25 m wide. There are four transit sheds each with a storage capacity of 3,500 T just behind the wharf. Further there is vacant back up area of almost 100 acres. The port is approachable by a 2 lane road which is about 500 m from the main road. In addition there is a slipway to facilitate repair of vessels upto 30 m x 8 m weighing upto 150 T.

It has been indicated by the port that the maximum cargo handling rate will be 2,000 TPD with one ship at a time. Accordingly the overall capacity of the port will be about 0.3 to 0.4 MTPA.

The port was in operation for 17 years from 1990-91 to 2006-07. Afterwards, the regular maintenance dredging was not carried out and the mouth got silted up. For the past 9 years, there is no operation at the Port and the existing facilities are idling without generating revenue. The availability of depth all along the channel is around 2 to 2.5 m depth and close to the wharf the depth is less than a meter.

The satellite picture of the new port as existing presently is shown in the **Figure 2.6** and the picture of the wharf with the transit sheds are shown in the **Figure 2.7**.

Figure 2.6 Layout of the Current New Port

Figure 2.7 Wharf with the Transit Sheds

2.4 Fishing Harbour

As shown in the location drawing, the fishing harbour is located on the other side straight ahead of the entrance. It has its own berths and back-up infrastructure and service facilities. While the fishing harbour is located at around 700 m of sailing distance from the river mouth, the New Port is located at around 1500 m of sailing distance from the mouth. The satellite picture of the fishing harbour is shown in the **Figure 2.8**.

Figure 2.8 Fishing Harbour with Back Up Facilities

3.0 KEY ISSUES IN THE PORT'S OBLIGATIONS

3.1 Significant Obligations of Each Port

3.1.1 Chennai Port

a. Technical Assistance to Pondicherry Port for dredging of Mouth/Channel/Berth area during the first year to achieve a draft of 3.7 m.

b. Maintenance Dredging of Mouth/Channel/Berth area of Pondicherry Port from 2nd year onwards till the agreed period.

c. Maintenance of the draft at the mouth and the channel, and manage handling of cargo on priority basis from second year onwards.

3.1.2 Pondicherry Port

a. Dredging of Mouth and the shallow patch of Channel to enable commencement of commercial Shipping operation during the first year immediately.

b. The Pondicherry Port will frame Port tariff as per the policy of the Govt. of Puducherry and will collect the revenue. However, CHPT will provide assistance to fix tariff for Pondicherry Port activities and have preference in service provided by Pondicherry Port for utilizing these yards, sheds and other developed facilities, etc.

c. Sharing a mutually agreed percentage of their Gross Revenue from port operations with the Chennai Port on an annual basis in order to meet the maintenance dredging cost.

3.2 Key Issues in Chennai Port Obligations

Chennai Port is obliged to carry out the annual dredging of the mouth/channel/berth to maintain the required draft for handling the traffic from the second year onwards.

Pondicherry Port will frame the Port tariff and collect the revenue. It will share a mutually agreed percentage of their Gross Revenue with Chennai Port on an annual basis to meet the maintenance dredging costs.

The implication of these obligations is that Chennai Port is expected to carry out the annual maintenance dredging of the mouth and channel to retain the required depths. The volume of material to be dredged and the costs thereof are variables and has financial implications to the Port.

As regards Pondicherry Port, collecting the port charges and sharing a percentage of the Gross Revenue with Chennai Port is also variable as it depends on the actual traffic and the tariff fixed. It is necessary to ensure beforehand that it is possible to achieve a Gross Revenue that is much more than the costs of maintenance dredging so that both the Ports are benefited.

3.3 Study of the Variables for arriving at a Reasonable Assessment

The extent of accretion near the mouth has been assessed through mathematical model studies by CWPRS, Pune during 1978. The new port entrance has been constructed based on their recommendation. Their Specific Note has been referred to understand the phenomenon.

Subsequently, Pondicherry Port authorities have been maintaining it for some time. Even now, without any commercial operations at the port, they are maintaining the depths at the entrance for the use of fishing vessels of the Fisheries Harbour. Their experience is also considered.

Pondicherry Port authorities are getting the maintenance dredging done through external agencies through open tendering. The contractors are supposed to use the port's own dredger with fuelling done by the contractors. The costs for such dredging are available for reference.

Chennai Port has assessed the potential traffic through Pondicherry Port. AECOM, during the site visit to the port, had interacted with the port authorities and assessed the ground situation. Reasonable and possible traffic volumes could be estimated.

Chennai Port has assumed certain tariff levels in their calculation. AECOM, during their interaction with Pondicherry port authorities, have obtained outline of their proposed revision of tariff.

All these aspects are discussed in detail in the subsequent sections.

4.0 CWPRS SPECIFIC NOTE No. 1758

4.1 Need for Further Development of Port

During seventies, there was a proposal for the setting up of thermal power station at Pondicherry which required coal from Haldia to be brought by coal carriers. The annual requirement of coal was estimated to be 1.5 MTPA and there was a need to evolve schemes for handling this coal. The Govt. of Puducherry referred this problem to M/s Consulting Engineering Services (India) Pvt. Ltd**.**, New Delhi. The Consultants studied the problem and came out with three alternative schemes. After considering the pros and cons of these three schemes, the Port Officer, Govt. of Puducherry selected one option and desired that CWPRS carryout the model studies for this scheme.

4.2 Scheme given by Port to CWPRS for Study

The scheme involved cargo from ships at anchorage to be transloaded on to barges which will enter the river and discharge it at the berth. The salient features of this scheme are as follows:

1. A rubble mound groyne on the south side of the navigation channel initially 230 m long to be extended by 200 m in the ultimate stage. The north (inner) face of the groyne is to be vertical, in order to provide adequate reach for the sand pump to be installed on the groyne to undertake dredging of the channel.

2. A rubble mound groyne of 150 m long on the north side of the entrance.

3. A trestle on the south side of the southern groyne over which three sand pumps having a total capacity of 313 m^3/ hr of solids will be installed. A sand trap of capacity 32,000 m^3 would be provided along the trestle to arrest the movement of sand. The trestle will be 225 m long initially and would be extended by another 75 m in the final stage.

4. One pump of 60 m^3/ hr at the tip of the southern groyne and one on the northern groyne would be provided.

5. An entrance channel of 60 m wide dredged to 3 m below CD which is proposed to be deepened to 6 m below CD in the ultimate stage.

6. An inner harbour at the mouth of Ariyankuppam River for lighterage.

The CWPRS Specific Note No. 1758 dt. 17th June 1978 deals with the studies conducted for the development of the port according to the proposal as above. The salient features of this study are reproduced hereunder.

4.3 Waves & Cyclone

CWPRS collected wave data from IMD for the period 1949 to 1960 which were reported by ships operating in the quadrant bounded by Latitude 11° 30' N and 14° 30' N and Longitude 80° 0' E and 82° 0' E. It was observed that the predominant waves occur from south and south-west from April to October and they veer around clockwise and become north-east during the months November to February. Statistical analysis of these data was made in order to determine the number of days during which the wave heights exceed a particular value. The results are shown in **Table 4.1** from which it can be seen that for about 50 days in a year the wave height exceeds 1.8 m while for over 110 days the wave height exceeds 1.2 m.

Table 4.1 Wave Exceedence Data

S. No.	Month	Number of Days Waves Exceeding Height (m)					
		0.60	1.20	1.80	2.40	3.00	3.60
1.	January	19.30	13.30	4.70	1.40	1.00	0.80
2.	February	19.00	8.70	2.70	0.60	0.30	-
3.	March	14.20	3.70	0.80	0.46	0.46	0.15
4.	April	15.70	3.30	0.30	0.30	0.30	0.30
5.	May	20.60	10.70	6.20	1.40	0.77	0.77
6.	June	23.10	15.10	9.10	2.10	0.30	0.30
7.	July	20.70	13.05	6.00	2.70	0.60	0.30
8.	August	23.50	12.40	3.70	0.30	-	-
9.	September	19.90	10.20	2.70	0.75	0.75	0.30
10.	October	18.70	8.00	3.10	0.30	0.30	-
11.	November	20.70	9.00	3.40	0.75	-	-
12.	December	24.80	2.80	6.80	2.30	0.90	0.60
	Total	239.00	122.90	49.30	13.26	9.18	2.60

The above data is based upon the wave heights in deep water observed by ships in the vicinity of Pondicherry port. However, as the waves approach the coastal waters, their direction and heights are considered modified due to refraction. As the coastline is oriented approximately north – south with a bearing of 10° East of North, the waves from west and south-westerly direction will have no effect on the coastline. Accordingly taking only the waves from the eastern sector into consideration and neglecting the effect of refraction, the number of days of occurrence of waves from different directions and indicated in Table 4.2. It would be seen that waves from south – east and north – east directions are predominant during the SW and NE monsoons respectively and the wave heights normally exceed 0.9 m during these periods.

Table 4.2 Number of Days of Occurrence of Waves Exceeding a Particular Height from Different Directions

S. No.	Direction	Number of Days Waves Exceeding Height (m)							
		0.00	0.60	1.20	1.80	2.40	3.00	3.65	4.26
1.	N	13.50	9.30	3.80	1.80	0.85	0.42	0.21	0.00
2.	NNE	19.65	12.65	6.12	3.17	0.64	0.21	0.00	0.00
3.	NE	48.35	36.80	19.15	8.95	2.29	1.04	0.42	0.00
4.	ENE	25.80	18.30	8.12	3.53	1.46	1.04	0.84	0.00
5.	E	31.15	17.10	8.65	3.80	0.85	0.63	0.63	0.42
6.	ESE	10.35	5.23	2.32	0.42	0.00	0.00	0.00	0.00
7.	SE	17.39	9.70	2.32	1.06	0.21	0.00	0.00	0.00
8.	SSE	10.11	4.65	1.90	0.42	0.00	0.00	0.00	0.00
9.	S	41.60	25.80	10.32	4.65	0.42	0,21	0.00	0.00
10.	SSW	40.50	29.50	13.50	5.28	0.64	0.42	0.00	0.00
11.	SW	51.50	39.90	23.20	9.92	1.90	0.85	0.21	0.00
12.	WSW	26.40	19.40	12.25	4.00	1.05	0.42	0.42	0.21
13.	W	14.35	9.72	4.01	1.78	0.21	0.00	0.00	0.00
14.	WNW	4.85	2.11	0.85	0.42	0.21	0.00	0.00	0.00
15.	NW	3.80	2.53	0.63	0.42	0.42	0.00	0.00	0.00
16.	NNW	5.06	2.56	1.05	0.63	0.00	0.00	0.00	0.00
	Total	365.00	245.70	118.90	49.50	11.50	5.24	2.73	0.63

4.4 Littoral Drift

The wave climate in this region induces a predominantly northerly drift during the months of March to September, while a return drift sets in towards south during the months of November to February. In view of its proximity to Chennai, it is considered reasonable to assume that the net littoral drift at Pondicherry is of the same order as that at Chennai, as the wave climate and the bearing of the coastline are almost the same at both the places.

In the absence of actual data regarding the quantity of littoral drift along a coastline, empirical formulas correlating the quantum of littoral drift with the alongshore wave energy available in literature can be made use of similar calculations were made with respect to Chennai Port based upon the alongshore wave energy during different months. Assuming the draft to be proportional to the alongside wave energy, the drift during different months were worked out. It was seen that the maximum northerly drift occurs during the months from May to July and the net drift is in southerly direction from November to February. As the total southerly drift is 25% of the net drift, assuming a net littoral drift of 0.6 million m^3, the net northerly and southerly drifts work out to 0.75 million m^3 and 0.15 million m^3. The distribution of the drift as a function of depths requires detailed calculations of wave energy in each depth zone. It may be reasonably assumed that on an average, about 50% of the drift could be assumed to be moving within the 2 m contour and approximately half of it between the 2 m and 4 m contours.

4.5 Freshets in the River

It was stated by the Port officials that the river is completely dry during the non-monsoon season. The catchment area of the river calculated from topo sheets is only 12.6 sq.km. Computations of the peak discharge by Ryves's formula and Dicken's formula indicates values of 50 m^3 /sec and 120 m^3/sec respectively. Hence, it is reasonable to assume that the maximum freshet discharge does not exceed 120 m^3 /sec in the river. As the discharge through this river even during the monsoon is very meagre and occurs only for a few days during the monsoons and also as the river is practically dry throughout the year, it can be concluded that the stability of this mouth is mainly governed by the tidal flow and the freshets have only a marginal effect on this mouth.

4.6 Model Studies

For examining the hydraulic aspects of the scheme, a tidal model was constructed to scale 1/250 horizontal and 1/50 vertical with a vertical exaggeration of 5. The sea portion of the model was reproduced upto the 18 m contour, based on the hydrographic survey of the MoS, GoI during January 1967. The shoreline on the north and south sides of the river were reproduced upto 4 km and 3.5 km respectively. The river portion was reproduced upto 3.7 km from the mouth i.e. upto Murungapakkam bridge.

4.6.1 Stability of the Inlet

The stability of the tidal inlets can be examined by applying various criteria suggested by different investigations. The results of such an analysis have been indicated in the earlier Specific Note no. 1267 dt.20th July 1972 which have shown that this inlet is unstable in view of the predominance of the littoral drift as compared to the meagre tidal flow available for flushing the inlet.

It was concluded based on present studies that unless some artificial means are adopted for periodical maintenance of the approach channel, the formation of a bar and the consequent closure of the inlet cannot be avoided. As such, the stability and the maintenance of the required depths in the inlet will not be possible unless periodical maintenance dredging is undertaken in the channel.

The data regarding drift indicates that during the month of July, 33% of the total drift amounting to 200,000 m^3 moves along the coast. Of this, it could be assumed that only about 60% travels along the coast upto 3 m contour. Assuming that the sand pumps in the trestle are not operable throughout the entire month of July, about 120,000 m^3 of material will accumulate in the sand trap which is required to be cleared during the subsequent calm periods. As the capacity of the sand trap is only 32,000 m^3, in the absence of working of any sand pump on the trestle, the overflow of this trap and the subsequent siltation of the approach channel is unavoidable even assuming the efficiency of the trap to be 100 %.

4.6.2 Concluding Remarks of the Specific Note

For eliminating the sand pump altogether, a sand trap up-drift of the channel and protected by an offshore groyne appears satisfactory. The sand trap is having a capacity of 140,000 m^3 and the offshore groyne has a length of 250 m. With this arrangement the channel could be maintained to the desired depth with the procurement of a cutter suction dredger having a capacity of 4,000 m^3/day.

Programme of dredging:

It is evident that maximum siltation in the sand trap with the minimum possibility of dredging occurs during SW monsoon period. Accordingly, one would expect maximum filling of the sand trap during this period and it should be ensured that the capacity of the trap should be adequate to permit the filling under such circumstances. It would be necessary to examine the filling of the trap and the dredging required based upon the likely drift during various months and the quantity of dredging possible. The results are indicated in **Table 4.3**.

Table 4.3 Dredging of Sand Trap During South West Monsoon (cum)

Month	Accumulation in the Trap Due to Drift	Total Accumulation in the Trap	No. of Dredging Days	Quantity of Dredging	Backlog at the End of the Month
April	31,400	31,400	25	1,00,000	-
May	1,08,700	1,08,700	22	88,000	20,700
June	1,18,200	1,38,900	17	68,000	70,900
July	69,400	1,40,300	23	92,000	48,300
August	44,500	92,000	25	1,00,000	-
TOTAL				4,48,000	

Note: Capacity of the sand trap: 140,000 cum and capacity of the dredger -4000 cum/day

1. The dredged material could be pumped to the north side by providing a submerged pipeline across the entrance channel. It is required to be ensured, however, that the pipeline is submerged below the level of the anticipated future depths of the channel. The combination of the sand trap, offshore groyne and the dredger could be made in such a way as to permit accumulation of drift in the trap and avoid at the same time the overflowing of the trap.

2. In the event of non-availability of the dredger during any monsoon, it would be necessary to provide necessary provision for the dredging of the trap in order to avoid it's overflowing, resulting in heavy siltation and ultimate closure of the inlet.

3. Periodical observation of the shoaling south of the sand trap between the southern end of the offshore groyne and the shoreline is required to be made and the depths in this region are to be maintained by dredger in order to permit uninterrupted movement of drift through the gap.

4.7 Scheme as Constructed

The Port department of the Govt. of Puducherry implemented the recommendations of CWPRS and the facilities as constructed are presented hereunder.

- Offshore groyne of 250 m length on the southern side
- Sand trap of size 185 m × 155 m dredged to 8 m below CD with a capacity of 140,000 m3
- Shore based groyne of 150 m length on the northern side
- A submarine tunnel of 240 m length and of inside cross section 2.0 m × 2.2 m and accommodating 2 × 16” dia. pipelines for sand by-passing.

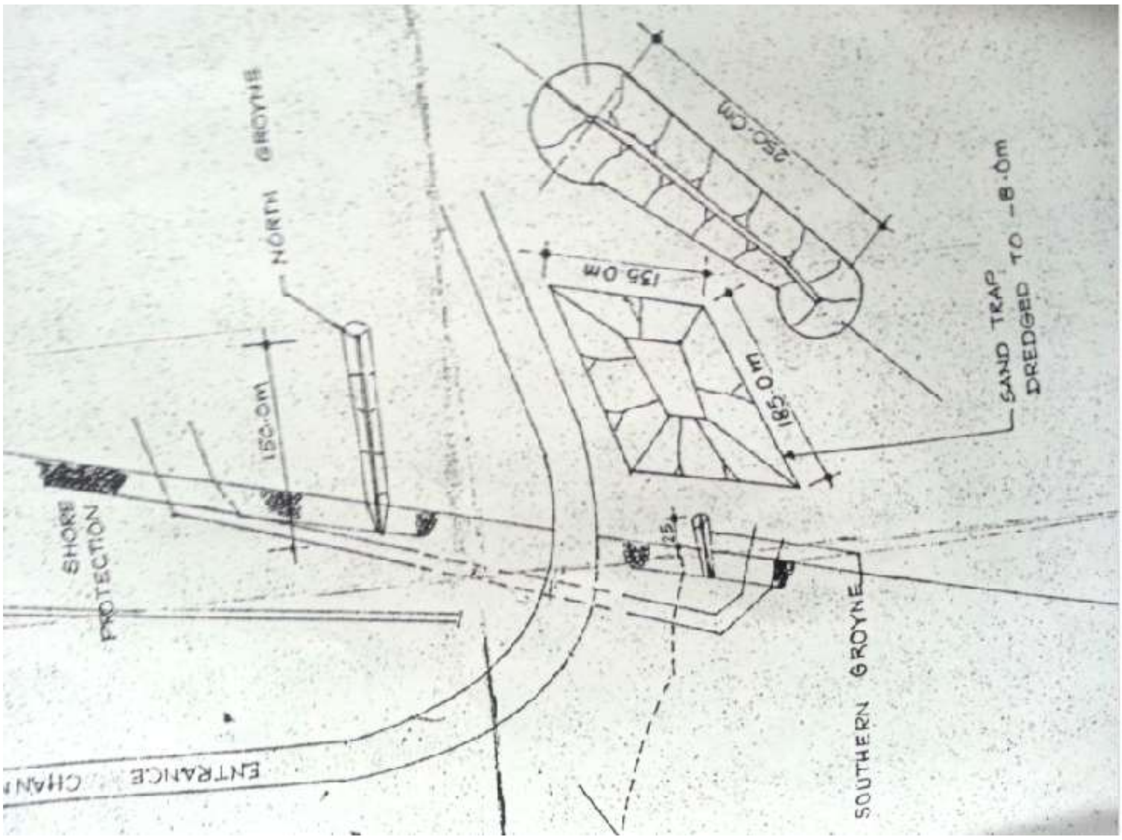

Figure 4.1 Gryones and Sand Trap

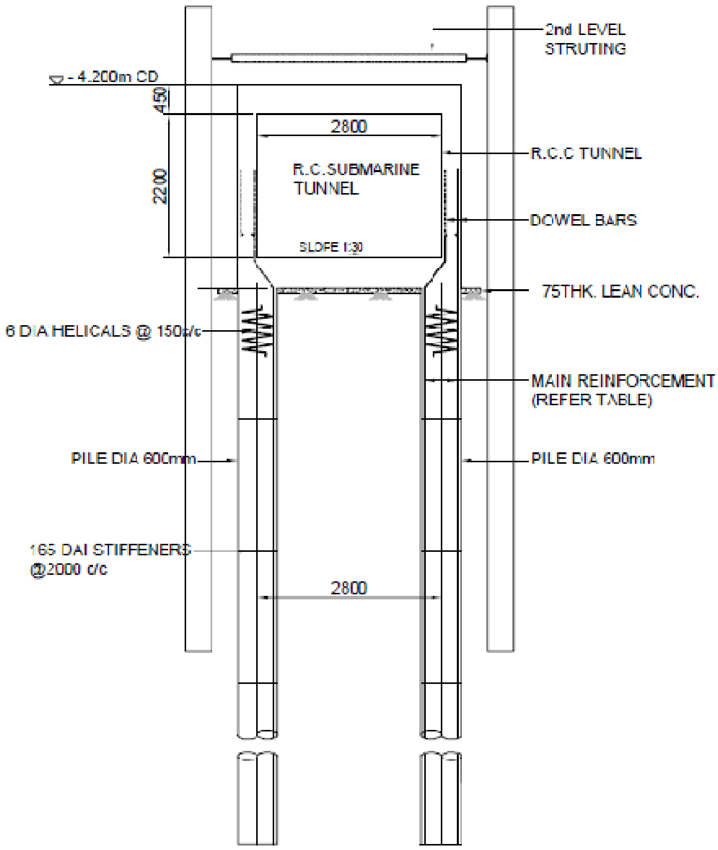

Figure 4.2 Cross Section of Submarine Tunnel

Figure 4.3 Submarine Tunnel with 2 ×15" Pipelines

Figure 4.4 Outer View of Submarine Tunnel

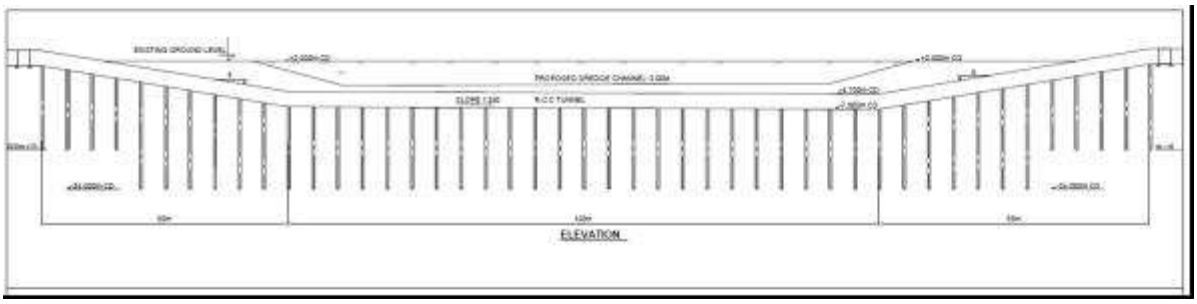

Figure 4.5 Longitudinal Sectional of Submarine Tunnel

5.0 ASSESSMENT OF MAINTENANCE DREDGING

5.1 Dredging Volumes

As indicated in the earlier section, CWPRS have assessed the maximum accumulation of sand in the sand trap due to littoral drift as 372,000 m^3 occurring during the months April to August with the peaking happening during May & June.

Recently, National Institute of Ocean Technology (NIOT), who are engaged in a project for the Management of Coastal Erosion along Pondicherry Coast, have made the following observations in their report of May, 2015.

The 18 km length of coastline of Pondicherry was divided into four zones for analysis. The first zone (Zone A) covering a length of 3.5 km represents the zone of direct influence of Pondicherry harbour. The sand has accumulated upto the tip of the south breakwater with maximum accretion of 180 m and the sediment started bypassing to the north. The northerly side of the harbour is protected by a seawall and sediment deposition is noticed during the NE monsoon due to the southerly drift. The maximum erosion is about 40 m at a distance of 600 m from north breakwater from 1991 to 2000. The second zone (Zone B – 4 km) which is part of Pondicherry Township is protected by a seawall. Souring at the foot of the seawall is noticed during active monsoon. The third zone (Zone C – 2.5 km) is protected by a series of disjointed groynes. These groins were constructed during 2005 – 2007 and accretion to the extent of 90 m is noticed at northern longest groyne located at Thathiriyanpakkam. The accretion at all groynes compartments indicates availability of sediments along the Pondicherry coast during both monsoons.

The CWPRS (1978) has reported that the net drift was estimated to be about 500,000 m^3 at the time of design of Pondicherry Harbour but the present estimated rate of net drift by us would be in the order of 20,000 – 280,000 m^3, which needs to be confirmed by detailed coastline monitoring.

- During the recent interaction of AECOM with the port authorities, it was indicated that the estimate for the net accretion is to the tune of about 250,000 m^3
- The levels of accretion and erosion near the mouth and approaches over the past few years at the end of NE and SW monsoons are presented in the **Figure 5.2** to **Figure 5.8**. These will give a general idea about the pattern of siltation.
- It is considered that an assessment of 300,000 m^3 annual maintenance dredging should be taken for further working.

5.2 Dredging Costs

The port is having an operational cutter suction dredger with which they are carrying out the maintenance dredging to keep the mouth open for fishing vessel to move. It is operated by a Kirloskar Cummins diesel engine of 620 HP. The dredge pump has a capacity of 1300 m^3/hr and can discharge upto a distance of 1,300 m. The pontoon size is 21.5 m × 7.5 m × 1.2 m. It is shown in the **Figure 5.1**.

Figure 5.1 Cutter Suction Dredger of Port

The port normally invites open tender for executing this dredging work utilising this port dredger. During recent times, the engine not being in working condition, the port puts a condition that the contractor has to bring his own engine to operate the dredger and take it back after the work. The contractor has to arrange the fuel for running the engine at his cost. It is ascertained from the port authorities that the rate quoted is **Rs. 217 / m^3** under these conditions. The quantity to be dredged will be about 100,000 m^3.

Table 5.1 Tender Details-1

S. No.	Tender ID	Name of Work	Estimated Amount (Rs.)	Cost of Tender Schedule (Rs.)	Eligibility of Contractors
1.	2015_PORT_933	Dredging with the Department Dredger at the Ariyankuppam river mouth/channel to facilitate movement of vessels -2013	2,17,00,000	1,500 + Vat @ 5%	As Stated above and in NIT

It is also understood that the contractor has an obligation to engage 35 local fishermen in the work for handling the pipes etc. The quoted rate includes the wages for these fishermen also. There is an unwritten understanding with the local fishermen that they have to be engaged in this work. The dredged sand is pumped through the pipelines to the northern shore from where it is moved near the Gandhi Statue for shore replenishment.

Presently, the port has invited tenders for carrying out the capital dredging at the mouth and the approach channel. The estimated quantity is 300,000 m^3. It is proposed that the contractor has to bring his own dredger for carrying out the work. From the NIT it is noted that the estimated cost is Rs. 14.25 crores. This works out to more than Rs.400 / m^3.

Table 5.2 Tender Details-2

S. No.	Tender ID	Name of Work	Estimated Amount (Rs.)	Cost of Tender Schedule (Rs.)	Eligibility of Contractors
1.	2015_PORT_1007	Dredging wat the common entrance of Puducherry Fishing Harbour and Commercial Harbour with outsourced dredger and discharging of dredged sand between pier and Gandhi Statue for Beach Nourishment	14,25,00,000	1,500 + Vat @ 5%	As Stated above and in NIT

Under such circumstances, it is considered that Chennai Port will be utilising the port dredger as is being done by the Pondicherry port for its maintenance dredging and the present rate of Rs 217 / m^3 could be taken. It is unlikely that the local working conditions will change with Chennai Port taking up the work.

NIOT, under their project of Management of Coastal Erosion, are planning for an offshore structure to arrest the erosion of the coast. If this scheme is executed and prove to be effective, there may not be any more need to shift the sand for shore replenishment. In that case, the port can use trailing suction dredgers and dump the sand in the sea. Then the dredging rate is likely to be much lower, even less than half of the present rate.

For the present, considering the rate of Rs. 217 / m^3 and taking that 300,000 m^3 of sand to be dredged every year, the recurring cost of dredging per annum works out to **Rs. 6.5 cr**.

Figure 5.2 End of NE Monsoon 2005 (31.01.2005)

Figure 5.3 End of SW Monsoon 2005 (17.09.2005)

Figure 5.4 End of NE Monsoon 2010 (22.03.2010)

Figure 5.5 End of SW Monsoon 2011 (18.07.2011)

Figure 5.6 End of NE Monsoon 2012 (08.03.2012)

Figure 5.7 End of NE Monsoon 2014 (14.03.2014)

Figure 5.8 End of NE Monsoon 2016 (23.03.2016)

6.0 ASSESSMENT OF TRAFFIC POTENTIAL

6.1 Past Traffic Scenario

The cargo handled at Pondicherry port is of diverse nature. The principal commodities include cement, fertiliser, sugar, food grain, molasses and other general cargo. Molasses used to be handled through the Old Port, but because of the poor condition of the pier this activity was discontinued and the molasses storage tanks were removed from the port area. During 1980s the Old Port had handled maximum traffic of over 400,000 T. This was mainly through transhipment. However, after the New Port was commissioned, the traffic levels were lower and the maximum traffic handled was just over 100,000 T. The historical cargo handled at the port since 1990 is given in the **Table 6.1**.

Table 6.1 Traffic Handled at Pondicherry Port

S. No.	Year	No. of Ships	Tonnage Handled	Import/Export	Cargo Handled
1.	1990 - 91	4	70,468	Import	Fertilisers
2.	1991 - 92	2	52,890	Import	Fertilisers
3.	1992 - 93	2	46,688	Import	Fertilisers
4.	1993 - 94	2	22,295	Import	Fertilisers
5.	1994 - 95	2	22,600	Import	Iron Scrap
6.	1995 - 96	4	56,313	Import	Fertilisers
7.	1996 - 97	3	45,419	Transhipment	CBFS
8.	1997 - 98	1	173	Import	Rejected Rice
9.	1998 - 99	1	22,500	Import	Wheat
10.	1999 - 00	-	-	-	-
11.	2000 - 01	4	75,511	Export	Molasses
12.	2001 - 02	11	95,281	Export	Molasses
				Import	Styrene Monomer
13.	2002 - 03	13	19,247	Export	Cement
				Import	Styrene Monomer/ Fluorspar
14.	2003 - 04	45	1,07,328	Export	Cement / Sugar / Fly Ash
				Import	Fluorspar / Palmolein / Machinery
15.	2004 - 05	25	58,650	Export	Cement / Sugar
				Import	Fluorspar / Palmolein / Copra meal
16.	2005 - 06	42	96,213	Export	Cement / Neem cake
				Import	Fluorspar / Palmolein / Timber log
17.	2006 - 07	18	35,883	Export	Cement / Food items
				Import	Fluorspar / Styrene Monomer / Timber log

The New Port was not in operation since 2006 – 07 till date. The traditional cargo shifted to other ports – Chennai, Kattupalli and Krishnapatnam and had to travel back and forth all the way.

6.2 Present Scenario

In recent times, there has been a significant increase in containerization of cargo. Container traffic has registered an annual growth much greater than the total cargo growth rate. This trend of higher growth rate is expected to continue. This is evident from the setting up of an ICD by Sattva Hi-Tech and Conware Pvt. Ltd. at Pondicherry in 2000. The Sattva ICD is located on a 10 acre plot about 12 km from Pondicherry. It is notified by Customs for storing of bonded cargo and also declared as a Customs Station (ICD) for the unloading of imported goods and the loading of export goods. Thereby, the processing of documents and examination of the containers would now be done in Pondicherry. In addition there are also two CFS by JWC Logistics Pvt. Ltd. and Indev Logistics Pvt. Ltd.

6.2.1 Assessment by Chennai Port

After the visit by the senior officials of Chennai Port to Pondicherry, they made their own assessment of the possible traffic and this is presented in the **Table 6.2**.

Table 6.2 Traffic Assessment by Chennai Port (Per Month)

Commodity	No of Voyages	TEU's / T per Voyage	Total	Unit
Container	30	200	6,000	TEU's
Bagged Sugar	3	2,000	6,000	T
Bagged Cement	3	2,000	6,000	T
Rice	2	2,000	4,000	T
Timber Logs and Sawn	2	2,000	4,000	T
Edible Oil	3	5,000	15,000	T
Industrial Edible Oil	2	2,500	5,000	T
Fertilisers	2	7,500	15,000	T
Minerals (Flourspar)	2	7,500	15,000	T
Liquid Chemical	2	2,500	5,000	T
General Cargo Total	21		75,000	

As regards the general cargo, it appears to be an ambitious assessment with the total annual traffic going upto 900,000 T. It has to be noted that the capacity of the existing facilities at the New Port is only 300,000 to 400,000 T only according to Pondicherry Port.

6.2.2 Assessment by AECOM

During their site visit, AECOM interacted with the Port authorities and discussed with them the immediate potential for traffic. AECOM also had an opportunity to interact with the representatives of M/s Seaside Container Freight Station, Pondicherry who were in dialogue with the port for operating a CFS at the sheds at the New Port and M/s Sai Ramnarayan Enterprises Pvt. Ltd., who were planning to operate a feeder container vessel from Pondicherry to Chennai.

The feeder vessel " Chougule 8 " proposed is presented in the **Figure 6.1**.

Figure 6.1 Container Feeder Vessel : "Chowgule 8"

Its size is 67 m x 9 m x 3.5 m. It has a 45 T crane onboard for handling the containers. It has a capacity to accommodate 75 TEU loaded containers or 105 TEU empty containers. In addition, they are planning to operate 6 no. of 500 T to 800 T barges for transhipment of general cargo. These barges are of size 50 m to 60 m; 5 m to 6 m; 2m to 2.5 m. The feeder vessel could make on round trip per day between Chennai Port and Pondicherry while each barge could make 2 round trips per day for transhipment.

Based on these discussions and with their input, AECOM have made its own assessment of immediate traffic potential which is presented in the **Table 6.3**.

Table 6.3 Traffic Assessment by AECOM (Per Month)

Commodity	No of Voyages	TEUs / T per Voyage	Total	Unit
Container	30	150	4,500	TEU's
Bagged Sugar	2	1,800	3,600	T
Bagged Cement	2	1,800	3,600	T
Rice	2	1,200	2,400	T
Timber Logs and Sawn	2	1,200	2,400	T
Edible Oil	2	3,000	6,000	T
Industrial Edible Oil	2	2,250	4,500	T
Fertilisers	-	-	-	T
Minerals (Flourspar)	-	-	-	T
Liquid Chemical	-	-	-	T
General Cargo Total	12		22,500	T

7.0 ASSESSMENT OF GROSS REVENUE

7.1 Tariff for Consideration

The tariff related to cargo handling at Cuddalore (TNMB), Pondicherry and Chennai Ports are given hereunder in **Table 7.1**.

Table 7.1 Tarrif Comparison (Cargo Related Charges)

<table>
<tr><th colspan="2">Type of Charges</th><th>Cuddalore (Rs.)</th><th>Pondicherry Present Rates (Rs.)</th><th>Chennai Port (Rs.)</th></tr>
<tr><td colspan="2">Wharfage</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Containers</td><td>20' Load</td><td>1036.80</td><td rowspan="4">Not Available</td><td>710.00</td></tr>
<tr><td>20' Empty</td><td>259.20</td><td>56.80</td></tr>
<tr><td>40' Load</td><td>1555.20</td><td>1065.00</td></tr>
<tr><td>40' Empty</td><td>388.80</td><td>87.20</td></tr>
<tr><td colspan="2">Bagged Sugar</td><td>36.00</td><td>15.00</td><td>50.80</td></tr>
<tr><td colspan="2">Bagged Cement</td><td>43.20</td><td>15.00</td><td>40.60</td></tr>
<tr><td colspan="2">Rice (Food Grains)</td><td>36.00</td><td>20.00</td><td>50.80</td></tr>
<tr><td colspan="2">Timber Logs And Sawn (1 CBM = 1.86 T)</td><td>57.60</td><td>15.00</td><td>66.77</td></tr>
<tr><td colspan="2">Edible Oil (In bulk)</td><td>43.20</td><td>20.00</td><td>78.10</td></tr>
<tr><td colspan="2">Industrial Edible Oil</td><td>43.20</td><td>20.00</td><td>78.10</td></tr>
<tr><td colspan="2">Fertilisers</td><td>43.20</td><td>15.00</td><td>40.60</td></tr>
<tr><td colspan="2">Minerals (Fluorspar)</td><td>43.20</td><td>20.00</td><td>40.60</td></tr>
<tr><td colspan="2">Liquid Chemical</td><td>72.00</td><td>10.00</td><td>137.50</td></tr>
</table>

Pondicherry Port is planning to revise their Scale of Rates. Chennai Port, in their calculations have taken the revised tariff as 40% of ChPT rates. However, Pondicherry Port authorities informed AECOM during the site visit that they are planning to have the revised rates set as 10% less than that of Cuddalore under Tamilnadu Maritime Board. Applying these rates, the revenue per month due to cargo handling operations are presented in **Table 7.2** hereunder.

Table 7.2 Gross Revenue Assessment by AECOM (Per Month)

Commodity	No of Voyages	TEUs / T per Voyage	Total	Unit	Rate: Rs per TEUs / T	Revenue in Rs.
Container	30	150	4,500	TEUs	1,166.40	52,48,800
Bagged Sugar	2	1,800	3,600	T	32.40	1,16,640
Bagged Cement	2	1,800	3,600	T	38.88	1,39,968
Rice	2	1,200	2,400	T	32.40	77,760
Timber Logs and Sawn	2	1,200	2,400	T	51.54	1,23,696
Edible Oil	2	3,000	6,000	T	38.88	2,33,280
Industrial Edible Oil	2	2,250	4,500	T	38.88	1,74,960
Fertilisers				T	38.88	
Minerals (Flourspar)				T	38.88	
Liquid Chemical				T	64.80	
Total Revenue per Month						61,15,104
Total Revenue per Annum						7,33,81,248

The revenue on account of cargo handling will be about **Rs. 7.3 crores**.

The annual revenue on account of other services like storage charges, harbour entry fees, etc. will be only marginal and have not been considered.

8.0 CONCLUSIONS & RECOMMENDATIONS

8.1 Conclusions

1. Even though Pondicherry Port has been inactive for almost 10 years, the trade is looking forward for its revival based on traffic demand and inherent advantages.

2. In recent times, there has been a spurt in the growth of container trade which had not been handled earlier at Pondicherry. Presently, containers are moved from Pondicherry to Chennai / Kattupalli ports by road. The prospective feeder operator is confident that the trade will switch over to the marine route to Chennai as the total transportation cost by sea versus by road is almost half. Moreover, the usual hurdle of port entry and exit for containers by road is avoided. It is understood that once this mode is established, even the ICD operator Sattva will be interested to move their containers through the sea.

3. The lighterage operations with ships waiting at the offshore anchorage and cargo moved through barges could be revived. Small time players will find it advantageous to lighter the vessel at Pondicherry than getting their products unloaded at Chennai and moving them by road.

4. Presently, Pondicherry Port has its limitations in that the approach channel cannot be dredged below 4 m (w.r.t CD) because of the presence of the submarine pipeline tunnel. However, this will not be a hindrance to the lighterage operations and for the movement of container feeder vessels.

As indicated earlier, the draft of the proposed vessel is only 3.5 m. As regards barges for lighterage operations, a representative list of barges is furnished in **Table 8.1**.

Table 8.1 Typical Barge Dimensions

DWT	LOA (m)	Beam (m)	Loaded Draft (m)
5000	73.50	24.30	3.80
2300	70.00	14.00	3.15
1800	65.00	12.00	3.20
1334	60.15	10.30	3.05
1060	52.40	10.00	3.10
950	52.00	10.00	2.92
800	47.00	9.00	2.90
750	54.80	15.24	2.80

1. The liability of Chennai Port in committing to undertake the recurring annual maintenance dredging of the mouth and the channel cannot be precisely defined as at present. The volumes could only be estimated. Exact volumes will be known only after repeating the dredging for a couple of years.

2. The rate for dredging has also been assumed with the provision that the existing port dredger will be utilised and the dredged material has to be used for shore replenishment. The rate could come down if the dredged material is allowed to be dumped in the sea.

3. The possible traffic potential has also been estimated. It is likely that it may take some time for this to materialise once the port becomes operational. Consequently, the revenue generation will also grow gradually.

4. It is definitely advantageous for Chennai Port to develop Pondicherry Port as its feeder port as there are good indications of increased container traffic in the region.

8.2 Recommendations

- With a very conservative estimate of the extent of maintenance dredging and the likely traffic that may pass through Pondicherry Port, there will be a marginal net surplus in the financials.

- This proposed interaction between these two ports will be definitely advantages to both. As of now both Chennai Port as well as Pondicherry Govt. is keen on this tie-up. As the proverb goes "*hit the iron when it is hot*" it is recommended that Chennai Port go ahead with this project and sign a MOU/Agreement.

- However, the two crucial variables viz. dredging & traffic have to be properly quantified, a process that may take some time. Hence, it is suggested that Chennai Port closely monitor the developments once the port activities are revived with the initial capital dredging done by Pondicherry Port. This should cover the traffic pick up as well the rate of siltation.

- It is also suggested that Chennai Port keep a relief provision in the MoU/Agreement for re-negotiating the revenue share if found necessary.

Potential Location of Major Port in Central Andhra Pradesh - Narsapur

1. Location of Port at Narsapur

Narasapuram (or Narsapur) is a town in West Godavari district in Andhra Pradesh. For setting up of a greenfield port at Narasapuram three alternate locations have been studied by M/S RITES and judiciously the location at South west of Vasista river mouth was selected as shown in Figure below:

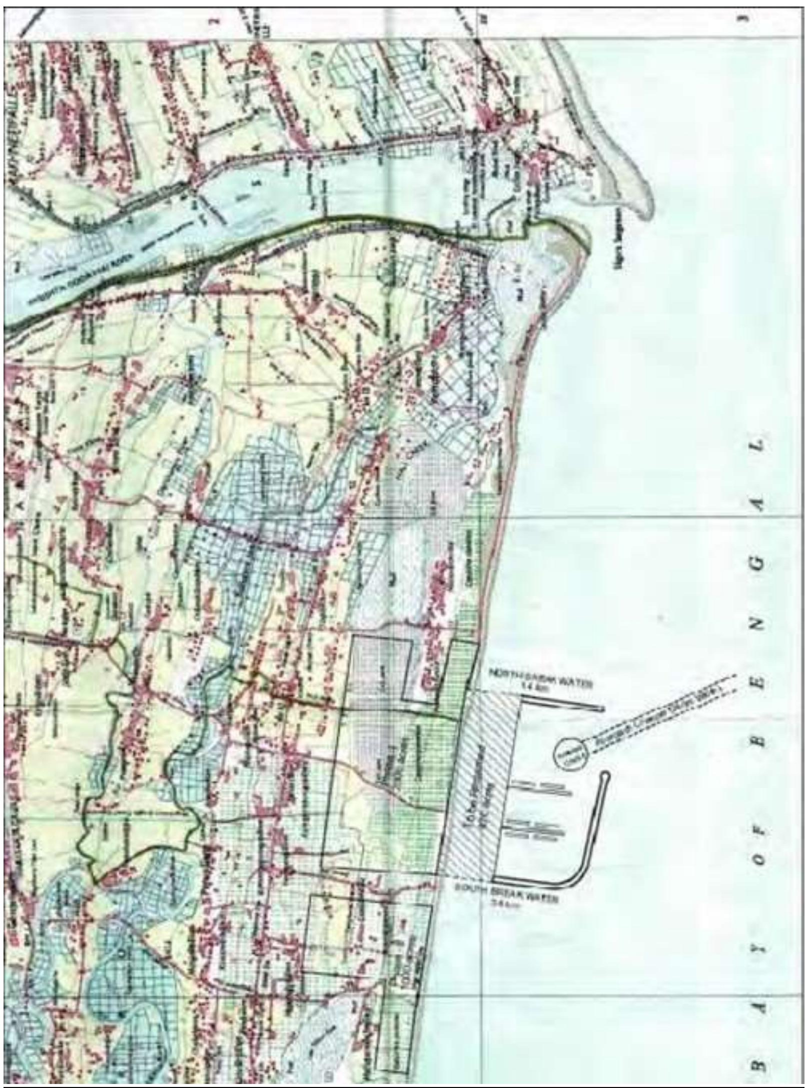

Figure 1 Location of Narsapur Port

2. Specific Site Characteristics

The hydrographic data indicates that 10 m contour is located at about 11 km and that 15 m contour is located about 15 km away from the shoreline. Beyond 15 m contour the offshore seabed slope is very steep and within 2 km from 15 m contour 20 m contour exists.

The deep water wave climate is dominated by south-westerly and north-easterly conditions associated with the (south-westerly) monsoon and the post-monsoon respectively. The project site is directly exposed to the waves and the proposed port would need breakwater protection for round the year operations. Previously many cyclones have passed nearby the region.

The geotechnical investigations carried out at site indicate very weak soil upto a depth of 30 m.

The connecting state roads to site are single lane of width about 3 m and are connected to NH-214A Narasapuram Mogalturu road, which is also only 5 m wide. The connectivity to NH5 is at a distance of about 36 km.

For rail connectivity about 16 km of new railway line connecting the project site is required to be laid.

3. Traffic Potential and Facility Requirement

As part of OD study carried out as part of the Sagarmala assignment, traffic potential for the port at Central AP was estimated. Thermal coal, cement and containers are found to be the key commodities for which this port could be planned.

In the initial years the traffic potential for thermal coal is expected to be about 11 MTPA while that for containers and cement is expected to be 80,000 TEUs and 6.6 MTPA respectively.

However the traffic can grow in the master plan phase to about 15 MTPA, 1.0 MTEUs and 23 MTPA for thermal coal, containers and cement respectively even in the base case scenario. Significant traffic for cement is on account of expected cement cluster that could be set up at a nearby location. It may be important to note that the cement traffic would be moved to the port mainly through road.

Considering the traffic potential, it is expected that initially one fully mechanized coal berth and about 2 multipurpose berths and 2 mechanized cement berths would be needed. Additional berths with associated handling system would be added over the master plan horizon commensurate with traffic.

It is assessed that for port operation and storage of cargo about 100 Ha. of land would be needed in Phase 1 development and that about 250 Ha. for the master plan stage. The land requirement excludes the land area needed for providing proper connectivity to site.

4. Site Assessment for the Projected Traffic

Significant traffic potential exists for any port to be developed in Central Andhra region. Therefore suitable location would be the one which could be developed expeditiously so as to have the first move advantage and where the projected traffic could be handled in cost economic manner.

However, the following factors do not support setting up of a major port at Narsapur:

1. None of the land along the waterfront is available and would need to be acquired for storage of cargo and port operations. Similarly considering the cement being the predominant cargo, the majority of the cargo shall be moved in and out of port through road and hence strong road network would be needed which would require significant land acquisition. The land acquisition details have not been identified yet in the report prepared by RITES.
2. As 20 m contour is about 17 km from shore and therefore significant capital dredging would be needed to create depths for handling cape size ships and even for handling panamax size ships. The Vasista River brings significant quantity of sediments from upstream which will get deposited in the channel and harbour area of port resulting in significant maintenance dredging.
3. The boreholes carried out at site indicate very weak soil upto a depth of 30 m. Under these site conditions, it is preferable to have lagoon type harbour with small breakwaters, which is not possible at this location due to land constraints. This means that the cost of breakwaters construction would be very high.
4. As the dredged spoil does not seem to be suitable for reclamation, borrowed fill would be needed resulting in higher cost of reclamation.

In view of the above, it is suggested that alternative location be studied for port development at Central AP.

Mechanized Fertilizer Import Terminal for Kandla Port

Prepared for

Ministry of Shipping / Indian Ports Association

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DELD15005 - DRG - 10 - 0000 - CP - KND1003	General Arrangement of Bagging Shed
DELD15005 - DRG - 10 - 0000 - CP - KND1004	Bagging Shed Cross Sections
DELD15005 - DRG - 10 - 0000 - CP - KND1005	General Arrangement of Bulk Shed
DELD15005 - DRG - 10 - 0000 - CP - KND1006	Bulk Shed Typical Section
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1.0 INTRODUCTION

1.1 Preface

With the intention of maximising agricultural production, the Government of India promotes and assists production of Fertilizers and also plans and arranges import of fertilizers for the entire country.

India has serious raw material constraints in producing fertilizers required for the country. While India is somewhat self-supporting in Urea production, it is perpetually dependent on import of phosphoric fertilizers to a large extent and 100% dependent on import for Potash. Additionally, the country also imports Urea to bridge the gap between indigenous production and actual requirement which varies year to year.

Kandla port's geographical position makes it unique to handle such imports required for the large agrarian economy of north and North West part of country which actually produces all most all the wheat required for the country.

While Kandla already handles fertilizers to a substantial extent, off-late Mundra port located very close to Kandla has developed capabilities to handle fertilizer imports with better facilities by way of mechanization of bulk imports, bagging and evacuation.

1.2 Traffic Forecast

1.2.1 Traffic Handled at Port

During 2014-15 Kandla port has imported 3.66 MT of Fertilizers all in bulk as detailed below.

Table 1.1 Fertilizers Imports Handled During 2014-15

	Quantity (T)	No of Vessels	Max Vessel DWT (T)	Min Vessel DWT (T)	Max Parcel size (T)	Min Parcel Size (T)	Average Parcel Size (T)
Fertilizers (Alone without FRM - Dry and Ammonium Sulphate	36,57,686	96	82,153	22,019	66,000	6,750	38,100

Table 1.2 Fertilizers Raw Material Imports Handled at Port (T)

Commodity	2011-12	2012-13	2013-14	2014-15	2015-16
DAP/urea	4,126,160	2,987,481	1,683,544	2,709,023	3,534,157
MOP	1,171,006	690,485	959,959	1,137,899	827,833

Table 1.3 Finish Fertilizers Imports Handled at Port (T)

Commodity	2011-12	2012-13	2013-14	2014-15	2015-16
Rock Phosphate	658,433	945,810	991,391	655,378	169,869
Sulphur	102,607	0	0	0	00

During the financial year 2015-16, Kandla Port has handled 4,361,990 T of finished fertilizer like DAP, MOP, Urea, etc. and 169,869 T of fertilizer raw material like rock phosphate, sulphur etc.

1.2.2 Rationale

The objective to develop Mechanized fertilizer handling facility at Kandla port for handling of Import fertilizer (Urea, MOP, DAP) inside the port premises is:

- to enable efficient handling of vessels, leading to their faster turnaround time
- to enable faster turnaround time of rakes
- to minimize the manual intervention to achieve lower handling cost
- ensuring clean environment

1.2.3 Potential for Import through Kandla

As part of the traffic projections provided by McKinsey as part of the Sagarmala assignment, it is estimated that Kandla port would handle roughly 6.1 MTPA of fertilizers by 2020, 8 MTPA by 2025 and 11-13 MTPA by 2035. A significant proportion of the projected fertilizer traffic could be handled by mechanised terminal.

2.0 THE PORT AND SITE CONDITIONS

2.1 Kandla Port

Port of Kandla governed by Kandla Port Trust is located at the west coast of India, is one of the 12 major ports of India and the only Major Port in the state of Gujarat. It was declared as a Major Port on April 8, 1955.

Kandla Port is a natural harbour situated in Kandla Creek and is 90 km from the mouth of Gulf of Kutch. Geographically, the port is spread in three locations viz., Kandla, Vadinar and Tuna Tekra. These site locations are as shown in the **Figure 2.1**.

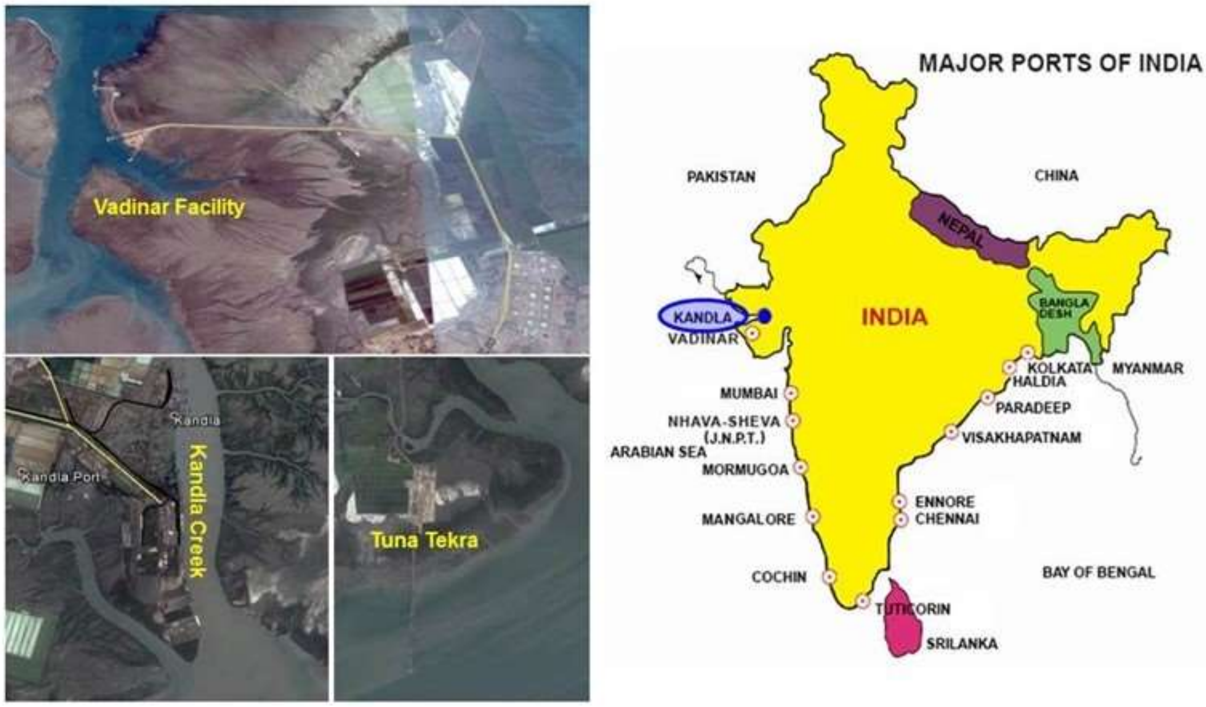

Figure 2.1 Geographic Location of Kandla Port

2.2 Rail and Road Connectivity

2.2.1 Background

Access to the port will play a key role in linking the port expansion to the rest of its supply chain. Ensuring that surface transport links to the port expansion are adequate will be crucial in ensuring the efficiency of the overall supply chain. Kandla Port needs to have an efficient "whole of chain" system to maximise the port's attractiveness to shippers and thus its competitiveness.

Whilst the mode split of cargo to and from the port will be determined to a large extent by the types of products hauled, and hence the detailed road and rail requirements, there are a number of general issues which need to be considered concerning road and rail access.

It is clear that road and rail infrastructure in the port is already in place which could be utilised to serve the port expansion, although some additional facility will be required to customise the connections to the various terminal areas and to upgrade the internal transport infrastructure generally to provide the level of service required.

With regard to the external connectivity, the Port is well connected by the network of rail and road. It caters to the trade requirements and provides gateway port for export and import of traffic of one of the most highly productive granary and industrial belt of the country stretching across the hinterland states of northern Indian states of Jammu & Kashmir, Delhi, Punjab, Himachal Pradesh, Haryana, Rajasthan, Gujarat and parts of Madhya Pradesh, Uttaranchal and Uttar Pradesh.

2.2.2 Road Connectivity

Kandla Port is connected with National Highways NH 8A connecting Ahmedabad and Mundra/ Mandvi through Gandhidham. The four lane NH 8A extends right up to the port's main gate. The port is also connected through NH 141. The port also has fully developed road network, both in and around the Port area to facilitate faster movement of cargo. The road network within the port area is as below:

- Inside Cargo jetty area: 30km
- Outside Cargo Jetty area: 31km

2.2.3 Rail Connectivity

Broad gauge (BG) tracks directly connect the Port at Kandla with the principal cities of Mumbai, Ahmadabad, Surat, Baroda, etc., and also Delhi, Punjab and Haryana through the route Ahmadabad – Ratlam – Kota – Mathura to Delhi. The second route is via Palanpur – Ajmer to Delhi. The nearest railway station is Gandhidham railway station is 24.3 km.

The port has railway connectivity inside the cargo jetty area up to berth no. 10 and is being extended till berth no. 16.

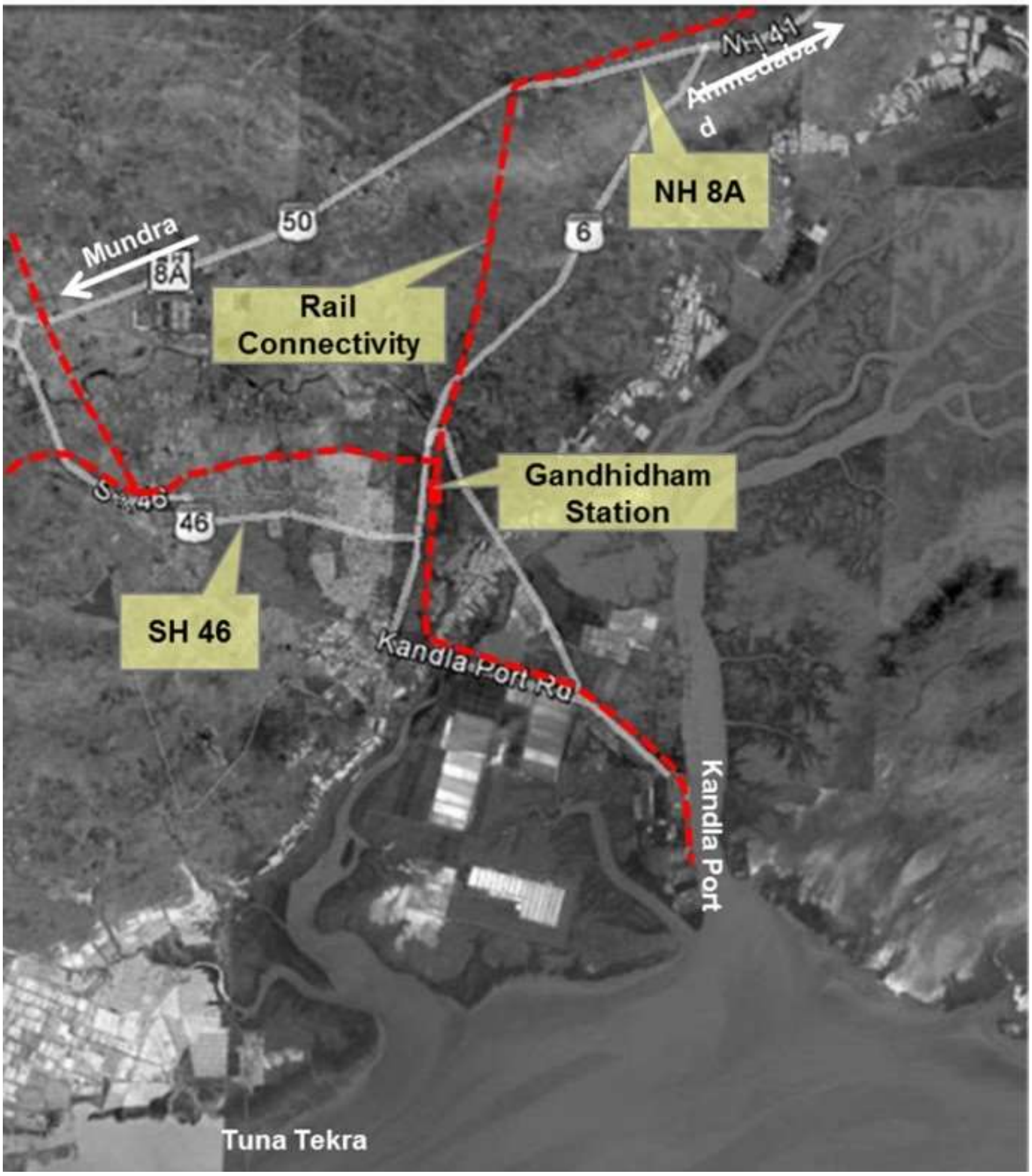

Figure 2.2 External Rail and Road Connectivity to Kandla

2.3 Site Conditions

2.3.1 Meteorology

The climate at Kandla is governed by the monsoons. In the months June-September, the south-west monsoon occurs. The later period is often indicated as the post-monsoon period.

2.3.2 Winds

Non cyclonic maximum winds (30-40kmph) occur during May-August. Wind speeds are relatively less during North East Monsoon. However, wind speeds up to 180 KMPH have been observed during cyclonic storms.

2.3.3 Rainfall

Rainfall at Kandla is low. Annual average rainfall is about 322 mm per annum with the total number of rainy days of 17 per year, about 90% of which is received during the south-west monsoon season, i.e., between June and September with a maximum of 153 mm in July. April and May are dry months with average rainfall below 0.6 mm per month.

2.3.4 Temperature

The mean daily maximum temperature is 34°C and with 40°C the highest occurring in May. Mean daily minimum temperature is 20°C and with 12°C the lowest occurring in January.

2.3.5 Visibility

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

2.3.6 Relative Humidity

Relative humidity is generally high and rises to about 80% during the monsoons in the month of August.

2.3.7 Oceanography

2.3.7.1 Tides

The tides at Kandla are semi-diurnal with tidal levels, relative to the Chart Datum (CD), as follows:

Mean High Water Spring (MHWS)	+6.6m
Mean High Water Neap (MHWN)	+5.7m
Mean Sea Level (MSL)	+3.8m
Mean Low Water Neap (MLWN)	+1.8m
Mean Low Water Spring (MLWS)	+0.8m

2.3.7.2 Cyclone

In general the west coast of India is less prone to cyclonic storms compared to the east coast. It is observed from the cyclonic tracks in the Arabian Sea that only 6 storms endangering the Kandla coast have occurred till date with maximum speed recorded was 100 kmph. However, in 1998 a severe cyclone hit the Kandla Port with a wind speed of 150 kmph resulting in high tidal waves of 10.5m causing extensive damage to port installations.

2.3.8 Geotechnical Data

Based on the geotechnical information, the Kandla port area substrata comprises of silty clay up to 10m depth below seabed followed by followed by hard silty clay up to 26 m and beyond which is dense sand. Any heavy engineering structure would require piled foundations.

2.3.9 Topography

Topography at the proposed location of mechniased fertilizer terminal is at the level of +9.0m CD.

3.0 LOCATION OF THE PROPOSED TERMINAL

3.1 Proposed Fertiliser Terminal

As berths 1 to 6 have draft to cater the design ship size (handymax vessels) for fertiliser, based on the extensive discussions with Kandla port, it has been decided that the proposed fertiliser terminal be established at the existing berth 6 and the available backup area behind the berth.

The terminal facilities would include mechanized unloading of finished fertilizers from ship to shore, conveyance to transit storage in bulk, transfer to bagging shed, subsequent transportation of bagged fertilizer to railway loading platforms and finally loading into closed railway wagons for despatch to hinterland.

The available area for the development of proposed terminal is shown in **Figure 3.1**.

Figure 3.1 Proposed Location for Mechanised Fertiliser Terminal

4.0 FACILITY PLANNING

4.1 Traffic Assumptions and Cargo Characteristics

The terminal is to be designed for fertilizers and based on the review of the previous data, it is expected that four types of material namely Urea, DAP, MOP, Rock Phosphate would be mainly handled at this terminal.

To arrive at the basic outline of the terminal and planning of the material handling system, the assumptions on the different types of materials to be handled and their properties have been made as indicated in the enclosed **Table 4.1**:

Table 4.1 Characteristics of the Material to be Handled

Commodity		Urea	MOP	DAP	Rock Phosphate
Material Characteristics	Density (T/cum)	0.8	1.1	1.0	1.3
	Angle of repose	34	35	35	30
Size		(1- 2.8 mm) 98% - granules	(0.25-1.7 mm) 65%	(1-4 mm) 95% -granules or in powder form	Fines or in powder form

It is also understood that there will be different grades of materials and different users and thus requiring separate stockpiles.

4.2 Sizing of the Terminal and Handling Facilities

4.2.1 Berth Capacity

4.2.1.1 General

The capacity of the berth is governed by the time for which the berth is available, parcel size of the ships and capacity of the ship unloading system.

The fertilizer is being brought to the port in handymax size vessels and the average parcel size is about 25,000 T. The same figure is assumed for all types of fertilizers.

The type and capacity of the ship unloading system is most important component in deciding the berth capacity. The different types of system and the recommended system are discussed below:

4.2.1.2 Unloading of Fertilizer Vessels

The fertilizer unloading from ship to shore is affected by a variety of arrangements like Gantry type grab unloaders, Mobile harbour cranes and screw type unloaders etc. The typical systems are described below:

4.2.1.2.1 Grab Unloaders

This equipment could be Gantry type grab unloader/ ELL cranes or mobile harbour cranes. These equipment shall unload the material from the ship using grabs and transfer it to connected hopper (a separate mobile hopper in case of ELL cranes and MHCr). From hopper the material is transferred to the conveyor located underneath and the conveyor finally takes the material to the bulk storage shed. Typical arrangement is shown in **Figure 4.1**:

Figure 4.1 Typical Arrangement of Mobile Harbour / ELL Cranes with Mobile Hopper

4.2.1.2.2 Screw Type Unloader for Ship to Shore Unloading

A typical screw type unloader consists of a vertical screw conveyor arm, which after lifting the dry bulk fertilizer transfer it to the horizontal arm that contains a closed conveyor which finally transfers through the central column on to the dock side conveyor.

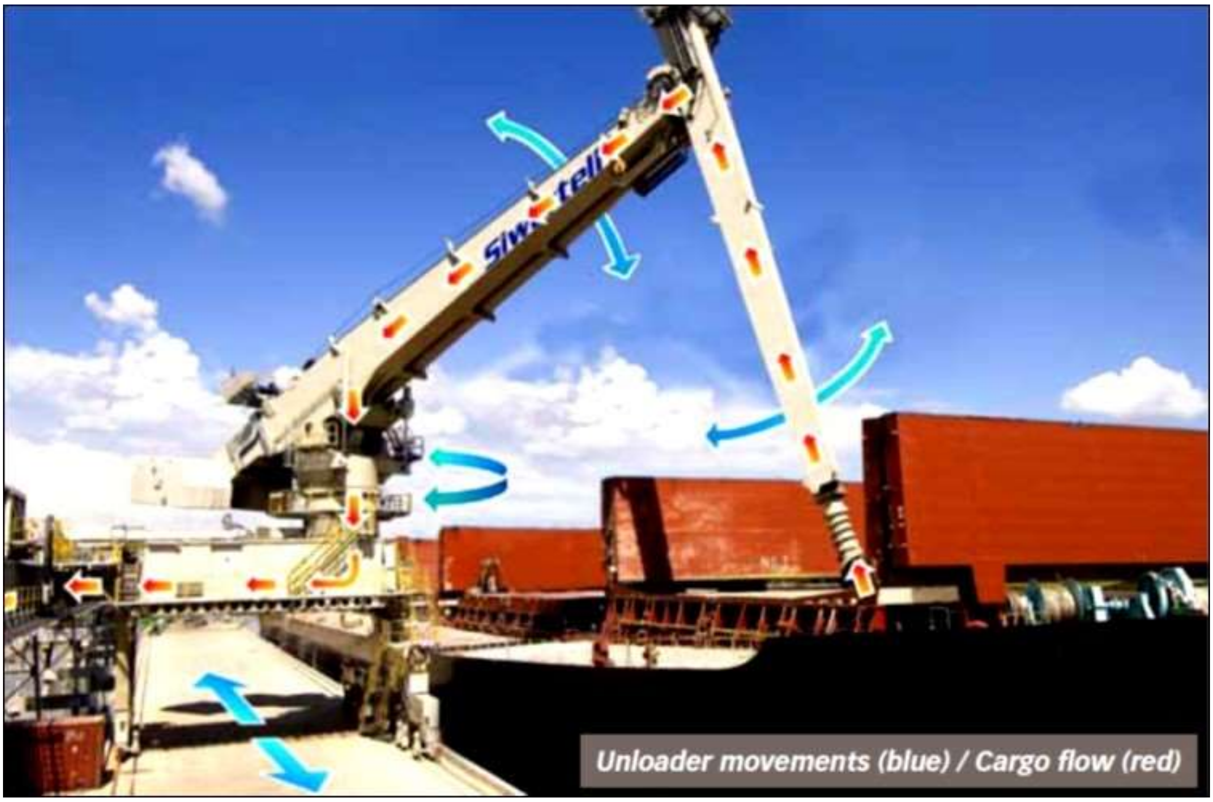

Figure 4.2 Screw Type Unloader

The vertical screw can dig through the material as it is positioned and the screw ensures a high degree of filling of material, thus ensuring uninterrupted flow. As the cargo leaves the vertical conveyor, it is transferred through a completely sealed box to a horizontal screw conveyor.

The horizontal screw that runs to the complete length of horizontal arm transfers the fertilizer into the vertical gravity chute in the slewing tower. Here the material is directed onto the receiving jetty conveyor which is covered on three sides with only the front side open to facilitate transfer of material as the unloader moves along the length of jetty.

4.2.1.2.3 Comparison of Options for Unloading System for Proposed Terminal

Both the ship unloading systems discussed above have their own merits and demerits. While the grab unloaders are the conventional machines suitable to handle variety of cargoes, the screw type unloaders are sophisticated machines requiring careful operation and maintenance while dealing with different product types. The screw unloaders allow uniform and higher handling rate as compared to the equivalent grab unloader.

It is however proposed to use the grab type ship unloaders with integrated hoppers due to the following reasons:

1. Different grades of material to be handled and unlikely their compatibility issues with the screw unloaders
2. It is possible to deploy similar grab cranes on the rail tracks that are currently being used at the berths 1 to 6, without having to check the structural stability of the berth. However, Screw type unloader would need to be tailor made to limit the loads and match the rail span.
3. The cost of two grab type cranes may be equivalent to cost of one screw type unloader, however they would unload vessel more uniformly as compared to the single screw unloader.

4.2.1.2.4 Suitable System for Proposed Fertilizer Terminal

Considering the ship sizes and parcel sizes to be handled and the requirement of utilising the existing berth, it is proposed to deploy two grab type unloaders with integrated hoppers. Each grab unloader shall have design unloading capacity of 1,000 TPH. This would provide an average unloading rate of 25,000 tonnes per day through a ship. It may be noted that for arriving the design unloading rate of system material considered is predominant commodity is Urea, with bulk density of 0.8 T/cum.

A conveyor of design capacity 2,000 TPH shall be provided at the berth to receive the material from the two connected hoppers and transfer it to bulk shed where it shall pass through a tripper conveyor for stacking in the bulk shed.

4.2.1.3 Capacity of Berth

The berth capacity has been calculated considering the following parameters:

- allowable berth occupancy of 65%.
- 6 hours of berthing and deberthing time per ship
- Average parcel size - 25,000 T

Based on the above, capacity of berth has been calculated as 4.55 MTPA. However, in reality the offtake of fertilizer peaks during the Khariff and Rabi seasons and are lean in the remaining time. This roughly corresponds to peak requirement for 9 months and subdued offtake in the remaining 3 months. Thus in practice the berth occupancy for the same throughput will be about 70% during peak season, which is considered acceptable.

4.2.2 Storage Area for Bulk Fertilizer

The storage capacity required at the terminal has been calculated based on the following criteria:

- Atleast equal to the maximum parcel size assumed as 40,000 T
- Average Dwell time of 10 days
- Atleast 5 separate stockpiles of average parcel size of 25,000 T considering different customers and different grades

Basis above the minimum storage capacity required for bulk fertilizers unloaded from ships works out to 125,000 T. This would require a shed of 45 m width and 700 m length for storage of bulk material.

4.2.3 Bagging and Evacuation Requirements

The bulk material stored in the bulk shed will need to be transferred to the bagging shed for bagging and stitching. For this purpose it is proposed to deploy a portal type scraper reclaimer at the bulk shed. This machine shall reclaim the material from the relevant stockpile and transfer it to the connected conveyor system. From conveyor the material shall be taken to the top of the bagging shed, where a series of hoppers shall be provided along its length. The material shall be dropped to the main hopper one by one using the plough feeders.

There shall be an intermediate floor in the bagging shed for the bagging and stitching of the fertilizers from where the bags shall be transferred to the platform level through chute. A total of 22 bagging machine shall be provided in the shed along its length i.e. each covering 2 wagons. The bagging machines are proposed to be semiautomatic type with design capacity of 700 bags per hour each. With this system it would take about 4 hours to bag the material for loading to one rake.

The bagging plant will typically consist of two units. The first unit comprises one tower of height 22 m, at each location of bagging cum stitching unit for its support. The second unit will be about 9 m high provided for storage of bagged fertilizers from where the bags are led to covered loading railway platform for despatch through rail wagons. At platform level the bags are stored prior to loading to wagons.

Considering the maximum rake length of 680 m, the length of bagging shed shall also be around 680 m. This would enable rail lines on either side of shed to enable handling of full length of rakes. The overall width of the shed is taken as about 23 m so as to provide cover to the wagons positioned for loading on either side of the shed which has platforms in th emiddel. The platform will have a width of 15 m.

Considering the predominant manual operations in bagging, only 16 working hours are assumed in a day. The proposed bagging system would provide annual capacity of about 2.7 MTPA. For arriving at the size of platform the suitable space for storage of cargo for two complete rakes has been considered. The minimum platform width works out to about 12 m.

To match with the peak bagging rate, it is proposed to provide the scraper reclaimer at the bulk shed with design capacity of 800 TPH. This duly allows for lower reclaiming rate achieved for the bottom cargo of the stockpile. However, the conveyor system for transfer of material from bulk shed to the bagging machines in the bagging shed shall have the design capacity of 1600 tonnes per hour to allow for taking feed from one more scraper reclaimer.

As the reclaiming conveyor would be provided towards one side only, the other side shall be available for entry of the front end loaders/dumpers to provide operational flexibility of reclaiming the material by semi-mechanized method of front end loaders and dumpers.

4.2.4 Capacity of Various Components of Mechanised Handling System

The effectiveness of a fertilizer import terminal lies as much in efficient evacuation as in ship unloading. An efficient layout with relative positions of transit storage, bagging area and wagon loading platforms decides the efficacy of the whole system.

1. The proposed two grab unloaders, each with design capacity of 1000 TPH, alongwith connected hopper provide the berth capacity of 4.55 MTPA as indicated in para 4.2.1.3.
2. The bulk shed has been planned to provide a storage capacity of 125,000 T and thus this can also support the berth capacity of 4.55 MTPA assuming the dwell time of 10 days.
3. 22 semi-automatic bagging machines, each with a design capacity of 700 bags per hour, shall be provided and as indicated in para 4.2.3 the annual bagging capacity work out to 2.7 MTPA. In future another set of 22 machines and the connected conveyor system could be provided to increase the bagging capacity.
4. The proposed portal type scraper reclaimer has adequate capacity to match with that of one set of 22 bagging machines. Another machine could be added in future to support another set of bagging machines. The reclaiming conveyor in the bagging shed has already been designed considering the future requirements.
5. It is assessed that initially one number of loading sidings shall be provided along with an engine escape line, which shall be on the other side of the shed. Considering the turnaround time of each rake to be around 5 hours (from exchange yard), the annual capacity of one rake loading siding works out to 2.7 MTPA which also matches with the bagging capacity of the system. Once the facility is expanded, one more siding shall be provided so that loading of rakes could be carried out simultaneously on either side of the shed.

4.3 Estimated Capacity of Fertilizer Unloading Terminal

Based on the proposed mechanised system, the capacity of fertilizer terminal will be 2.7 MTPA in the Phase 1 development. With the addition of one set of bagging machines, one scraper reclaimer and one loading siding the system capacity shall increase to 4.2 MTPA, governed by berth capacity.

5.0 LISTING OF PROJECT COMPONENTS AND ENGINEERING DETAILS

5.1 Project Components

The detailed list of project components is provided below:

S. No.	Item Description	Quantity and Capacity
A	**Berth 6**	**205.73 m long with contiguous backup area**
B	**Material Handling System**	
1.	Ship Unloaders with integrated mobile hoppers	2 No. with design capacity of 1000 TPH each
2.	Conveyor System at berth and till Bulk Storage Shed	Design capacity of 2000 TPH
3.	Tripper and Conveyor in Bulk Shed	One No. with Design capacity of 2000 TPH
4.	Portal Type Scrapper Reclaimer	Two no. with Design capacity of 800 TPH each
5.	Dispatch Conveyor in bulk shed and upto transfer Tower TT3	Design capacity of 1600 TPH
6.	Dispatch Conveyor between bulk shed and bagging shed and along the bagging shed	Design capacity of 800 TPH
7.	Dust Extraction System	
8.	Intermediate Hoppers and Semi-automatic Bagging & Stitching Machines	22 bagging machines with design capacity of 700 bags per hour each
9.	Miscellaneous items such as flap gates, fixed tripper, belt weighers, magnets, metal detectors, plough feeders, hoists and handling devices, etc.	LS
C	**Buildings and Sheds**	
1.	Gate House	2 lanes each for incoming and outgoing
2.	Bulk Storage Shed	700 m long x 49 m wide
3.	Bagging Plant and Wagon Loading Shed	690 m long x 23 m wide

S. No.	Item Description	Quantity and Capacity
D	**Electrical and Control System**	**LS**
E	**Onshore Infrastructure and Utilities**	
1.	One loading line and one engine escape line	Total length of 3500 m
2.	Roads	2 lane existing road
3.	Fire Fighting System	LS
4.	IT/Communication system	LS

The details of these components are discussed in the subsequent sections.

5.2 Berth Structure

5.2.1 Details of Existing Berth Structure

The total length of berth 6 is 205.73 m and it is contiguous to land. The existing structure of berth comprises of RCC superstructure of slab and beams supported over piled foundation. This berth is currently under redevelopment / maintenance and likely to be completed by end of this year.

5.2.2 Design Criteria of Existing Berth

As per the information available with port the existing berths 1 to 6 have the following design criteria:

- The deck has been designed for a uniformly distributed load of 3.3 T/sqm
- The designed dredged level at the Berth is -9.1 m CD
- The berth is designed for grab type gantry cranes which travel over crane rail provided

5.2.3 Modifications Needed at Berth

It is considered that the same berth structure would be suitable for handling the proposed grab cranes and connected hoppers. However, new crane rails would need to be laid.

5.3 Material Handling System

5.3.1 Brief System Description

The handling system at the proposed fertilizer terminal in the form of flow diagram is shown in **Drawing No. DELB15005-DRW-10-0000-CP-KND1002**. The description is provided below:

- Two rail-mounted quay cranes provided on berth shall have a design capacity of 1000 TPH each.
- There shall be a single conveyor from berth to yard to meet the requirements of the terminal. To match the unloading rate of two cranes the design capacity of the conveyor shall be 2000 TPH.
- The conveyor on the berth will be elevated to reduce the fall of material from the unloader so that undue material degradation is avoided. This conveyor will be level and open in the entire loading zone.
- A series of elevated conveyors and transfer points will follow to carry the cargo to the yard area, and transferred to elevated conveyor with travelling tripper to cover the entire length of the storage shed.
- The system is planned such that bulk material from berth could be transferred to the Bulk shed, which is provided with a tripper conveyor on the top for stacking the material.
- It is proposed to deploy one portal type scraper reclaimer in shed for reclaiming the material. As the reclaiming conveyor would need to be provided towards one side only, the other side shall be available for entry of the front end loaders/dumpers to provide operational flexibility of reclaiming the material manually. To match the design capacity of bagging it is proposed to have the design capacity of scraper reclaimer as well as reclaiming conveyor as 800 TPH.

- There shall be provision in bulk shed for deployment of mobile hoppers over the reclaiming conveyor to feed material using front end loaders. This shall help in meeting any contingent requirements in the event of any downtime of scraper reclaimer.
- The material reclaimed from the shed shall be transferred to conveyor which will carry the material to the bagging shed.
- The bagging shed shall receive the material at one end on the conveyor located at its top. Provision shall be kept for another similar stream of conveyor.

5.3.2 Design Criteria

5.3.2.1 General

The equipment selection and design has been planned keeping in view the maximum utilisation of the indigenously available components and materials required, thereby restricting the dependence of spare parts or maintenance service from outside India to the minimum.

For instance, even if the equipment is procured from abroad, it would be kept in view while making the basic design and specifications:

- Generally all consumables are available in India,
- Servicing of all components could be carried out from India,
- Design and entire supply will conform to the local regulatory authorities' requirements, such as electricity authorities, dock safety, etc.

However, it is assessed that most of the equipment proposed in this facility can be manufactured in India.

All design will conform to the relevant Indian Standards and Codes of Practice. In case any information is not available in the Indian Codes, equivalent codes issued elsewhere will be suitably adopted subject to approval.

Equipment shall be designed with careful consideration of the accessibility of all drives and other machinery for inspection and maintenance.

Machine components such as motors, reducers, bearings, etc., shall be standardised.

All equipment shall be suitable for heavy duty and continuous operation.

Provision of space for future requirement shall be kept wherever applicable.

5.3.2.2 Cargo Characteristics

The cargo characteristics considered for arriving at the size of storage as well as planning of the material handling system have been previously given in **Table 4.1**.

5.3.2.3 Cargo Handling Rates

5.3.2.3.1 Berth to Storage Shed

Design capacity of each of the two ship unloaders proposed at berth is 1000 TPH. Therefore it is proposed to provide the conveyor system with design capacity of 2000 TPH from berth to storage sheds.

5.3.2.3.2 Storage Sheds to Bagging Plant

The conveyor system to bagging shed shall feed 22 bagging machines. The design capacity of each machine is 35 TPH. Keeping some allowance it is proposed to provide the reclaiming conveyors with design capacity of 800 TPH.

5.3.3 Ship Unloaders with Integrated Mobile Hoppers

The material shall be unloaded into an integrated mobile hopper, which is connected to the ship unloader and moves on the same rail span. The mobile hopper shall transfer the material to the conveyor located underneath and the conveyor then finally takes the material to the bulk storage shed.

5.3.4 Conveyor System

Conveyor system in a facility of this type is expected to meet the basic requirements of reliability, sustained operation with minimum maintenance and operation costs. The main considerations guiding the designing of conveyor system are as follows:

5.3.4.1 General

Belt Conveyors shall be complete in all respects and shall include but not limited to idler rolls with supports, pulleys, drive units with base frames, belting, head and tail frames, take-up units, skirt boards, scrapers, transfer chutes, stringer frames, short supports, deck plates, (limited to loading zone, except for berth conveyor and stacking/ reclaiming conveyors in the sheds which shall be provided with deck plate throughout the travel length of the Ship Unloader, Tripper or Scraper-Reclaimer as applicable), seal plates, etc. and all bolts including anchor bolts.

Belt sag on the carrying side shall not exceed 2% of idler spacing. Maximum operating tension in the belt shall not exceed eighty (80) percent of maximum allowable working tension of the belt at the specified load.

Wrap angle shall be generally 200° / 400° for single snub drive/dual drive pulley respectively. All drive pulleys shall be lagged.

All Conveyors shall be capable of starting fully loaded.

5.3.4.2 Transfer Points & Galleries

The transfer points design will limit the material fall to the minimum from one conveyor to another which will not only reduce impact on the belt and idlers but also keep the dust generation to the minimum. Special seals and hoods will be provided to minimise the dust escape. Chutes will be provided with suitable type of liners and all joints forming edges will be ledged.

To enable easy and quick clean-up, if spillage does occur at transfer points, certain minimum clearance under the conveyors will be maintained. Floors at transfer houses will have a suitable slope so that the wash down or any water which may come in due to leakage of cover sheeting will be drained off quickly. At all transfer points, necessary scrapers, return plows and deck plates will be provided to stop material falling onto return belt in case of spillage, which otherwise will get lodged between belt and pulley and ultimately damage the belt.

To guide the falling material onto the lower belt, skirt boards upto 3 m length will be provided at all feeding points.

The conveyors will generally be provided with covered galleries. However, for the conveyor at the berth shall be open in the entire loading zone and elevate with covered gallery connecting with the first transfer point.

Clearance between top of rail track/road and bottom of conveyor gallery, wherever applicable, shall be kept at least 5.5 m.

Crossovers shall be provided for all conveyors at 100 m spacing. For each conveyor less than 100 m length, minimum 1 crossover shall be provided.

<u>5.3.4.3</u> ***<u>Conveyor System Components</u>***

Depending upon the take-up travel length and preference to vertical gravity type take-up, belting of either Nylon-Nylon type or EP type will be selected. Keeping in view the duty, belt flexing, elongation characteristics (permanent and elastic suitable safety factor) will be provided in selecting the belt sizes.

Convex and concave vertical curves in the conveyor profile will be used only wherever necessary. Generous radius will be provided to minimise edge tensions and to eliminate belt lifting off the idlers and consequent spillage.

All carrying idlers shall be three roll interchangeable rolls fixed type having 2 degree forward tilt, with 45 degree troughing angle for receiving conveyor & 35 degree for dispatch conveyors and return idlers shall be V-Type with 10 degree trough.

Impact type idlers shall be three (3) roll type provided with number of tough rubber discs with minimum shore hardness of 55 to 60 deg on shore ‘A’ scale.

All idlers shall be made out of ERW tube with outside diameters of carrying and return idler rolls not be less than 152.4 mm and 139.7 mm respectively. The roll dia. for impact idlers shall be minimum 139.7 mm with outside dia. of rubber ring as 190 mm.

The self-aligning idlers with side guide rollers shall be provided.

The idlers used will be of sturdy nature, easy to maintain provided with greased for life bearings and having a friction factor not exceeding 0.022.

To maintain belt sag within permissible limits of 2% which otherwise will lead to material spillage and also to provide minimum belt tension required for effectively driving the belt suitable tension through counter weight will be provided.

Pulleys provided will be of sturdy construction, with shaft mounted on spherical roller bearings. All drive pulleys will have grooved lagging and non-driven pulleys will have plain lagging.

Plummer blocks shall be 4 bolt centre split type, cast steel construction equipped with double row self-aligning spherical roller bearings with labyrinth seals and grease nipples suitable for use in saline atmospheric condition.

Deck plate made out of 3.15 mm thick MS sheet at loading points / area shall be provided. 5 mm thick Seal plate shall be provided where conveyor gallery crosses roads, buildings, and railway tracks.

Multiple blade spring operated type belt scrapers (primary & secondary) will be provided at discharge end of each conveyor for removing the heavy residue of materials adhering to the belt surface. The v-plough (internal) scrapers shall be fitted in front of tail pulley and take-up pulley to prevent the material which is falling on the top surface of return belt.

Effective guards or shrouds shall be provided for all rotating pulleys, shafts, gears, chains, v-belts, pinions, couplings, etc.

5.3.4.4 Drives

All conveyor drives will be generously sized to take care of occasional surges or overloads. Drive unit consisting of motor, fluid coupling, gear reducer and flexible coupling will be mounted on common steel base. Motors, reducers, couplings, etc., will be rated to meet the duty requirements and will be standardised to facilitate inter-changeability.

5.3.4.5 Safety Devices and Interlocking

Belt conveyor system; though less troublesome, can at times prove hazardous if proper safety precautions have not been taken. Pull cord, under speed, and belt sway switches at suitable intervals will be provided all along the length of conveyors.

Chutes will be provided with plug chute switches to indicate any undue build-up of material at transfer points.

To ensure that belt conveyor is running at the designed speed, under speed switches will be mounted on tail pulley of each conveyor, which, apart from indicating the slippage between pulley and belt, will also control the sequential starting of the conveyor system.

For preventing material build up in chutes caused by differential coasting times of the following and preceding conveyors, brakes of compatible ratings will be provided on the drives. The brake ratings will be based on the inertia of the conveyors and will be selected for the required torque and thermal ratings. Wherever found necessary hold back will be provided on the drive pulley of an inclined conveyor so as to ensure that no rolling back of conveyor occurs when the loaded belt is stationary.

5.3.4.6 Maintenance

Generally, belt conveyors are the least troublesome equipment known in material handling systems. However, unforeseen breakdowns requiring minor on the spot repairs or major maintenance, cannot be ruled out. Long shutdown of plant can be altogether avoided by keeping suitable spares handy. The number of necessary spares will be kept to a minimum by providing a system design incorporating inter-changeability and standardisation of components involved.

For easy maintenance of heavy components like the drive units located at elevated transfer houses, necessary monorail hoists will be provided.

Transfer towers/ galleries will be designed to suit easy replacement and vulcanising of belts.

5.3.4.7 Gates

The motor operated 2 position flap gates shall be provided in transfer chutes as specified and shall be complete with electrically operated actuators. The gates shall be of robust construction and suitable for trouble free operation.

5.3.4.8 Suspended Magnets and Metal Detector

a) Suspended Electro-Magnet (s) shall be provided on conveyors as shown in the Flow Diagram to remove tramp metals being carried along with the material on the belt.

b) Two (2) nos. of metal detectors shall be provided for each magnet. One (1) no. before the magnet and One (1) no. after the magnet which shall detect presence of any metallic pieces and subsequently send signal to the magnet to remove it.

5.3.4.9 Belt Weigher

The weigh scale shall be automatic and electronic type. It should be designed for continuous automatic weighing, metering and printing of cargo flow for a range of 20% to 120% of design capacity with an accuracy of +/-0.25%.

5.3.4.10 Hoisting and Handling Facilities

Suitable hoists shall be provided for erection & servicing of all major equipment. The equipment to be covered shall include (but not limit to) all conveyor drive units, all pulleys, magnetic separators, various service water/potable water pumps, gravity take up units, removal of any other major equipment.

5.3.5 Trippers

Motorized mobile trippers with two way discharge shall be provided for stacking the cargo in the bulk storage shed.

The tripper shall have a sturdy, welded, structural steel frame and supports for mounting all the machinery. A service platform shall be provided on one side. Tripper shall be equipped with welded steel cross over platform with handrail and access ladder at each end of the platform. It shall be located in front of and attached to the discharge chute. The tripper shall be mounted on two (2) sets of flanged cast steel, quenched and tempered wheels, axles of medium carbon steel. Antifriction bearings with suitable dust seals and easily accessible pressure gun lubrication fittings shall be provided. Adequately sized rails with sturdy supporting structure, foundation bolts, other embedment etc. shall be provided to cover the runway length. Necessary guide rollers with bearings etc. shall be mounted on the tripper.

5.3.6 Scraper Reclaimer

It is proposed to deploy one portal type scraper reclaimer on bulk shed. The rail span of the scraper reclaimer is proposed as 43.5 m and it shall be capable of reclaiming cargo upto 16 m height. The typical cross section of the scraper reclaimer within bulk shed is shown in **Drawing No. - DELB15005-DRW-10-0000-CP-KND1006**

The scraper reclaimer shall consist of a main and auxiliary scraper boom hinged near the lower end of the fixed side portal. The material is reclaimed in layers by the scraper boom with the travel of the machine and is discharged via impact table attached to the reclaimer machine at the fixed side rail on to the ground mounted conveyor. The conveyor shall be positioned inside the rail.

The travel mechanism comprises of the shaft mounted bevel helical gear unit, the pin and bush type brake coupling, the thruster operated jaw brake, the AC motor with frequency controller, and the base frame.

The portal structure and carriage would be of MS steel plate construction, and provided with the transfer chute.

The scraper chain will consist of double strand block link chain with blade holders, Scraper blades made from base plate of 10 mm thick MS plate with 10 mm thick Tiscral liners on bottom of side face of scraper blade equipped with cutting teeth.

The scraper boom would be of welded plate construction with horizontal and diagonal rolled steel section ties/ Tubular section.

The hoist mechanism consisting of foot mounted electric hoist with precision lifting speed electrical motor with VFD panel and brake, ropes, sheaves, etc.

Motorized grease lubrication system for rail travel mechanism & Motorized oil lubrication system for scraper shaft bearing block shall be provided.

Long travel drives shall be electric motor driven mechanical type with gear reducers shaft mounted on the driven wheels.

5.3.7 Plough Feeders

The plough feeders with linear actuator shall be equipped on the intermediate hoppers feeding belt conveyor located at the top of the bagging shed for further feeding into intermediate hoppers. The plough feeder shall have a sturdy, welded, structural frame and supports for mounting of machinery. The plough shall be mounted on two (2) sets of single flanged steel frame of hardened treads and fixed, cold rolled steel axles. Plough feeder size shall match the size of belt conveyor. Limiting arrangement provided at the ends to limit the movement of actuator shall be of heavy-duty type and interlocked with sequential interlocking system of conveyors.

Each plough feeder shall be provided with lifting table (or impact pad table) & plough to hold it in fixed position. Lifting table is required at each unloading point of conveyor where it flattens the belt with the help of a lifting table arrangement and diverts the cargo to intermediate hoppers openings. Serrated rubber seal shall be provided at open side to prevent dust nuisance.

5.3.8 Semi-automatic Bagging and Stitching Machines

It is proposed to deploy 22 semi-automatic bagging and stitching machines along the length of bagging shed. Each machine shall get fed from conveyor through a small hopper placed on top of the shed (Typical system shown in **Drawing No. - DELB15005-DRW-10-0000-CP-KND1004**). The brief system description is given below:

- Bagging and stitching machines shall consist of net weigher, loading spout, slat conveyor, stitching machines, etc. This system is a semi-automatic type which requires minimum two skilled labours to assist. One to put the empty bag at the opening of incoming cargo and other one to hold the bag moving on slat conveyor for stitching. After stitching, bags will automatically transfer to the platform through the spout for loading manually into wagon or stacking at the platform.
- The material received at the conveyor on top of the bagging shed shall be sent to intermediate hoppers with the help of plough feeders.
- Intermediate hoppers shall be provided along the platform spaced at about 30 m for loading the entire rake. Each intermediate hopper has one slat of bagging & stitching lines.
- The capacity of Intermediate Hoppers shall be kept as 70 T for smooth feeding of material to Bagging & Stitching machines.

The broad specifications of the bagging and stitching machine are given below:

- Each unit shall be complete with surge hopper, gravity feeder, net weigher, microprocessor based electronic controller for weighing, discharge chute, filling spout, stitching machine, slat conveyor & bag turner, discharging bags upto receiving chutes.
- The Surge hopper of appropriate capacity shall be provided as a surge between intermediate hoppers and the weigher. These hoppers shall be provided for smooth flow of fertilizer cargo to the gravity feeder. The gravity feeder controls and meters the flow of fertilizer cargo from the hopper to meet the specified discharge flow rate.
- The net weigher accurately and continuously weighs pre-selected quantities of fertilizer cargo. The main components are housing, weigh hopper, 3 load cells for accurate measuring, hopper suspension, check links and electronic measuring & control module type microprocessor.
- Stitching/Sewing Machine: Sewing head of higher outputs fitted with automatic pneumatic cylinder operated knifes, precision built with cast iron case & fully interchangeable parts in hardened steel on high grade bronze shall be required.
- Heavy duty conveyor shall be required, on which bags after being filled shall be conveyed in a vertical position to stitching machine and further discharging onto the platform through chute.

5.3.9 Dust Control System

Dust from the operation of belt conveyors originates mainly at the tail pulley where material is received and at the head pulley where material is discharged. Dust generation depends on belt width, belt speed and height of fall of material to be conveyed.

5.3.9.1 Design Requirements for Dust Control System

a. Dust control and abatement systems shall be provided to contain escape of dust into atmosphere while the facilities are in operation. The systems shall be designed to conform to the permissible limit of dust emission by the concerned statutory pollution control authorities.

b. The concentration of RSPM-10 shall be limited to an average 2 mg/normal cum over and above the ambient dust concentration measured at a circumferential distance of 5 m from the dust generation source.
c. The filtering efficiency shall not be less than 95%.

5.3.9.2 Proposed Dust Extraction System

The Dust Extraction system to be provided in the Transfer Towers shall be compact reverse pulse jet type with Invertible Filter Bags at the dust generation points with a provision to feed the dust collected in the bags back to the conveyor/system without any loss of material.

However, in bagging station, since hoppers are placed at every 30m distance, four (4) numbers of hoppers as well as dust collecting points of bagging machines below, connected to one integrated unit of dust collection & extraction are proposed. This makes the system more flexible and redundant for maintenance & other operational requirements.

5.3.10 Technical Data Sheets of Major Equipment

4.12.1	**Level Luffing Crane with Integrated Hopper and Belt Feeder Arrangement**	
1.	Type of Mounting	Rail mounted
2.	Rail Gauge	13 to 15 m
3.	Number of Cranes Proposed	2
4.	Materials to be handled and Density	MOP – 1.0 T/cum ; DAP – 0.95 T/cum; Urea – 0.75 T/cum ; Rock Phosphate – 1.3 T/cum
5.	Crane Capacity (SWL)	60 T (On Hook)
		45 T (On Grab)
6.	Minimum Peak Discharge rate	1000 TPH
7.	Minimum Grab Volume	To suit material type
8.	Maximum Cycles per hour	60
9.	Minimum pay load for different materials	To suit the peak discharge rate
10.	Max Outreach	38 m
11.	Ship Sizes to be handled	10,000 to 65,000 DWT

4.12.1	**Level Luffing Crane with Integrated Hopper and Belt Feeder Arrangement**	
12.	Size of Travel Rail	CR 100
13.	Maximum wheel load and spacing	30 T per wheel with spacing between wheels > 1 m
14.	Group classification	A8
15.	Class of Utilization of Individual mechanism as a whole	U8
17.	State of Loading	Q3
18.	Minimum clearance below crane Portal	NA
19.	Length of travel for each crane	170 m
20.	Crane controls	AC Frequency controlled drive with PLC System
21.	Crane Monitoring system	PLC based (For monitoring operation status and history)
22.	Centralized lubricating system	To be provided (With provision to lubricate without interruption to operation.)
23.	Hopper Arrangement	Surge hopper with capacity to hold material of not less than two grabs capacity integrated with the grab crane with arrangement for transfer of cargo to the belt Conveyor.
24.	Chute Work	The chutes shall be of Mild steel plates with welded steel fabricated section assembled by bolted joints. Minimum plate thickness of chutes shall be 12 mm. Surface of chutes shall be lined with 8mm thk, SS-409M Liner to be stitch welded to parent plate.
25.	Berth conveyor FBC-01 details	Design Capacity: 2000 TPH Conveyor speed: 2.6 m/s Belt Width: 1600 mm Trough angle: 45 degree
26.	Impact table	Suitable to take the impact with sufficient clearance above berth conveyor.
27.	Dust control system (DES)	Insertible type bag filter provided on receiving and discharge points of revisable belt feeder.
28.	Safety Devices	As per indicative list
29.	Electrical power supply	3 Ph, 6.6 kV, 50 Hz AC

4.12.1	Level Luffing Crane with Integrated Hopper and Belt Feeder Arrangement	
30.	Other miscellaneous items	Supply of rails, storm anchors, end buffer stopper, jacking point for machines, earthing for equipment rails, all necessary bolts and fixtures etc.

4.12.2	Conveyor System		
	General		Troughed belt conveyor
1.	Design Capacity	TPH	For receiving conveyors:- 2000 For dispatch conveyors:- 1600/800
2.	Conveyor Length	m	About 3500 m
3.	Number of streams	Nos.	For receiving conveyors:-Single Stream For dispatch conveyors :- Single stream (provision for one future conveyor)
4.	Conveyor speed		Shall not be exceed than 2.6 m/s
5.	Belt Width	mm	For receiving conveyors:-1600 (Indicative) For dispatch conveyors:- 1000/1400 (Indicative)
6.	Trough angle	Deg.	45 for receiving conveyors 35 for dispatch conveyors
7.	Conveyor Belt		Nylon-Nylon and EP belt with suitable for heavy duty application and energy efficient low resistance rubber covers to reduce power consumption.
	Cover grade		M-24
	Minimum thickness of cover	mm	Minimum Top – 5 / Bottom – 3 (Nylon-Nylon / EP)
	Factor of safety of the belt		minimum 9 for Nylon –Nylon & EP
	Fill factor		80-85%
	Max Belt Sag Between Idlers		2%
8.	Friction factor (f) for calculation of belt tension Te as per IS 11592:2000		0.022 (Minimum)
9.	Conveyor Drive Assemblies		
9.1	Motor rating		Calculated motor kW x 1.1 (Minimum).

4.12.2	**Conveyor System**		
9.2	Gear reducers		Helical / Bevel helical gears
			Gear box Housings of cast steel or fabricated MS
			kW Rating of gear box – minimum 1.5 times the calculated kW of conveyor or 1.25 times motor rating whichever is higher.
9.3	High speed couplings between motor and gear box		Resillient type flexible couplings for conveyors with motor power less than 30kW.
			Traction type fluid couplings for conveyors with motor power 30kW and above but less than 200 kW.
			Actuator operated scoop type fluid couplings for conveyors with motor power 200 kW & above.
			In case of VF drives, high speed couplings shall be of grid type spring resilient couplings .
9.4	Low speed couplings between gear box and drive pulley		Grid type resilient / flexible geared couplings
			Gread couplings size - minimum 1.5 times the motor power
9.5	Brakes		To be provided as necessary for controlled stopping
			Rating minimum 1.5 times the calculated torque
9.6	Hold back		To be provided if there is a possibility of rolling back
			Rating minimum 1.5 times the calculated torque
10.	Conveyor Pulley assemblies		
10.1	Type and material		Heavy duty type. Minimum shell thickness 16 mm - drive pulley, 14mm – all other pulleys, MS.
10.2	Lagging		All drive pulleys shall have 20 mm thick diamond grooved lagging. 6 mm wide x 6 mm deep spaced at 30 mm centres around the circumference. The rubber hardness shall be IRHD 60. All non-drive pulleys shall have plain lagging of minimum 12 mm thick. The hardness of rubber

4.12.2	**Conveyor System**		
			shall be IRHD 60 for drive and discharge pulleys and IRHD 55 for all other pulleys.
10.3	L10 Bearing life	Hrs.	60,000 (minimum)
10.4	Pulley face width	mm	Belt width + 200
10.5	Bearings		Heavy duty antifriction double row self-aligning spherical roller bearings with double labyrinth seal, SKF/ FAG make in Cast steel horizontally split pillow blocks with four bolts.
10.6	Pulley shaft		Shaft deflection limited to 1/2000 of distance between bearings and the angular deflection at pulley hub shall not more than 5 minutes for Drive Pulleys and 8 minutes for other pulleys (In the worst loading condition)
			The pulley shaft and hub shall be connected through Ring feeder locking arrangement of proven design and of Ring feeder (Germany) / BICON (Japan) make
11.	Idler assemblies		
11.1	Carrying idlers		Fixed Type, 3 equal roll, with 45° troughing for receiving conveyors. Fixed Type, 3 equal roll, with 35° troughing for dispatch conveyors.
11.2	Carrying idlers Spacing	mm	1000
11.3	Return idlers		2 equal roll V type. Minimum one flat return idler near each pulley.
11.4	Return idlers Spacing	mm	3000
11.5	Impact idlers		Three (3) roll type provided with number of tough rubber discs with minimum shore hardness of 55 to 60 deg on shore ‘A’ scale. Dia 139.7mm (minimum), ERW pipe with outer rubber ring dia. 190mm(minimum)
11.6	Impact idlers Spacing	mm	400
11.7	Minimum numbers		Min. 6 Nos. impact idlers shall be provided at each feed point.
11.8	Self-aligning carrying idler		Fixed Type, 3 equal roll, spacing at 10m.

4.12.2	**Conveyor System**		
11.9	Self-aligning return idler		2-roll V type with 15º troughing angle, spacing at 30m.
11.10	Transition idler		15 deg., 25 deg., 35 deg. (1 nos. each) transition idler shall be provided at head & tail end on each conveyor .
12.	Technological structures		
12.1	Stringers/Short supports		Support spacing not more than 3m. Alternatively, member sizes and spacing as per proven experience and design.
12.2	Deck plate		3.15 mm thick MS sheet at loading points
12.3	Seal Plate		50 mm thick –RCC sealing shall be provided where conveyor gallery crosses roads, buildings, and railway tracks extending an additional three (3) meters on both sides of crossing. 3m long sealing for gallery shall also be provided at entry/ exit of transfer tower / tower / drive house
13.	Conveyor Safety switches		
13.1	Zero speed switch		One for each conveyor at non-drive pulley. 240V, 10A, 50Hz, AC with 2NO+2NC, dust proof totally enclosed industrial application. The degree of protection should be IP: 65.
13.2	Belt rip detection		Distance for vulcanizing of sensor loops shall be 100m. One complete set up for belt rip detection comprising transmitter, receiver, etc. Belt rip detection system shall be located at skirt board area.
13.3	Belt splice monitoring		One complete set.
13.4	Pull cord switches		One pair at head end & Tail end and at every 25 m interval (on both side of conveyor). 240V, 10A, 50Hz, AC with 2NO+2NC, dust proof totally enclosed, industrial application, addressable. The degree of protection should be IP: 65.
13.5	Belt sway switches		One pair each at head end & Tail end and at every 50 m interval (on both side of conveyor) 240V, 10A, 50Hz, AC with 2NO+2NC, dust proof totally enclosed, industrial application, addressable. The degree of protection should be IP: 65.

4.12.2	**Conveyor System**		
13.6	Chute Block Switches		To be provided.
13.7	Take-up Switches		To be provided.
14.	Tensioning arrangement		Gravity type take-up Cast iron/Concrete counter weights Travel based on expected stretch of belt + one splice length. Bottom of take up assembly at lowest travel position – Not less than 1.5m above ground level
15.	Chutes, Hoods and Intermediate hopper		
15.1	Material and thickness		The chutes shall be of Mild steel plates with welded steel fabricated section assembled by bolted joints. Minimum plate thickness of chutes shall be 12 mm. Surface of chutes shall be lined with 8mm thk, SS-409M Liner to be stitch welded to parent plate. Material of Hood above C.L. drive / head pulley shall be 6 mm thk, MS (IS: 2062). The weight of any one plate of liner shall not exceed 20 kg.
15.2	Minimum valley angle of transfer chutes		60 degrees
16.	Belt cleaners		
16.1	Discharge ends – :		Two stage cleaning
	- Pre Cleaner		Pre Cleaner with modular 40 mm thick PU blades. The cleaner assembly should be mounted on elastomount type mounting arrangement.
	- Main cleaner		Multi- blade sprung type, blade with tungsten carbide tip with SS base. With Spring action at individual blade holder as well as at elastomount type mounting arrangement.
16.2	Tail end (V Plough)		'V' Type cleaner assembly to clean the inside of the blade, MS plate with PU blade and elastomount arrangement.

4.12.2	**Conveyor System**		
17.	Skirt board		-Length at each feed point :6m (min.) -Side plate 6mm(min.) MS ,Height 750mm - Liner :12 mm thick SS 409 - Cover plate 5 mm(min) MS

4.12.3	**Flap Gate**		
1.	Type		Linear actuator type
2.	Location		As per flow diagram
3.	Capacity	TPH	As required
4.	Material of construction		M.S with suitable composite wear plate which can take abrasion
5.	Quantity	Nos.	As per flow diagram

4.12.4 (a)	**Magnetic Separator**		
1.	Type		Suspended electro-magnet
2.	Nos. required		3 Nos.
3.	Location		As Per Flow Diagram
4.	Operating Height (approx.)		400 mm
5.	Flux Density (Minimum)		1000 Gauss at operating height specified above
6.	Force Index		Minimum 100000
7.	Magnet Core Material		Pure annealed iron or equivalent having high magnetic permeability
8.	Coils		Aluminium wounded coils with class “H” insulation
9.	Rectifier		3 ph., full wave bridge using Silicon Diodes forming rectifier set
10.	Tramp Metal Chute		Suitable tramp metal chute (5 mm thk M.S.)

4.12.4 (b)	**Metal Detector**		
1.	Detector type and capacity		Electronic solid-state type, single channel suitable to detect 20 mm dia. aluminium ball and MS nut of size M-20. Each unit shall be complete with search coil, electronic cabinet, signal lamp, signal horn, sand bag marker, and provision for testing the unit.
2.	Quantity		6 No.
3.	Location		As Per Flow Diagram
4.	Conveyor parameters		As mentioned above
5.	Material		As mentioned in section 2
6.	Annunciation / Hooter provided		Yes
7.	Audible range of hooter		300 m
8.	Indication type		Audio and visual

4.12.5	**Belt Weigher**		
1.	Type		Electronic load cell type, Multi idler.
2.	No. required		3 No.
3.	Location		As per Flow Diagram
4.	Belt width	mm	1600 for FBC-01, 1400 for FBC-04, 1000 for FBC-5A
5.	Weighing capacity (max.)		120% of conveyor design capacity
6.	Weighing capacity (min.)		20 % of conveyor design capacity.
7.	Type of Speed sensor		Mechanical through speed sensing non-wearing wheel / roller.
8.	Type of load sensor.		Mechanical Weighing mechanism (Pendulum Resistant)
9.	Type of calibration device		Test chain
10.	Guaranteed Min. accuracy (%)		(+) 0.25% at all ranges from 20% to 120% of conveyor design capacity.
11.	Rate indication		Digital (local and remote), six digit
12.	protection class		I.P. 56

4.12.5	**Belt Weigher**		
13.	Design temperature		700C
14.	Design relative humidity		1
15.	Installation		Indoor, but dusty
16.	Structural capacity		250% of design belt scale capacity

4.12.6	**Hoists (Electric & Manual Operated)**		
1.	Type		Electrically operated hoist & trolley And Manually operated hoist & trolley as required.
2.	Speed control of hoist		Bidder to indicate
3.	Monorail track		Straight/Curved
4.	Gear		
4.1	Type		Helical
4.2	Material		Forged/cast steel.
5.	Brake		
5.1	Type		Electro-magnetic or equivalent.
5.2	Brake to be provided for		Hoist & trolley
5.3	Holding torque		150% of the load torque for hoisting & 125% for trolley.
5.4	Method of actuation.		Automatic/Manual.
6.	Bearing		
6.1	Type		Ball/Roller
6.2	Life (Hrs)		10,000.
6.3	Lubrication		Oil/grease
6.4	Shaft		Steel -En8/Equivalent
7.	Class of Hoist		Class – 2 for Electrical Hoist Class – 1 for manual Hoist
8	Hook		
8.1	Material		As per IS-3815

4.12.6	**Hoists (Electric & Manual Operated)**		
8.2	Design		As per IS:8610
9.	Wire Rope		
9.1	Factor of safety		Six (6)
9.2	Construction		Construction 6 x 37/6x36 as per IS-3938, regular lay with a minimum strength of 160-180 Kgf/Sq.mm.
10.	Other requirements		As per IS:3938 & IS:2266
11.	Hoist Drum & Sheave		
11.1	Material		MS/Cast Steel as per IS-3938
11.2	Other requirements		As per IS:3938
11.3	Hoist drum surface		Hard faced.
12.	Catalogue/Leaflet provided		Yes
13.	Inching operation of hoist motor		Required

4.12.7	**Travelling Tripper**		
1	Type		Motor operated travelling tripper
2	Location / Designation No.		On Conveyor in bulk shed
3	Qty.		One
4	Type of drive unit for tripper Travel.		Motor (reversible) coupled to gear box & gear box coupled to drive axle complete with flexible couplings or with shaft mounted gear box.
5	Rail size		60 lb/yard sq. bar
6	Rail Gauge		2100 mm (approx.)
7	Type of belt cleaner required at tripper head pulley.		Double bladed CWT type with rubber blade, 16 thk.
8	Tripper capacity		Tripper installed on Conveyor having 1600 mm belt x 450 Tr. X 2000 TPH (Design capacity)

4.12.7	**Travelling Tripper**		
9	Travel speed of Tripper (approx.)		10 m/min.
10	Type of discharge chute		Two-way
	Travel Wheels		
a	Number & diameter		Main : 4 Nos. & 500 mm Dia (indicative)
b	Gauge		~ 2100 mm (indicative)
c	Wheel Spacing		~ 4300 mm (indicative)
d	Type & material of wheel		Flanged, Cast Steel , quenched and Tempered wheels
e	Type & life of Bearings		Spherical roller bearing having 30000 hr. (B-10) life. Method of lubrication through grease nipple
f	Axle material		CK-45 N/EN-8. One axle assembly (1 pair of wheels) driven by drive unit
2	Rail clamps		Manually operated rail clamps, 1 Nos. per Tripper
3	Head, Bend & Hold down Pulley		
a	Type		M.S. welded construction (IS : 2062)
b	Size		630 mm Dia. x 1800 mm Face width (Head & Bend Pulley)
c	Material & Thickness of lagging		12 thk, plain natural rubber lagging (Head & Bend) and 12 thk plain natural rubber lagging on Hold down pulley.
4	Limit Switches		
	Type		Mechanical Lever operated type (back-up)/proximity (Main), 230 V.AC 5Amp/220V, DC, 1Amp.
5.	Mechanical End Stop provided		Yes
6.	Type of operation		Only Local operation to be provided

4.12.8	**Rail Mounted, Portal Type Scraper Reclaimer**		
1.	Technical Parameters		
1.1	Type of Reclaimer		Rail mounted, Portal scraper Reclaimer
1.2	Quantity		1 No. (one more in future)
1.3	Reclaiming capacity		800 TPH (Design)
1.4	Reclaiming main line Conveyor		1000 mm wide, 35 Deg. Trough
2.	Material characteristic		As mentioned in section 2
2.1	Stockpile		Linear
3.	Scraper boom length		Suit
4.	Scraper boom luffing range main	Deg.	-8 to +53 (w.r.t horizontal)
5.	Operating speeds		
5.1	Scraper chain	m/s	0.72 to 1
5.2	Scraper hoisting (at bottom tip)	m/s	3
5.3	Travel	m/s	3-10 for operation and 20 for transportation
6.	Scraper blade & chain (Main)		
6.1	Type of chain		Roller bush chain
6.2	Chain pitch	mm	400 (indicative)
6.3	Scraper blade pitch	mm	800 (indicative)
6.4	Dimension of scraper blade	mm	2400 x 500 (indicative)
7.	Scraper blade & chain (Auxiliary)		
7.1	Type of design		Open
7.2	Dimension of scraper blade	mm	1500 x 300 (indicative)
7.3	Scraper blade pitch	mm	630 (indicative)
7.4	Type of chain		Roller bush chain
8.	Track rail		
8.1	Rail center to center	M	43.5

4.12.8	**Rail Mounted, Portal Type Scraper Reclaimer**		
8.2	Size		CR80
9.	Wind loads		Not applicable – located in covered shed
10.	Power Supply		6.6 kV+ 10% / 433 V + 10%, 50 Hz + 3%, 3 Ph, 3 Wire power supply for motors drives/local panels (combined variation + 10%).

4.12.9	**Plough Feeder**		
1.	Location		On Conveyor bagging shed
2.	Required numbers		Twenty Two (22)
3.	Conveyor capacity (Design)		800 TPH
4.	Belt width (mm)		1000
5.	Type of discharge chutes		Two (2) way
6.	Limit switches numbers		As applicable
7.	Lifting Table		On conveyor at plough feeder area

4.12.10	**Semi-Automatic Bagging & Stitching System**		
1.	Application		Open Mouth Bagging Line
2.	Type of Feeder		Gravity Feeder
3.	Type of Weigher		Electronic Net Weigher (Duplex)
4.	Flow Characteristics		Free Flowing
5.	Weighment Size		50 kg
6.	Output (Design)		25 bags / min
7.	Accuracy		± 50 grams, 2 Sigma
8.	Bag Material		HDPE/PP
9.	Bag Size		Shall be furnished later
10.	Type of Bag		Open Mouth
11.	Area Classification		Non hazardous - safe area

4.12.10	**Semi-Automatic Bagging & Stitching System**		
12.	Environment		Corrosive
13.	Utilities available:		
13.1	Power		6.6 kV+ 10% / 433 V + 10%, 50 Hz + 3%, 3 Ph, 3 Wire power supply for motors drives/local panels (combined variation + 10%).
13.2	Compressed Air		Dry Air, Instrument Quality, 4-6 kg / cm^2, 8 Ltr./ Weighment

5.4 Buildings, Sheds and Other Structures

5.4.1 Terminal Buildings

Any standalone terminal comprises many terminal buildings like administration and operations, worker amenities, workshop, customs etc. However this project being taken up by Kandla port on EPC mode, it is suggested that existing buildings available with Kandla port shall be utilised for this terminal as well.

5.4.2 Gate Complex

The gate complex comprises a gate house and entrance/exit area to provide two entry and two exit lanes. The gates shall be equipped with security cabins. The gate complex will also have traffic control barriers (electrically operated drop-arms) and electrical signage and signalling devices. Security cabins have a total built up area of about 50 m^2 in ground floor, which segregates the entry/exit. Security and gate complex will be manned by a staff of about 7-10 persons. Piles interconnected with tie beams are provide as foundations for this building.

5.4.3 Bulk Shed

The proposed bulk shall be mainly built using structural steel. Portals are kept at a distance of 12m and to support the sheeting, extra portal is kept at 6m transferring its load to main portal via tie girder as shown in **Drawing No. - DELB15005-DRW-10-0000-CP-KND1005** general arrangement of the shed. Toe wall and grade slab are provided for maintaining the finished floor level at +10.0m CD so as to give a clear height of 500 mm above road level. A small retaining wall shall be provided towards the stack so as to provide required profile to the floor to enable reclaiming by scrapper reclaimer. On top of the retaining wall, along the entire length, a small rail shall be provided to support one end of the mobile hopper, the other end of which shall be supported on the rails of scrapper reclaimer.

For foundations, longitudinal beams supported on piles are provided for rail track of scrapper reclaimer, whereas portals are resting on pile cap provided at every 12 m c/c. Foundations of both the structures are integrated with the foundations of the shed structure to achieve overall economy.

5.4.4 Bagging Plant and Wagon Loading Shed

A separate bagging plant cum wagon loading shed shall be provided along the length of the southern boundary of the plot. The overall width of the shed is taken as 23 m so as to provide cover to the wagons positioned for loading on either side of the platform. The overall length of shed is 700 m.

There shall be an intermediate floor in the bagging shed for the bagging and stitching of the fertilizers from where the bags shall be transferred to the platform level through chute.

Bagging plant structure will also be a pre-engineered steel structure but will be designed without side and gable walls. It shall be designed as framed structure with bracing system and steel beams to serve as support to Bagging Plant unit. Adequate steel doors /rolling shutter and windows for natural lighting / ventilation shall be provided.

Bagging plant consists of two units. The first unit comprises one tower of height 22 m, at each location of bagging cum stitching unit for its support. The secondly unit is about 9 m high provided for storage of bagged fertilizers.

5.4.5 Water Tank & Pump House

The water tank cum pump house will be located in the area between the bulk shed and bagging shed. The storage capacity of the water tank would be about 224 cum to cater to the potable water needs of the terminal and static fire water storage. The water supply shall be from the existing water network available at Kandla Port.

5.4.6 Conveyor Structures

5.4.6.1 Conveyor Galleries

a) The general parameter for conveyor galleries shall conform to the provisions of IS 11592 unless specified otherwise in technical specifications.
b) Galleries shall be analyzed with one end pinned and other end roller.
c) Gallery shall have walkways on both sides of the belt. The width and clear height shall be followed as per Mechanical drawings.
d) Cross over platform will be provided at 90-100m intervals and located over four-legged rigid trestle location.
e) The location of four legged trestle will be planned in such a way that wind force (acting along the conveyor) corresponding to a maximum length of 90 – 100 m only will be transferred to it.
f) End of conveyor Gallery which will be supported over transfer points / buildings shall be so detailed that only vertical reaction is transferred from conveyor gallery and no horizontal force (Longitudinal Force along the Belt) is transferred from conveyor gallery to transfer point structure and vice-versa with help of PTFE Bearings.

5.4.6.2 Trestles

a) Trestles shall be of structural steel, braced adequately at suitable locations to control the lateral deflection.
b) Trestles shall be either a two-legged Trestle or four-legged trestle. Four legged Trestles shall be placed at a maximum interval of 90-100 meters to transfer the lateral loads along the conveyor.
c) Preferably Trestles with height more than 10 meters shall be flared with increased width at base to reduce uplift forces on the foundation.
d) All Gallery-supporting Trestles shall be so proportioned that the transverse deflection (Perpendicular to Gallery) of Gallery due to wind load should not exceed trestle height/ 1000.

5.4.6.3 Transfer Towers

a) All Transfer towers shall be designed as framed structures with bracing system on outer grid to transfer the lateral loads and considering pinned supports at base or rigid frame or combination of two.
b) Drive Floors in Transfer towers shall be of RCC slab supported on steel beams.
c) Concrete floor shall be considered to provide continuous lateral support to the top (compression) flange of the supporting beams. Hence compression flange is considered to be completely restrained and the allowable bending stress in tension or in compression for the beam is considered as 0.66fy for design.
d) Chequered plate floor shall neither be considered to provide lateral support to top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support in the form of horizontal bracing shall be provided as required.
e) For all transfer towers / building , the main supporting element of roof shall be of roof trusses provided at suitable spacing with slope 1 in 3
f) All structural steel floor beams supporting the RCC floor slab with shear connectors (minimum size of ISA 50x50x6-75mm long at 300mm c/c).
g) For all transfer towers one number of external exposed staircase from ground to the topmost working floor with MS gratings stair treads and landings have been considered along with adequate hand railing.

5.4.7 Design Criteria of Civil / Structural Works

5.4.7.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions. All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. It is well understood that when a brand name is given for a material, the Contractor has the right to propose any equivalent material of any other brand for approval of the Employer / Engineer.

All works shall satisfy the requirement of latest relevant codes, standards and regulations prevailing till July 2013 for the works as per Tender. Indian Standards shall generally be followed. In case, any work or item is not covered by the Indian Standards, following standards shall be adopted in order of preference.

- British Standards
- American Standards
- General Standards

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted.

5.4.7.2 Design Life

The permanent works shall be designed and constructed to give the following design lives:

Component	Design Life
Buildings	40 years
Mechanical and electrical equipment	As per manufacturer's recommendations
Steel Structures	40 years

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse subject to the regular inspection and preventive maintenance but not the major repairs and rebuilding.

5.4.7.3 RCC Structures

5.4.7.3.1 General

All RCC structures shall be designed satisfying the Codal provisions. Loading shall be as per IS:875 & IS:1893. While designing, provision for an additional floor shall also be considered in the foundation and structure design for all the buildings except workshop. The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, air-conditioning, water distribution etc. Following minimum considerations shall be followed:

- Grades of concrete: M-30 for all items as suggested in relevant codes
- Grade of steel : Thermo-mechanically treated corrosion resistant steel Fe500
- Floor to floor height shall satisfy the bylaws of National Building Code.
- A 750 mm wide plinth protection shall be provided around each building.

- Finished floor level of buildings shall be 1000 mm above the finished ground level unless specified otherwise.
- All external walls shall be of 230 mm thick, all partition walls shall be minimum 115 mm thick with 1:4 cement mortar

5.4.7.4 Steel Structures

5.4.7.4.1 Permissible Stresses

Permissible stresses and permissible increase or decrease of stresses shall be in accordance with the relevant IS standards, whichever is applicable.

5.4.7.4.2 Permissible Deflections

The permissible deflections of various steel members under normal loading conditions shall be limited as per the relevant IS codes.

5.4.7.4.3 Structural Steel

Material

a) Rolled steel sections & plates upto 20mm thick –as per IS:2062 (Grade-A)
b) Rolled steel plates above 20mm thick- as per IS:2062 (Grade B - Normalized)
c) Chequered plate conform to IS:3502 – 1994, Grade – A of IS 2062
d) Steel tubes as per IS: 1161 or equivalent. Medium duty for handrails.

Design and Fabrication

a) Structural steel elements shall be designed as per IS 800
b) Gusset plate thickness shall not be less than 8mm.
c) Chequered plates shall be intermittently welded wherever supported on the framework.
d) All steel structures shall be welded connection. Except field connections which shall be provided with 2 nos. 16mm dia erection bolts (min), After the erection alignment, same shall be site welded for the full strength and erection bolt holes can be plug welded.
e) Welding work shall be done as per relevant I.S. codes.

All connections shall generally be welded connection (minimum size of weld 6mm) unless bolted connection is specifically required for erection otherwise

5.4.7.5 Loads and Load Combinations

Design loads and load combinations will comply with the requirements of IS: 875 & IS: 1893, as a minimum, unless more stringent requirements are specified herein. The following type's loads will be considered in general for the analysis and design of structures and foundations.

5.4.7.5.1 Dead Loads

Dead loads will include the weight of all structural and architectural components and other permanently applied external loads. Self-weight of materials will be calculated on the basis of unit weights given in IS: 875 (Part I). Equipment load will be considered as separate load case and will not form part of dead load.

Table 5.1 Load Details of Various Components

Materials	Unit Weight
Structural Steel	7.85 T/m^3
Reinforced Cement Concrete	2.5 T/ m^3
Plain Cement Concrete	2.4 T/ m^3
Ordinary Red Brick (in mortar)	2.0 T/ m^3
Fertilizer's	1.3 T/m^3
Sea Water	1.05 T/m^3

5.4.7.5.2 Equipment Loads

All structural components will be designed to accommodate anticipated Static and dynamic loading from equipment. Where the uniform floor live load adequately accounts for the equipment weight, the weight of such equipment as a dead load need not be considered.

Table 5.2 Load Data of Various Equipments

S. No.	Equipment Details	Load Data
1.	Scraper Reclaimer	
	• Wheel on each rail	4
	• Wheel spacing	1 m
	• Vertical Wheel load including impact	40 T each
2.	Conveyors	
	• Vertical Load per m length of conveyor	2.0 T
3.	Bagging Machines	
	• Bagging Machine Load/Slate	3.0 T
	• Dead Weight of Single hopper	25 T
	• Material Weight in Single Hopper	70 T

Manufacturer's technical specifications will be followed for any other equipment loading considerations during detailed design stage.

5.4.7.5.3 Live Loads

Live loads shall consist of uniform live loads. Uniform live loads are unit loads, which are sufficient to provide for movable and transitory loads, such as the weight of people, portable equipment and tools, equipment, or parts, which may be moved over or placed on floors during maintenance operations. These uniform live loads shall not be considered on floor area, which are permanently covered with equipment.

Foundations and fixing arrangements for items of equipment, which generates vibration, shall be designed to prevent transfer of such vibrations to the adjoining structures.

Floors and supporting members, which are subject to heavy equipment loads shall be designed on the basis of the weight of the equipment in addition to a live load of 500kg/sqm or specifically designed live load whichever is more.

Flat Roof	150 kg/m^2 + Dust load of 100 kg/m^2 hanging load for pipe shall be considered as 100 Kg/m^2 and 50 Kg/m^2 for electrical, ventilation & air conditioning (wherever applicable)
Non-accessible roof	75 kg/m^2 + Dust load of 100 kg/m^2
Inclined roof	Roof slope upto 10 Deg: 75 Kg/m^2 +50 Kg/m^2 Roof slope above 10 Deg: [(75-(θ-10) x2] + 50 Subjected to a minimum of (40+50) =90 Kg/ m^2 For sloping roofs with slope greater than 10°, members supporting the roof purlins, such as trusses, beams, girders etc may be designed for two-thirds of live load stated above
MCC Floor	300 kg/m^2 +1.2T/m of Panel
Ground floor	1500 kg/m^2
Suspended floors	1500 kg/m^2
Grating & Chequered plated	500kg/m^2 for grating & Chequered plates and the supporting beams of walkways of conveyor
Galleries	300 kg/m^2 or a concentrated load of 200 kg at center whichever is critical. In addition to this, load due to cable trays, fire fighting/ service water pipes shall also be considered.
Platform/walkway	300 kg /m^2

5.4.7.5.4 Wind Load

All structures will be designed for wind loads in accordance with IS: 875 (Part 3). A basic wind speed of 50 m/s will be considered under storm conditions.

5.4.7.5.5 Seismic Load

All structures will be designed for seismic forces in accordance with the provisions of IS: 1893. The importance factor of 1.5 shall be considered.

5.4.7.5.6 Temperature Load

Structures subject to high temperature stresses shall be designed for temperature loads as per the relevant code wherever applicable. Suitable expansion/contraction joints will be provided in the longitudinal direction wherever necessary.

5.4.7.5.7 Impact Factor

- For Manual monorail/Hoist design an impact factor of 1.20 shall be considered in design.
- For Electrical monorail/Hoist design an impact factor of 1.25 shall be considered in design.
- For design of R.C.C. beams supporting drive machinery like head end, tail end, drive pulley, gear boxes etc. an impact factor of 1.5 shall be considered for design.

5.4.7.5.8 Surcharge Load / Earth Pressure / Water Table

- A surcharge load 2.0 T/m^2 will be considered in addition to other loads e.g. earth and water pressure.
- Loading due to stacking of fertilizers shall be calculated assuming 15 m as maximum stacking height.
- Dispersion of loads (arising out either of railway load, dozer load surcharge or any other load) through soil and fertilizer shall be considered 2 vertical : 1 Horizontal or 1 vertical : 1 horizontal, whichever is critical.
- Unit weight of saturated soil to be considered in design is 1.8 T/cum
- Submerged unit weight of soil to be considered in design is 0.8 T/cum

5.4.7.5.9 Load Combinations

The general combination of loads for design shall be as follows. However all required combinations as per IS code shall be included in design.

- DL+ LL+ Equipment Load
- DL + LL +Equipment Load + Belt Tension
- DL + LL + Equipment Load +WL+ Belt Tension
- DL + Reduced LL + Equipment Load + Seismic Load + Belt Tension
- 0.9*DL + W.L.+ Belt Tension
- 0.9*DL + Seismic Load. + Belt Tension

Load due to earth pressure/surcharge will be considered as per specific structures requirement.

5.5 Electrical and Automation Works

5.5.1 Electrical Power Requirements

The main requirement for electrical load on the port shall be on account of mechanized unloading system with two ship unloaders on berth, conveyor system and other equipment for stacking, reclaiming, bagging and stitching machines at the berth, till yard and within the yard.

Other infrastructure such as illumination on the berths, general lighting inside the terminal area and buildings, Pump House, bulk storage shed, bagging shed etc.), power for auxiliary services like dust extraction system, fire-fighting system will also need their share of electric power.

Taking all such aspects and after applying suitable diversity factors, the estimated connected power load are estimated to be around **(2.7 MVA)** for the terminal has been estimated.

5.5.2 Source of Power Supply

The power shall be tapped from the existing substation of Gujarat Electricity Board located near Kandla Special Economic Zone and brought to the substation located between the bulk shed and bagging shed. At SS1 two numbers of 33 KV / 6.6 KV, 3.0 MVA, HT transformers will be installed. Each of the two transformers is designed to cater to 100% of the maximum demand of the terminal. The normal operation shall be on 50-50% when both the transformers are healthy.

5.5.3 System Arrangement

The substation shall be equipped with metering systems, circuit breakers etc. Further, the substations shall be provided with capacitor banks (6.6kV) for automatic power factor (PF) correction and monitoring the PF so that it will not fall below 0.95. In case of lighting loads, feeder pillars shall be provided near the respective buildings.

The voltage for the different systems shall be as under:

• Main incoming power from main substation of port	33 KV
• Fault level at 33kV	26.3kA
• Distribution to HT Loads from SS	6.6 KV
• Ship Unloader	6.6 KV
• LT feeders from the substation (for illumination etc.)	433/230V. 3/1 Ph.

5.5.4 Control System

The control system shall be installed at first floor of the proposed Substation (SS) to ensure safe and reliable operation of conveyors and others facilities of the terminal. The core of the system shall consist of centralized, redundant servers, Redundant PLC system, redundant data network (Optical fibre) with Universal Open Protocols and intelligent RI/O modules with advanced CCTV –NVR System backed up by UPS having Minimum 2-Hours capacity.

The control system shall be installed to ensure safe and reliable operation of conveyors and others facilities of terminal operations. PLC system shall read the inputs, perform all system logic, conduct online diagnostics, sequencing control and control the outputs. The processor based distributed control system is envisaged to control and monitor the material handling operations as well as the bagging, so as to carry out the control operating is an integrated mode from plant central control room. Software for operating Terminals shall have interfacing capability with all equipment and SAP.

5.5.5 Surveillance CCTV system

Surveillance CCTV with NVR Server system has been envisaged to ensure effective observation of plant and other areas as well as create secured record for post event analysis. The system shall provide an online display of video images on TFT/LCD monitors located in Control Room. System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be redundant NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components likewise Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards. CCTV system shall also be equipped with workstation for System Administration / Maintenance.

5.6 Onshore Infrastructure and Utilities

5.6.1 Land Grading

The proposed terminal area is already in use and the levels in the yard are quite uniform. It is proposed to maintain the yard level same as existing i.e. +9.0m CD. This shall be taken as a reference levels for all structures in the yard.

5.6.2 Rail Tracks

The railway link to the terminal shall be tapped from the under construction rail line which is being provided for the berth 13, 14,15 and 16.Initially it is proposed to initially provide two loading lines, one on either side of the bagging shed. One of these shall act as engine escape line. Once the terminal throughput increases another rail line shall be added so that two rake could be loaded simultaneously. Total length of Railway Track to be newly laid is about 3.5 Km.

5.6.3 Roads

The terminal buildings shall be connected through the existing two lane road within the port.

5.6.4 Surface Drainage

As the proposed terminal is located where existing port operations are being carried out, there is no elaborate drainage arrangement envisaged. It is proposed to collect the storm water in the terminal area through secondary drains and discharge the collected water into the sea through main drains.

5.6.5 Water Supply System

The water requirement in the terminal is estimated to be about 40 Kl per day. Therefore it is recommended to provide an underground water tank of 220 cum capacity. The water tank shall have two chambers. One chamber shall be for static storage of 137 cum of fire water as per codal requirements. The other chamber shall be to hold 80 cum of potable water. Water from the sump shall be pumped to various load centres by means of pipelines of size 80 mm NB.

Suitable tap off shall be taken for water supply to custom post and gate house through 50 NB pipes. Two pumps of 25 cum/hr capacity each (including one standby) shall be provided at the sump.

5.6.6 Fire Fighting System

The fire protection shall cover buildings located in the proposed terminal, transfer towers (between yard and berth area) and the berth area. The buildings/towers are listed as below.

- Gate complex
- Pump House
- Customs office
- Bulk shed
- Bagging plant and Wagon loading shed
- Transfer towers

All the above structures shall be classified as light hazard.

Fire-fighting system at the terminal shall comprise of fire hydrant system provided at intervals of 60 m in stackyard and berth area and near buildings and transfer towers. Each hydrant connection shall be provided with a suitable length of hose and nozzle to permit effective operation.

The master fire alarm panel shall be placed at the control room located at substation SS. Each floor of all the buildings shall be provided with one hose reel which shall be connected to the general water supply / overhead water tank. The fire hydrants shall be provided at the ground level of the transfer towers.

The main fire-fighting pumps (1 Working + 1 Standby) of capacity 137 cum/hr will be provided in the pump house. In addition jockey pumps will be provided to maintain the minimum pressure of 3.5 kg/cm^2 in the remotest hydrant.

5.6.7 Sewerage System

No separate sewage system is envisaged within terminal.

6.0 COST ESTIMATES AND IMPLEMENTATION SCHEDULE

6.1 General

The capital cost estimates have been prepared for the implementation of the mechanised fertilizer terminal at Kandla port. These are based on the project description and drawings given under the relevant sections of the present report. The quantities have been calculated from the drawings for cost estimation purpose. These will be further developed by the EPC contractors based on their design during implementation stage.

The following is to be noted with respect to the cost estimates:

- 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 referring to the cost of such works in recent projects within India.
- The costs of equipment are based on the quotations received from manufacturers, wherever applicable and also in-house data.
- All costs towards overheads, labour, tools, materials, insurance etc., are covered in the rates for individual items.
- The costs towards plant and machinery include manufacture, supply, installation and commissioning of the respective items.
- The price level used for the estimates is as of the first quarter of 2016.
- Provisions towards contingencies, engineering, and other pre-operative expenses are not included.
- The costs include all taxes and duties.

The 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.

6.2 Capital Cost Estimates

The capital cost estimates for the proposed terminal have been worked out as indicated in **Table 6.1**

Table 6.1 Mechanised Fertilizer Terminal - Estimated Overall Capital Cost

S. No.	Item	Quantity	Unit	Rate (Rs.)	Capital Cost (Rs. In Crores) Phase 1 - Capacity 2.7 MTPA	Phase 2 - Total Capacity 4.55 MTPA
Mechanical and Electrical Works						
1	Level Luffing Crane (Incl. Hoppers), Capacity 1000 TPH each	2	no.	15,00,00,000	30.00	
2	Rail for LLC	180	m	8,000	0.14	
3	Conveyor from Berth to bulk Shed (Capacity:-2000 TPH)	1,080	m	90,000	9.72	
4	Tripper Conveyor within bulk shed (Capacity:-2000 TPH)	730	m	90,000	6.57	
5	Reclaiming Conveyor within bulk shed to Transfer Tower TT3 (Capacity:-1600 TPH)	912	m	90,000	8.21	0.00
6	Conveyors from Transfer Tower TT3 upto Tranfer Tower TT4 (Capacity:-800 TPH)	42	m	75,000	0.32	0.32
7	Tripper (Capacity:-2000 TPH)	1	No.	50,00,000	0.50	
8	Scraper Reclaimer (Capacity:-800 TPH)	1	No.	10,00,00,000	10.00	10.00
9	Bagging Plant- Conveyor System including plough feeders etc. (Capacity:-800 TPH)	704	m	95,000	6.69	6.69
10	Semi automatic Bagging Machines	22	No.	25,00,000	5.50	5.50
11	Dust Extraction System	22	No.	5,00,000	1.10	1.10
12	Fork Lifts	10	No.	10,00,000	1.00	
13	Electrical Works		LS		8.00	3.00
14	Control and Communication System		LS		5.00	
15	In-motion Rail Weigh Bridge	1	No.	20,00,000	0.20	
16	Misc. Equipment and Spares		LS		1.00	
	Total - Mechanical and Electrical Works (Rs. In Crores)				**93.95**	**26.60**
Civil Works						
1	Civil work for fixing Rail on Berth	500	m	1,500	0.08	
2	Civil and structural works for conveyors outside sheds including transfer towers	1,800	m	1,25,000	22.50	3.00
3	Civil and structural works for Bulk Shed including foundation for conveyors, Tripper and Scraper Reclaimer, as applicable	34,300	sqm	16,000	54.88	
4	Civil and structural Works for Bagging and Wagon Loading shed including platform, Supports for Bagging Machines and Conveyor system	16,310	sqm	13,000	21.20	3.00
5	Formation of Railway Tracks	3,500	m	15,000	5.25	1.70
6	Formation of roads	14,000	sqm	1,500	2.10	
7	Surface drainage and Sewerage	1	LS	50,00,000	0.50	
8	Customs Building	37	sqm	30,000	0.11	
9	Substation		LS		1.00	
10	Gate House	25	sqm	25,000	0.06	
11	Water Tank & Pump house	50	sqm	40,000	0.20	
	Total - Civil Works (Rs. In Crores)				**107.88**	**7.70**
Other Items						
1	Water supply system		LS		0.10	
2	Boundary Wall/ Fencing		LS		1.50	
3	Engineering and PMC		LS		5.00	1.00
4	Environmental Measures		LS		0.50	
5	Site Clearing, levelling		LS		0.25	
	Total - Other Items (Rs. In Crores)				**7.35**	**1.00**
Total Cost of Terminal (Rs. In Crores)					**209.18**	**35.30**
Contingencies @10% (Rs. In Crores)					20.92	3.53
Engineering and Project Management @2.5% (Rs. In Crores)					5.23	0.88
Total Capital Cost of Fertilizer Terminal (Rs. In Crores)					**235.32**	**39.72**

6.3 Operation and Maintenance Costs

6.3.1 General

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

6.3.2 Repair and Maintenance Costs

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

- 5% of 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.

6.3.3 Manpower Costs

The estimated manpower for the initial phase of development is about 225. The manpower costs have accordingly been calculated considering the number and types of personnel deployed.

6.3.4 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. 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 Firefighting & Pollution Control - 3% per annum

6.3.5 Annual Operation and Maintenance Costs

Based on the various criteria discussed above, the annual operation and maintenance cost are summarised in **Table 6.2** below.

Table 6.2 Annual Operation and Maintenance Costs

S. No.	Item		Quantity	Unit	Rate	Unit	Annual Costs (Rs. in Crores)
A.	**REPAIR AND MAINTENANCE COSTS**						
	1.	Civil Works	108	Rs. in crores	0.01	% of Cost	1.1
	2.	Mechanical and Electrical Works	94	Rs. in crores	0.05	% of Cost	4.7
	3.	Utilities	7	Rs. in crores	0.03	% of Cost	0.2
B.	**OPERATION COSTS**						
	1.	Manpower Costs			LS		13.2
	2.	Electricity					
	a.	Electricity Consumption	1,00,59,600	units per annum	4.5	Rs. Per unit	4.5
	b.	Fixed Charges on Demand Load	2,726	kVA	225.0	Rs. Per month	0.7
	3.	Water	14,897	cum per annum	50.0	Rs.	0.1
	4.	Diesel Driven Equipments	30	Rs. in crores	0.05	% of Cost	1.5
C.	**TOTAL**						**26.1**
	Administrative Expenses @ 5%						**1.3**
	Contingencies @ 10%						**2.6**
D.	**TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS**						**30.0**

6.3.6 Implementation Schedule

The main components for the mechanised fertilizer terminal are grab cranes, conveyor system, sheds and the mechanical equipment. The construction time of terminal is likely to take about 24 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.

7.0 FINANCIAL ANALYSIS

7.1 Assumptions for Financial Assessment

The following assumptions are made while carry out the financial analysis for the proposed terminals

- Terminal Capacity - 2.7 MTPA
- Tariff - Rs. 350 per tonne

  (Currently, it costs Rs. 400 /T all inclusive to handle fertilizers at port. The ship related charges are about Rs. 50 /T and thus the maximum tariff possible is Rs. 350/T)
- Life of Asset - 20 years
- Construction period 2 years with investment of 40% in first year and 60% in second
- Development Option - Project to be executed by Kandla Port Trust in EPC mode through internal funding.

7.2 Financial Analysis

Based on the capital and O&M costs of the terminal, the project IRR works out to over 25%, which is very attractive rate of return. This indicates that the project should be taken up on top priority.

Technical Note for Oil Jetties & Associated Pipelines at Kandla Port

Technical Note

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1.0 Introduction

Kandla port handles liquid bulk at two locations – at Vadinar (Jamnagar Dt) and at Kandla.

The facilities at Vadinar includes 3 SBMs (two of IOCL and one of Vadinar Oil Terminal Ltd.) for handling crude oil and two jetties for handling POL products. The SBMs can accommodate VLCCs of over 300,000 DWT while the jetties can accommodate the tankers up to 105,000 DWT. The IOCL SBMs handles crude for their refineries at Koyali, Mathura and Panipat. The VOTL SBM handles crude for Essar Refinery at Jamnagar. The VOTL jetties handle the POL products export from Essar Refinery. During 2014-15, the SBMs handled 40.26 million tonnes of crude oil and 13.10 million tonnes of POL products.

The facilities at Kandla include 6 jetties for handling chemicals, POL products and fertiliser raw materials. These jetties can accommodate upto 56,000 dwt. During 2014-15, these jetties handled 8.83 million tonnes of POL products, chemicals and fertiliser raw materials.

Thus the total liquid bulk traffic handled at Kandla port was over 62.00 million tonnes.

This Technical Note covers the liquid bulk handling facilities at Kandla only.

2.0 Existing Berthing Facilities

Presently the Port has six oil jetties for handling POL products, Chemicals, Edible oil and raw Fertilizers at Kandla. Out of the six jetties, the first four jetties constructed during 1975 to 2000 belong to Kandla Port and the two other jetties have been constructed, operated and maintained by M/s. IFFCO and M/s. IOCL respectively.

All these jetties are similar in that they are all open piled jetties with isolated dolphins. The service platform and the berthing dolphins have been integrated to serve as a continuous berthing face. Pairs of mooring dolphins have been provided on either side of the central platform for taking on the mooring ropes.

The location of these six jetties, through satellite imagery, is shown in **Figure 2-1** and the technical details of the jetties are given in **Table 2-1** hereunder.

Figure 2-1 Location and Layout of the Kandla Oil Jetties

Table 2-1 Technical Details of the Kandla Oil Jetties

S. No.	Name of Jetty	Berthing Face (m)	c/c Distance of Outer Mooring Dolphins (m)	Designed Depth (m)	Maximum of LOA of Tanker (m)	Maximum Size of Tanker (DWT)
1.	OJ 1	89.6	282.0	10.4	213.4	40,000
2.	OJ 2	110.0	247.0	10.0	183.0	52,000
3.	OJ 3	84.2	235.0	10.7	213.4	40.000
4.	OJ 4	110.0	275.0	10.7	216.0	56,000
5.	OJ 5 – IFFCO	110.0	277.0	10.7	216.0	45,000
6.	OJ 6 - IOCL	110.0	242.0	10.0	216.0	45,000

3.0 Details of Topside Facilities

At Kandla Port, for common user oil jetties OJ 1 to 4, only the berth structures have been provided by the port and the topside facilities have been installed by the respective user agencies. As regards the captive jetties OJ 5 (IFFCO) and OJ 6 (IOCL) the berthing structure as well as topside facilities have been provided by the respective agencies.

3.1 Ship – Shore Product Transfer

The ship-shore product transfer is effected through flexible rubber hoses. In case of IOCL captive jetty 3 × 12” and in the case of IFFCO 1 × 8” marine unloading arms have been provided.

3.2 Jettyhead to Tankage Pipelines

As indicated earlier, the user agencies have laid their own pipelines from the jetty heads to their tankage terminals. Depending on their requirements, some have put multiple pipelines in each jetty. This has resulted in each jetty having a number of pipelines clustering the jetty heads and approaches. Moreover, many pipelines have branched out on the jetty platform into two or three headers for connecting more number of hoses simultaneously for possible connection to more than one unloading pump from the tanker. This has led to utilization of more space and consequent encroachment depriving the facility for other users. Illustrative pictures are presented hereunder in **Figure 3-1** and **Figure 3-2**.

Figure 3-1 Typical Headers with 2 Branches for each Pipeline at OJ 1

Figure 3-2 Cluster of Pipelines with Headers & Hoses

The number and size of pipelines at each of the oil jetty for each type of cargo are presented in the following **Table 3-1**.

Table 3-1 Details of Pipelines at Kandla Oil Jetties

	CARGO TYPE	NO. OF USER AGENCIES	OIL JETTIES					
			OJ 1	OJ 2	0J 3	0J 4	0J 5	OJ 6
1	POL PRODUCTS	4	4 x 24"		1 x 24"	4 x 24"		4 x 24"
			2 x 20"	2 x 20"	3 x 20"	1 x 20"		1 x 22"
			2 x 16"		1 x 16"	1x 16"		
					2 x 8"			1 x 6"
			8	**2**	**7**	**6**		**6**
2	EDIBLE OIL	6		1 x 12"	1 x 12"	1 x 12"		
			2 x 10"	4 x 10"	2 x 10"	2 x 10"		
				2 x 8"	4 x 8"	4 x 8"	2 x 8"	
				2 x 6"				
			2 x 3"	4 x 3"	3 x 3"	3 x 3"	1 x 3"	
			4	**13**	**10**	**10**	**3**	
3	CHEMICALS	12			1 x 16"			
			1 x 14"	1 x 14"	1 x 14"	1 x 14"	1 x 14"	
				1 x 12"	2 x 12"	2 x 12"	1 x 12"	
			2 x 10"	1 x 10"	2 x 10"	1 x 10"		
			2 x 8"	15 x 8"	10 x 8"	6 x 8"	5 x 8"	
				1 x 6"	1 x 6"			
			1 x 4"	2 x 4"	2 x 4"	1 x 4"	1 x 4"	
			1 x 3"	4 x 3"	4 x 3"	3 x 3"	3 x 3"	
			7	**25**	**23**	**14**	**10**	
4	FRM (LIQUID)	1					1 x 14"	
							1x 12"	
							2 x 8"	
							2 x 6"	
							6	
5	Flushing	KPT	1 x 20"	1 x 20"	1 x 20"	1 X 20"		
	Water supply		1 x 8"	1 x 8"	1 x 8"	1 x 8"		
	Anti Pollution		1 x 4"	1 x 4"	1 x 4"	1 x 4"		
			3	**3**	**3**	**3**		
			22	**43**	**43**	**33**	**19**	**6**

It may note that many of the users have provided 3” pipeline for pigging with air for clearing the products from the pipelines. It is understood that many of them receive edible oil in heated condition. While they have their tankage heated, the corresponding pipelines are not heated and hence there is a need to push the products off the pipelines once the tanker completes its unloading. This has added to the pipeline crowding on the jetty heads.

4.0 Details User Agencies

There are 23 user agencies who have their tankage at Kandla. Out of these 14 agencies have their tank farms in the area behind the oil jetties. 9 have tankages away from the jetties. Some of the agencies have their tank farms but they are not linked to the jetties by pipelines.

The agencies who have their tank farms near the jetties are as follows:

1. IOCL (Foreshore)
2. IFFCO
3. BPCL
4. Friends Salt Workers & Allied Industries (FSWAI)
5. Friends Oil & Chemical Terminal (FOCT)
6. National Dairy Development Board (NDDB)
7. Chemicals & Resins Ltd. (CRL)
8. United Storage Tankage Terminals Ltd (USTTL)
9. Synthetic Chemicals Ltd.
10. Indo Nippon
11. Kesar Enterprises
12. JR Enterprises
13. Kiran Logistics
14. Bayer India Ltd.

The locations of these tankage terminals are shown through satellite picture as well as in a layout drawing in **Figure 4-1** and **Figure 4-2** hereunder.

Figure 4-1 Satellite Picture of Tankage Terminals

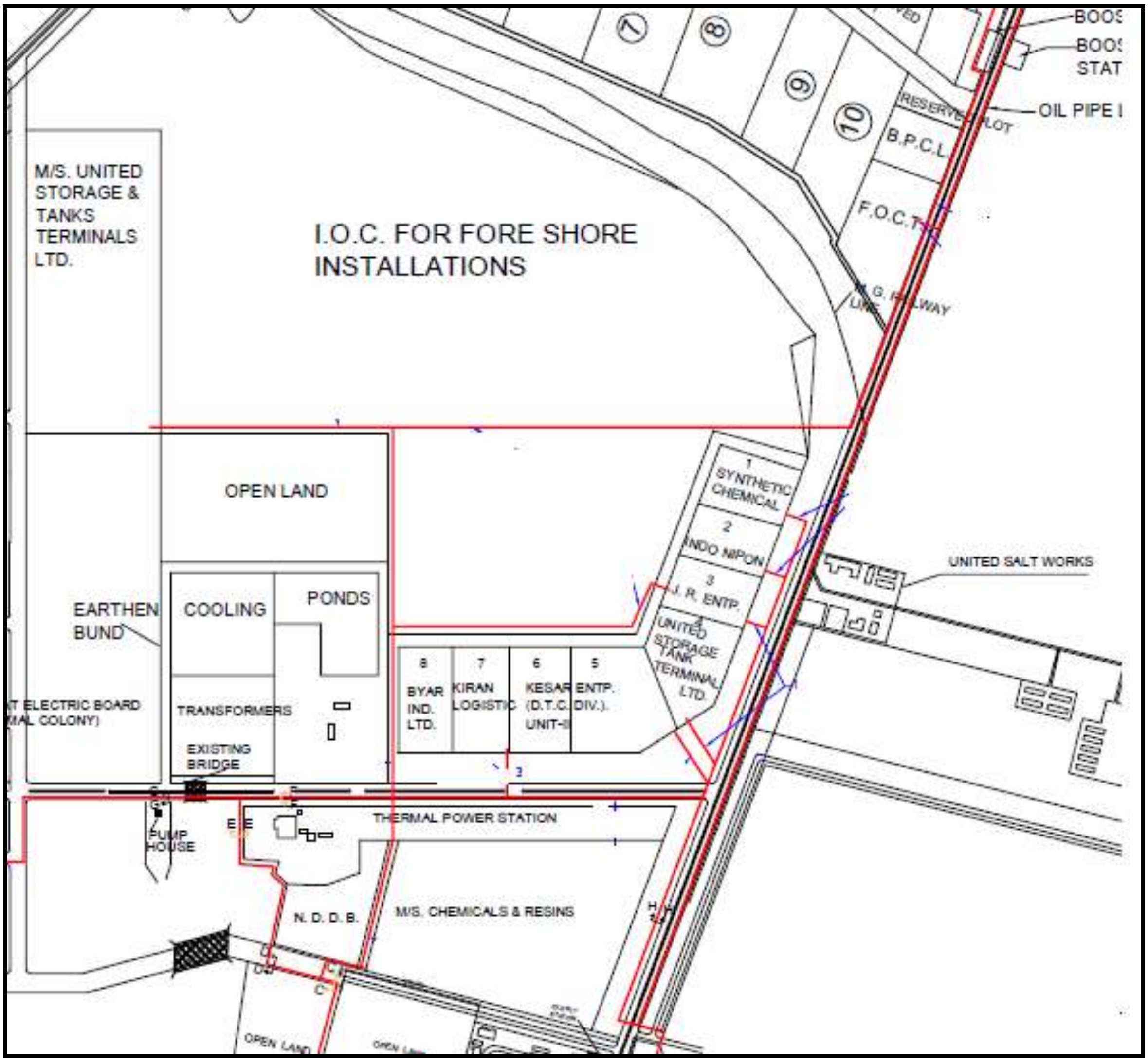

Figure 4-2 **Location Drawing of Tankage Terminals**

The details of all the terminals with their tankage capacity and their linkage to the various oil jetties are furnished in the **Table 4-1** hereunder. This table also shows the tankage terminals who do not have pipeline linkage to the oil jetties.

Table 4-1 Details of Tankage Terminals with Capacity & Pipeline Linkage

POL PRODUCTS									
	AGENCIES	TANKAGE		OJ 1	OJ 2	0J 3	0J 4	0J 5	OJ 6
1	IOCL	24 No.	485,000 KL	2 x 24"		1 x 24"	1 x 20"		4 x 24"
		7 No.	71,000 KL	2 x 16"		1 x 20"	1 x 16"		1 x 22"
		2 No. LPG	30,000 KL						1 x 6"
2	BPCL	25 No.	235,510 KL	1 x 24"			1 x 24"		
				1 x 24"			1 x 24"		
3	HPCL	21 No.	167,000 KL	2 x 20"	2 x 20"	2 x 20"	2 x 24"		
4	USTTL (GAS)	2 No. LPG	30,000 KL			1 x 16"			
						2 x 8"			

EDIBLE OIL								
	AGENCIES	TANKAGE		OJ 1	OJ 2	0J 3	0J 4	0J 5
1	CRL	45 No.	105,000 KL	1 x 10"	4 x 10"	2 x 10"	2 x 10"	
				1 x 3"	1 x 3"	2 x 8"	1 x 8"	1 x 8"
						1 x 3"	1 x 3"	1 x 3"
2	AGENCIES & CARGO CARE	36 No.	60,000 KL	1 x 10"	1 x 12"	1 x 8"	2 x 8"	
				1 x 3"	1 x 3"	1 x 3"	1 x 3"	
3	NP PATEL	10 No.	42,100 KL		2 x 6"	1 x 8"	1 x 8"	1 x 8"
					1 x 8"			
4	NDDB	9 No.	53,000 KL		1 x 12"	1 x 12"	1 x 12"	
					1 x 3"	1 x 3"	1 x 3"	
5	FSWAI	20 No.	88,100 KL					
6	PARKER AGRO	13 No.	17,500 KL					
7	DEEPAK ESTATE AGENCY	9 No.	14060 KL					
8	LIBERTY INVESTMENT	6 No.	16,000 KL					
9	AVEAN INTERNATIONAL	20 No.	28,000 KL					
10	TEJMALBHAI & CO	9 No.	13,000 KL					

CHEMICALS

	AGENCIES	TANKAGE		OJ 1	OJ 2	0J 3	0J 4	0J 5
1	FOCT	21 No.	50,500 KL	1 x 10"	1 x 8"	2 x 8"	1 x 12"	1 x 3"
				1 x 3"	1 x 3"	1 x 3"	1 x 3"	
2	FSWAI	138 No.	291,900 KL	1 x 14"	1 x 16"			
				1 x 8"	1 x 14"	1 x 14"	1 x 14"	1 x 14"
				1 x 4"	1 x 12"	1 x 12"	1 x 12"	1 x 12"
					1 x 10"	2 x 8"	1 x 10"	1 x 8"
					1 x 4"	1 x 4"	1 x 4"	1 x 4"
3	CRL	76 No.	160,000 KL	1 x 10"	2 x 8"	1 x 8"	2 x 8"	1 x 8"
						1 x 6"		
4	JK SYNTHETICS / RISHI KIRAN	14 No.	32,220 KL	1 x 8"	3 x 8"	2 x 8"	1 x 8"	1 x 8"
					1 x 4"	1 x 4"	1 x 3"	1 x 3"
					1 x 3"	1 x 3"		
5	KESAR ENTERPRISE LTD.				3 x 8"	3 x 8"	2 x 8"	2 x 8"
		29 No.	55,140 KL		1 x 6"			
		35 No.	72,300 KL		1 x 3"	1 x 3"	1 x 3"	1 x 3"
6	USTTL	31 No.	115,810 KL			1 x 10"		
					1 x 3"	1 x 3"		
7	JR ENTERPRISES	15 No.	25,320 KL		1 x 10"	1 x 8"	1 x 8"	
8	BAYER ABSL LTD.	11 No.	13,310 KL		1 x 8"	1 x 8"		
9	INDO NIPPON	10 No.	22,870 KL			1 x 8"		
10	SYNTHETICS & CHEMICALS					1 x 8"		

FERILISER RAW MATERIAL

	AGENCIES	TANKAGE		OJ 1	OJ 2	0J 3	0J 4	0J 5
1	IFFCO	16 No.	96,000 KL			1 x 12"		1 x 14"
								1 x 12"
								1 x 8"
								2 x 3"

5.0 Performance of Oil Jetties

The performance of these oil jetties was analysed for the years 2014-15 and 2015-16. The details are furnished in the **Annexure 1**. However, the summary of the analyses are furnished hereunder.

The product wise traffic handled during these two years are given in **Table 5-1** hereunder.

Table 5-1 Liquid Products Handled at Oil Jetties During 2014-16

S. No	Products	2014-15	2015-16
1	Edible Oil	3.57	4.84
2	Chemicals	2.10	2.48
3	POL Products	1.85	1.82
4	FRM Liquids	1.28	1.79
	TOTAL	**8.80**	**10.93**

It can be seen that the traffic in edible oil had a significant increase, while chemicals and FRM liquids have marginal increase. The traffic in POL products has more or less remained stagnant. The berth wise performance for these two years are presented in the **Table 5-2** and **Table 5-3** hereunder.

Table 5-2 Performance of Oil Jettie During 2014-15

S. No	Cargo Type			OJ 1	OJ 2	OJ 3	OJ4	OJ 5	OJ 6
1	Edible Oil	Total volume handled	Te.	2,13,005	5,34,677	6,25,855	17,58,131	4,39,605	
		No. of tankers	No.	17	49	48	79	32	
		Average Parcel size	Te.	12,529	10,912	13,039	22,255	13,738	
		Average Productivity	TPD	5,861	5,821	6,175	7,464	5,511	
2	Chemicals	Total volume handled	Te.	4,968	7,07,807	7,81,472	3,15,186	2,91,807	
		No. of tankers	No.	1	137	136	55	59	
		Average Parcel size	Te.	4,968	5,166	5,746	5,731	4,946	
		Average Productivity	TPD	8,013	6,782	7,185	6,388	6,057	
3	POL Products	Total volume handled	Te.	2,45,992		2,94,057	2,64,920	33,000	10,10,593
		No. of tankers	No.	10		19	14	1	38
		Average Parcel size	Te.	24,599		15,478	18,923	33,000	26,595
		Average Productivity	TPD	16,599		12,222	12,657	18,132	14,022
4	FRM Liquids	Total volume handled	Te.			8,750		12,67,355	
		No. of tankers	No.			1		55	
		Average Parcel size	Te.			8,750		23,043	
		Average Productivity	TPD			16,827		20,766	
	TOTAL VOLUME HANDLED			**4,63,965**	**12,42,484**	**17,10,134**	**23,38,237**	**20,31,767**	**10,10,593**
	TOTAL NUMBER OF TANKERS			28	186	204	148	149	38
	BERTH OCCUPANCY			17.0%	85.4%	98.3%	118.6%	78.8%	32.7%

Note: It has been noted that at OJ 4 multiple berthing has happened on certain days as per the shipcard data. Hence the occupancy has been more than 100%

Table 5-3 Performance of Oil Jettie During 2015-16

S. No	Cargo Type			OJ 1	OJ 2	OJ 3	OJ4	OJ 5	OJ 6
1	Edible Oil	Total volume handled	Te.	11,94,655	4,82,020	5,22,635	21,19,682	5,24,435	
		No. of tankers	No.	79	43	39	90	34	
		Average Parcel size	Te.	15,122	11,210	13,401	23,552	15,425	
		Average Productivity	TPD	6,756	5,957	6,526	8,889	5,566	
2	Chemicals	Total volume handled	Te.	26,462	8,00,129	8,67,645	4,18,120	3,09,628	58,500
		No. of tankers	No.	8	159	149	63	58	2
		Average Parcel size	Te.	3,308	5,032	5,823	6,637	5,338	29,250
		Average Productivity	TPD	3,610	4,592	5,222	5,395	4,676	14,409
3	POL Products	Total volume handled	Te.			2,61,643	3,65,821		11,92,611
		No. of tankers	No.			25	20		54
		Average Parcel size	Te.			10,466	18,291		22,085
		Average Productivity	TPD			7,564	8,775		9,935
4	FRM Liquids	Total volume handled	Te.					17,86,259	
		No. of tankers	No.					82	
		Average Parcel size	Te.					21,784	
		Average Productivity	TPD					14,481	
	TOTAL VOLUME HANDLED			**12,21,117**	**12,82,149**	**16,51,923**	**29,03,623**	**26,20,322**	**12,51,111**
	TOTAL NUMBER OF TANKERS			87	202	213	173	174	56
	BERTH OCCUPANCY								

6.0 Observations

(i) The primary observation is the number and layout of the pipelines on the jetty heads. Giving the users free hand to have their own pipelines has led to haphazard layout of the pipelines with multiple headers as indicated earlier. Moreover, the jetty heads are clustered with a number of pipelines. It is also noted that some of the pipelines of some users are not used for quite some time.

Ideally, the port should have laid the pipelines, say two lines for each product, and taken upto a common manifold at the 'Y' junction from where individual users should take off to their own terminals. A typical example is the situation at Jawahar Dweep at Mumbai Port. There are four jetties and the port has laid a set of pipelines from the jetty heads upto a common manifold on the Trombay side across the creek for a distance of about 4 km (including a major submarine section). The users, such as HPCL, BPCL and IOCL have taken off from this common manifold to their respective refineries and marketing terminals. Even if multiple lines are to be laid, these could have been done properly if executed by the port.

A typical jetty head at Antwerp Port is shown **Figure 6-1** hereunder for reference.

Figure 6-1 A Typical Jetty Head with Pipeline Headers at Antwerp Port

(ii) Another observation is the size of the pipelines. For a particular product, one has to relate the parcel size to the rate of discharge. This is to be noted in the case of Edible oil. While the average parcel size is between 10,000 Te to 15,000 Te the observed discharge rate is relatively less. This is because the size of the pipelines. Since the lines are laid by the users, they have laid smaller pipelines depending on their individual requirement. Out of the 26 no. of pipelines, the size distribution is as follows: 4 x 12”; 10 x 10”; 10 x 8”; 2 x 6”. Ideally 2 x 16” pipelines would have ensured a discharge rate of over 10,000 TPD.

Similarly in the case of Chemicals only 18 pipelines are between 10” to 16” diameter while 47 pipelines are between 4 “ to 8” diameter. Accordingly, the average discharge rate varies from 3,500 TPD to 5,500 TPD only.

(iii) Based on the shipcard data available for 2014-15, it is noted that at most of the berths, the percentage of non-working time has been quite high. This has also contributed to the high berth occupancy.

(iv) Yet another observation is that IOCL, even though they have their own captive jetty, are handling POL products at berths OJ 3 & OJ 4. The total volume handled at these berths is more than 50% of what they had handled at their own jetty . It can be seen from the tables that the occupancy level of their captive jetty is less than 35%, which implies that their jetty is under utilised while the other jetties are over stretched.

7.0 Recommendations

- The first action to be taken is to examine the details of non-working time at the berths and bring them down to acceptable limits. This will reduce the congestion.

- IOCL should be asked to shift all their POL products handling to their own jetty. If they want to maintain flexibility in berthing of tankers, they should permit other users to handle tankers at their berth by laying suitable pipelines. Though the berth is constructed by them, it is KPT's responsibility to ensure that their waterfront is optimally utilised. In can be seen in the case of another captive jetty, IFFCO, the berth is utilised like other berths allowing other products also.

- Rationalisation of pipelines: This is relatively complicated. At a time only one tanker carrying one particular product will be berthed at a jetty. Ideally it is preferable to have a couple of common-user pipelines for each product at each jetty for handling the products. As indicated earlier, these pipelines could be laid upto the 'Y' junction leading to a common manifold for each berth from where individual users could connect their pipelines leading to their tankage.

Selecting the optimal sizing has to done in consultation with the users and considering the distance to their tankage. (*It coud be seen that IFFCO are able to achieve a discharge rate of 20,000/14,500 TPD with 14" & 12" pipelines as their tankage is just behind the berth*). If larger diameter is selected for the common-user pipeline, it will result in higher velocity in the user's smaller pipelines beyond the 'Y' junction. This higher velocity has to be within permissible limits. Or else, the users will also have to change their pipelines to a higher diameter.

There will be a requirement for pigging arrangement for each of the pipeline as the product of each consignee has to be pushed off the pipeline to get the line ready for the next consignment. If the user does not want to hold any line content, he has to have another pigging arrangement for his line segment beyond the 'Y' junction.

This pipeline rationalisation, therefore, needs a careful and detailed study in consultation with the users.

															ANNEXURE 1
PERFORMANCE OF OIL JETTIES DURING 2014-15 & 2015-16															
S. No	Cargo Type			OJ 1		OJ 2		OJ 3		OJ4		OJ 5		OJ 6	
				2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
1	Edible Oil	Total volume handled	Te.	2,13,005	11,94,655	5,34,677	4,82,020	6,25,855	5,22,635	17,58,131	21,19,682	4,39,605	5,24,435		
		No. of tankers	No.	17	79	49	43	48	39	79	90	32	34		
		Average Parcel size	Te.	12,529	15,122	10,912	11,210	13,039	13,401	22,255	23,552	13,738	15,425		
		Average Productivity	TPD	5,861	6,756	5,821	5,957	6,175	6,526	7,464	8,889	5,511	5,566		
		Working time at berth	days	36.34	176.84	91.85	80.92	101.35	80.08	235.55	238.47	79.77	94.22		
		Non-working time	days	5.78		52.15		33.00		85.97		37.16			
2	Chemicals	Total volume handled	Te.	4,968	26,462	7,07,807	8,00,129	7,81,472	8,67,645	3,15,186	4,18,120	2,91,807	3,09,628		58,500
		No. of tankers	No.	1	8	137	159	136	149	55	63	59	58		2
		Average Parcel size	Te.	4,968	3,308	5,166	5,032	5,746	5,823	5,731	6,637	4,946	5,338		29,250
		Average Productivity	TPD	8,013	3,610	6,782	4,592	7,185	5,222	6,388	5,395	6,057	4,676		14,409
		Working time at berth	days	0.62	7.33	104.36	174.24	108.77	166.14	49.34	77.5	48.18	66.22		4.06
		Non-working time	days	0.37		63.44		73.87		26.87		23.79			
3	POL Products	Total volume handled	Te.	2,45,992				2,94,057	2,61,643	2,64,920	3,65,821	33,000		10,10,593	11,92,611
		No. of tankers	No.	10				19	25	14	20	1		38	54
		Average Parcel size	Te.	24,599				15,478	10,466	18,923	18,291	33,000		26,595	22,085
		Average Productivity	TPD	16,599				12,222	7,564	12,657	8,775	18,132		14,022	9,935
		Working time at berth	days	14.82				24.06	34.59	20.93	41.69	1.82		72.07	120.04
		Non-working time	days	4.25				16.71		14.35		0.27		47.44	
4	FRM Liquids	Total volume handled	Te.					8,750				12,67,355	17,86,259		
		No. of tankers	No.					1				55	82		
		Average Parcel size	Te.					8,750				23,043	21,784		
		Average Productivity	TPD					16,827				20,766	14,481		
		Working time at berth	days					0.52				61.03	123.35		
		Non-working time	days					0.40				35.64			
TOTAL VOLUME HANDLED				**4,63,965**	**12,21,117**	**12,42,484**	**12,82,149**	**17,10,134**	**16,51,923**	**23,38,237**	**29,03,623**	**20,31,767**	**26,20,322**	**10,10,593**	**12,51,111**

Techno-Economic Feasibility Report for Development of Port at Dugarajapatnam

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Executive Summary

Introduction

To make best use of economies of scale, increased global trade and to achieve efficient management of supply chain, larger sized ships are being built (cape size vessels for moving bulk cargoes) to ply on international routes and as well as Coastal shipping lines. This benefits the cargo owners who have to bear lower freight costs which eventually lead to low cost of final product for the end user. This trend is seen globally and it is envisaged by Ministry of Shipping that all major ports in India shall have infrastructure and equipment's that will be at par with their global peer group.

Port at Dugarajapatnam

Andhra Pradesh has only one major port i.e. Vizag Port. Vizag port is constrained with its expansion due to development of city around it. The Ministry of Shipping, Government of India has already notified Greenfield port at Dugarajapatnam in Andhra Pradesh, as the major port under the Port Trust Act.

The proposed port site of Dugarajapatnam lies on the eastern coast of India in the Nellore district of Andhra Pradesh. It has operational non-major port of Krishnapatnam on the north and major ports of Chennai and Ennore on the south. Southern Andhra Pradesh would be the primary hinterland of the port while Karnataka and parts of Telangana would be the secondary hinterland. Considering the location of the proposed site and the presence of other ports in proximity, Dugarajapatnam port would have to compete for the same hinterland with ports of Krishnapatnam, Chennai, Ennore and Katupalli.

Based on the Origin–Destination studies carried out under Sagarmala assignment, it has been assessed that the port has the potential of about 7.8 MTPA in 2020 increasing to 20 MTPA in 2035 with thermal coal being predominant cargo.

The port is expected to divert part of the traffic currently handled by Krishnapatnam port. Rayalseema in Cuddapah district and Raichur can be the potential power plants using Dugarajapatnam for movement of thermal coal. The traffic for both these plants expected to be handled by the proposed port will be ~3.4 MTPA by 2020. Apart from the thermal coal for power based usage, non-power based coal traffic of ~3.5 MTPA is also expected by 2020.

Port Development Plan

It is proposed that the port facilities shall be developed in the phased manner commensurate with traffic growth. Most of the quantity is likely to be moved through Panamax size ships and therefore it would make sense to limit the initial phase development for Panamax size ships only. However, as the proposed port has to compete with adjacent ports at Krishnapatnam and Ennore who have capability to handle cape size ships, it would be important that the planning should be such that the port should be able to handle cape size vessels by carrying out capital dredging at appropriate time as per market demand

The proposed port layout comprised of south breakwater of 3340 m and north breakwater of 1240 m. In Phase 1 development of the port, it is proposed to provide 1 Coal and 1 Multipurpose berths and the estimated capital dredging for Phase 1 development is about 21 Mcum and the reclamation quantity is 8.3 Mcum. The stacking area for the bulk cargoes has been proposed in the reclaimed area.

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.

Additional berths, equipment and other infrastructure shall be in staged manner till the ultimate stage development added.

The estimated capital cost of Phase 1 port development is INR 2,472 crores and additional INR 1030 Crores would be needed for the rail/road connectivity to the port, INR 270 Crore for land acquisition for port. Phase 1 of port development would have an implementation time of about 4 years.

Assessment and Recommendations

The viability analysis for the project has been carried out considering three alternative models for port development i.e. development by project proponents, by full-fledged concession to private operators and landlord model.

In the project proponent model the project shall be executed by a Special Purpose Vehicle (SPV), which may include Vizag and other government entities. SPV shall arrange funds, manage and operate the port. The IRR for project proponent model works out to 2.1%.

In the full-fledged concession to operator model the entire project is given to private developer and costs towards external rail/road connectivity, land acquisition for connectivity and port facilities shall be taken up by the government entities. The project cost of INR 2,472 cr is considered and the IRR works out to 8.6% considering the private entity does not do the revenue sharing with the government.

In the Landlord model, SPV shall be responsible for providing the entire basic infrastructure for the port including the external connectivity and land acquisition to the port. The cargo handling terminals and associated facilities shall be developed by PPP operator, who shall be responsible terminal operations & maintenance and also sharing the revenue with the SPV. Limiting the project IRR to 15% for the PPP operator, 35% of the revenue share with the SPV which is overall IRR of -3.6% for SPV making the investment totally unviable.

With this in view, Full Fledged Concession to Private Operator could be explored with the following basic conditions so that there is no financial burden on the SPV:

1. The cost of Rs. 720 crores for External road connectivity to the port including the land acquisition be provided by NHAI or Bharat mala project
2. The cost of Rs. 310 crores for External rail connectivity to the port including the land acquisition be borne by South Central Railway or IPRCL
3. The cost Rs. 270 crores for 100 Ha of land acquisition for port be borne by state government or Sagarmala Development Company

Therefore further support from the central government may be sought through viability gap funding (VGF) of 20% and same VGF of 20% be formulated at State level to generate project IRR of 14%. The bidder who seeks minimal VGF shall be selected for port development.

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.

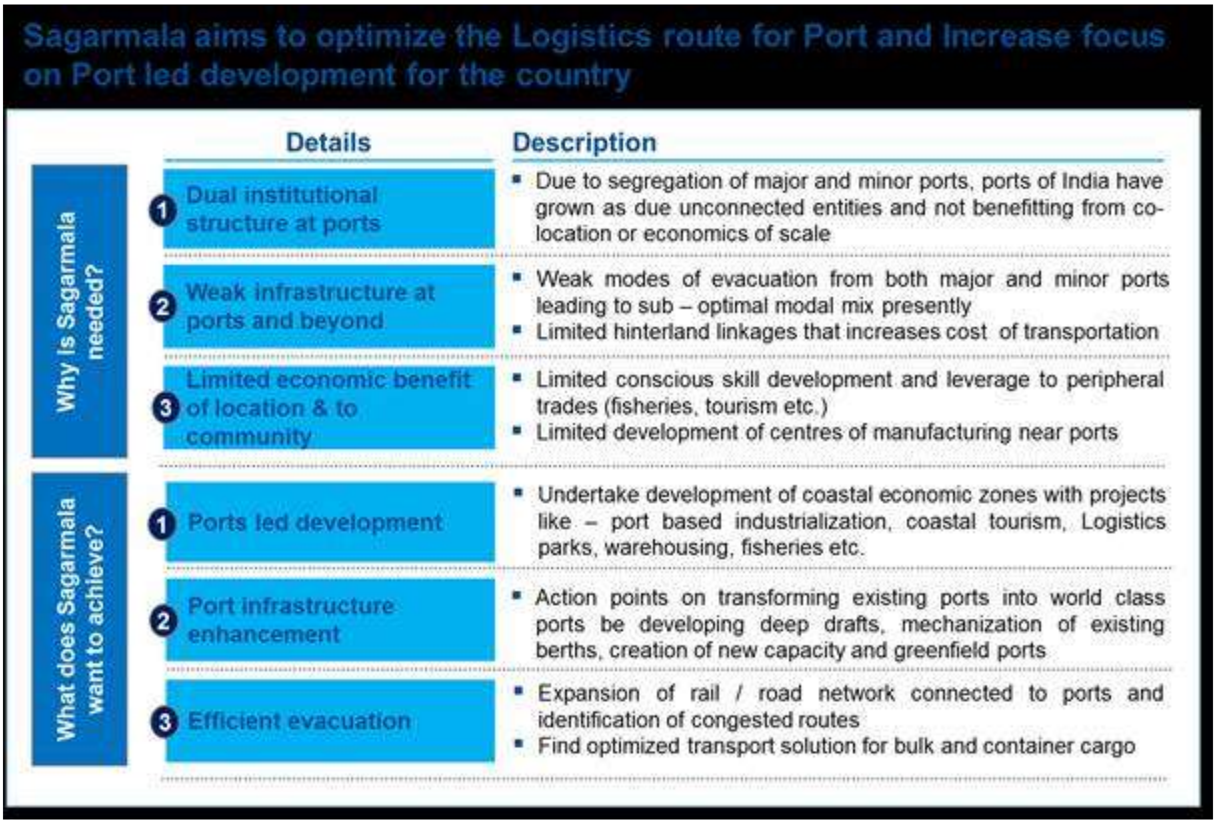


Figure 1.1 Aim of Sagarmala Development

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.

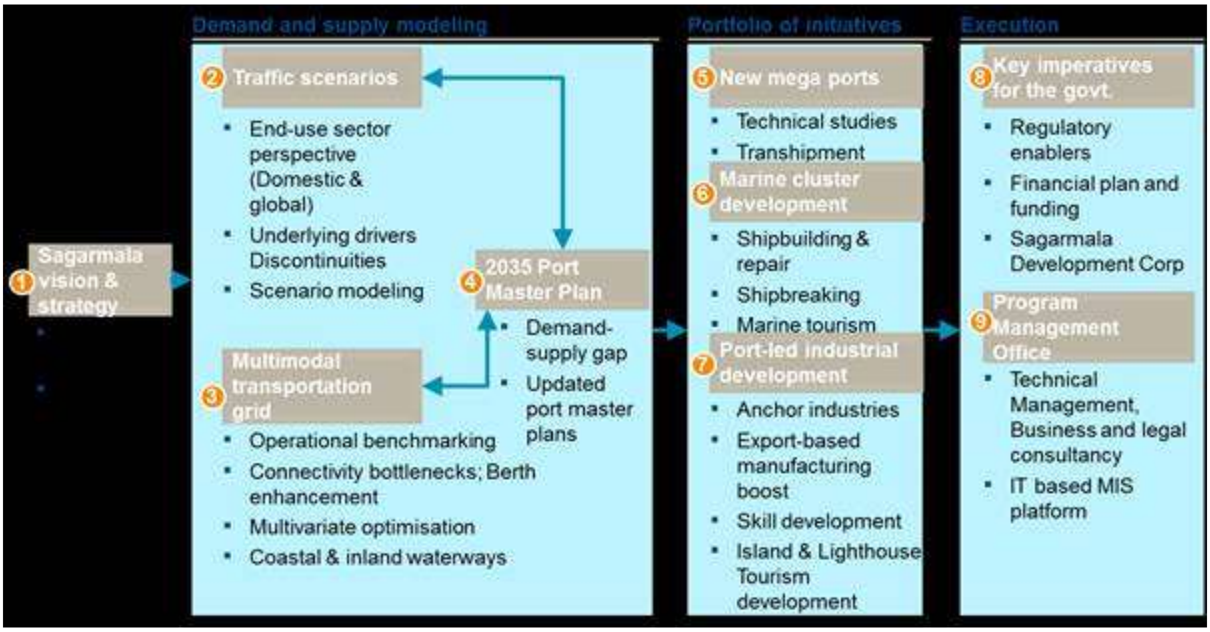


Figure 1.2 Governing Principles of our Approach

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 Development of Proposed Port

Andhra Pradesh has only one major port i.e. Vizag Port. Vizag port is constrained with its expansion due to development of city around it. The Ministry of Shipping, Government of India has already notified Greenfield port at Dugarajapatnam in Andhra Pradesh, as the major port under the Port Trust Act.

Dugarajapatnam is known for port related activities since times immemorial. In the seventeenth century, when the British East India Company decided to build a factory on the east coast, it is believed that Dugarajapatnam was selected as the site in 1626 to develop port facilities since the site is ideally located to develop sea port.

The capacity addition and the productivity improvements achieved by the major ports coupled with growing participation of Private Sector in cargo handling have had a favourable impact on efficiency of cargo handling operations at India's major ports. RITES have already prepared a feasibility report for Development of port at Dugarajapatnam in Andhra Pradesh. However they have assessed very high cost of port development, due to which MoS would like to have a relook at the entire project and accordingly have asked Mckinsey and AECOM to prepare a Techno-economic feasibility report for this site as part of the terms of reference of the Sagarmala assignment.

1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for development of Dugarajapatnam Port, Andhra Pradesh. This report is organised in the following sections:

Section 1 : Introduction
Section 2 : Site Information
Section 3 : Traffic Projections
Section 4 : Design Ship Sizes
Section 5 : Port Facility Requirements
Section 6 : Preparation of Dugarajapatnam 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 : Way Forward

2.0 Site Information

2.1 Location of Project Site

2.1.1 General

The proposed Dugarajapatnam port location is as shown in **Figure 2.1**. Dugarajapatnam is a small village with 2388 inhabitants, lie adjacent to Buckingham Canal, very near to sea shore in Vakadu Mandalam of Nellore District of Andhra Pradesh. Important towns like Gudur are at a distance of 40 km and Vakadu at 10 km. It is surrounded heavily with marshy land with tidal influence. Dugarajapatnam is a fishing village on fringe of Pullicat Lake.

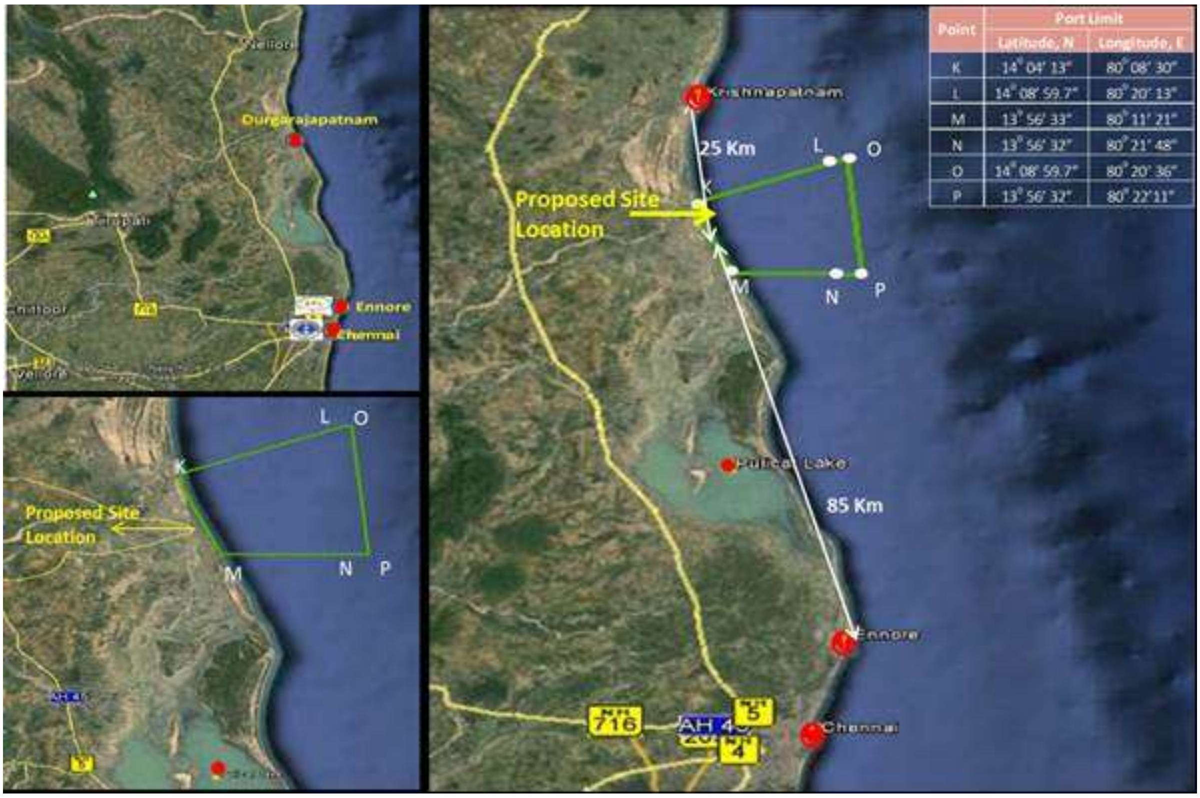


Figure 2.1 Location of Project Site

Dugarajapatnam is approximately 40 km from the Krishnapatnam port, 23 km from Srikharikota (ISRO) and 85 km from Ennore. The port is located in the vicinity of Buckingham canal which is the mainstay of inland water transportation plans through National Waterway 4. The port site is located south of the mouth of Swarnamukhi River near Vaggaru at Tupilipalem village. Tupilipalem is located 20 km from Dugarajapatnam.

2.2 Field Survey and Investigations for Dugarajapatnam Port

For planning of the port facilities, RITES in 2013 conducted the following surveys and investigations at Dugarajapatnam as part of the Techno-economic feasibility studies. The following surveys and investigations were conducted at the proposed site.

- Hydrographic survey
- Tide and Current measurements
- Geotechnical Investigation

For the purpose of the current TEFR, the survey data already available for the Dugarajapatnam site have been referred.

2.3 Meteorological Data

2.3.1 Climate

The climate of the region is characterised by two seasonal monsoons viz. north-east and south-west. North-East monsoon occurs between November and January and is characterised by predominant north-easterly winds. During this period the risk of a tropical storm or cyclones is higher than in most months. South-west monsoon extends from June upto September and is characterised by occurrence of rain, with predominantly south westerly winds followed by the north-east monsoon in October-December with predominant north easterly winds.

2.3.2 Winds

During the south-west monsoon period winds are predominantly from the southwestern direction. During the post monsoon seasons winds are mainly north-western to north in the mornings and north-eastern to east in the afternoons. During the rest of the periods winds are mainly from directions between east and south. During summer and monsoon season wind speed is about 9 km/hr while it about 5 km/hr during the rest of the period. During north-east monsoon, wind velocity may go up to 50 km/hr and during cyclonic periods the wind speeds may go up to 105 km/hr.

2.3.3 Rainfall

The region experiences two monsoon viz., south-west monsoon and north-east monsoon. The rainfall during south-west monsoon amounts to 31% of the annual rainfall, while about 50% of the rainfall occurs during the north-east monsoon period. The southern half of the district, particularly the coastal part under which the project site falls, receives rainfall during the early north-east monsoon period also. October and November are the months with highest rainfall. The average rainy days range between 40 and 44 days in a year. The average annual rainfall in the district varies from 1000-1200 mm. The maximum annual rainfall of 1100 mm and above is recorded all along the coastal part of the district.

2.3.4 Temperature

In May, the mean daily maximum and minimum temperatures are 40.1ºC and 27.2ºC respectively. During December, the mean daily maximum and minimum temperatures are 28.7ºC and 20.2ºC respectively. The highest maximum and lowest minimum temperatures recorded at Krishnapatnam are 47ºC and 14.4ºC respectively.

2.3.5 Visibility

Visibility is good throughout the year at Krishnapatnam Port area. On an average, visibility is well above 4 km for 320 days in a year.

2.4 Oceanography

2.4.1 Bathymetry

Based on the hydrographic charts and survey undertaken by M/s RITES in the year 2013; it can be seen that the 6 m contour is very close to the shore, i.e., within 500 m from the shore. The 8 m contour is 1.5 km and 10 m contour is 3.0 km away from the shore. The 12 m contour is 6 km away from the coast. The 12 m contour itself spreads over a width of about 6.75 km that is up to about 12.75 km from the coast. There is a huge shoal formed in the off shore area at 12 m contour. Further offshore, the sea bed is steep, that is, within 5 km from 12 m contour 20 m contour exists. About 16 km away from the coast 20 m contour exists. The bathymetric detail for the proposed Dugarajapatnam is presented in **Figure 2.2**.

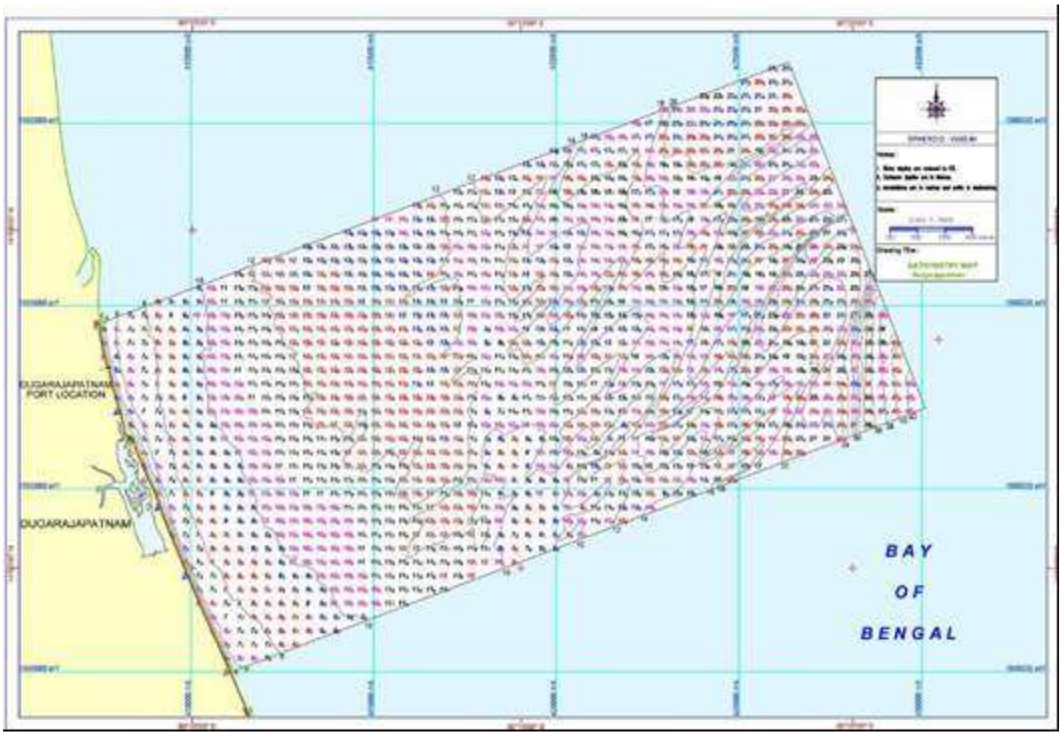


Figure 2.2 Bathymetry Details for Dugarajapatnam

The variation of seabed is as shown in **Figure 2.3**.

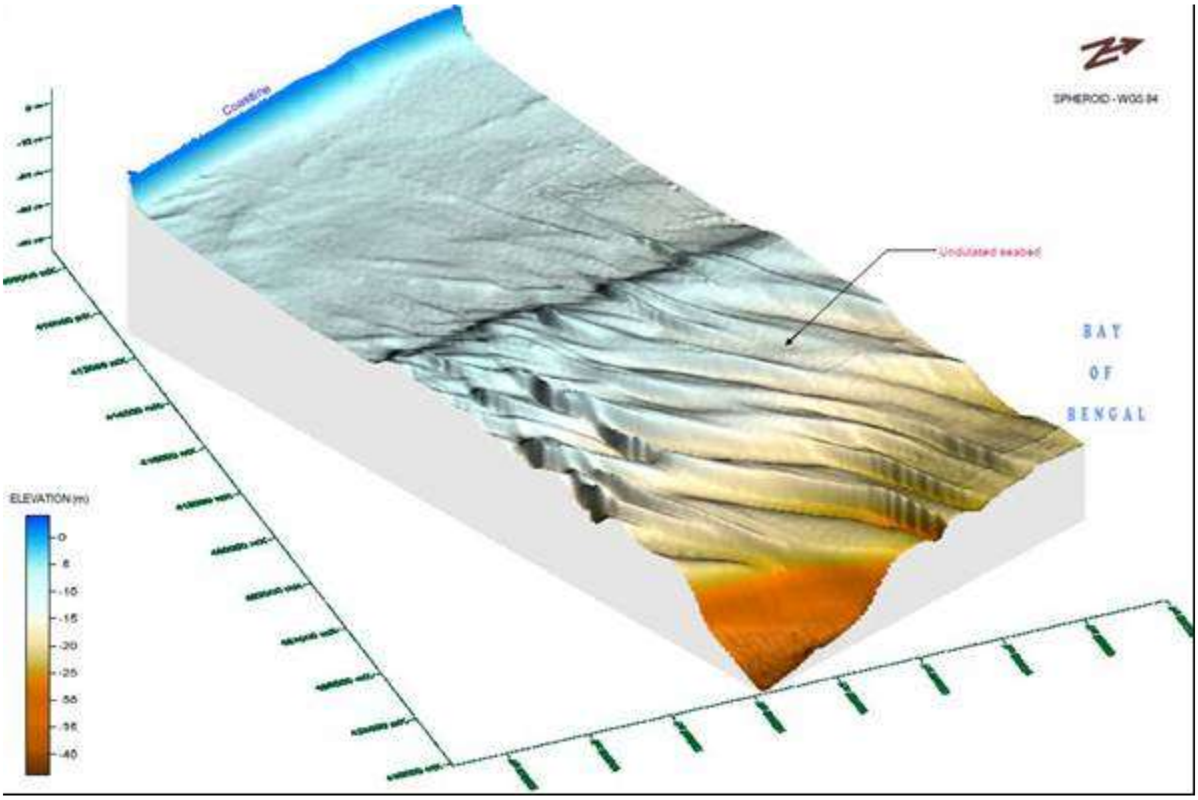


Figure 2.3 Variation of Seabed at Dugarajapatnam

2.4.2 Tides

Tide and current measurement's at the proposed site were carried out by M/s RITES in 2013. Measurements were carried at two locations viz., Tupilipalem sea water intake, just north of proposed port location, and the second one is at Ennore port, south of proposed port.

The tide at Dugarajapatnam is semidiurnal with two high tides and two low tides in a day. The various tidal levels at Dugarajapatnam port with respect to Chart Datum (CD) are as follows:

Highest High Waters (HHW)	:	+1.5	m
Mean High Water Spring (MHWS)	:	+1.2	m
Mean High Water Neap (MHWN)	:	+1.0	m
Mean Sea Level MSL	:	+0.8	m
Mean Low Water Neaps (MLWN)	:	+0.7	m
Mean Low Water Springs (MLWS)	:	+0.5	m
Mean Lowest low water (MLLW)	:	+0.3	m

2.4.3 Currents

The variations of current speed and direction were measured at three locations using Aanderaa Seaguard SW RCM current meters at three locations.

The maximum current velocity is 0.65 m/sec during the ebb tides and 0.61 m/sec during the flood tide.

2.4.4 Waves

2.4.4.1 Offshore Wave Data

To arrive at a suitable design wave for the marine facilities, the offshore significant wave heights for different return periods are calculated by probabilistic analysis.

The wave characteristics such as significant wave height and significant wave period at the offshore location have been extracted and presented in **Table 2.1** and **Table 2.2**.

The frequency distribution of significant wave height, the peak wave period and mean wave direction are shown in **Figure 2.4** and **Figure 2.5**. It is seen from the deep water data that the predominant wave directions in the deep sea off Dugarajapatnam are from SE to E.

Table 2.1 Monthly Max and Avg Values of Significant Wave Heights (m)

Month	Maximum	Average
January	1.04	0.80
February	0.98	0.72
March	1.02	0.62
April	1.03	0.87
May	1.39	0.72
June	1.07	0.75
July	1.22	0.83
August	1.11	0.86
September	1.31	0.88
October	1.34	0.84
November	1.31	1.00
December	1.34	0.93

Table 2.2 Monthly Max and Avg values of Mean Wave Period (s)

Month	Maximum	Average
January	7.1	5.9
February	7.8	5.9
March	7.4	5.9
April	8.4	6.6
May	8.2	6.2
June	8.6	6.8
July	9.8	7.6
August	9.2	7.8
September	9.2	7.7
October	8.0	6.6
November	6.8	6.2
December	6.8	6.1

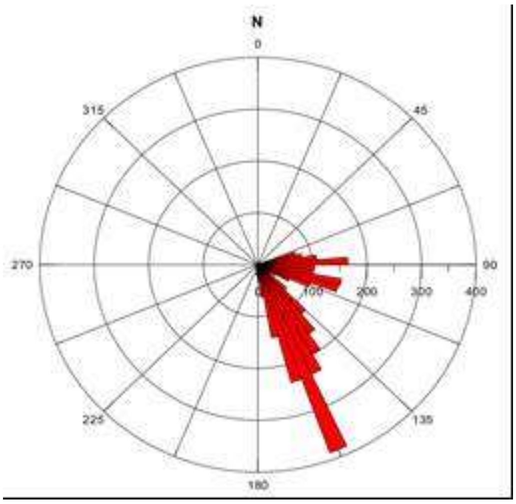


Figure 2.4 Wave Rose Diagram for Typical Annual Year

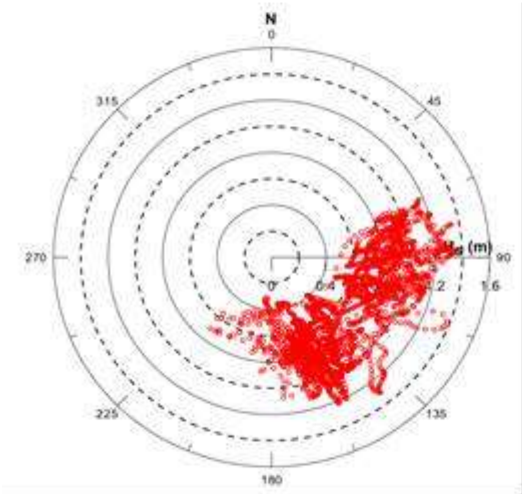


Figure 2.5 Wave Height Rose Diagram for Typical Annual Year

The offshore significant wave heights for different return periods based on wave data are shown in **Table 2.3**.

Table 2.3 Offshore Significant Wave Heights

Return Period T_r (years)	Offshore significant wave heights (m)
1	5.3
50	8.2
100	8.9

2.4.5 Cyclones

In the post monsoon period, storms and depressions originating in the Bay of Bengal pass through the district and neighbourhood causing wide spread heavy rains with gusty winds. Thunder storms occur during the period from March to November, being more frequent during the late half of the south-west monsoon and in the early part of retreating monsoon season.

2.4.6 Geotechnical Data

Detailed geotechnical investigations at the proposed site were carried out by M/s RITES in 2013; they conducted 6 no. of land boreholes and 9 no. of marine boreholes. The boreholes were terminated at a maximum depth of 30 m. The location plan of boreholes is presented in **Figure 2.6**.

Figure 2.6 Location Plan of Land and Marine Boreholes

2.4.6.1 Marine Boreholes

Soil profiles for all the marine boreholes were developed as shown in **Figure 2.7** and **Figure 2.8** to study the distribution of the sub strata. The subsoil strata consists of dense sand followed with the layer of stiff sandy clay and hard clay.

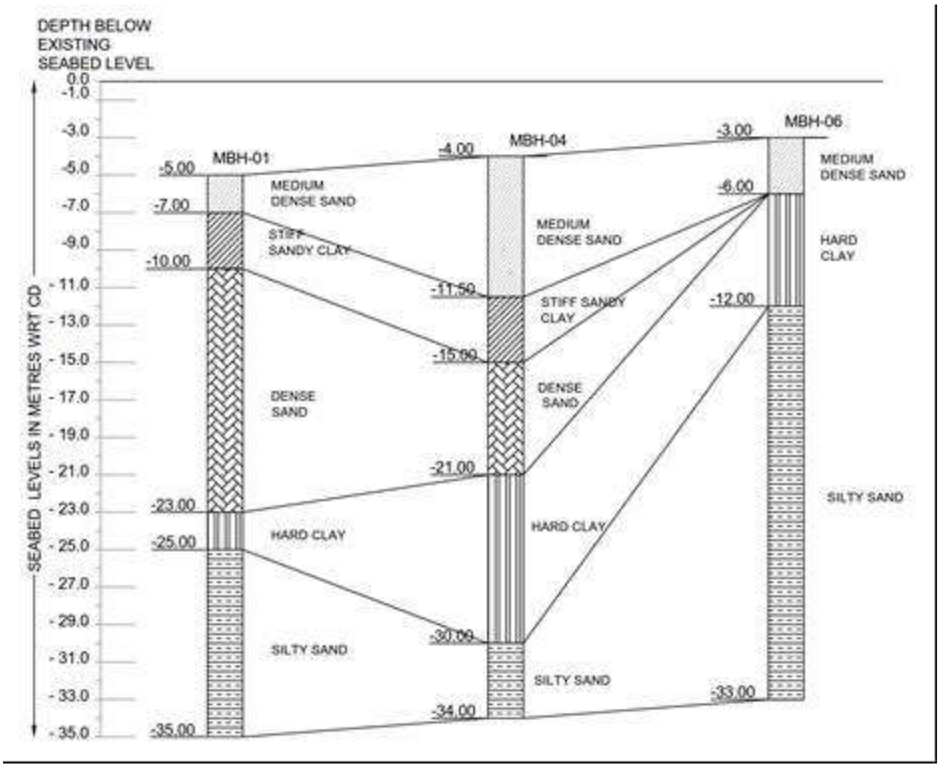


Figure 2.7 Subsoil Profile along MBH1, 4, 6

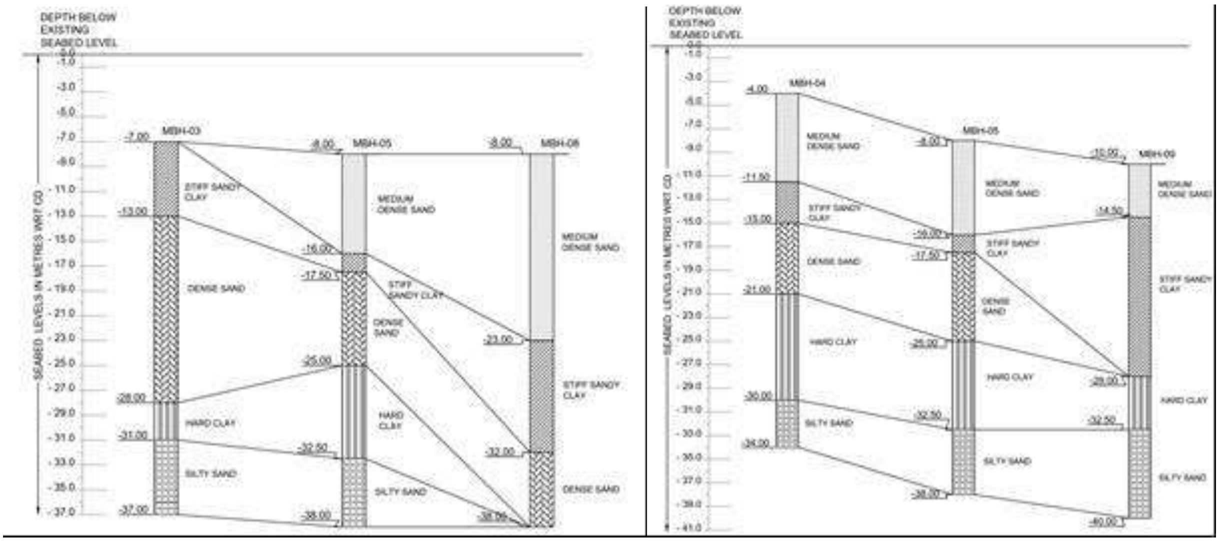


Figure 2.8 Subsoil Profile along MBH3, 5, 8 and along MBH4, 5, 9

2.4.6.2 Land Boreholes

The results of laboratory test conducted on samples collected from the onshore boreholes indicate the presence of 5 soil layers as shown in **Figure 2.9**:

- Dense sand
- Stiff Clay
- Very Dense Sand
- Clayey Sand
- Hard Sandy clay

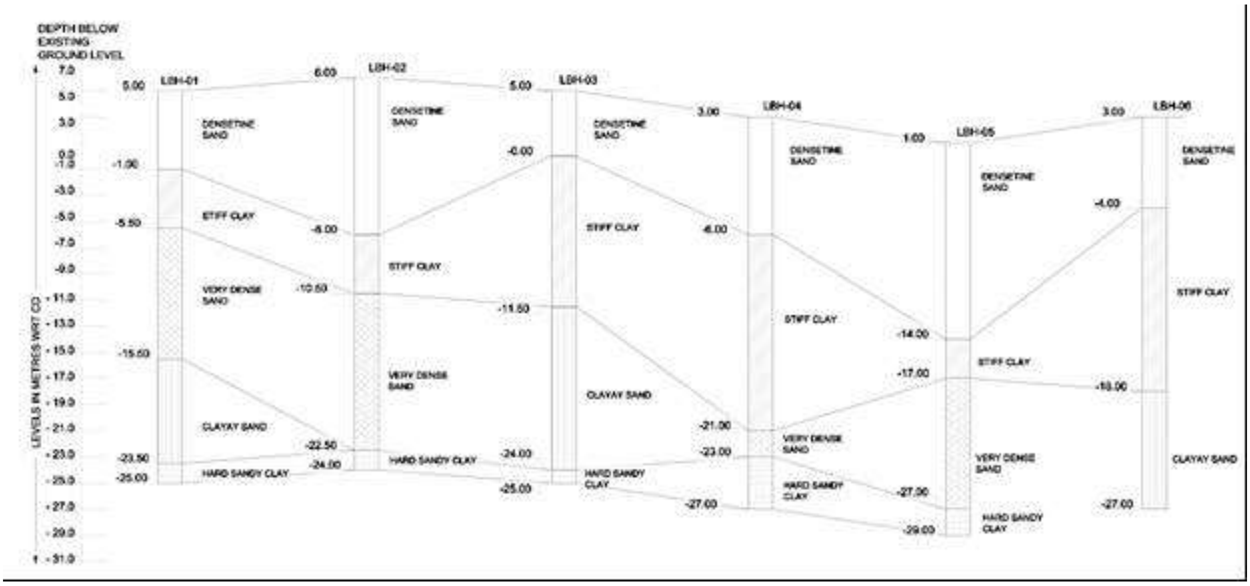


Figure 2.9 Subsoil Profile along LBH1, 2, 3, 4, 5 & 6

2.5 Site Seismicity

Dugarajapatnam is in **Zone III** of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone (**Figure 2.10)**.

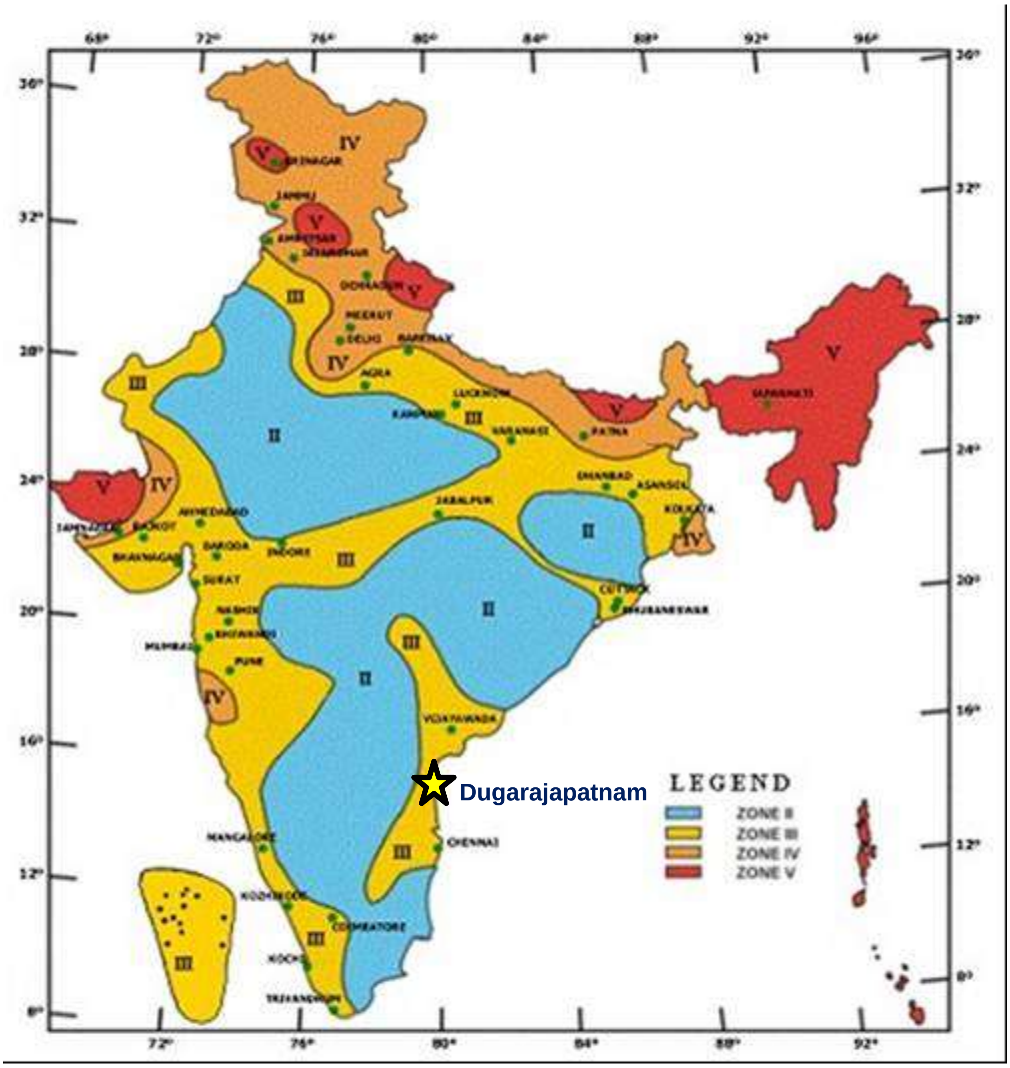


Figure 2.10 Seismic Zoning Map of India as per IS-1893 Part 1 - 2002

2.6 Topographic Information

The topographic survey carried out at the backup area of the proposed port shows that the ground levels vary between 0 to 3 m above MSL. 3 D view of the topography along the coast is as shown in **Figure 2.11**.

All along the coast prawn culture hatcheries are located.

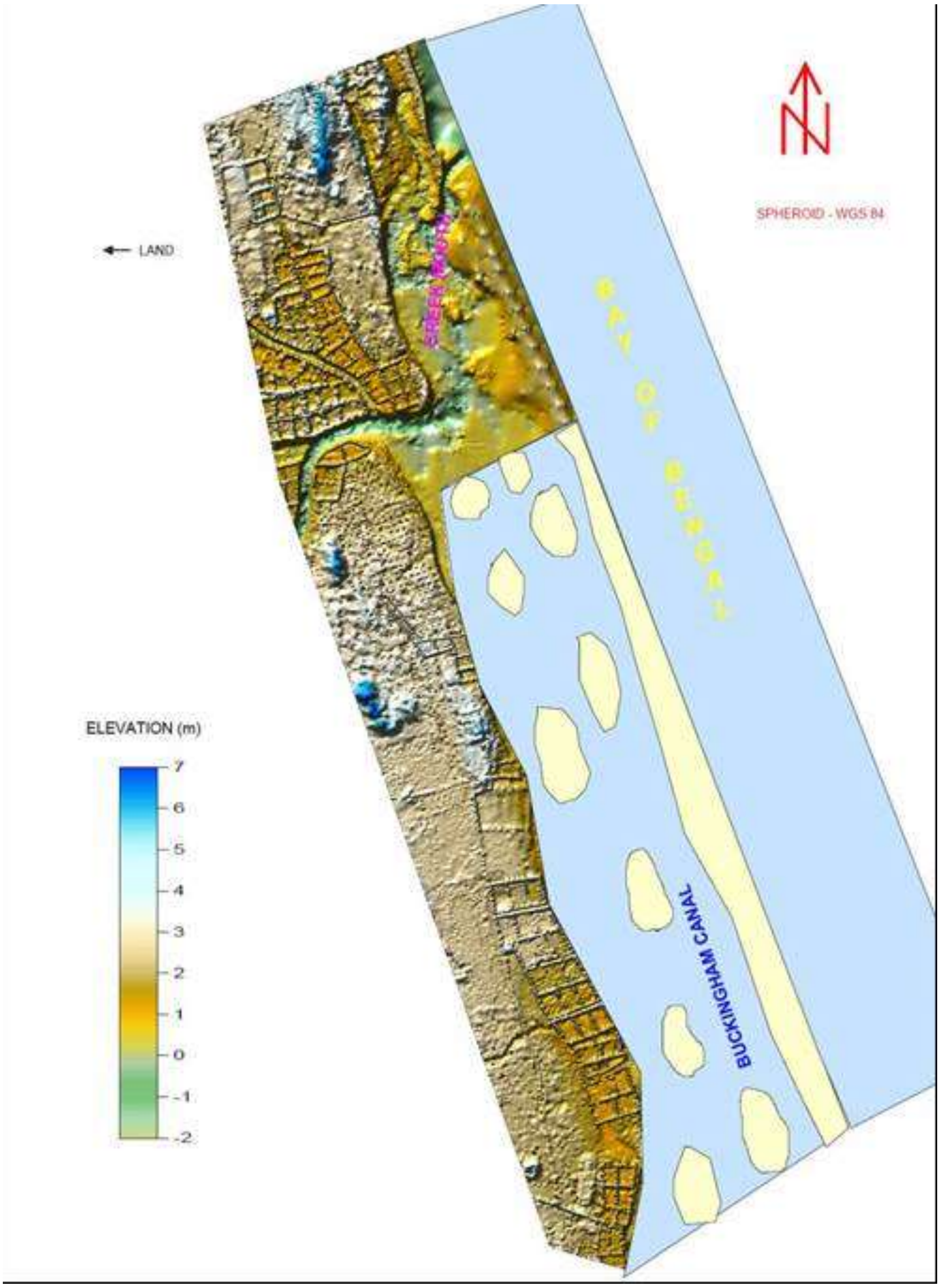


Figure 2.11 Topography of the Backup Area of the Proposed Port

2.7 Connectivity to Port Site

2.7.1 Existing Rail Connectivity

Though the port location does not have any direct connectivity by rail, there is already a proposal to connect this area by a broad gauge single line section between Guduru and Dugarajapatnam (nearly 42 km) by South Central Railways.

Guduru is a prominent railway junction and is a major transportation hub close the proposed port location. The existing rail connectivity to Dugarajapatnam is shown in **Figure 2.12**.

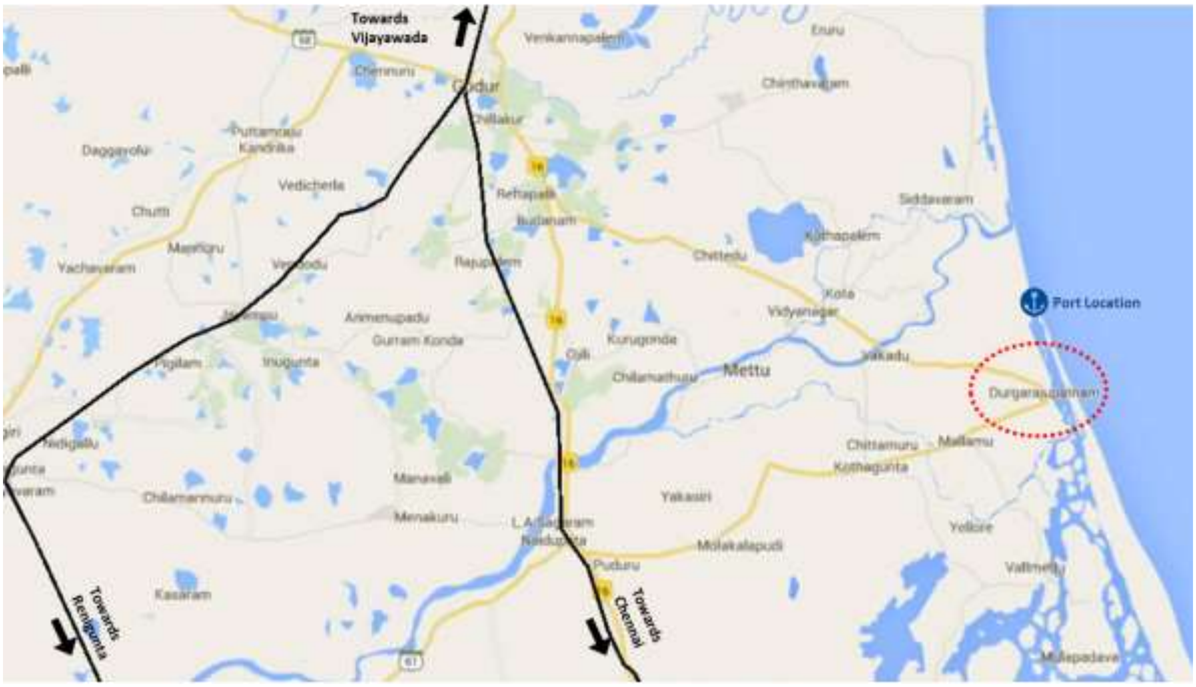


Figure 2.12 Existing Rail Connectivity to Dugarajapatnam Port

2.7.2 Existing Road Connectivity

The port site is connected to national highways by two routes namely Chillakur linking road and Naidupet linking road. The road near Chillakur crossing is 6 m wide (2 lane and 0.5 m carriage width either side) and takes 37 km to connect with NH5. The other district road from Naidupet is 3 m wide (1 lane and 0.5 carriage width on either side) bituminous road and takes 32 km to connect NH5. There are no major bridges along these routes except a bridge of length 400 m at Swarnamukhi river crossing. On development of port, these roads need to be upgraded to suit the port's requirement. On either side of the linking roads to NH5 to port site, most of the lands are paddy farmed and built up area or occupation by habitants are low.

The existing road connectivity to the proposed Dugarajapatnam port is as shown in **Figure 2.13**.

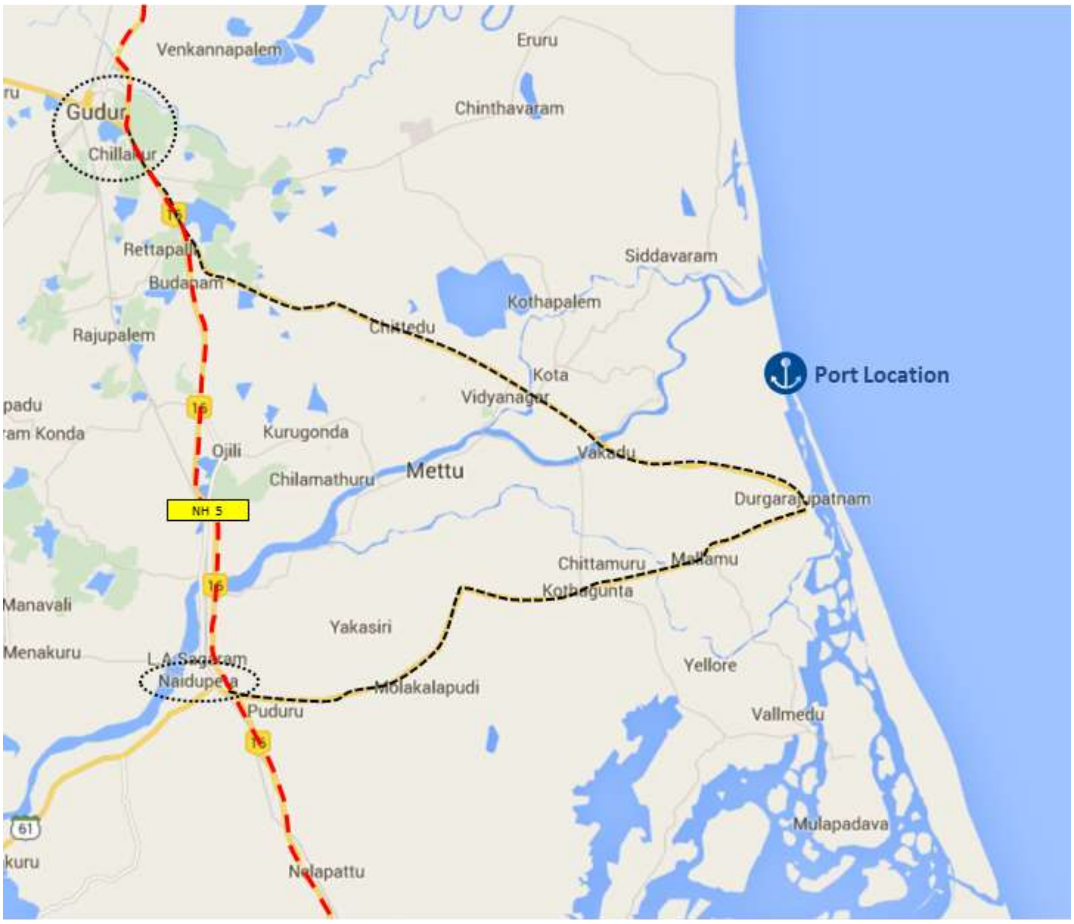


Figure 2.13 Road Connectivity to Dugarajapatnam Port

2.8 Water Supply

Presently, potable water to Dugarajapatnam village is being fed through pipelines from borewells driven near Swarnamukhi River at Vakadu. The required water for Port usage also can be obtained from same source through AP rural water supply board.

2.9 Power Supply

Dugarajapatnam has a 33/11 KV substation having 8 MVA capacity, which is being fed from 132/33 KV substation at Chendodu having 40 MVA (2-20MVA transformers) capacity. As the power requirement for the Port can't be met from these substations, AP govt. may supply from 400/220 KV substation near Kagitalapur (about 50 km from Port) having more than 200 MVA capacity.

The power is received from TCAPL at the main receiving substation at Manubolu (400 kV/220kV), as shown in **Figure 2.14** below.

Figure 2.14 Electrical Substation near Manubolu

3.0 Traffic Projections

3.1 General

The proposed port site of Dugarajapatnam lies on the eastern coast of India in the Nellore district of Andhra Pradesh. It has operational non-major port of Krishnapatnam on the north and major ports of Chennai and Ennore on the south. Southern Andhra Pradesh would be the primary hinterland of the port while Karnataka and parts of Telangana would be the secondary hinterland. Considering the location of the proposed site and the presence of other ports in proximity, Dugarajapatnam port would have to compete for the same hinterland with ports of Krishnapatnam, Chennai, Ennore and Katupalli.

3.2 Major Commodities and their Projections

As per the TOR of the Sagarmala assignment, the consultants are expected to map out the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports and develop traffic scenarios for a period of 20 years. Accordingly, based on a macro-level analysis the traffic potential for proposed port at Durgarajapatnam has been assessed by Mckinsey.

Thermal coal and containers would be the key commodities that can be catered to by the proposed port most of which would be diverted away from the existing port of Krishnapatnam.

3.2.1 Containers

The proposed port is expected to attract traffic of ~60,000 TEUs by 2020 primarily from the hinterlands of southern AP, Guntur, Hyderabad and other parts of AP. This traffic would be diverted mainly from the port of Krishnapatnam. Going into the future, this traffic is expected to increase to ~75-94,000 TEUs by 2025 and ~124-168,000 TEUs by 2035.

In the case of a new transhipment hub coming up on the Southern tip of the country the potential traffic is expected to further decline owing to the fact that part of the South AP containers will go directly to the transhipment hub.

Figure 3.1 below shows the hinterlands for the proposed Dugarajapatnam port.

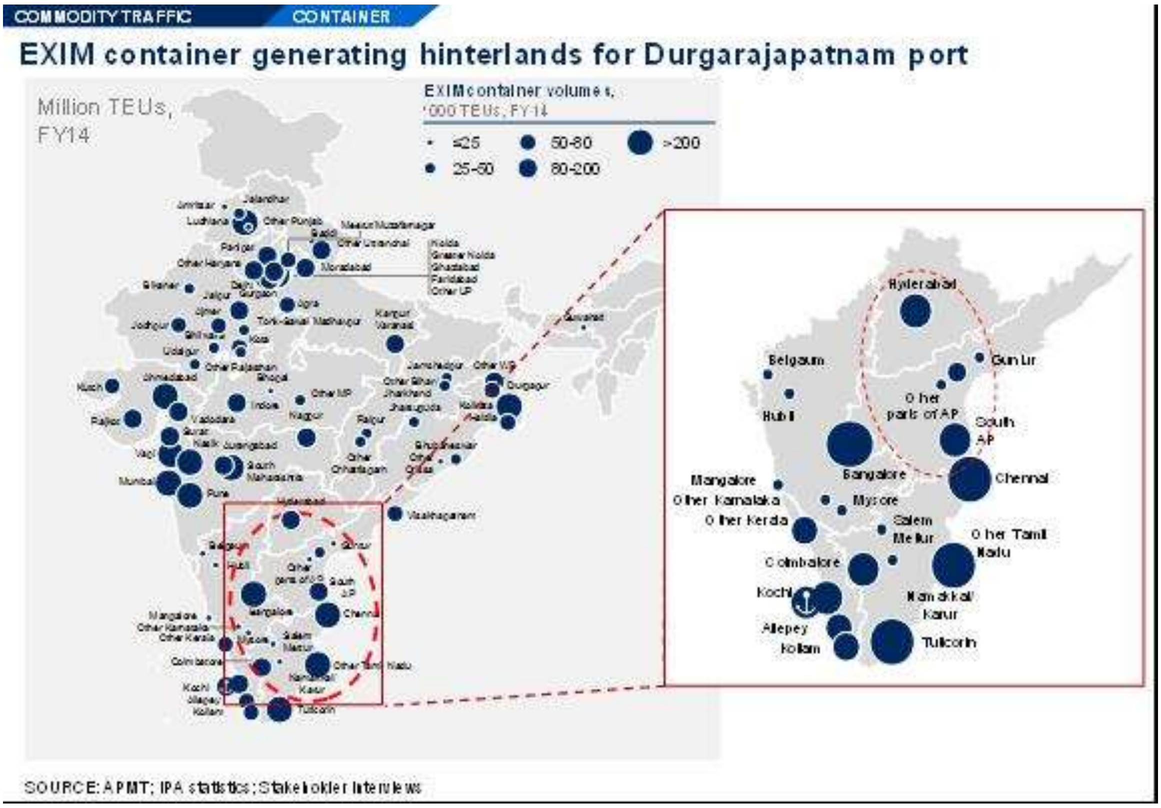


Figure 3.1 EXIM Container Generating Hinterland

3.2.2 Thermal Coal

The port is expected to divert part of the traffic currently handled by Krishnapatnam port. Rayalseema in Cuddapah district and Raichur can be the potential power plants using Dugarajapatnam for movement of thermal coal. The traffic for both these plants expected to be handled by the proposed port will be ~3.4 MTPA by 2020. Apart from the thermal coal for power based usage, non-power based coal traffic of ~3.5 MTPA is also expected by 2020.

The total thermal coal traffic at the port may increase to 8.5-9 MTPA by 2025 and 14-17 MTPA by 2035.

The overall commodity wise projections for the port are as shown below.

Table 3.1 Dugarajapatnam Traffic Projection

Durgarajapatnam Port - Traffic Projections

Units: MMTPA (except Containers)

xx Base Scenario | xx Optimistic Scenario

Commodity	2020	2025 (Base)	2025 (Optimistic)	2035 (Base)	2035 (Optimistic)
Dry and Break Bulk Cargo					
Thermal Coal (Unloading)	6.9	8.4	9.3	13.8	17.5
Containers and other Cargo					
Containers ('000 TEUs)	61.1	75.1	94.1	124.4	168.5
Total (MMTPA)	7.8	9.5	10.7	15.7	20.0

Conversion Factor Used for Container Projections: 1 TEU = 15 Tons

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 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 Dugarajapatnam have been identified as:

- Thermal Coal Import
- 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

Presently, the coastal shipping of thermal coal to southern states is carried out using ship sizes limited to Panamax size. However more and more facilities are being built in the southern states to receive vessels up to cape size. The costal shipping in cape size carried offer additional cost advantage for many of the users and it would be prudent the proposed port should also have unloading facilities for cape size ships in the future phases.

4.3 Containers

Container ships are classified into six broad categories viz. Feeder, Feedermax, 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]

In view of its location the port at Dugarajapatnam is expected to handle feeder vessels only and therefore the design ship size for container is likely to be limited to 4,000 TEUs.

4.4 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed port are presented in **Table 4.2**.

Table 4.2 Parameters of Ship Sizes

Commodity	Design Ship Sizes (DWT)	Maximum Parcel Size (T)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Dry Bulk	**80,000**	**72,000**	**240**	**32**	**14.5**
	120,000	110,000	260	40	16.5
	200,000	200,000	300	50	18.3
Container	1000 TEUs	700 TEUs	160	22	10.0
	4000 TEUs	1,200 TEUs	290	32	13.5

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

1. Initial development for Panamax Size ships having draft of 14.5 m.
2. Initial development for cape size ships of draft upto 18.3 m
3. Initial development for Panama Size ships and Deepening of the channel and harbour basin to handle cape size ships in phase-wise manner as per the market demand.

The major commodity for the proposed port is coal which is likely to move to this site from Paradip/ Dhamra through coastal shipping. Most of the quantity is likely to be moved through panamax size ships and therefore it would make sense to limit the initial phase development for Panamax size ships only.

However, as the proposed port has to compete with adjacent ports at Krishnapatnam and Ennore who have capability to handle cape size ships, it would be important that the planning should be such that the port should be able to handle cape size vessels by carrying out capital dredging at appropriate time as per market demand.

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

5.2.2.1 Bulk Cargo

For bulk cargo like thermal coal, it is proposed to be handled through fully mechanised system comprising of gantry type unloaders at berth, connected conveyor system from berth to yard, stacker and reclaimer at yard and wagon loading system.

5.2.2.2 Containers

For containers, it is proposed to be handled through mobile harbour cranes. For handling at the container yard suitable number of Rubber Tyred Gantry Cranes (RTGCs) shall be provided. At the railway yard reach stacker shall be provided for loading and unloading of rakes.

5.2.3 Operational Time

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.

5.2.4 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.

5.2.5 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.

5.2.6 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 5.1** below:

Table 5.1 Estimated Berths for Dugarajapatnam Port Development

S. No.	Berth Type	Commodities Handled at Berths	Import (I) / Export (E)	Total Berth Provided		
				2021	2026	2036
1.	Bulk Import	Coal	I	1	1	2
2.	Multipurpose Terminal	Break Bulk, Containers	I/E	1	1	1

5.2.7 Port Crafts Berth

For the initial stage development, the port would require 4 tugs (3 operational + 1 standby) with a capacity of 40 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.

5.2.8 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.

The proposed length of isolated berth for the different design ships are presented in **Table 5.2** below.

Table 5.2 Total Berth Length

Berth Type	Design Ship Size	Design Ship's LOA (m)	Minimum Berth Length (m)
Bulk Berths	80,000 DWT	240	290
	120,000 DWT	260	310
	200,000 DWT	300	350
Container berths	1000 TEUs	160	200
	4000 TEUs	250	300

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,
- 5 days for Containers

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 14 ha. increasing to 28 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

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 Dugarajapatnam, as shown in **Table 5.3**.

Table 5.3 Evacuation Pattern for Various Cargo

S. No.	Commodity	2020		2025		2035	
		Road Share %	Rail Share %	Road Share %	Rail Share %	Road Share %	Rail Share %
1.	Bulk Import	20%	80%	20%	80%	20%	80%
2.	Container	80%	20%	80%	20%	80%	20%

5.5.2 Port Access Road

The port would need to be connected to national highway NH5 for evacuation which is approximately 40 km from the port site. There is already an existing access road to the port which connects to NH5 and it would need to be widened from two lanes to four lanes initially and later to six lanes once the throughput picks up in later phases of development.

5.5.3 Rail Connectivity

The port shall be connected to the nearest rail link for effective evacuation of cargo.

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 0.30 MLD increasing to about 0.6 MLD in the master plan phase.

5.7 Power Requirements

HT and LT power supply at the port would be required for Handling Equipment, 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 9 MVA increasing to about 16 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at various berths.

5.8 Land Area Requirement for Dugarajapatnam 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 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 5.4** below:

Table 5.4 Land Area Requirement for Dugarajapatnam Port

S. No.	Commodity	Allocated Area (sqm)		
		2020	2025	2035
1.	Storage Space for various Cargoes	1,39,043	1,70,316	2,78,087
2.	Internal Roads and Circulation Space in Storage areas @ 25%	34,761	42,579	69,522
3.	Rail and Road Corridor	1,10,000	1,34,740	2,20,000
4.	Port Building Complexes including parking	5,000	5,151	9,295
5.	Landscaping, Green belt and other for Expansion	50,000	50,000	75,000
	Total Land Area (Sqm)	**3,38,804**	**4,02,786**	**6,51,903**
	Total Land Area (Acres)	**84**	**100**	**161**
	Total Land Area (Hectares)	**34**	**40**	**65**

The master plan details have been worked out based on traffic studies only up to 2035. However, ports are normally planned for 50 to 70 years of growth and hence there is need to provide at least double the area over the area requirement assessed for the year 2035.

6.0 Preparation of Port Layout

6.1 Layout Development

The key considerations that are relevant for the establishment of layout for the proposed port at Dugarajapatnam 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
  - Ability to cater for Littoral Drift
  - 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 and R&R 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 for Dugarajapatnam Port.

6.2.1 Potential Traffic

The potential traffic that the proposed 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 Dugarajapatnam Port development.

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. As Krishnapatnam port located towards north and Ennore port located towards south are close to this port location and both can cater to the cape size ships, it would be important that the proposed port at Dugarajapatnam be designed for handling cape size ships. However, in the initial stage of development it should at least be able to handle 80,000 DWT design ships. Accordingly, suitable water depths would need to be provided in the initial stages or subsequent years.

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. Based on the information available from the RITES report soil mainly comprise of silty medium sand and clayey sand at some locations. Therefore most of the dredged material shall be suitable for reclamation. The presence of silty sand at about 25 m below bed level indicates good founding strata for piled foundations. Therefore the geotechnical conditions at the proposed site are considered favourable.

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. The ports located along east coast are subject to waves from NE direction during NE monsoons and that from SW direction during SW monsoon period. The orientation of the breakwaters would need to be decided accordingly.

6.2.2.4 Ability to Cater for Littoral Drift

The phenomenon of littoral drift of sediments along the east coast of India is well known. The drift of sediments along the coast is caused by the action of waves impinging on the coastline at an angle, and this slowly drives the material in the direction of the waves. This is predominantly from south to north along the east coast of India, but there is some reverse drift in the NE monsoon season.

6.2.2.5 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 and breakwater. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. As per the information obtained during site visits, there are no quarries suitable for breakwater rock in the Nellore district and rock have to be brought from at least over 100 km away from Prakasam district. Any additional sources of rock shall need to be identified during detailed study.

6.2.2.6 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.

6.2.2.7 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.

6.2.2.8 Flexibility for Development in Stages

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

6.2.2.9 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. Same is the case for reducing the area required to be reclaimed in the initial phase.

6.2.2.10 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 2035 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing in 2035. 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.

It is understood that based on the RITES report the state government is in process of acquiring land as shown in **Figure 6.1**.

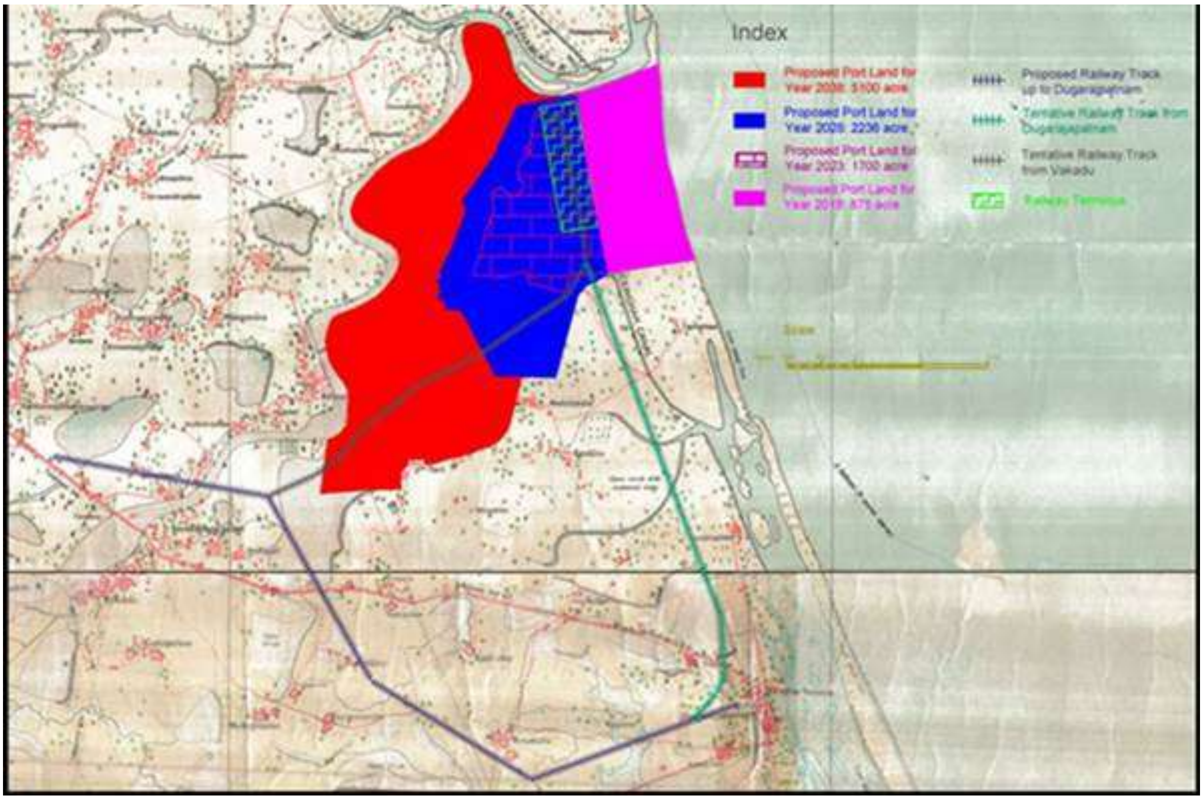


Figure 6.1 Demarcation of Land to be Made Aavailable for Port

Based on the studies carried out by RITES, it has been proposed for the land acquisition of 875 acres. However, in view of the much lower projected traffic and reduced requirements of facilities, so much land would not be required for the port facilities. The port layout would be developed with minimum land acquisition.

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. 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.

It is noticed that 12 km out of 15.4 km demarcated as port limits are coming under proposed Pulicat Lake Bird Sanctuary (PLBS) and its eco-sensitive zone. This area has been defined as 'No Development Zone' and no new industrial activity or construction can be undertaken in this zone.

Figure 6.2 Pulicat Lake Boundary Limits

Boundary of proposed PLBS and its eco-sensitive area is to be de-notified in order to take this project forward.

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 seawards of the navigational channel then take the ship to the harbour.

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=1.0 m to Hs=1.5 m depending on 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 ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for 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
Containers	0.5 m	0.5 m
Break bulk	1.0 m	0.8 m

6.3.2 Breakwaters

The purpose of breakwater is to provide tranquil conditions inside the port in operating conditions. The predominant wave attack is from SE and E directions. This would require two breakwaters to provide round the year wave tranquillity within the harbour. Final layout and alignment of the breakwaters shall be decided based on the wave tranquillity studies and the length shall be kept minimum to limit the overall capital expenditure.

6.3.3 Berths

The estimated number of berths for the various phases of development has been worked out and is presented in the **Table 6.2** below.

Table 6.2 Berth Requirement Estimation

S. No.	Berth Type	Commodities Handled at Berths	Import (I) / Export (E)	Total Berths Provided	
				2020	2035
1.	Bulk Import	Coking Coal	I	1	2
2.	Multipurpose Terminal	Break Bulk/ Container	I/E	1	1

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.

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 advantage, 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

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 (DWT)	Beam (m)	Channel Width (m)				Loaded Draft (m)
		Straight Channel		Curved Channel		
		One Way	Two Way	One Way	Two Way	
200,000	50	270	570	280	590	18.3
80,000	32	175	365	180	376	14.5

The channel length for handling 2,00,000 DWT ships works out to approximately 17 km and therefore the transit time of the ships in the channel will be about 1.15 hours at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1 hour, maximum of 10 ship movements per day (5 in and 5 out) could be accommodated with one set of tugs. Taking an average of about 8 ship movements per day in the channel, a one way channel can handle about 1,460 ship calls per year using one set of tugs. Considering the much lower projected traffic and consequent ship movements, one way channel would be adequate for the proposed port.

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.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship as calculated in **Table 6.5** below:

Table 6.5 Dredged Levels at Port for the Design Ships

Ship Size (DWT)	Draft (m)	Approach channel outside breakwater (m CD)	Inner channel and manoeuvring area (m CD)	At Berths (m CD)
80,000	14.5	16.7	16.0	16.0
200,000	18.3	21.0	20.1	20.1

It may however be noted that above values are arrived at considering the design ship navigates the channel and harbour basin during low water levels and therefore without the advantage of tide. However, in case the port is designed for cape size ships, the number of calls of such ships would be limited in the initial years and therefore a tidal advantage of at least mid-tide level of +0.8 m above CD could be considered. This would enable phasing of the capital expenses on the dredging. This aspect can however be dealt during execution stage.

6.3.5 Elevations of Backup Area and Berths

Considering the Highest high water level as +1.5 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 proposed as +5.0 m CD. The finished levels of onshore areas will be kept at around +4.7 m CD.

6.3.6 Scheme for Littoral Drift Management

When a breakwater is constructed protruding out from the coastline it creates a barrier to the natural drift. Therefore the drift material will accumulate against the breakwater as shown in **Figure 6.3** below:

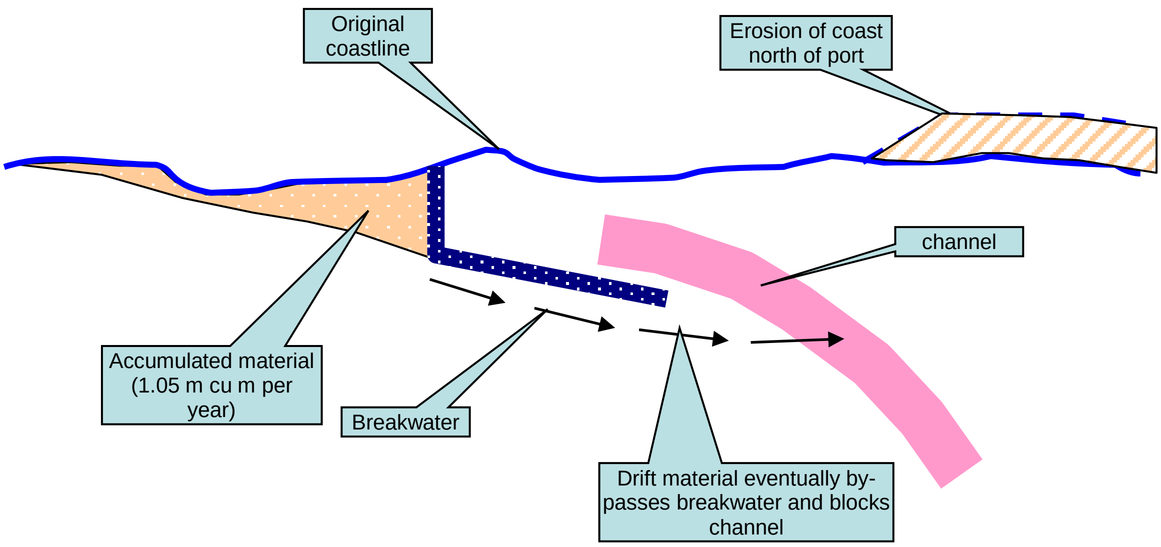


Figure 6.3 Diagramatic Illustration of Littoral Drift

Figure 6.3 shows what can be expected to happen if no action is taken to deal with the drift. The coastline north of the port is starved of the material which has occurred naturally in the past. The consequent erosion of the coastline north of the port would certainly be environmentally unacceptable.

Therefore it is necessary to collect the material and deposit it north of the port as part of an essential environmental management plan. Three possible methods of dealing with this problem for the proposed port are illustrated diagrammatically in **Figure 6.4** to **Figure 6.6**.

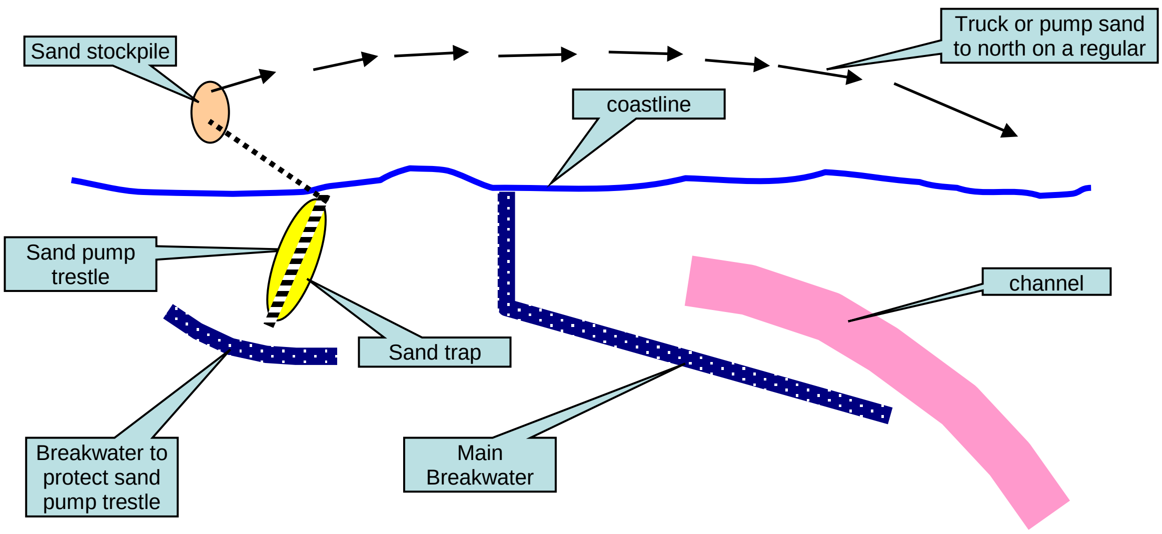


Figure 6.4 Littoral Drift Management Scheme 1

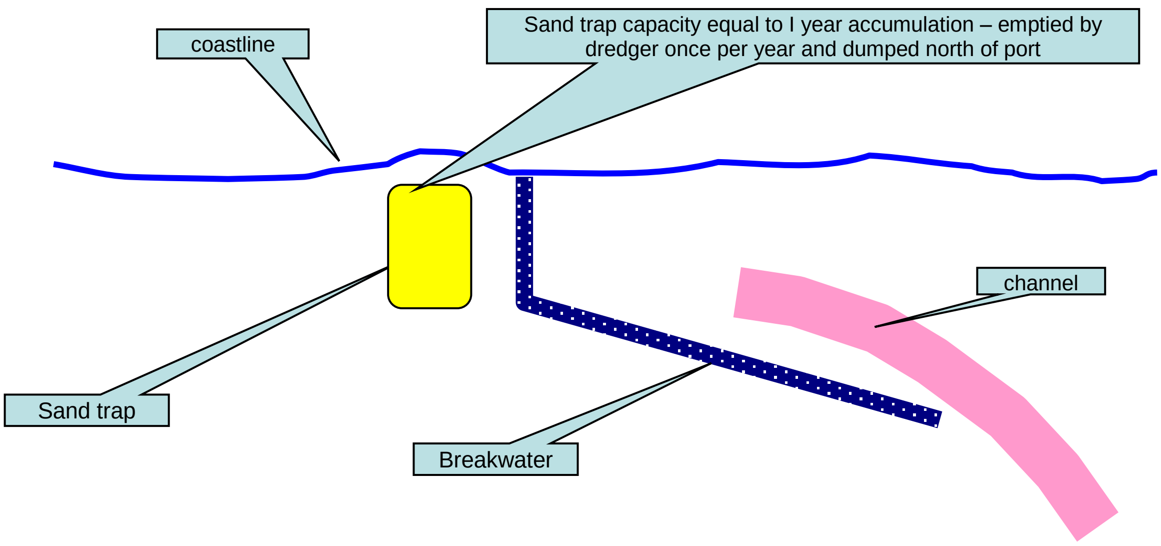


Figure 6.5 Littoral Drift Management Scheme 2

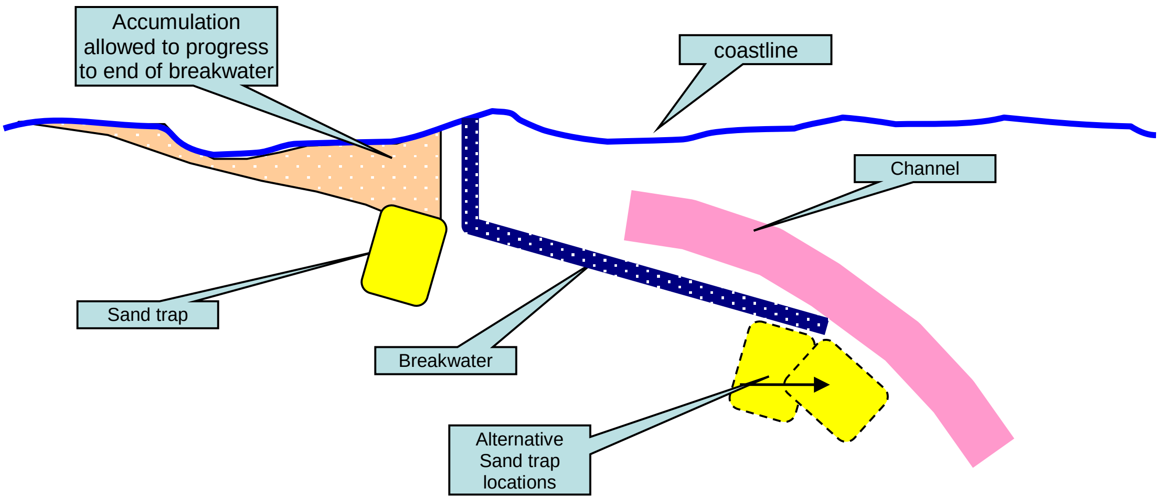


Figure 6.6 Littoral Drift Management Scheme 3

The drift occurs mainly between the high water line and -6.0 m contour. In all three schemes, therefore, the aim is to interrupt the accumulation of material in this zone.

In scheme 1, a sand trap is provided south of the port in the location of the existing 0-6 m contours i.e. before any accumulation of material has occurred. A sand pump mounted on a trestle removes the material monthly and pumps it round to the north, or alternatively to a stockpile ready for trucking to the north. The trestle and sand pump need to be protected by an island breakwater, and for this reason the scheme incurs a high capital cost. Its only advantage is that it can replenish the northern side on a regular monthly basis.

In scheme 2 a sand trap is provided in the same location as in scheme 1. This sand trap would have enough capacity to hold an entire 1 year's accumulation of drift material, and it would be emptied by a dredger annually. The annual dredged material would be deposited by the dredger on the northern side by rain-bowing technique or any other suitable method. The capital cost is much less than scheme 1, being merely an extension of the capital dredging contract by 1-1.5 million cubic metres.

In scheme 3 the coastline is allowed to advance to the end of the breakwater before any measures are taken to collect the drift material. Thereafter the scheme is the same as scheme 2, with a sand trap provided between the new high water mark and the new -6.0 m contour. This scheme creates valuable additional land and would be considered acceptable provided that during the few years taken for the southern beach to advance, suitable measures can be taken to protect the northern beaches, which could be by way of constructing groynes or dumping any surplus material.

It is therefore suggested that breakwaters are extended upto 6 m contour so that no material from littoral drift is directly accumulated at the channel but fully blocked by the breakwaters.

6.4 Alternative Marine Layouts

Two basic layouts for the port development have been considered for the Dugarajapatnam Port. These are discussed below:

Alternative Layout 1 involves offshore harbour option where the harbour area is located away from the shore. This alternative is envisaged to involve higher cost for breakwaters but less for dredging. Also it would be possible to utilise all the dredged material to create additional area by way of reclamation. The channel orientation at the harbour entrance is from NNE direction but after a suitable distance from harbour a bend is provided in the channel to reach deeper depths at a shortest possible distance. The channel orientation from SE direction was also planned but was not found suitable in view of presence of shoal towards the south direction. This alternative is shown in **Drawing DELD15005-DRG-10-0000-CP-DRP1001** and **DRP1002**.

Alternative Layout 2 is a coastal harbour option with most of the berths located close to the shore. As compared to Alternative 1, this alternative would result in shorter breakwater length but higher dredging quantities. The channel orientation is similar to as that of Alternative 1. This alternative is shown in **Drawing DELD15005-DRG-10-0000-CP-DRP1003** and **DRP1004**.

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 both alternative layouts. Therefore, for cost comparison for these two 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 Key Items for Alternative Layouts

Item	Phase 1 Development		Master Plan Development *	
	Layout 1	Layout 2	Layout 1	Layout 2
Breakwaters	917	526	917	526
Dredging	310	401	1143	1249
Reclamation	411	125	665	179
Total	**1,638**	**1,051**	**2,648**	**1,953**

* It is assumed that dredging for cape size ships shall be carried out for master plan layout

In order to further optimise the alternative layout 1, the option with a single offshore breakwater was also considered but it was not found to be cost effective and therefore did not pursued further.

From the above table, it is observed that cost of development is much lower in case of layout 2-Nearshore option.

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

Alternate	Estimated Rock Quantity (MT)	Estimated Construction Time (months)
Alternative 1	6.21	33
Alternative 2	3.53	22

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. Considering a patch of state government land right opposite the waterfront, it is required that limited land could be reclaimed utilising the suitable dredged material for the required cargo storage and operational areas.

6.5.4 Expansion Potential

It is observed that alternative layout 1 offer higher number of berths as compared to alternative 2. However, considering the traffic projections the number of berths available in alternative 2 is much higher than required at the master plan stage.

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
1.	**Soil Profile**	The soil characteristic would dictate the cost of dredging and marine structures.	The soil comprises of medium silty sand and thus forms reasonable founding strata for breakwaters and piled foundation.	Same as Alternative 1.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	Most of the dredged material is suitable for reclamation.	Optimal use of dredging and reclamation material.
3.	**Protection to the berths from waves and swell**	The predominant wave direction is from E and SE	The proposed breakwaters provide adequate tranquility to the berths	Same as Alternative 1.
4.	**Ability to cater to Littoral drift**	The scheme should be able manage littoral transport so as to minimize the shoreline changes	A sand trap would need to be provided outside the south breakwater	Same as Alternative 1.
5.	**Suitable location of back-up land for storage of cargo and port operations**	The storage area should located so as to provide faster receipt / evacuation of cargo and also provide separation between dirty and clean cargo	Effective utilization of backup area. Clear separation of clean and dirty cargo possible.	Same as Alternative 1.
6.	**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	Suitable rail and road connectivity can be provided in the land proposed to be acquired for port development	Same as Alternative 1.
7.	**Environmental issues related to development**	Presence of Pulicat Lake Bird Sanctuary	Proper EMP needs to be prepared to avoid any impact of proposed development.	Same as Alternative 1.
8.	**Potential Reclamation Area**	The higher reclamation area could be used to meet the storage and operation requirements of master plan stage	284 Ha	88 Ha

S. No.	Factor Description	General	Alternative 1	Alternative 2
8.	**Capital Cost of Phase 1 Development**	Optimized capital cost for the initial phase development so as to increase the project viability	Base case	Much Lower than alternative 1
9.	**Expansion Potential**	Maximum number of berths possible in the harbour so as to meet the demand at least for master plan horizon	Total 11 berths possible	Total 8 berths possible

6.7 Recommended Master Plan Layout

It could be observed from above that alternative layout 2 appears to be the best in terms of minimal investment for Phase 1 development and it also meets the long term expansion requirements of the port.

In order to minimise the overall project cost in terms of land acquisition and reclamation, this layout was further optimised and a new alternative layout i.e. recommended layout has been developed as shown in **Drawing DELD15005-DRG-10-0000-CP-DRP1005**.

6.8 Phasing of the Port Development

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 2020	Master Plan - Year 2035
Maximum Ship Size		
• *Dry Bulk (DWT)*	*80,000*	*200,000*
• Breakbulk (DWT)	*80,000*	*80,000*
• Containers *(TEUs)*	*4,000*	*4,000*
Number of berths (Total length of berths in meters)		
• *Bulk Import Berths*	*1(350m)*	*2(750)*
• *Multipurpose berths*	*1(300m)*	*1(300m)*
Navigational Areas		
• *Length of Approach Channel (m)*	*18,000*	*16,500*
• *Width of Approach Channel (m)*	*175*	*270*
• *Diameter of Turning Circle (m)*	*550*	*600*
Breakwaters		
• *South Breakwater (m)*	*3,340*	*3,340*
• *North Breakwater (m)*	*1,240*	*1,240*
Design Draft of the Ship (m)	14.5	18.3
Dredged Depths at Port (m below CD)		
• *Approach Channel*	*16.7*	*21.0*
• *Manoeuvring Areas*	*16.0*	*20.1*
• *Berths*		
○ *Breakbulk*	*16.0*	*16.0*
○ *Bulk*	*16.0*	*20.1*
Incremental Dredging Quantity (million cum)	*21.0*	*42.4*
Incremental Reclamation Quantity (million cum)	*8.3*	*3.63*
Total Reclamation Area (Ha)	*88*	*144*

The recommended Phase 1 development of Dugarajapatnam Port is indicated in **Drawing DELD15005-DRG-10-0000-CP-DRP1006**.

7.0 Engineering Details

7.1 Mathematical Model Studies on Marine Layout

These layouts have been duly checked after carrying desk based assessment for the wave tranquillity within the harbour. Mathematical model studies for wave penetration shall be carried out on the selected layout but it is unlikely to result in any change in the orientation of the berths and breakwater.

7.2 Onshore Facilities

The main consideration, in locating the facilities has been to minimise the land acquisition. Therefore the onshore facilities have been located in the reclaimed land. The areas for cargo handling and port operations have been segregated.

While arriving at the layout it has been ensured that adequate space has been earmarked for the railway lines to be provided within the port area.

7.3 Breakwater

7.3.1 Basic Data for design of Breakwater

7.3.1.1 Design Wave Height

The probable significant wave heights off Dugarajapatnam coast for different return periods have been discussed in Section 2. From this, the offshore design wave height is chosen as 8.9 m and the period as 11.4 s. Applying mathematical model MIKE 21 to this offshore wave data, results in shallow water wave height of 4.5 m at the breakwater location at -7m CD. However, since the MIKE 21 model underestimates the shallow water wave heights for extremely flat bottom conditions, the design wave height is adopted as 5 m.

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

7.3.1.2 Design Water levels

The storm surge of 1.5 m is expected at this site based on the desktop study. 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 is considered to be negligible. It is therefore proposed to use +3.0 m CD (Mean High Water Springs i.e. +1.5 m CD plus 1.5 m storm surge), as the design high 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.

7.3.1.3 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.

7.3.1.4 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 Core-loc 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 values for K_D considered for design of revetment is 2.8.

7.3.3 Geotechnical Assessment of Breakwaters

The seabed level at the breakwaters varies from +3.0 m CD nearshore to a maximum of -10.0 m CD. The crest level of breakwater at the maximum depth is about +9 m CD.

The stability of the breakwater foundation needs to be analysed for the subsoil conditions. This would be more relevant for the sections in deeper water. Based on the subsoil data, dense sand up to -6 m CD under layered by stiff sandy clay up to -9 m CD and therefore likely to provide reasonably good founding strata for the breakwater. There is unlikely to be requirement for any soil replacement which would increase the cost estimates for breakwater significantly though wider toe may need to be provided at some locations to provide stability. However, any shortfall in the stability found at the detailed engineering stage could be managed by increasing the toe width and/or depth.

7.3.4 Rock Quarrying and Transportation

7.3.4.1 Location of Quarries

It is understood that there are no quarries located suitable for breakwater construction in Nellore district. The rock for the construction of breakwater works need to sourced out from the quarries located at distant places in Praskasam district which are approximately 120 to 150 km from the proposed site.

7.3.4.2 Transport to Site

The quarry material will have to be transported in through dumpers. Some localise road improvement measures will need to be undertaken near the quarries and near the project site to enable moving of the large quantity of stones by road using trucks.

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-DRP1006**. Ideally the Container / 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 high dredging requirement at the berth locations it is proposed to provide the bulk and container berth away from the shore and backup area to which the connection shall be by approach trestle.

The bulk import berths and that multipurpose cum container berth is oriented at 59° N.

7.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +5.0 CD. This deck elevation will prevent the waves slamming the deck during cyclones. This 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 bulk and 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 7.1** below:

Table 7.1 Characteristics of Design Ships

Commodity	Design Ship Size (DWT)
Coal	200,000
Multipurpose	80,000
Containers	4,000 TEUs

7.4.3.2 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -21 m CD.

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

- *Loads due to Gantry type unloaders with rail centres at 20 m c/c on bulk berth*
- *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*

- **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 below:

Table 7.2 Details of Berthing Energy, Fender and Berthing Force Applied at Berths

Parameters	Bulk Berth	Multipurpose Berth
Berthing Energy	2975 kNm	1234 kNm
Fender	Trellborg Cell Type Fenders SCK 2500H E1.1 or equivalent	Trellborg Cell Type Fenders SCK 2000H E1.0 or equivalent
Rated Berthing Force	2711 kN	1397 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 Bulk Berths

The access from berth to the backup area is provided through a 15 m wide approach trestle. 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.

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 30 m. The total length of the one bulk berth is taken as 300 m.

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 6.0 m c/c in the longitudinal direction. The piles will be founded in dense clay at levels beyond -40 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 300 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 conveyor supports are provided in the rear side of the berth at a spacing not exceeding 24 m. The typical cross section of Bulk berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-DRP1007**

7.4.4.2 Container cum Multipurpose Berths

The container cum multipurpose berth is connected to land by means of approach trestle. Due to the requirement of placing the ship’s hatch covers additional area has been created by reclaiming the land behind the berth and hence the width of the berth is taken same as that of bulk berth i.e., 30 m.

The structural arrangement of the berth is based on the design criteria. The proposed scheme consists of four rows of vertical bored cast-in-situ RCC piles of 1.2 m diameter, spaced at 6.0 m c/c in the longitudinal direction. The piles will be founded in dense clay at levels beyond -40 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 third 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. The typical cross section of Container cum Multipurpose berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-DRP1008**

The berth is connected to the shore by means of 1350 m long and 15 m wide approach trestle to back up area. The approach trestle shall be supported over three rows of 1.1 m diameter bored cast in situ piles. The structural arrangement of the approach trestle would be similar to that of the container and multipurpose berth.

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 **21 Mcum**. The soil is likely to comprise of loose to dense fine sand. At some area stiff sandy clay is also expected. Nearly half of the dredged material shall be used for reclamation and balance shall be disposed off at a suitable location offshore at about 30 m contour.

7.5.2 Maintenance Dredging

Based on the RITES model studies the total littoral transport of about 1.5 Mcum per annum from south to north would be obstructed by the south breakwater, this shall result in accretion on the south of the south breakwater. Most of the material shall be accumulated in the proposed sand trap from where it could be periodically dredged and transported to nourish the shoreline to the northern side of the port.

7.6 Reclamation

It is proposed that the area behind the bulk and container cum multipurpose berths shall be reclaimed to provide the space transit storage and area along the shore line to create the backup area for storage and operation.

The required reclamation quantity of **8.3 Mcum** in Phase 1 development can be carried out using suitable material obtained out of capital dredging. 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 using Rock/ boulders. Thereafter the reclamation levels within the bunds are raised in suitable stages, to prevent overloading of the underlying subsoil. Part of 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 +1.2 m above CD. Between the elevations +1.5 to +4.5 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. The ground improvement of the reclaimed area would be carried out using band drains and placing of surcharge as per design requirements.

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 4,400 TPH to ensure faster turnaround of vessels at berth.

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 panamax 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. The system details are shown in **Figure 7.1**.

Figure 7.1 Typical Gantry Type Ship Unloader

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 4,400 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. One of the equipment shall be used to receive coal from the ship and stacking in the yard and simultaneously other equipment can be utilised to reclaim the coal from stackyard for transfer 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 4,400 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 and 50 m wide stockpiles.

Figure 7.2 Typical Stacker cum Reclaimer

7.7.1.5 Wagon Loading

It is proposed to provide rapid loading system for loading of the rakes. The system comprise of one concrete/steel silo with a capacity to hold 800 T of coal fed from the stackyard by a conveyor system. The cylindrical shaped silos have a conical discharge chute with gate system, load cells to automatically discharge coal/limestone into a moving rake. The silos have necessary chute level sensors, heat sensors, and raw water sprinkling system for efficient, safe and clean operations.

Figure 7.3 Typical in-motion Wagon Loading System

The diesel loco hauls the empty rake which passes under the silos. As the first wagon of the empty rake which is in motion comes under the silo discharge chute, the wagon loading starts through the chute with the quantity of loading automatically getting controlled by load cells and the speed of movement of the rake. The diesel locos and track side equipment with creep control devices provided for maintaining slow speeds required will ensure correct loading of each wagon.

7.7.2 Container Handling System

7.7.2.1 Mobile Harbour Crane

The projected container traffic is in the initial phase of development is only 61,000 TEUs per annum which increases to 124,000 TEUs per annum in the year 2035. In view of the limited throughput in the initial years it is proposed to initially handle the containers at the multipurpose berth. Mobile Harbour Cranes (MHCr) fitted with the spreader attachment are well proven for the efficient handling of containers.

Figure 7.4 Mobile Harbour Crane with Spreader Arrangement

This arrangement will have benefit in the sense that the cranes can also be used to handle breakbulk cargo using appropriate grab or hook attachment.

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 7.5** shows an E-RTG in operation.

Figure 7.5 Typical E-RTG for Yard Operation

Figure 7.6 Typical Details of Electric Buss Bar Arrangement for E-RTG

7.7.2.3 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 7.7 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.

7.7.2.4 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 7.8 Snapshot of Typical Reach Stacker Handling

Considering the throughput of the import export containers of gateway traffic, it is proposed to provide two numbers of Reach Stackers for train loading/unloading.

7.7.2.5 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 7.9 Typical ITV for Handling Containers

7.8 Road Connectivity

7.8.1 External Road Connectivity

During the study, it is observed that there is a single lane existing road which can provide the connectivity in between port and National Highway 5. AECOM team travelled on this road and the existing conditions are given in the following photographs:

Single Lane road to Dugarajapatnam from NH 5

Single Lane road Junction with NH 5

Road Crossing Swarnamukhi near Burlavaripalem

M/s. RITES carried out the alignment of the external road connectivity to NH 5 which is 42 km from the port site. Currently, there exists a single lane road from Chillakuru near Guduru on NH 5 to Dugarajapatnam port and this road need to be widened.

There are no major bridges along the proposed road except a bridge of length 400 m is required at Swarnamukhi river crossing. The Swarnakukhi barrage road caters to 2 lane traffic. By the north side of the barrage another road bridge of 4 lanes is proposed. Additional land, Right of Way (ROW), requirement for widening existing 2 lanes to six lane road is worked out to 180 ha. As per National Highway standards, 3 culverts/ km are considered in the proposed 6 lane road. On either side of the existing road connecting NH 5 to Dugarajapatnam, most of the land is with paddy fields, built up area and occupation by habitants are less.

The proposed rail alignment will cross the existing road to Dugarajapatnam between the villages Nellipudi and Kodivaka. A road cross over bridge is required at this rail crossing (**Figure 7.10**).

Figure 7.10 Proposed Road Connectivity to Dugarajapatnam Port

As per the RITES assessment, the cost of widening of existing 2 lane road to 6 lane is about INR 720 crores including INR 240 crores for land acquisition for the corridor.

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 one way circulations to avoid any criss crossings.

7.9 Rail Connectivity

7.9.1 External Rail Connectivity

Though proposed port location does not have any direct connectivity by rail, there is already a proposal to connect this area by a broad gauge single line section between Guduru and Dugarajapatnam (nearly 42 km) by South Central Railways. Similar to the road alignment, M/s. RITES carried out the rail connectivity alignment study. Number of lines may be enhanced in future depending upon the requirement to facilitate rail borne traffic estimated to be handled at the Port. The proposed rail connectivity to Dugarajapatnam is shown in **Figure 7.11**.

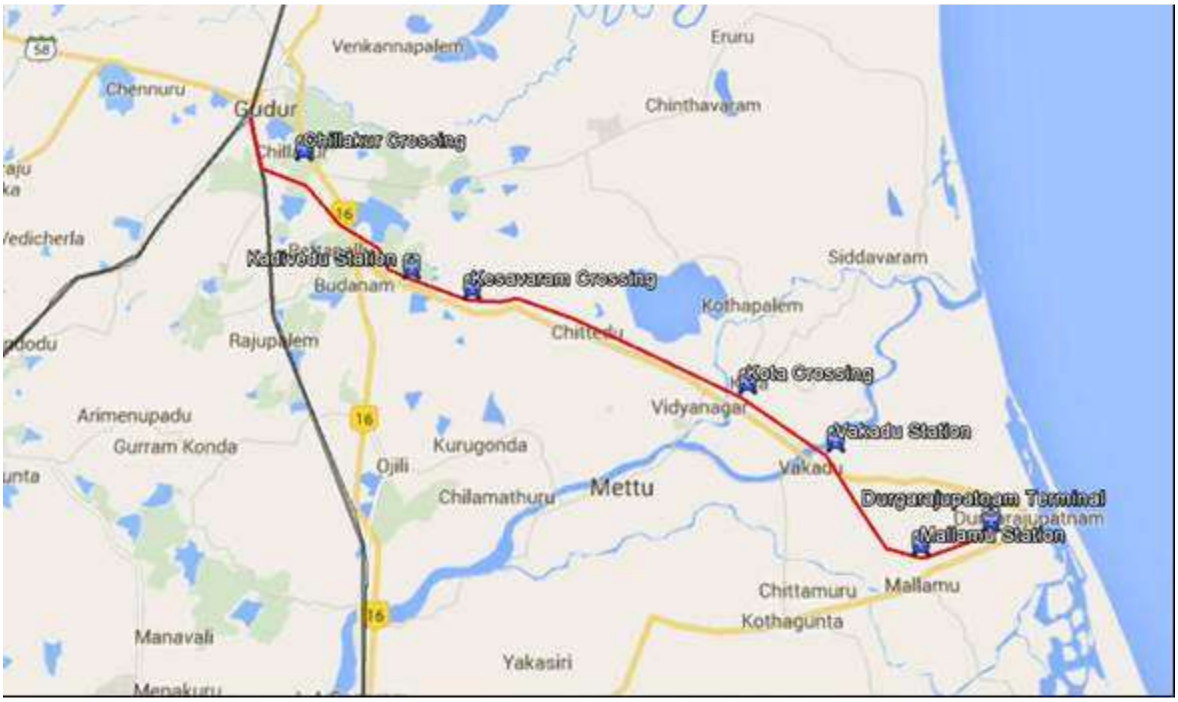


Figure 7.11 Proposed Rail Connectivity to Dugarajapatnam Port

Guduru is a prominent railway junction and is a major transportation hub close the proposed port location.

7.9.2 Internal Rail Links

The internal rail lines will be developed so that the rakes could be taken to the wagon loading system. It shall be ensured that their location does not obstruct the movement of port vehicles. 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 within the port boundary.

7.10 Port Infrastructure

7.10.1 Electrical Distribution System

7.10.1.1 Introduction

The handling systems for bulk loading and unloading are power intensive and hence require considerable high tension electrical power for their operation. 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. The various terminals within port will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

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 9 MVA. This is expected to go up to 16 MVA over the proposed master plan horizon.

7.10.1.3 Source of Power Supply

Power supply to Dugarajapatnam Port can be tapped from the 400/220 KV substation near Kagitalapur (about 50 km from Port) having more than 200 MVA capacity. It is proposed that the transmission lines be tapped off and extended up to the proposed location of the main receiving substation.

7.10.1.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the boundary of the proposed port, where the main substation shall be located. This outdoor switch yard will have two numbers of 33 KV transformers with 9 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 the bulk terminal and other for container cum multipurpose 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 at each of the two substations. 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 7.3** below:

Table 7.3 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 m 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 0.97.

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 100 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 unloaders, MHCr, 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 Dugarajapatnam 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
- 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 Dugarajapatnam 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.

7.10.4 Water Supply

7.10.4.1 Water Demand

The water demand for the Dugarajapatnam Port has been worked out in the **Table 7.4** below:

Table 7.4 Estimated Water Demand for Dugarajapatnam Port

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	261	507
2.	Potable Water (KLD)	33	52
	Total Water Demand at Port (KLD)	**294**	**559**

7.10.4.2 Sources of Water Supply

The water requirement for Dugarajapatnam port shall be sourced from AP Rural Water Supply and Sanitation Department. Alternatively providing a desalination plant at the port can also be explored during the implementation stage.

7.10.4.3 Storage of Water

The water supply from the main header shall be fed to the underground water tank of 600 cum located at the port boundary which is equivalent to about 2 day 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).

The water from the main sump would be pumped to secondary sump of 300 cum capacity located near the stackyard and. The sump 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, ships and greenery, where a small filtration unit shall be provided. The third compartment of 100 cum will provide water for dust suppression system in the bulk 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 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 26 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 vessels a minimum of four harbour tugs of 40 T bollard pull capacity are required initially, including tug for standby/ emergency.

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 would 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 Phase 1 development of Dugarajapatnam Port are given in **Table 7.5** below.

Table 7.5 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 40 T bollard pull	4
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 has a total length of 17 km from the breakwater head which require 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 nm. In addition some buoys are proposed in the harbour basins as well. IALA maritime buoyage system as per region A, in which Dugarajapatnam 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 long 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 Dugarajapatnam 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 Fire Fighting 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.

7.10.9.2 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 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.

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 Vagarru, Tupilipalem. 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.

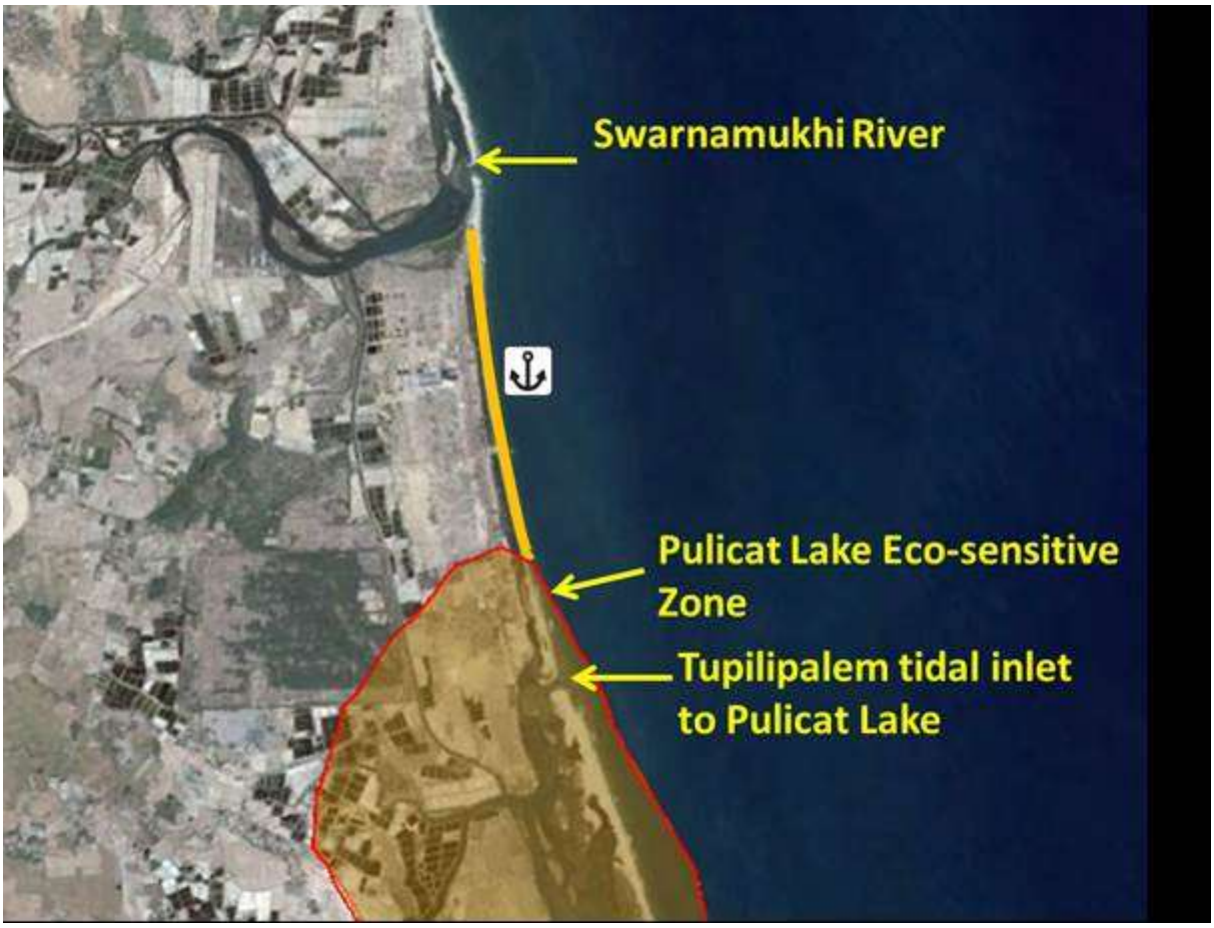
8.2 Site Setting

A Greenfield port is planned to be developed on the coast near the Tupilipalem village. The waterfront identified for port development is devoid of any habitation but has some commercial activities like salt manufacturing and aqua culture.

The proposed site is bound with River Swarnamukhi on the north and eco-sensitive zone boundary of Pulicat lake on the south. Buckingham Canal runs on the west of the proposed site (**Figure 8.1**).

Pulicat Lake is the second largest brackish water lagoon after Chilika Lake of Orissa. Three major Rivers which feed the lagoon are Arani river, Kalangi river and Swarnamukhi river. It is connected to the sea through three tidal inlets, one each at Tupilipalem, Rayadoruvu and Pulicat villages respectively, from north to south. The sea mouths are not simply a passage of water into lake but a bio-corridor for survival of both aquatic fauna and avian fauna. Thus, any development near the tidal inlet shall be planned carefully avoiding impacts on the eco-system of the area.

The coast at the proposed port location is demarcated as medium to low accretion zone (**Figure 8.2**).



Proposed site with Casurina Plantation in the back drop

Flat terrain and vegetation on the landward site

Figure 8.1 Location of the Proposed Site

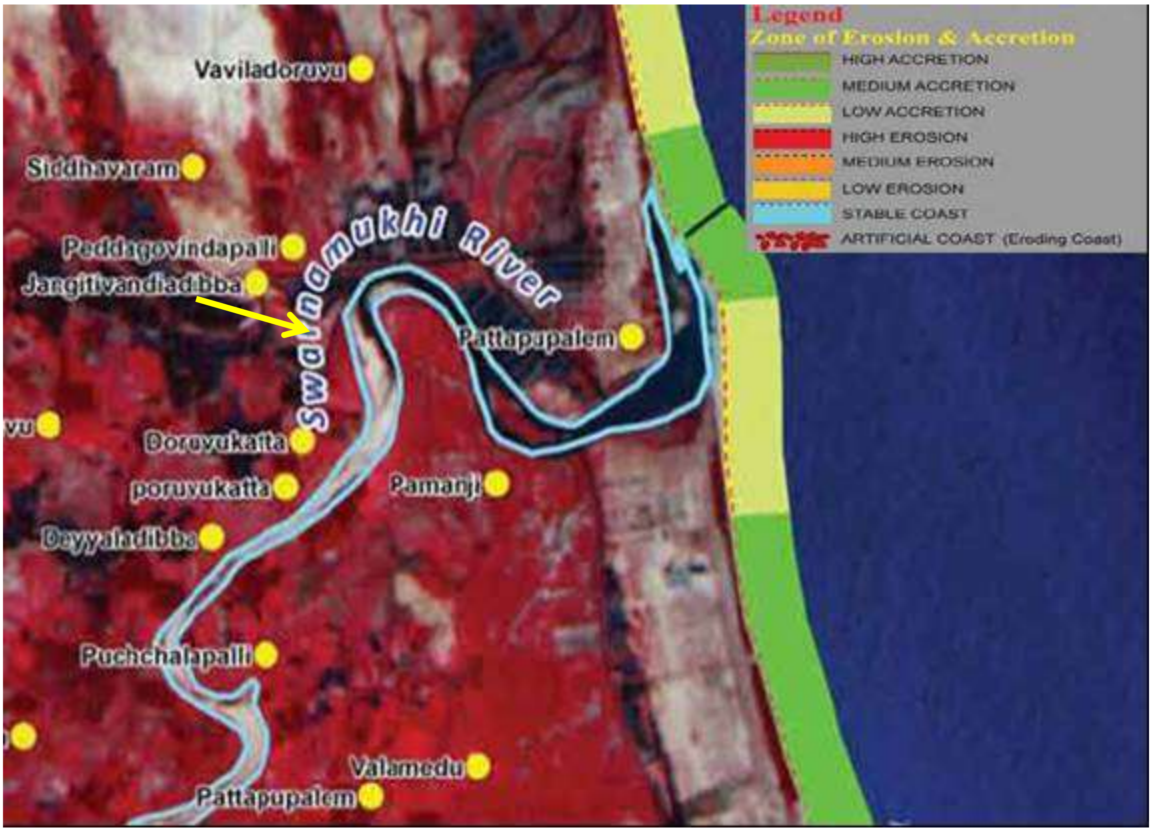


Figure 8.2 Coastal Stability Map Proposed site (Source: http://www.ncscm.res.in/)

8.3 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 forest land is involved in the project.	MoEF & CC; Department of Forest, GoAP
3.	Wild Life (Protection) Act, 1972	• To protect wildlife in general and National Parks and Sanctuaries in particular • Permission for working inside	Pulicat Lake Bird Sanctuary is within 10 km radius	Chief Conservator of Wildlife, Wildlife Wing, Forest

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
		or diversion of sanctuary land		Department, GoAP; 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	Andhra Pradesh 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	Andhra Pradesh Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Andhra Pradesh 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.	Andhra Pradesh 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, GoAP
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.

8.4 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. • Construction of breakwater	• 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. • Shoreline changes	• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• Shoreline changes due to permanent breakwater structures • 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

Environmental aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	Potential Impacts	Activities	Potential Impacts
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	• Operation of vehicles and construction machinery • Quarrying and transportation of material to the site.	• Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery Including stand-by generators	• Increase in noise • Health impacts on workers
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 • Influx of outside workers/ population	• 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	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **Positive Impacts** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

8.5 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.

8.5.1 Impacts on Land and Soil

The sea shore of the proposed Site 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 11 m depth. Only a limited amount of land (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 from 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 to designated solid waste collection point.

8.5.2 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 AP Rural Water Supply and Sanitation Department, for which all the required permissions from the state authorities will be sought.

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 26 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 stored 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 sea or 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 APCB 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 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.

8.5.3 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.
- 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 Andhra Pradesh 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.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.

8.5.4 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.

Mitigation Measures

- 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.

8.5.5 Impacts on Ecology

The proposed site is an accretion zone, further to this construction of breakwater will advance accretion on the southern side of the port. This will negatively impact the tidal mouth of the Pulicat Lake, i.e., Tupilipalem whereby closing this inlet. This tidal inlet plays a significant role in maintain right balance of sea water and salinity in the lake which is essential for the brackish eco-system of the lake.

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.

Mitigation Measures

- All measures shall be taken to ensure the maintenance of tidal inlet, regular dredging shall be undertaken.
- 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.

8.5.6 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 on reclaimed land.

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.

8.6 Impacts during Operation Phase

8.6.1 Impact on Land and Shoreline

At present the proposed coast falls under accretion zone but with the construction of breakwaters, the southern side of the port will experience higher accretion while north of breakwaters will have erosion.

Higher accretion on the south will negatively impact the tidal mouth of the Pulicat Lake, i.e., Tupilipalem whereby closing this inlet. This tidal inlet plays a significant role in maintain right balance of sea water and salinity in the lake which is essential for the brackish eco-system of the lake.

Mitigation Measures

- All measures shall be taken to ensure the maintenance of tidal inlet, regular dredging shall be undertaken.
- Regular inspection shall be held to anticipate the need of the dredging of the inlet.
- A sand trap shall be provided on the south of the proposed port facility.
- Sand bypassing must be adopted so as to nourish the eroding coast on the north of the facility.

8.6.2 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 stack yard 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 waste 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 coastguard personnel 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 at proposed Port area for prevention of marine pollution.

8.6.3 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, 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.
- It will be a responsibility of labour contractors to provide for clean fuel to the labours.

8.6.4 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 shall 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.

8.6.5 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.

Due to maintenance dredging, some 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.

8.6.6 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.

8.7 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

8.8 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 first quarter of 2016.
- 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 $ = INR 65/-
- Provision towards contingencies, engineering and establishment has been included separately.

The 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 9.1** has been worked out. The same is furnished below in **Table 9.1**. The capital costs given for each phase are for the facilities created during that particular phase only.

Table 9.1 Block Capital Cost Estimates (INR in Crores)

A. Port Development Cost Only

S. No.	Item	2020	2035	Total
1.	Project Preliminaries and Site Development	60	15	75
2.	Dredging	421	940	1,361
3.	Reclamation	137	239	376
4.	Breakwater	526	-	526
5.	Berths	298	90	388
6.	Buildings	29	9	38
7.	Stackyard and Other Backup Area	37	37	73
8.	Internal Roads and Railway	35	55	90
9.	Equipment	463	458	921
10.	Utilities and Others	134	62	195
11.	Navigational Aids	10	1	11
12.	Total (1+2+3+4+5+6+7+8+9+10)	2,149	1,905	4,054
13.	Contingencies @ 10%	215	190	405
14.	Engineering and Project Management @ 5%	107	95	203
Incremental Capital Cost (Rs. In Crores)		2,472	2,191	4,662

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	2020	2035	Total
1.	Project Cost	2,472	2,191	4,662
2.	External connectivity including land acquisition			
	Rail	310		310
	Road	720		720
3.	Cost of Land for Port Development (100 Ha)	270		270
[redacted]				

These capital cost estimates do not include the following:

- 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.

9.2.2 Repair and Maintenance Costs

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

- 5% of 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 200 increasing to about 375 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. 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 Firefighting & Pollution Control - 3% per annum

9.2.5 Annual Operation and Maintenance Costs

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

Table 9.2 Annual Operation and Maintenance Costs (INR in Crores)

S. No.	Item	2020	2035
1.	REPAIR AND MAINTENANCE COSTS	39.3	28.5
2.	OPERATION COSTS	75.0	76.1
3.	TOTAL	**114.3**	**104.6**
4.	Contingencies (Rites , @ 10%-Aecom)	11.4	10.5
5.	Administrative Expenses @ 5%	5.7	5.2
Incremental O & M Costs (Rs. In Crores) per annum		131	120

The above O&M cost do not include the repair and maintenance of external rail and road connectivity.

9.3 Implementation Schedule for Phase 1 Port Development

9.3.1 General

The main components for the Development of Dugarajapatnam 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 Breakwaters

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, dredging and reclamation have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 3.54 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 120 to 150 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 up to 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 breakwaters could be completed in a period of about 22 months duly accounting for weather downtime.

9.3.3 Dredging and Reclamation

The overall dredging quantity is estimated to be about 21 Mcum. Once the breakwaters construction have reached 8 m contour, the dredging activity can commence and reclamation bunds shall be built to receive the suitable material from the dredging operations. The overall duration of the dredging and reclamation is expected to be 28 months.

9.3.4 Berths

As berths are not proposed to be contiguous to the land, construction of berths would be independent of the dredging. The construction of berths could be started either by launching the gantries from the shore or partly completed reclaimed area. However adequate breakwater shelter would be needed to avoid any downtime in construction. 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 24 months.

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. As the berths and approach trestle are continuous, it is possible to construct the piles using travelling gantries from the shore. 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.

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 Dugarajapatnam port is likely to take over 36 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 Dugarajapatnam Port is shown in **Table 9.3**.

Table 9.3 Implementation Schedule

10.0 Financial Analysis for Alternative means of Project Development

10.1 Assumptions for Financial Assessment

- Due to the minimal incremental traffic the financials have been worked out assuming the there is no expansion after Phase 1 development of port. However, any subsequent expansion would improve the project viability.
- Based on the profiling of competing ports following tariff has been assumed
  - Coal - Rs. 300 per tonne
  - Containers - Rs. 4500 per TEU
- The cost of Debt is assumed as 11% for PPP operator.
- The cost of Debt for the SPV, in case of Landlord model, is assumed at 4%.

10.2 Option 1 – By Project Proponents

In this option, the project shall be executed by the public sector entity i.e. (Visakhapatnam Port Trust and/or State Government/SDC), who shall also arrange funds for the project financing, manage and operate the port.

The financial analysis has been carried out considering the overall capital investment of Rs. 3,772 crores for Phase 1 port development. The project IRR in this scenario works out to about **2.1%**.

10.3 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.

In this case the costs towards External Rail and Road Connectivity to port and land acquisition for connectivity and port facilities shall be borne by the government entities.

Therefore the capital investment for the private operator shall be limited to Rs. 2,472 crores only. However, in this case also the project IRR for the private developer works out to **8.6%** only even after considering that the developer does not do any revenue sharing with government.

10.4 Option 3 – Landlord Model

In this option a Special Purpose Vehicle (SPV) shall be formed comprising of Visakhapatnam Port Trust and other government entities which may include Andhra Pradesh State Government, Sagarmala Development Corporation etc. The exact composition of SPV and the % share of the entities could be decided once the decision to go ahead with the project is taken. The following shall be modalities for development under this option:

1. The basic infrastructure in terms of Breakwaters, capital dredging, reclamation, access rail and road, water and power connection, harbour crafts etc. shall be arranged by SPV. Apart from that the SPV shall also be responsible providing external rail and road connectivity to port including any land acquisition for connectivity and port development. In addition SPV shall also be 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 authorities and administering subleases for the various marine terminals leased to users, terminal operators as applicable.
2. The cargo handling terminals and associated facilities comprising of berths, stackyard development, equipment, utilities etc. will be developed with private participation on PPP mode. PPP Concessionaire would be responsible for terminal operations and maintenance and sharing of its revenue with SPV as per the concession agreement.

In the proposed implementation model the cost split between the project proponents and the terminal operators is estimated as below in **Table 10.1**:

Table 10.1 Estimated Cost Split

A. Port Development Cost Only

S.No.	Item	Port	Concessionaire	Total
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	47	13	60
2.	DREDGING	421	-	421
3.	RECLAMATION	125	12	137
4.	BREAKWATER	526	-	526
5.	BERTHS	-	298	298
6.	BUILDINGS	24	5	29
7.	STACKYARD AND OTHER BACKUP AREA	2	35	37
8.	INTERNAL ROADS AND RAILWAY	25	10	35
9.	EQUIPMENTS	-	463	463
10.	UTILITIES AND OTHERS	83	50	134
11.	NAVIGATIONAL AIDS	10	-	10
12.	Total (1+2+3+4+5+6+7+8+9+10)	**1,263**	**886**	**2,149**
13.	Contingencies @ 10%	126	89	215
14.	Engineering and Project Management @ 5%	63	44	107
Incremental Capital Cost (Rs. In Crores)		**1,453**	**1,019**	**2,472**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

Components	Port	Concessionaire	Total
Project Cost	**1,453**	**1,019**	**2,472**
External Infrastructure			
Rail	310	-	310
Road	720	-	720
Cost of Land for Port Development (100 Ha)	**270**	-	**270**
Total Cost	[illegible]	1,019	[illegible]

To achieve the project IRR of 15% the PPP operator needs to share 35% of revenue with the SPV. However, the low traffic and therefore the low revenue will lead to the project IRR of -3.6% for the SPV making the investment totally unviable.

10.5 Conclusions and Recommendations

With the current traffic and estimated competitive tariff, the IRR for the project is very low in all the possible development options. Therefore the project is commercially not viable.

However, Dugarajapatnam has been notified as a major port under the act and thus all possible opportunities are explored for its development. With this in view Option 2 - Full Fledged Concession to Private Operator could be explored with the following basic conditions so that there is no financial burden on the SPV:

1. The cost of Rs. 720 crores for External road connectivity to the port including the land acquisition be provided by NHAI or Bharat mala project

2. The cost of Rs. 310 crores for External rail connectivity to the port including the land acquisition be borne by South Central Railway or IPRCL

3. The cost Rs. 270 crores for 100 Ha of land acquisition for port be borne by state government or Sagarmala Development Company

As explained in para 10.3 the project IRR for the PPP operator works out to 8.6% only. Therefore further support from the central government may be sought through viability gap funding (VGF) of 20% and same VGF of 20% be formulated at State level to generate project IRR of 14%. The bidder who seeks minimal VGF shall be selected for port development.

11.0 Way Forward

In case it is decided to pursue the project, the following action plan is recommended:

1. Formation of SPV for development of the project
2. Appoint a transaction advisor for project structuring and preparation of tender document
3. Coordination with the NHAI and Indian railways for providing road and rail connectivity to site.
4. Coordination with state government for land acquisition
5. Approvals from SFC/ EFC/ PIB/ PPPAC/ CCEA
6. Appointment of consultant for Preparation of EIA report and approval of MoEF
7. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

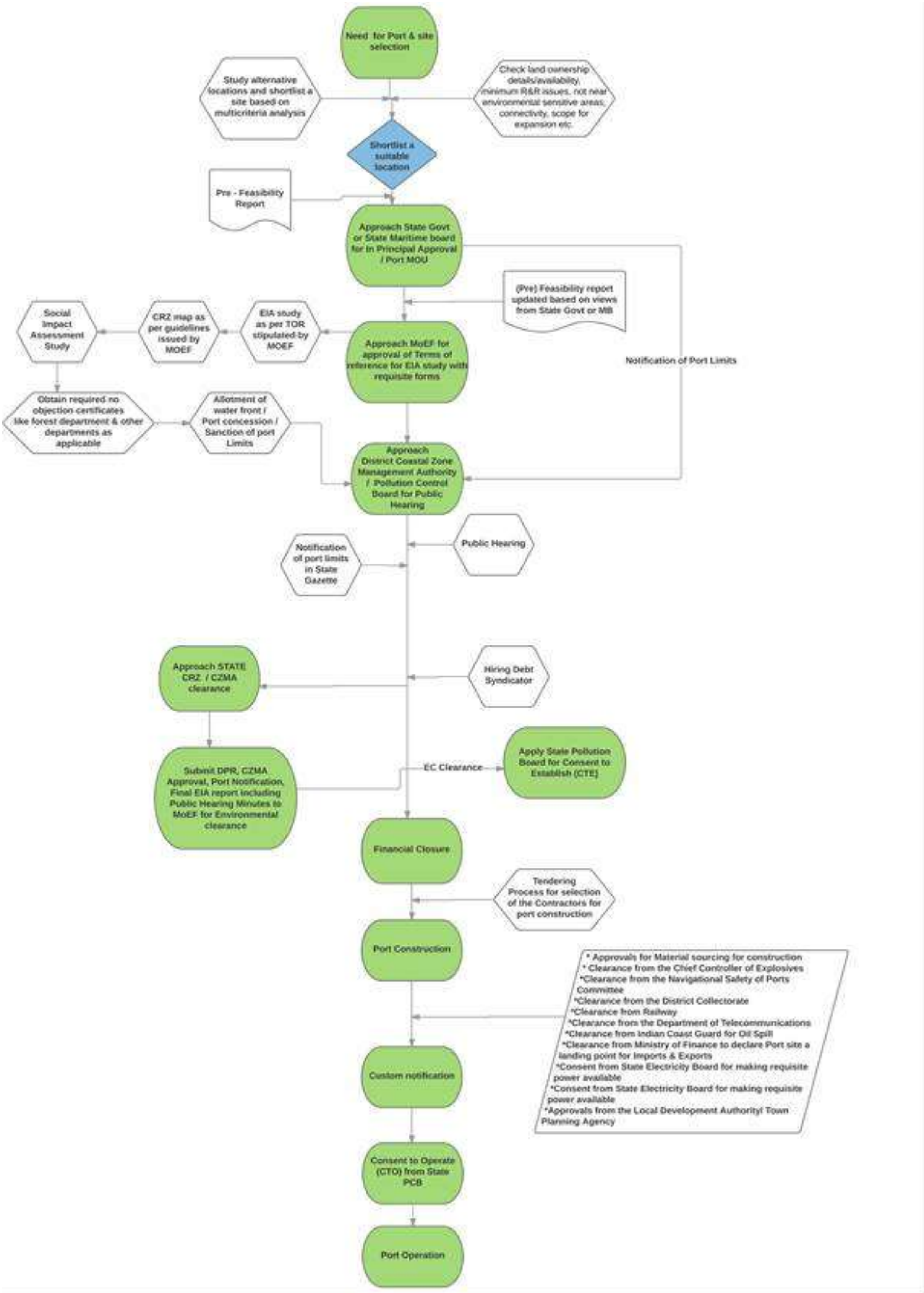


Figure 11.1 Process for the Greenfield Port Development

Techno-Economic Feasibility Report for Development of Port at Belekeri

Prepared for

Ministry of Shipping
Government of India

Ministry of Shipping / Indian Ports Association

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EXECUTIVE SUMMARY

Introduction

To make best use of economies of scale, increased global trade and to achieve efficient management of supply chain, larger sized ships are being built (cape size vessels for moving bulk cargoes) to ply on international routes and as well as Coastal shipping lines. This benefits the cargo owners who have to bear lower freight costs which eventually lead to low cost of final product for the end user. This trend is seen globally and it is envisaged by Ministry of Shipping that all major ports in India shall have infrastructure and equipment's that will be at par with their global peer group.

New Mangalore Port being only deep draft port in the state of Karnataka, shares primary hinterland with surroundings of Dakshina Kannada District and secondary hinterland with districts of North & Central Karnataka mainly where the boom of coal requiring industries viz., power plants and steel & Cement Industries exist. Due to its location, rising environmental concerns and lack of proper connectivity to the secondary hinterland, Mormugao port, Krishnapatnam port, Kamarajar port and Chennai port have been the natural competitors for the cargoes in this region.

To accommodate the deep draft vessels in the port, New Mangalore Port initially had plans to deepen its channel and inner harbour. However due to involvement of rock dredging and associated blasting which involves high cost and interrupts with port activities, there is no plan to deepen the harbour. Therefore, the concept of satellite port for NMP has emerged, which aims at proposal of a Greenfield port along the Karnataka coast that serve the requirements of secondary hinterland cargo of NMP and also over coming constraints of deepening harbour. The development of satellite port in the northern costal Karnataka would be a catalyst in aiding for speeding development of the region by providing the employment opportunities, industrialisation, cheaper end products to user etc.,

Based on the Origin–Destination studies carried out under Sagarmala assignment, it has been assessed that there is a good potential of about 37 MTPA of traffic for coastal movement of thermal coal from eastern region to power plants and steel industries located in the North & Central Karnataka. These industries can be better served by setting up a port on the coastline of north Karnataka. In addition to diversion of traffic, Belekeri port can also build upon the industrial growth of Karnataka, which is considered one of India's most industrialised states, comprising large public sector industrial undertakings as well as privately-owned industries, e.g., steel, sugar and textiles. The state has also evolved as the manufacturing hub for some of the largest public sector industries in India.

It is assessed that the proposed port shall cater to the total traffic volumes of 18 MTPA in Phase 1 and increasing upto 37 MTPA in Master Plan phase (year 2036).

Port Development Plan

It is proposed that the port facilities shall be developed in the phased manner commensurate with traffic growth. Considering that the coal would be the key commodity for the port, it is proposed that port facilities will be able to handle capsize vessels upto 200,000 DWT so as to be in competitive position over Krishnapatnam and Mormugao ports. However the initial phase development is proposed to be limited for Panamax vessels to minimise the initial capital investment and the deepening shall be carried out in for cape size ships in later stages of development.

The proposed port layout comprised of one south breakwater of 4780 m. In Phase 1 development of the port it is proposed to provide 2 Coal berths and 1 Multipurpose berth and the estimated capital dredging for phase 1 development is about 16.4 Mcum and the reclamation quantity is 8.6Mcum. The stacking area for the bulk cargoes has been proposed in the reclaimed area.

State of the art material handling system shall be provided to ensure faster turnaround of ships. The bulk import system shall comprise of four ship unloaders with design capacity of 2,200 TPH, one conveyor stream of 4,400 TPH, four stacker cum reclaimer units and one in motion wagon loader.

Additional berths, equipment and other infrastructure shall be in staged manner till the ultimate stage development added.

The estimated capital cost of Phase 1 port development is Rs. 2,595 crores and additional Rs. 225 crores would be needed for the rail/road connectivity to the port. Phase 1 of port development would have an implementation time of about 4 years.

Assessment and Recommendations

The viability analysis for the project has been carried out considering three alternative models for port development i.e. development by project proponents, by full-fledged concession to private operators and landlord model.

In the project proponent model the project shall be executed by a Special Purpose Vehicle (SPV), which may include NMPT and other government entities. SPV shall arrange funds, manage and operate the port. The IRR for project proponent model works out to 11.5%.

In the second model in which the entire project is given to private developer and costs towards external rail/road connectivity, land acquisition for connectivity and port facilities shall be taken up by the government entities. The project cost of Rs. 2,595 Crores is considered and the IRR works out to 12.4% considering the private entity does not do the revenue sharing with the government.

In the third financial model, SPV shall be responsible for providing the entire basic infrastructure for the port including the external connectivity and land acquisition to the port. The cargo handling terminals and associated facilities shall be developed by PPP operator, who shall be responsible terminal operations & maintenance and also sharing the revenue with the SPV. Limiting the project IRR to 15% for the PPP operator, he can share about 36% of the revenue with the SPV which is overall IRR of 9.9% for SPV. Though the estimated IRR for SPV is low, it can be managed if SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall reduce.

The thorough analysis of the development of port at Belekeri, it can be concluded that the port has a great potential and can be developed under Landlord model. However, the entire development of port is dependent on the completion of Hubali – Ankola rail line and the current road blocks on its completion need to be removed with active participation from State and Central government. It is also suggested that the proposed Hubli Ankola Rail link be extended till Belekeri as a single project to get synergy and also provide competitive multi-modal transport to the destination.

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

Based on the experience in port-led development, the major engagement challenge to develop a set of governing principles for our approach is shown in **Figure 1.2**:

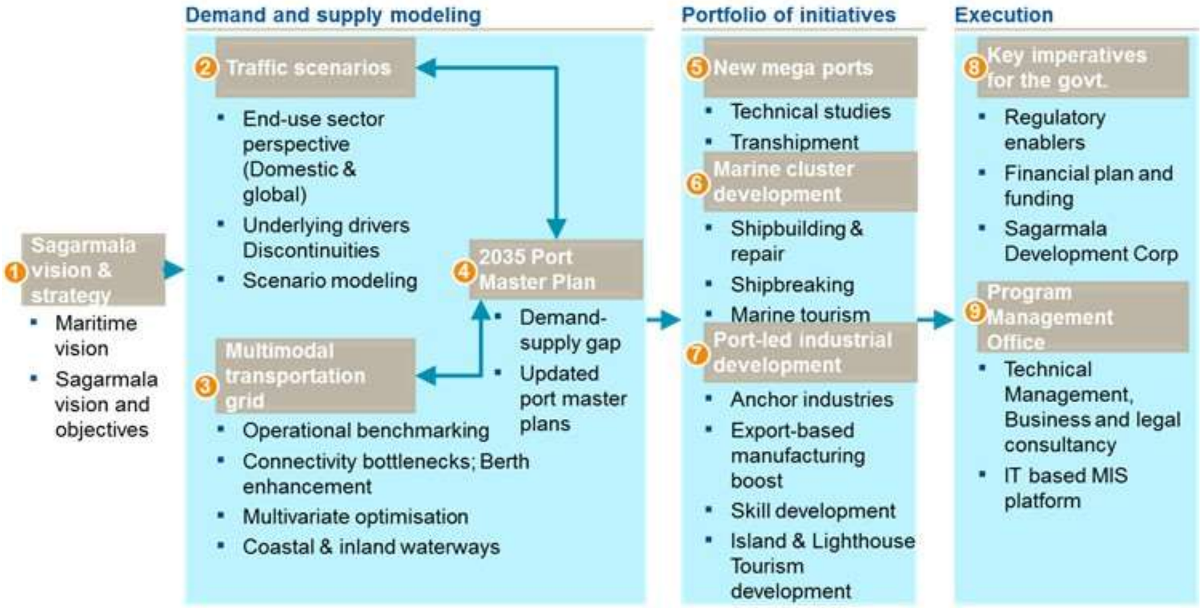

Figure 1.2 Governing Principles of Our Approach

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 Port at Belekeri

As part of the OD study carried out under Sagarmala assignment, it has been assessed that there is a good potential for coastal movement of thermal coal from the mines located in the eastern region (i.e. Mahanadi Coal fields, Talcher, IB Valley etc.) to the power plants located in the western region.

At Central Karnataka power and steel plants have been set up at Kudgi, Bellary etc. which can be best served by a port located along the coastline of north Karnataka. This is however subject to the timely completion of Hubli - Ankola rail line, which will act as a catalyst for the proposed port and the development of the region.

The existing New Mangalore port has draft limitations and also not suitably located to serve the north Karnataka hinterland. It is therefore proposed to develop a Port at Belekeri as a satellite port for NMPT. 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 Belekeri”, Karnataka. This report is organised in the following sections:

Section 1	: Introduction
Section 2	: Site Conditions
Section 3	: Traffic Projections
Section 4	: Design Ship Sizes
Section 5	: Port Facility Requirements
Section 6	: Preparation of Port Layout
Section 7	: Engineering Details
Section 8	: Environmental Settings and Impact Evaluation
Section 9	: Cost Estimates and Implementation Schedule
Section 10	: Financial Analysis and Alternative Means of Project Development
Section 11	: Way Forward

2.0 SITE CONDITIONS

2.1 Alternative Sites along the Coastline of Karnataka

Various alternative sites located between Mormugao port and New Mangalore Port were analysed as shown in **Figure 2.1**.

Figure 2.1 Alternative Sites for Location of Port

All sites have 10 m contour at about 4-5 km; 20 m contour at about 10 to 12 km. These sites were analyzed for the three main criteria comprising of:

- Habitation,
- Connectivity,
- Environmental Concerns

The location plan of each site and the preliminary assessment has been shown in **Figure 2.2** and **Figure 2.3**.

Figure 2.2 Evaluation of Sites (Belambar, Tadadi and Vannali)

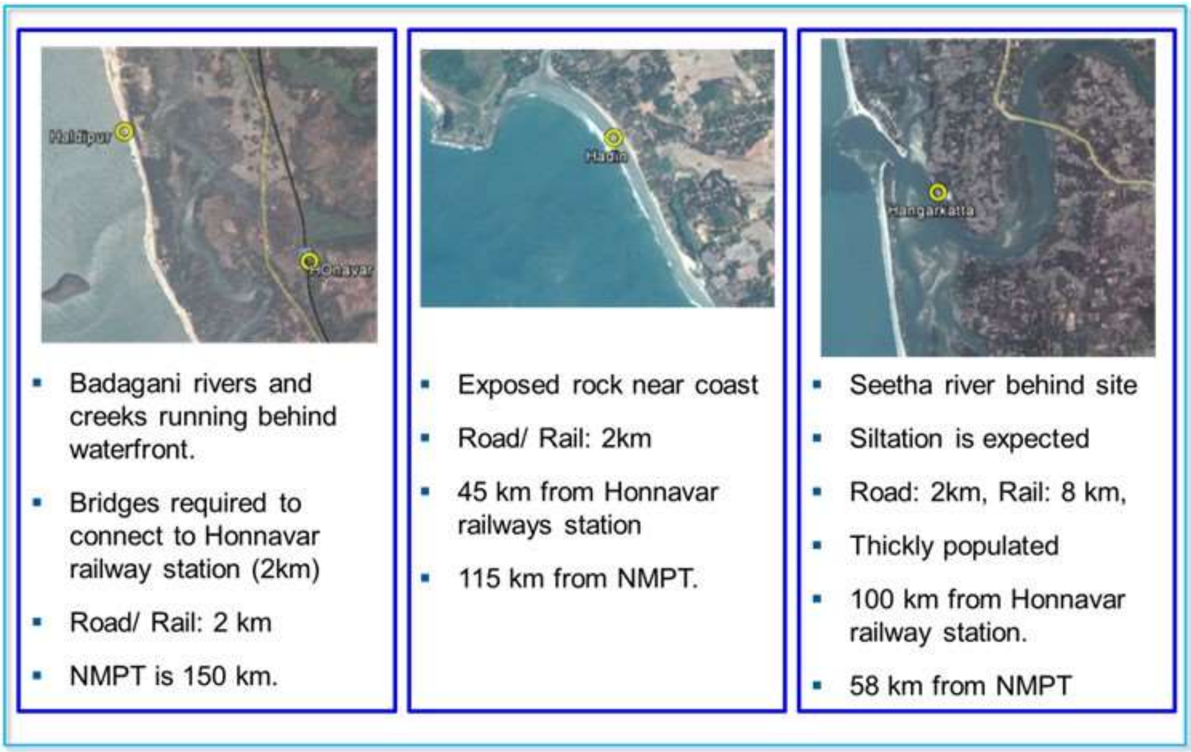

Figure 2.3 Evaluation of Sites (Haldipur, Hadin and Hangarkatta)

Out of these sites, two suitable sites are identified in order of preference Belekeri and Vannali (Kumta Beach). Considering the proximity of Belekeri to the proposed Hubli Ankola rail connection, this site has been shortlisted for the port development.

2.2 Port Location at Belekeri

The proposed site for development of Belekeri port is located in Ankola taluka of Uttara Kannada District of the state of Karnataka. The co-ordinates of the site are 14° 42' N and 74° 15' E (**Figure 2.4**).

The deep water contours are also close to the site and unlike most of the coastal stretch in Karnataka, Bhavikeri has relatively flat terrain. Bhavikeri village is approx. 500-700 m from the coast on the east of the proposed site. A suitable water front of about 2 km is available for port development between fishermen's colony and area earmarked for the Indian Navy (**Figure 2.5)**. Belekeri village is about 3.5 km north of the proposed port site. The backup area required for the Belekeri port development is proposed to be developed reclaiming the land on the coast of Bhavikeri village in Ankola taluka.

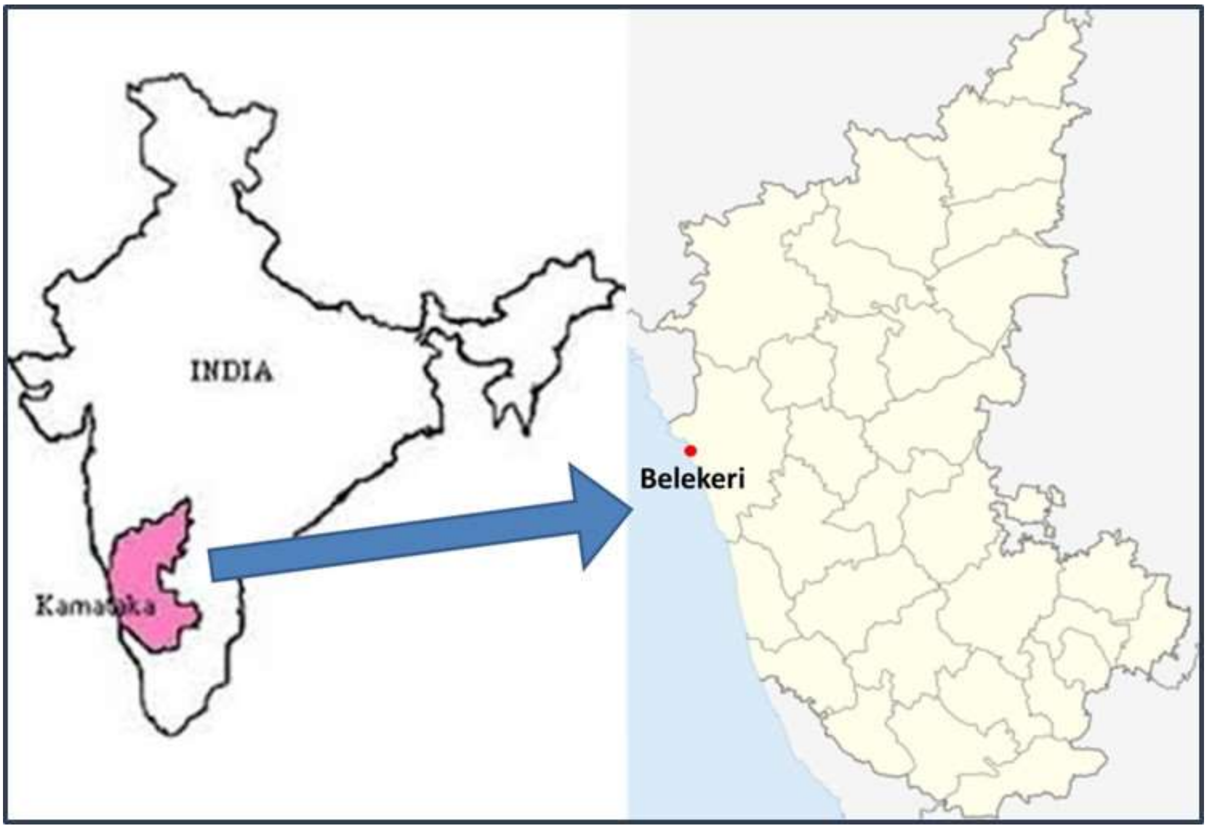

Figure 2.4 Location of Belekeri

Figure 2.5 Location of the Proposed Site

The waterfront identified for port development has a small village Keni in the immediate vicinity, while Bhavikeri village is about 500 m east of the sea coast (**Figure 2.6**).

About 100-120 households were found to be located in the village Keni and a total population of about 2000 has been reported. The villagers are mainly involved in small scale fishing and also agricultural activities.

Rain-fed agriculture activities are prevalent in the area where rice and groundnut are sown predominantly. Other crops that are grown in this area are coconut, Arecanut, Cashew, Banana, Water Melon and other leafy vegetables.

Figure 2.6 Picture Showing Identified Waterfront for Proposed Port

2.3 Meteorological Data

2.3.1 Climate

This region experiences tropical monsoon climate. The meteorological data for Karwar, which is about 35 km north from the proposed site, suggests that weather is hot and humid throughout the year (**Table 2.1**). The area may be broadly classified into four seasons. The temperature start rising from January and gets peaked in May. The summer is from March to May. During this season generally temperature may go up to 39°C.

The monsoon season is from June to September. The rain is fed to the area through South-West monsoon. The area gets 90% of its rainfall in this season. The average rainfall is more than 3000 mm. The period from October to December termed as Post Monsoon season. The period from January to March can be termed as dry season.

Table 2.1 Climatological Table for Karwar Based on Data Between 1961 – 1990

Months	Humidity (%)		Lowest Temp (°C)	Highest Temp (°C)	Monthly Rainfall (mm)	Mean Wind Speed (kmph)
	8:30	17:30				
January	76	62	15.8	36.4	0.4	5.7
February	80	67	16.6	38.1	0.0	6.4
March	79	70	18.6	39.0	0.7	8.0
April	75	70	21.9	38.9	6.4	9.4
May	76	73	22.8	37.3	140.7	11.7

Months	Humidity (%)		Lowest Temp (°C)	Highest Temp (°C)	Monthly Rainfall (mm)	Mean Wind Speed (kmph)
	8:30	17:30				
June	87	82	22.1	35.0	916.7	11.3
July	88	85	22.2	32.1	926.6	14.2
August	89	85	22.3	31.1	671.7	11.4
September	89	82	22.0	32.7	312.1	7.1
October	85	77	20.6	36.4	140.3	5.3
November	75	69	17.7	36.4	31.2	4.6
December	72	62	16.1	36.0	16.8	4.9
Average	81	74	14.8	39.0	3163.5	8.3

[Source: IMD, 2010]

2.3.2 Visibility

Visibility in the region is good throughout the year and is generally greater than 4 km. However, during the rainy season, the visibility is likely to be reduced when the rainfall intensity is high.

2.3.3 Wind

The predominant winds are South-westerly during summer and monsoon period and North-easterly during winter. As per IMD records, wind was found to vary between 4.6 kmph in November and 14.2 kmph during July.

The annual wind rose diagram for Karwar is shown in **Figure 2.7**, showing wind speed for number of hours from a particular direction. The wind speed is more between 0 and 12 kmph for about 1500 hours in a year, while 315 hours it exceeds 12 kmph.

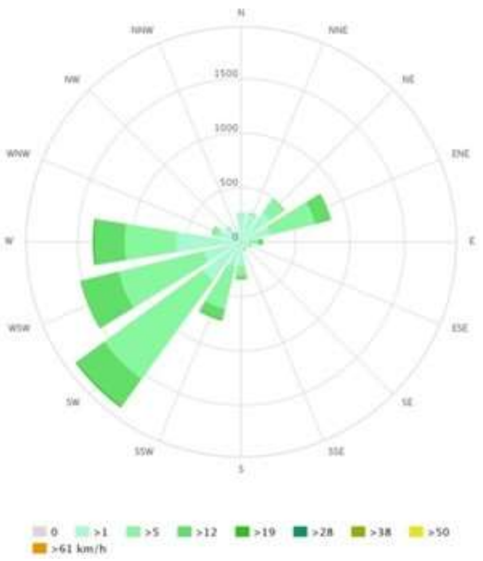

Figure 2.7 Annual Wind Rose Diagram

2.3.4 Cyclones

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), only 25% of the cyclones that develop over the Arabian Sea approach the west coast. It is observed from the tracks of the cyclones in the Arabian Sea from 1877 to 2012 that only one cyclone hit the Uttara Kannada district in a period of 110 years.

2.4 Site Seismicity

Belekeri 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.

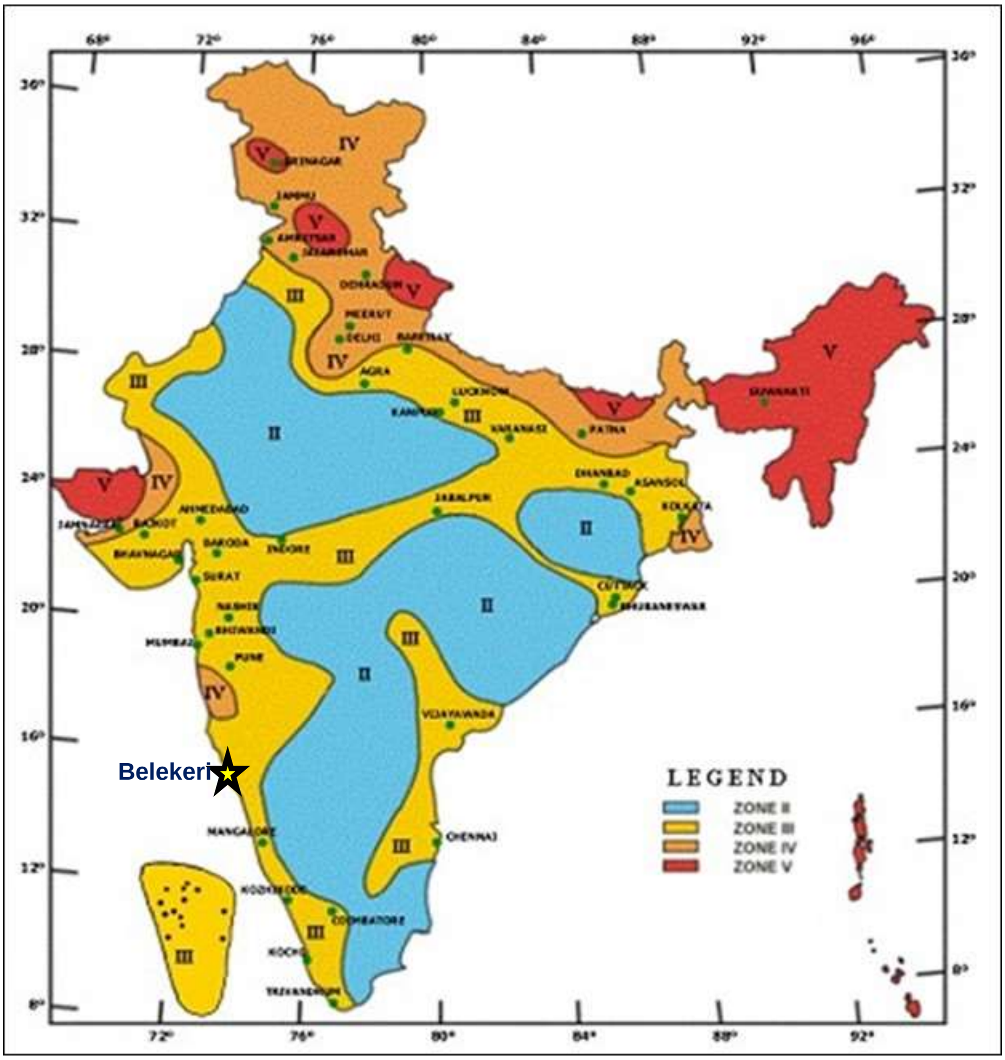

Figure 2.8 Seismic Zoning Map of India as per IS-1893 Part 1-2002

2.5 Oceanographic Information

2.5.1 Tide Levels

The tide at Belekeri is semidiurnal with two high tides and two low tides in a day. The tidal elevations referred to chart datum at Belekeri is as in **Table 2.2**.

Table 2.2 Tide levels

Tidal Datum	Elevation (m, CD)
Highest High Water Spring (HHWS)	+2.13
Mean High Water Springs (MHWS)	+1.90
Mean High Water Neaps (MHWN)	+1.64
Mean Sea Level (MSL)	+1.13
Mean Low Water Neaps (MLWN)	+0.92
Mean Low Water Springs (MLWS)	+0.32
Lowest Low Water Spring (LLWS)	+0.04

2.5.2 Wave Conditions

The west coast of India generally experiences higher wave activity during the Southwest Monsson and relatively clam sea condition during the rest of the year. The waves approach from West and West- South-West during the Southwest Monsoon, West-North-West during the Northwest Monsoon and Southwest during the fair weather. The annual offshore and nearshore rose diagrams is presented in **Figure 2.9**.

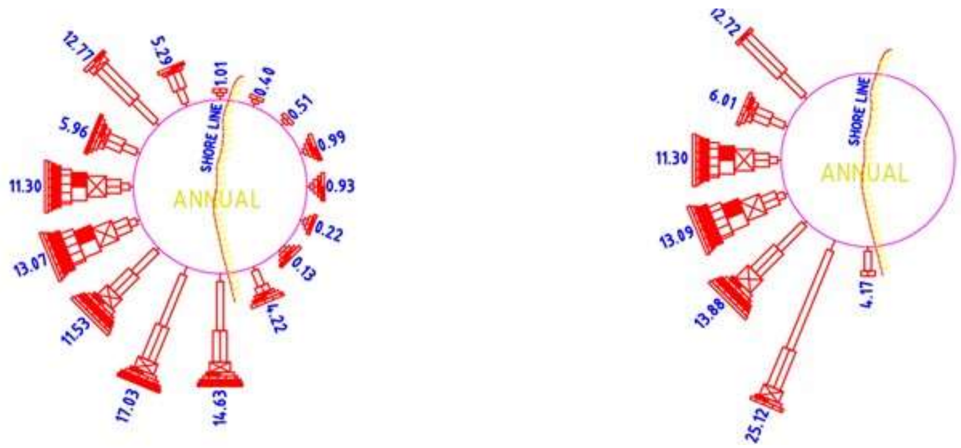

Figure 2.9 Resultant Annual Wave Rose Doagram for Deep and Nearshore Condition

As per the previous records/ database the monthly range of wave height and period are shown in **Figure 2.10**.

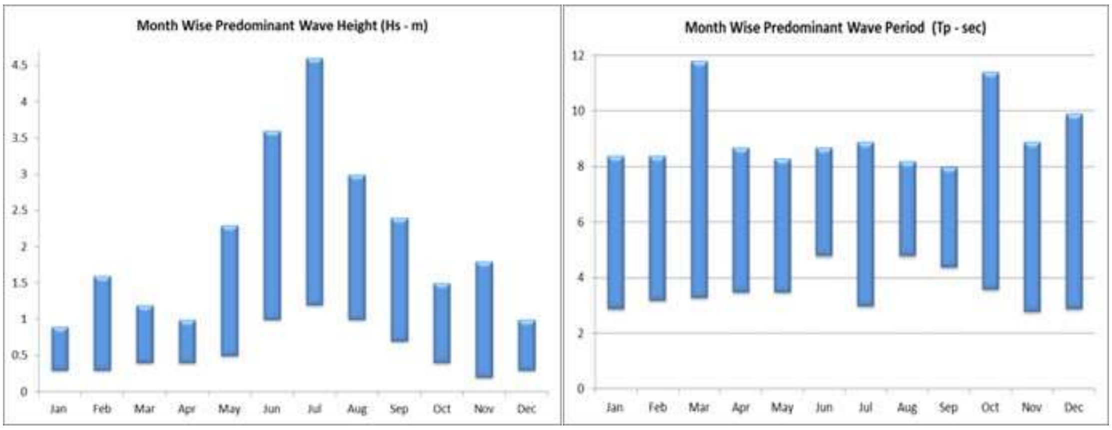

Figure 2.10 Range of Monthly Hs (m) & Tp (s)

2.5.3 Currents

The averaged current speed ranges from 0.1 m/s to 0.54 m/s. The flood currents (0.54 m/s) are stronger in the region as compared to ebb current (0.1 m/s). Currents are generally parallel to the coast, the flood currents are in a north-westward direction during the flood tide and south-eastward direction during the ebb tide.

2.5.4 Bathymetry

Naval Hydrographic Charts as presented in **Figure 2.11** suggests that 5 m contour is at around 2 km while 10 m and 20 m contour are about 6.5 km and 12.5 km from the coast. It is important to mention that the coast both upstream and downstream location to the proposed site is covered with rocks, but as NHC suggest the chosen site does not have dense rock patches except small area at about 1 km from coast on western direction.

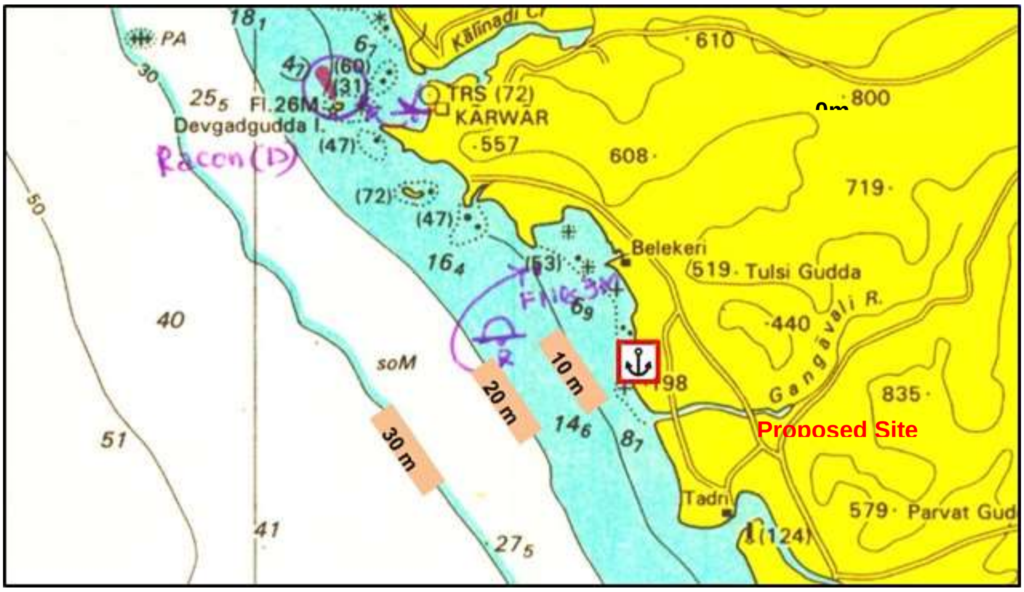

Figure 2.11 Hydrographic Chart of Proposed Port Site [Source: NHO Chart 293]

2.6 Littoral Drift

The longshore sediment transport is observed to be from north to south from March to September and from south to north the rest of the year. The yearly net longshore sediment transport is approximately 70,000 m^3/year southwards.

2.7 Connectivity

The proposed Belekeri Port location is about 3.5 km from Edapally-Panvel or Kochi-Panvel Highway (NH 66) and Konkan Railway Line (**Figure 2.12)**.

Figure 2.12 Belekeri Port w.r.t. Railway and Highway

2.7.1 Rail Connectivity

Konkan railway line is about 4 km from the site. The nearest railway station is Ankola which is about 6.7 km from the site on the SE direction. Harwada railway station is about 8 km on the North of the proposed site.

2.7.2 Road Connectivity

National Highway 66 (earlier known as NH 17) is about 3.5 km from the proposed site (**Figure 2.13**). The site may be reached from NH-66 via Ankola through Dr. Dinkar Desai road and further Keni Beach Road.

Site may also be approached from North through NH 66 via Hattikeri through Belekeri Port Road and thereafter taking a village road through Bhavikeri. This may not be a favourable route for port operations as this road intersects area reserved for Indian Navy.

Conditions of all the connecting roads are shown in **Figure 2.14**.

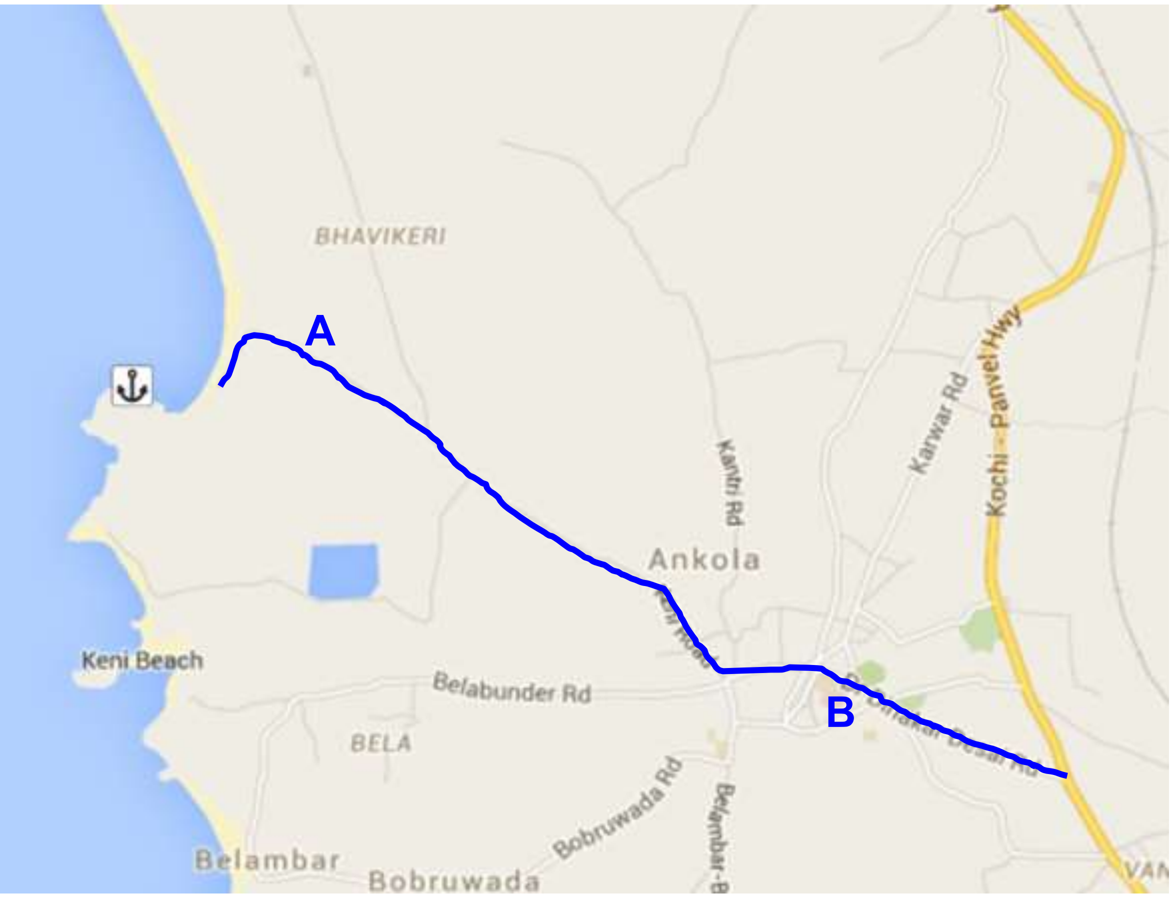

Figure 2.13 Existing Road Connecting to Proposed Site

	
Road from Belekeri to Bhavikeri (about 3.5 m); houses, schools, shops on both sides	**A.** Road to Keni village (Project site); kutcha road (3-4 m); agriculture land on both sides
	
B. Dr. Dinaker Desai Road (4 - 5 m) connecting to Keni Village road; 0.7 km stretch; dense commercial establishments and habitation on both sides	Dr. Dinaker Desai Road (7 m) connecting Ankola to NH 17; 1 km stretch; commercial establishments and habitation on both sides

Figure 2.14 Road Connecting to Proposed Port Site

2.8 Water Supply

At present Ankola is being served with piped supply from Honnalli Water Supply Scheme having a capacity of 41 MLD. Water is drawn from river Gangavalli at about 22 km upstream of sea, through submerged intakes and treated with Poly-Aluminium-Chloride for coagulation of organic and mineral colloids prior to sedimentation and/or filtration. After treatment water is stored in two underground tanks of capacity 1 lakh and 2 lakh Gallons respectively. Form this location, water is pumped to another underground tank located at Navagadde having a storage capacity of 6 lakh Gallons.

From this location water is supplied through a 700 mm pipeline to Ankola town, villages, Seabird site at Karwar, Aditya Birla Chemicals limited (Caustic Soda plant) at Karwar. This tank is about 10 km from the proposed port location.

	
Satellite image showing Honnalli Water Scheme	Intake of Honnalli Water Scheme

Figure 2.15 Honnalli Water Supply Scheme

2.9 Power Supply

A 110/33/11 KV substation is located at Balegulli at Ankola. This substation has 6 feeder lines supplying to Seabird Site at Karwar (2×33 KV), Ankola Area (33 KV), Massikatta (33 KV), Navagadde (11 KV) and a standby feeder of 33 KV to Honnalli Water Supply scheme. This substation is about 4.8 km from the proposed site.

Figure 2.16 Location of Balegulli Substation

2.10 Quarry Sites

Construction of breakwaters requires a large quantity of rock thus it is a prerequisite to identify sources of rock for any port development. During site visit, efforts were taken to identify nearby quarries in the region. The locals reported that most of the quarry sites have been closed after Supreme Court's Judgement banning quarry sites in the forest land without Forest and environmental clearance.

Though, three minor quarries still exist in the region two at Ankola and one near Karwar, which have very limited area and are producing small aggregates only suitable for the local construction activities. Site at Karwar possesses permit for mining till 2017. It was reported that to get further forest clearance for the quarry operations is very difficult as the area has been mapped under Western Ghats.

There is shortage of construction material in the area. It is important to mention that all the required material for Navy's Seabird project has been and will be sourced through the hill cutting falling within the Naval Base. All required permits and clearances were taken by the Navy for hill cutting and quarrying. Widening of NH 17 from 2 lanes to 4 lanes is underway in this region, where all material recovered from their widening operation is used for grading and levelling.

Considering the current situation, new quarry will have to be developed for the rocks required for breakwater construction. This would require identification of quarry area and obtaining Forest and Environmental clearance for the same.

3.0 TRAFFIC PROJECTIONS

3.1 General

The origin-destination of key cargo for port at Belekeri and development of traffic scenarios for a period of 20 years has been carried out by McKinsey & Co. as mandated for this project.

This section covers the traffic projections for the proposed port of Belekeri. The proposed port site of Belekeri lies on the western coast of India in state of Karnataka. It has operational major ports of Mormugao on the north and Mangalore port on the south.

3.2 Major Commodities and their Projections

Thermal coal, iron ore and coking coal would be the key commodities that can be catered to by the proposed port. Each of the possible cargo centres in the hinterland for the proposed port has been mapped to assess whether the proposed port at Belekeri could be a gateway for their traffic. The details are attached in **Table 3.1**.

3.2.1 Thermal Coal

The proposed port has a current potential of attracting attract traffic of ~2.3 MTPA which can go upto 3 MTPA by 2025.

This is based on the assumption that for JSW power, the plant is based on imported coal, mostly handled in Mormugao. The current potential is estimated on the basis of Belekeri being better placed given the shorter distance.

In future, the potential has been estimated assuming plants operate at 80% PLF.

3.2.2 Iron Ore

The port is expected to divert part of the traffic currently handled primarily by Krishnapatnam port. JSW steel currently imports iron ore at Krishnapatnam. There is potential for using Belekeri for importing this cargo. Hence the current potential of port to handle iron ore is around 6.8 MTPA. This traffic could go up to ~9.5 MTPA based on the assumption that capacity of the JSW steel plant increases from 12 to 17 MTPA with the proportion of iron ore imports remaining the same.

Belekeri port would be better placed to handle iron ore moving inbound to Bellary as compared to Krishnapatnam as the distance from Belekeri to Bellary is significantly lesser than the distance between Bellary and Krishnapatnam port. This will result in reduced logistic costs if Belekeri port becomes the primary port to handle iron ore traffic. It is to be noted that this estimation is contingent on the implementation of the proposed rail line between Hubli and Ankola and Ankola and Belekeri port.

3.2.3 Coking Coal

The current potential is estimated to be ~5.7 MTPA as Belekeri port could be better placed to handle coking coal for JSW steel plant currently being received at Krishnapatnam and Mormugao ports. This traffic is expected to go upto 8 MTPA by 2025 based on the assumption that capacity of the steel plant increases from 12 to 17 MTPA.

Table 3.1 OD Analysis for Cargoes at Belekeri Port

S. No.	Customer	Sector	Cargo	Current	Rationale - Current	Future (2025)	Rationale - Future	Direction	Origin / Destination	Distance - Belekri	Closest alternative	Alternative Distance	Potential	2020	2030	2035
1	NTPC Kudgi	Power	Thermal Coal	9.00	Actual current consumption (2014 numbers) - this is presently moving by rail but has potential for being shipped coastally subject to leveraging efficiency of larger vessels (Panamax). If it moves to coastal, Belekeri would be ideally placed to handle this cargo	17.12	This is based on eventual expansion to 4000 MW and a PLF of 80%	Inbound	Hazaribagh	310	Mormugao	320	Medium			
2	JSW Power	Power	Thermal Coal	2.35	This plant is based on imported coal, mostly handled in Mormugao. Belekeri would be better placed given the shorter distance	2.90	This is based on PLF improving to 80%	Inbound	Indonesia / South Africa	332	Mormugao	382	High	2.6	3.7	4.8
3	KPCL Raichur	Power	Thermal Coal	6.00	Actual consumption at current PLF (2014). Currently received partly by rail and partly by coastal shipping via east coast ports (e.g. Krishnapatnam). This potential is based on the assumption that the entire cargo shifts to coastal and Belekeri being the preferred unloading port for coal	7.40	This is based on PLF improving to 80%	Inbound	Chandrapur	461	Krishnapatnam	482	Low			
4	KPCL Bellary	Power	Thermal Coal	2.60	Actual consumption at current PLF (2014). Currently received partly by rail and partly by coastal shipping via east coast ports (e.g. Krishnapatnam). This potential is based on the assumption that the entire cargo shifts to coastal and Belekeri being the preferred	9.10	This is based on PLF improving to 80% and commissioning of ongoing 700 MW Unit taking total upto 1700 MW	Inbound	Chandrapur	334	Mormugao	396	Medium			
5	JSW Steel	Steel	Iron Ore	6.68	Iron ore is currently imported via Krishnapatnam. There is potential for using Belekeri for importing this cargo	9.46	This is based on the assumption that capacity of the steel plant increases from 12 to 17 MTPA with the proportion of iron ore imports remaining the same	Inbound	Australia	332	Mormugao	382	High	8.07	12.61	16.80
6	JSW Steel	Steel	Coking Coal	5.68	Coking coal is received via Mormugao and Krishnapatnam ports. Belekeri could be well placed to handle this traffic	8.05	This is based on the assumption that capacity of the steel plant increases from 12 to 17 MTPA	Inbound	Australia	332	Mormugao	382	High	6.86	10.72	14.28
7	Bellary Hospet Cluster	Iron Ore	Iron Ore	0.15	Iron ore exports from Bellary Hospet were as high as 10 MTPA but due to mining bans and sluggish global demand, the volumes have dropped dramatically. About 0.1 to 0.2 MTPA of iron ore are still being handled by Chennai which could shift to Belekeri	1	This is based on partial lifting of iron ore mining ban in the Bellary Hospet region	Inbound	East Asia	332	Krishnapatnam	482	Low			
8	Hubli ICD	Manufacturing	Container	0.3	The Hubli area generated about 16,000 TEU of traffic which has been taken at 15 tons/TEU. Other regions around north Karnataka account for the balance	0.51	This has been projected at a rate of 5%. However if industrialization led by Bengaluru Mumbai industrial corridor kicks in, the growth rate could be higher	Bidirectional	Global	131	Mormugao / JNPT	188/561	High	0.38	0.62	0.80
9	Coastal Fertilizer	Consumption	Fertilizer	0.25	Karnataka receives substantial volumes of fertilizers from key manufacturing states such as Andhra Pradesh and Tamil Nadu. A part of this has been assumed for coastal shipping potential. In turn about half of this has been considered for Uttara Kanara region which Belekeri can handle	0.43	This has been projected at a rate of 5%	Inbound	Coastal States	NA	Mormugao	NA	Medium	0.32	0.52	0.66
10	Coastal Cement	Consumption	Cement	0.5	There is potential for cement manufactured in Malkhed-Wadi-Gulbarga district can be potentially shipped to some coastal states instead of using rail. The movement from this cluster to Kerala has been considered under this head	0.86	This has been projected at a rate of 5%	Outbound	Kerala	NA	Mormugao	NA	Medium	0.64	1.04	1.33
11	Coastal Foograins	Consumption	Foodgrains	0.67	Karnataka receives substantial volumes of foodgrains from northern states and Gujarat. A part of this has been assumed for coastal shipping potential. In turn about half of this has been considered for Uttara Kanara region which Belekeri can handle	1.15	This has been projected at a rate of 5%	Inbound	Coastal States	NA	Mormugao	NA	Medium	0.86	1.39	1.78
12	Other cargo			1.71	Other cargo is considered at 5% of all the above traffic items	5.80	Other cargo is considered at 5% of all the above traffic items	Bidirectional		NA	Mormugao	NA	Medium			

The overall commodity wise projections for the port are as shown below.

Table 3.2 Belekeri Traffic Projection

S. No.	Cargo	I/E	2020	2025	2035
	Dry Bulk				
1.	Thermal Coal	I	2.6	2.9	4.8
2.	Coking Coal	I	6.9	8.0	14.3
3.	Iron Ore	I	8.1	9.5	16.8
	Containers				
4.	Total in TEUs	I/E	25,500	34,000	53,000
	Total in MT		0.38	0.51	0.80
	Total Traffic (MTPA)		**17.93**	**20.92**	**36.68**

3.3 Potential Trade and Development Opportunities for Belekeri Port

3.3.1 General

Above section provides the estimated cargo at the port that is certain if a port is established at Belekeri. In addition to diversion of traffic, Belekeri port can also build upon the industrial growth of Karnataka. The state is considered one of India's most industrialised states, comprising large public sector industrial undertakings as well as privately-owned industries, e.g., steel, sugar and textiles. The state has also evolved as the manufacturing hub for some of the largest public sector industries in India.

3.3.2 Hinterland Development

Some of the industrial sectors in Karnataka that might have implication on port traffic are:

- **Telecommunications and Electronics:** Karnataka has excellent telecom infrastructure with 140 of its 170 towns connected by Optic Fibre Cables (OFC) network. The districts of Hassan, Tumkur, Mysore, Mangaluru and Shimoga are the other new destinations that promote electronics and hardware industries.

- **Automotive:** Karnataka has a vibrant auto industry with investments of around USD 713 mn and annual revenues of USD 604 mn. The sector grew at a CAGR of 15 per cent from 2009 to 2014. The main locations for automobile industries are Bengaluru, Ramanagara, Kolar, Shimoga, Dharwad and Belgaum. It also has three auto clusters, one industrial valve cluster and one auto component cluster. Two manufacturing hubs are being developed in the Narsapur and Vemagal industrial areas in Kolar District.
- **Textiles:** Karnataka contributes over 20 per cent of the national garment production and 45 per cent of the national raw silk production. It is a major apparel sourcing destination for the global market. It is one of the leading producers of the key raw materials required for textile manufacturing units. According to the New Textile Policy 2013–18, the Karnataka government is planning to invest USD 1,650 mn in the sector.
- **Aerospace:** The state has been seen as the pioneer in the Indian aerospace industry. The state government plans to invest around USD 1.7 bn to develop an aerospace park. Further investment potential of USD 12.5 bn in this sector in the period from 2013 to 2023 has been identified and there are plans to develop aerospace clusters in different regions of the state.
- **Chemicals and Petrochemicals:** Karnataka has been trying to position itself as a major growth centre for the chemical industry with the presence of around 500 companies, such as MRPL and BASF. Mangaluru is evolving as the focal point of all chemical and petrochemical industries in the state.

3.3.3 Major Exports

Karnataka has a long tradition of overseas trade. While it has historically been a major exporter of coffee, spices, silk, cashew nuts and handicrafts, over the last two decades it has emerged as a major exporter of commodities such as electronics and computer software, engineering goods, readymade garments, petrochemicals, gems and jewellery, agro and food processing products, chemicals, minerals and ores and marine products.

As of 2014–15, total exports from Karnataka reached around USD 52.02 bn, approximately 13.01 per cent of India's total exports. The state's exports increased at a CAGR of 9.4 per cent from 2010–11 to 2014–15.

Some of the exports that can have impact on traffic at ports are –

- The engineering segment is the fastest growing sector of the state, seeing a 21.3 per cent CAGR growth between 2010–11 and 2014–15. Exports of engineering products increased from USD 1,605 mn in 2010–11 to USD 3,476.8 mn in 2014–15. The state is exporting engineering products to Germany, China, South Korea, Brazil, the US, Malaysia, Thailand, South Africa and Singapore. Exports include machine tools, industrial machinery, cutting tools, castings, automotive components, electrodes, welding equipment, construction and earthmoving equipment, and helicopter spares.
- Karnataka leads in the exports of silk in India accounting for approximately 25 per cent of the total Indian export market.
- Export of agriculture and processed food in the state grew at a CAGR of 11.8 per cent between 2010–11 and 2014–15. The export value increased from USD 146.9 mn in 2010–11 to USD 229.4 mn in 2014–15.

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 Belekeri have been identified as:

- Thermal/ Coking Coal
- Iron Ore
- Containers

4.2 Dry Bulk Ships

Dry Bulk as Coal and Iron ore are the main cargo commodities that are proposed to be handled at the proposed Belekeri Port. 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.

For dry bulk cargo, carriers are generally classified into the following groups:

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

Coal and Coking coal is to be imported to the area, for which Panamax vessels for the immediate phase and Cape size are considered for the year 2035. For Iron Import, Panamax size vessels are recommended for all the phases.

4.3 Container Ships

Container ships are classified into six broad categories viz. Feeder, Feedermax, 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
Nominal Capacity	1000	2000	4000	6000	9000
LOA (m)	160	200	290	320	350
Beam (m)	22	32	32	42	45
Loaded Draft (m)	10.0	11.0	13.5	14.0	15.0

[Source: Lloyds Fairplay Database]

4.4 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 Belekeri port are presented in **Table 4.2**.

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	55,000	240	32	14.5
	120,000	80,000	260	40	16.5
	200,000	100,000	300	50	18.5
Containers	1000 TEUs	500 TEUs	160	22	10.0
	4000 TEUs	1,200 TEUs	290	32	13.5

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, navigation aids, material handling equipment, storage area for each type of cargo, road and rail access for the receipt and evacuation of cargo, and other utilities. 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. Accordingly, it is proposed to consider the following options for phasing of port:

1. Initial development for panamax size ships having draft of 14.5 m.
2. Initial development for cape size ships of draft up to 18.3 m
3. Initial development for Panamax size ships and deepening of the channel and harbour basin to handle cape size ships in phase-wise manner as per the market demand.

Considering that the dry bulk would be the key commodity for the proposed port, it is important that Phase 1 port facilities are able to handle the Panamax ships. Thermal coal is one of the key commodities for this port which moves through coastal shipping. Most of the quantity for this commodity is likely to be moved through panamax size ships and therefore it would make sense to limit the initial phase development for Panamax size ships only. Also, the other dry bulk expected to the port is the imported coking coal and iron ore which can be handled in panamax as well as capsize vessels. However, the projections for iron ore and coking coal, which shall be imported, being significant, there is a case for developing this port for cape size ships so as to be in a completive position vis a vis Krishnapatnam and Mormugao ports against which the proposed port shall be competing.

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 Dry Bulk Import

It is proposed to provide a common facility with the fully mechanised handling system for dry bulk imports like thermal and coking coal, iron ore etc. The system comprises of gantry type unloaders at berth, connected conveyor system from berth to yard, stacker and reclaimer at yard and wagon loading system.

5.2.2.2 Breakbulk and Containers

For containers, it is proposed to be handled through mobile harbour cranes with spreader arrangement. For handling at the container yard, suitable number of Rubber Tyred Gantry Cranes (RTGCs) shall be provided. At the railway yard reach stacker shall be provided for loading and unloading of rakes.

5.2.3 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.

5.2.4 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.

5.2.5 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.

5.2.6 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 5.1** below:

Table 5.1 Estimated Berths at the Belekeri Port Based on Traffic Forecast

S. No.	Commodity	Total Berths Needed		
		2020	2025	2035
1.	Bulk	2	2	3
2.	Multipurpose cum Container Berth	1	1	1
	Total Berths	**3**	**3**	**4**

5.2.7 Port Crafts Berth

For the initial stage development, the port would require 4 tugs (3 operational + 1 standby) with a capacity of 50 T bollard pull, 2 pilot launches and 2 mooring launches.

It is proposed to utilise the approach bund area for berthing of port crafts initially. An exclusive berth for the port crafts could be provided in the later phases.

5.2.8 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.

The proposed berth lengths for different design ships are presented in **Table 5.2** below.

Table 5.2 Berth Length

Berth Type	Design Ship Size	Design Ship's LOA	Minimum Berth Length
Coal/ Iron Ore Berths	80,000 DWT	240 m	290 m
	120,000 DWT	260 m	310 m
	200,000 DWT	300 m	350 m
Multipurpose/ Container Berths	1,000 TEUs	160 m	210 m
	4,000 TEUs	290 m	340 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 24 Ha increasing to 49 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

Substation is envisaged to be provided for the proposed bulk 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 Belekeri port, as shown in **Table 5.3:**

Table 5.3 Evacuation Pattern for Various Cargo

S. No.	Commodity	2020		2025		2035	
		Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share
		%	%	%	%	%	%
1.	Thermal Coal	0%	100%	0%	100%	0%	100%
2.	Coking Coal	0%	100%	0%	100%	0%	100%
3.	Iron Ore	0%	100%	0%	100%	0%	100%
4.	Containers	100%	0%	100%	0%	100%	0%

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 to 6 lane 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.

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 1.0 MLD increasing to about 1.90 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 19 MW in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at bulk berths.

5.8 Land Area Requirement

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 5.4** below:

Table 5.4 Minimum Land Area Requirement for Belekeri Port

S. No.	Commodity	Land Allocation over Master Plan Horizon (sqm)		
		2020	2025	2035
1.	Storage Space for various Cargoes	240,240	279,511	485,917
2.	Internal Roads and Circulation Space within Port @ 25%	60,060	69,878	121,479
3.	Port Building Complexes including parking	20,000	30,000	50,000
4.	Landscaping, Green belt and other for Expansion	105,699	125,198	216,941
5.	Rail and Road Corridor	530,000	530,000	530,000
	Minimum Land Area (Sqm)	**955,999**	**1,034,587**	**1,404,337**
	Minimum Land Area (Hectares)	**96**	**103**	**140**

The master plan details have been worked out based on traffic studies only up to 2035. 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 2035.

6.0 PREPARATION OF 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 Belekeri.

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 port at Belekeri.

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. As indicated previously the proposed port has to compete with the existing Krishnapatnam and Mormugao Ports, both having capabilities (or under execution) to handle cape size ships, it must be able to cater cape size ships at least in the later stage of development if not in Phase 1. The initial stage of development it should at least be able to handle panamax ships size of 80,000 DWT.

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 rocky outcrop is observed close to the shore and therefore harbour area has to be located at a suitable distance away from shore.

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. The ports along the west coast are subject to waves from SW direction during southwest monsoons. North east monsoon has least impact in this region. The orientation of the breakwaters would need to be decided accordingly.

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 and breakwater. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. During the site visits, as discussed in section 2.10, most of the quarry sites have been abandoned after Supreme Court's Judgement banning quarry sites in the forest land without Forest and Environmental Clearance. New quarry sites need to be developed for sourcing the material required for breakwater construction and reclamation. This would require identification of quarry area and obtaining Forest and Environmental clearance for the same.

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 breakwater, 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 2035 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing in 2035. 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. **Figure 6.1** shows the current pattern of land along the proposed port site. Large chunk of area is reserved for Indian Navy behind Belekeri where no other development can take place. It may be noted that villages viz., Bhavikeri, Keni, Kolivada are located along the Belekeri bay. In order to avoid any land acquisition and subsequent R&R issues, it is therefore proposed that backup area of cargo storage and port operations be planned on reclaimed area.

Figure 6.1 Current Land Pattern along Proposed Site

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. 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 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 seawards of navigational channel and then take the ship to the harbour.

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
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. Breakwater is to be planned for predominant waves coming from South-West direction. This would require a south breakwater to protect harbour from the waves coming from southwest direction. The length of south 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 based on Traffic Forecast

S. No.	Commodity	Total Berths Required		
		2020	2025	2035
1.	Dry Bulk	2	2	3
2.	Multipurpose / Container Berth	1	1	1
Total Berths		**3**	**3**	**4**

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.

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

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 (DWT)	Beam (m)	Outer Channel Width (m)		Inner Channel Width (m)	
		One way Channel	Two way Channel	One way Channel	Two way Channel
200,000	50	230	380	170	270
80,000	32	150	300	110	210

The channel length for handling 200,000 DWT ships works out to approximately 12 km and therefore the transit time of the ships in the channel will be about 0.8 hours (49 mins) at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1 hour, maximum of 12 ship movements per day (6 in and 6 out) could be accommodated with one set of tugs. Taking an average of about 10 ship movements per day in the channel, a one way channel can handle about 1825 ship calls per year using one set of tugs. Considering the low projected traffic and consequent ship movements, one way channel would be adequate for the proposed port.

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 case the bed level comprises of rock and hence additional underkeel clearance of 0.5 m would be needed.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship as shown in **Table 6.5** below:

Table 6.5 Dredged Levels at Port for the Design Ships

Ship Size	Draft (m)	Approach channel outside breakwater (m CD)	Inner channel and manoeuvring area (m CD)	At Berths (m CD)
80,000 DWT	14.5	16.1	15.4	16.5
200,000 DWT	18.3	20.4	19.5	20.6

It may however be noted that above values are arrived at considering that the design ship would navigate the channel after taking advantage of the mid tide level of +1.1 m CD. Considering the limited number of ships that to be handled each day this is a reasonable assumption and would reduce the capital dredging requirement and thus cost.

6.3.5 Elevations of Backup Area and Berths

Considering the mean high water springs as +1.9 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 +5.0 m CD. This elevation would also protect the berth from slamming action of waves under cyclonic conditions. However, the finished levels of onshore areas will be kept at around +4.5 m CD.

6.4 Alternative Marine Layouts

Various alternative layouts for the development of Port at Belekeri have been prepared keeping in view various planning criteria as discussed above.

Alternative Layout 1 is a nearshore harbour option with most of the berths located close to the shore. This would result in shorter breakwater length but higher dredging quantities. The suitable material obtained from dredging shall be used for reclamation and balance disposed offshore at a designated location. The channel orientation at the harbour entrance is from NW direction but after a suitable distance from harbour a bend is provided in the channel to reach deeper depths at a shortest possible distance. The Phase 1 and master plan layouts of this alternative are as shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1001** and **BLR1002**.

Alternative Layout 2 involves offshore harbour option where the harbour area is located away from the shore. As compared to Alternative 1, the breakwaters in this alternative are longer but the amount of capital dredging is lower. The basic concept of developing this alternative is to minimise/ avoid the rock dredging, which is likely to be encountered within the dredged depths considering the geology of the area. The channel orientation is similar to as that of Alternative 1. The Phase 1 and master plan layouts of this alternative are shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1003** and **BLR1004**.

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, Nav-aids, 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 Key Items of Phase 1 Development for Alternative Layouts

Item Description	Phase 1		Master Plan	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Breakwater	426	705	426	705
Dredging	327	215	697	528
Reclamation	172	172	231	231
Total	**926**	**1296**	**1152**	**1465**

From the above table, it is observed that cost of development is much lower in case of Alternative 1-Nearshore option but with a greater risk of cost escalation in case rock dredging is involved. Hence the rock levels would dictate the final port layout for Phase 1 development.

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

Alternative	Estimated Rock Quantity (million tonnes)	Estimated Construction Time (months)
Alternative 1	3.04	27
Alternative 2	4.85	38

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. It is required that adequate land be reclaimed utilising the suitable dredged material for the cargo storage and operational areas.

6.5.4 Expansion Potential

It is observed that both the alternatives offer similar number of berths. However, alternative layout 2 would enable additional backup area by way of reclamation.

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
1.	**Rock Levels and Estimate of Rock Dredging**	The higher rock levels would involve costly rock dredging.	The marine facilities are located away from shore but still could involve some rock dredging.	The marine facilities are located offshore and may not involve rock dredging for panamax size ships but may involve some rock dredging for particularly for Cape size ships.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	Part of the dredged material can be used for reclamation and balance disposed offshore.	Optimal use of dredged material with minimal offshore disposal.
3.	**Protection to the berths from waves and swell**	The predominant wave direction is from SW during the SW monsoons	The berths are well protected from direct attack of waves	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	Effective utilization of backup area. Clear separation of clean and dirty cargo possible.	Same as Alternative 1.
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	Suitable rail and road connectivity can be provided along the land corridor proposed to be acquired for port development	Same as Alternative 1.
6.	**Connectivity to Hinterland**	Hubli - Ankola rail line for adequate traffic movement	The rail line is a key to provide cost economic movement of cargo. State government to pursue the EC for the rail line to come up	Same as Alternative 1
7.	**Environmental issues related to development**	Limitation of quarrying in Western Ghats	Proper EMP needs to be prepared to avoid impact due to quarrying required for port construction.	Same as Alternative 1.
8.	**Potential Reclamation Area**	The higher reclamation area would minimize the land acquisition.	Adequate land required for storage and port operations could be reclaimed	Same as Alternative 1.
9.	**Capital Cost of Phase 1 Development**	Optimized capital cost for the initial phase development so as to increase the project viability	Base case	Higher than alternative 1 but could be other way, if rock levels in the area are found to be higher.

S. No.	Factor Description	General	Alternative 1	Alternative 2
10.	**Expansion Potential**	Maximum number of berths possible in the harbour so as to meet the demand at least for master plan horizon	Total 6 berths possible	Same berth as alternative 1 but additional storage area could be created.

6.7 Recommended Master Plan Layout

It could be observed from above that alternative 1 appears to be the best in terms of minimal investment for Phase 1 development and it also meets the long term expansion requirements of the port. However during project appraisal appropriate contingency for the additional cost due to rock dredging would need to be taken into account.

The recommended master plan layout of Port at Belekeri is shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1005**.

6.8 Recommended Port Layout Beyond Master Plan Horizon

It is however possible that port could be expanded beyond the master plan horizon. The extent of expansion would depend upon the availability of right of way to the north side of the bay. There could be two possible alternatives as mentioned below:

Alternative 1: In this alternative the root of north breakwater is taken from middle of the Bhavikeri bay as shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1006A**.

Alternative 2: In this alternative the root of north breakwater is taken from tip of the north landmass of Belekeri Bay as shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1006B**. It is understood that the tip and land adjoining areas are with existing Belekeri port. However, it could be considered during implementation stage after completing the necessary modalities and duly taking into account the possible utility of the additional land created by reclamation.

Depending upon the detailed cost benefit analysis to be carried out at a later date, providing a north breakwater (either part or full) as shown in above alternatives could also be considered either in Phase 1 itself or the later stages of development. This would have benefit of getting additional land by way of reclamation and also eliminate the difficulties that would be faced for construction of north breakwater in future due to urbanisation of the area around the port after commissioning of the port. The same needs to be considered during DPR stage after duly taking into account the financial benefit and strategic advantage.

6.9 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 2020	Master Plan - Year 2035
Maximum Ship Size		
• *Dry Bulk (DWT)*	*80,000*	*200,000*
• Breakbulk	*80,000*	*80,000*
Breakwater		
• *Southern Breakwater (m)*	*4780*	*4780*
Number of berths (Total length of berths in meters)		
• *Bulk Berths*	*2*	*3*
• *Multipurpose berths*	*1*	*1*
Navigational Areas		
• *Length of Approach Channel (m)*	*7,300*	*12,000*
• *Width of Approach Channel (m)*	*150*	*230*
• *Diameter of Turning Circle (m)*	*500*	*600*
Design Draft of the Ship (m)	14.5 m	18.3m
Dredged Depths at Port (m below CD)		
• *Approach Channel*	*-16.1m*	*-20.4m*
• *Manoeuvring Areas*	*-15.4m*	*-19.5m*
• *Berths*		
○ *Breakbulk*	*-16.5m*	*-16.5m*
○ *Bulk*	*-16.5m*	*-20.6m*
Incremental Dredging Quantity (million cum)	*16.4*	*18.5*
Incremental Reclamation Quantity (million cum)	*8.62*	*11.4*
Total Reclamation Area to be Developed (Ha)	*102*	*154*

The recommended Phase 1 development of port at Belekeri is indicated in **Drawing DELD15005-DRG-10-0000-CP-BLR1007**.

7.0 ENGINEERING DETAILS

7.1 Mathematical Model Studies on Marine Layout

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.

The model bathymetry was created using the breakwater configuration and the approach channel shown in **Figure 7.1**. All the numerical simulations of the wave agitation were carried out with a water level corresponding to the Chart Datum (CD).

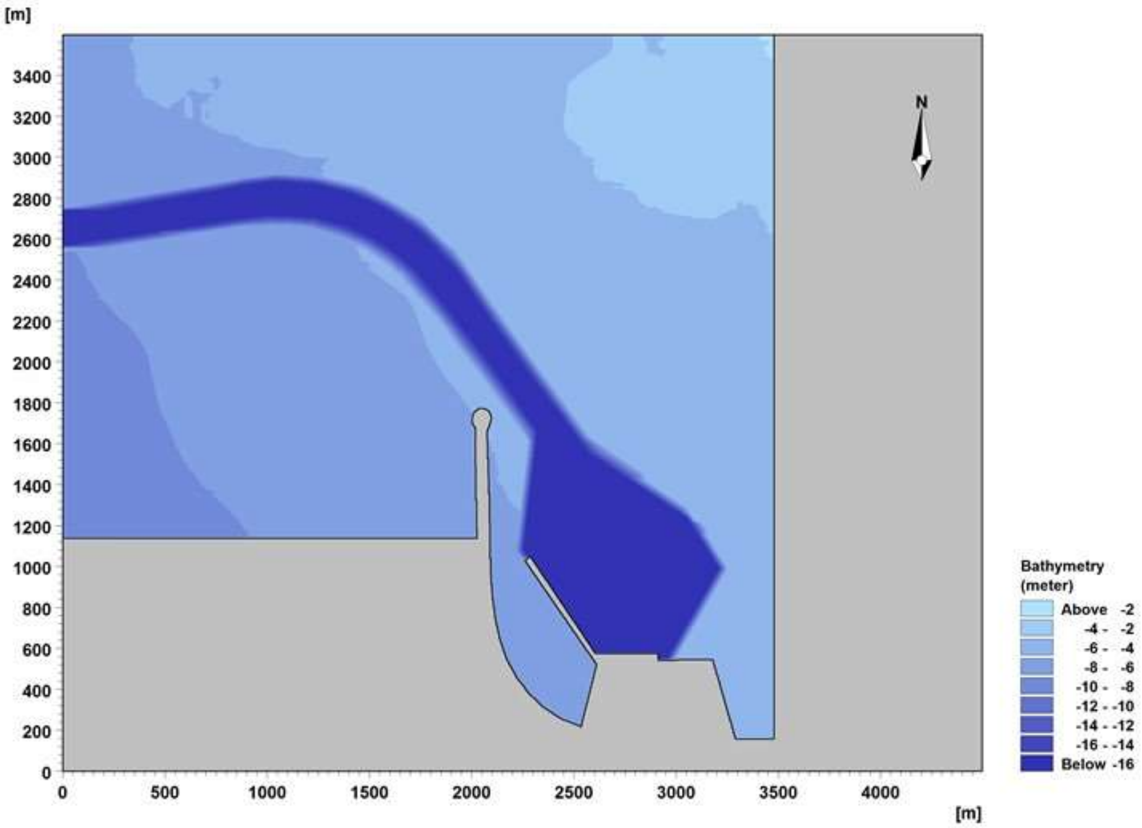

Figure 7.1 Bathymetry Used for the BW

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 closed boundaries (**Figure 7.2)**.

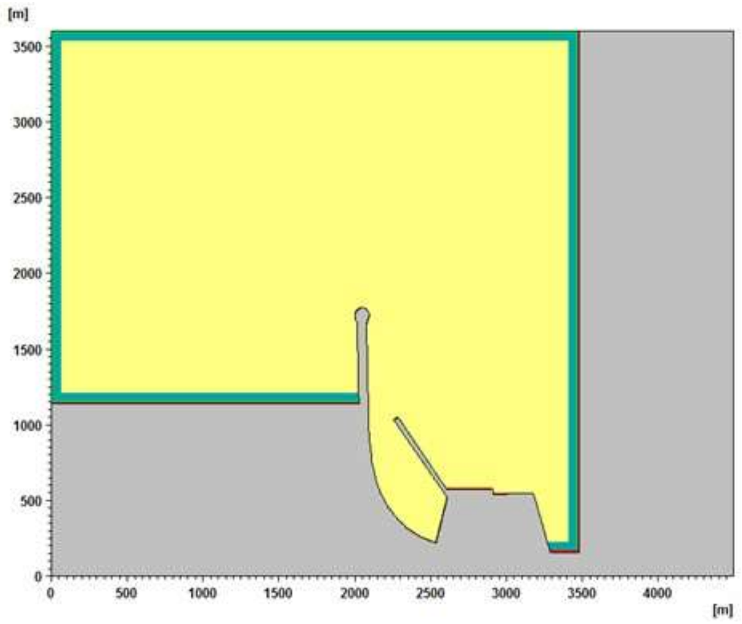

Figure 7.2 Sponge Layers (in Green) along the Non-Reflecting Boundaries

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 7.3**). For the present study, the porosity coefficient for the breakwater has been taken as 0.5 while that for berths a value of 0.8 has been considered.

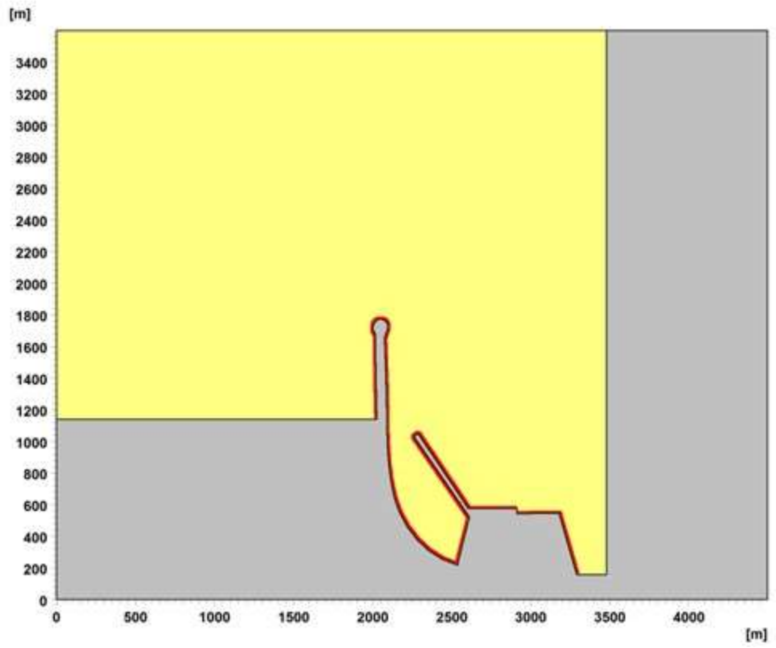

Figure 7.3 Porosity Layers (in Red) along the Port Structures

The proposed layout provides effective protection from W, SW, SSW direction. 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 6.5 s.

7.1.1 Model Results

Figure 7.4 to Figure 7.6 provides wave height that may be encountered within the harbor under the impact of 1 m waves from NNW, NW and W directions respectively. It may be observed that the waves entering from NNW, NW and W directions are mostly attenuated at the breakwater.

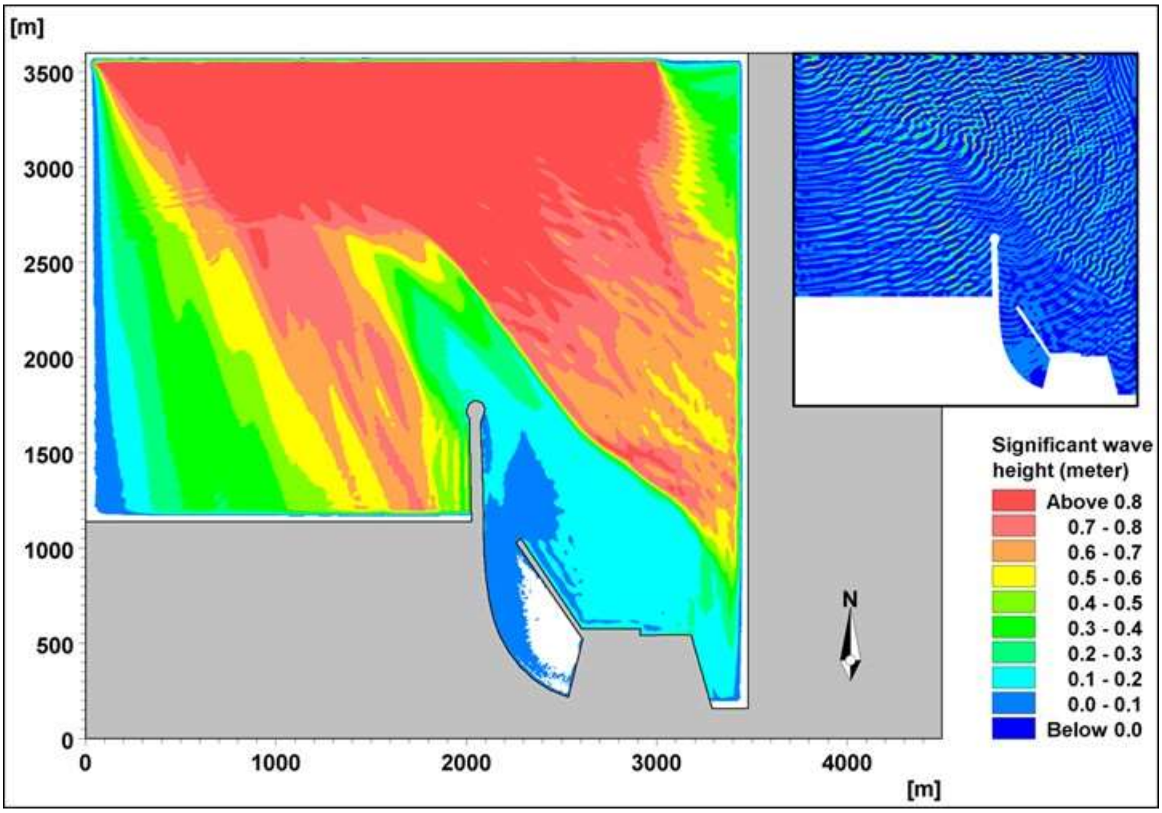

Figure 7.4 Wave Tranquillity Assessment for Waves from NNW Direction

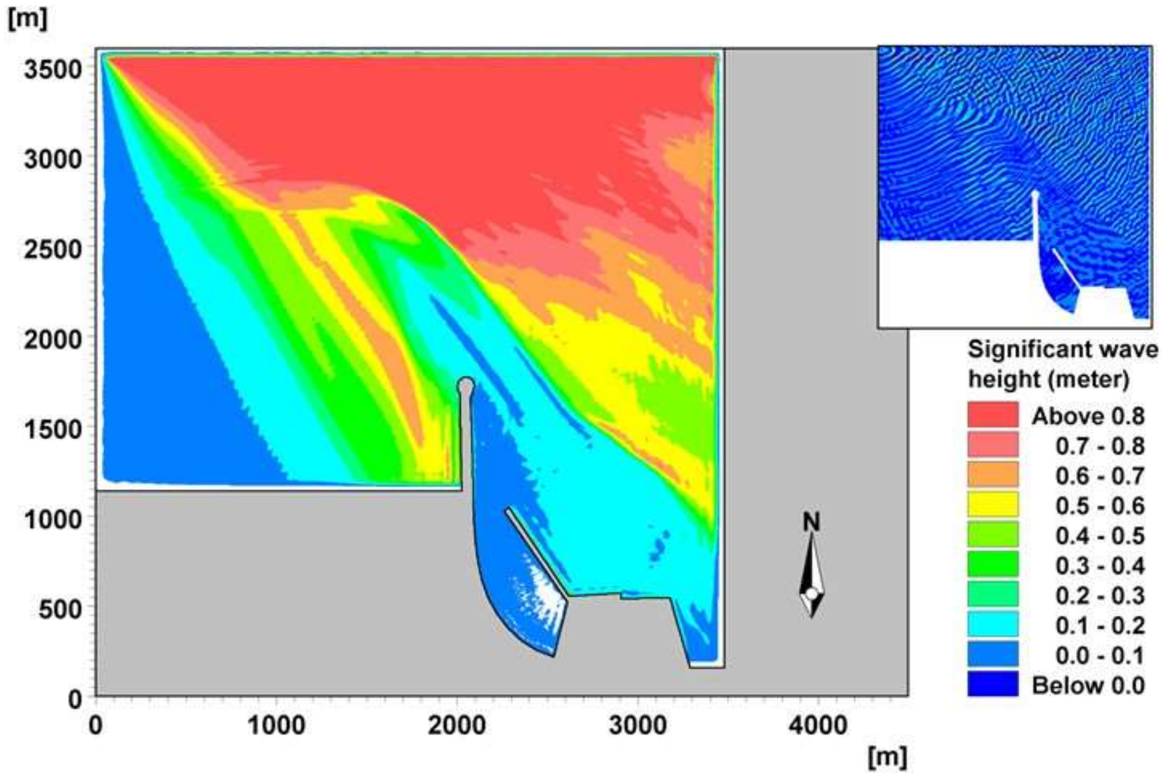

Figure 7.5 Wave Tranquillity Assessment for Waves from NW Direction

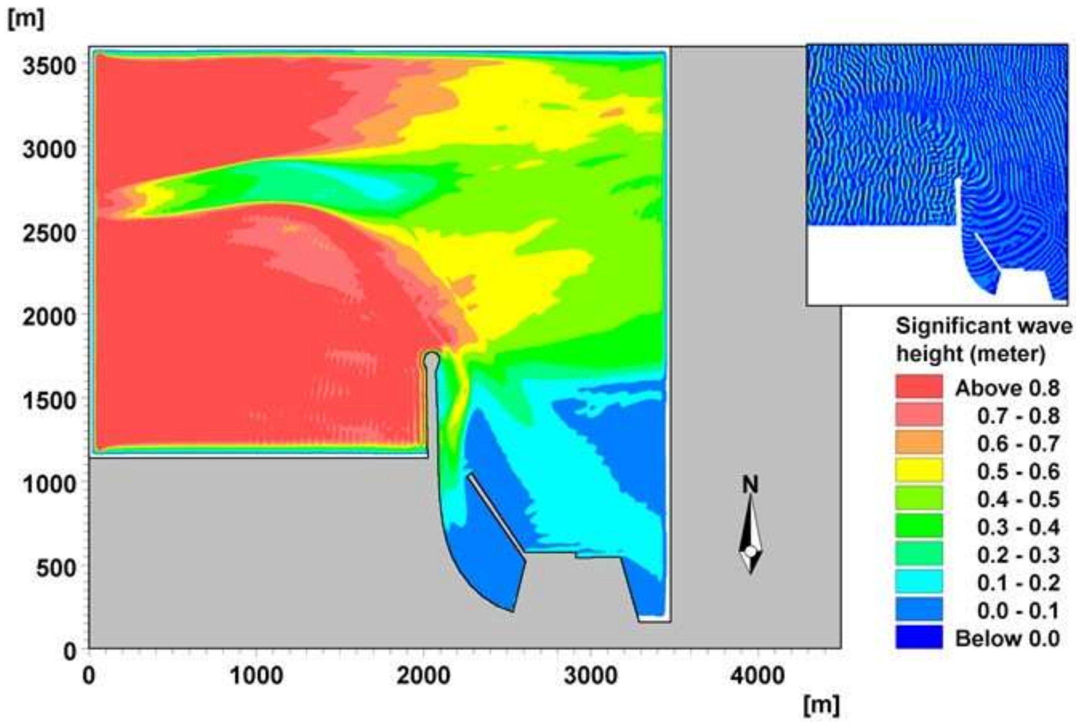

Figure 7.6 Wave Tranquillity Assessment for Waves from W Direction

Based on the model runs carried out for the above conditions the wave disturbance coefficients i.e. ratio of H_{mo} (Site)/H_{mo} (incoming), are calculated at the locations of proposed berths and turning circle (**Table 7.1**).

Table 7.1 Wave Disturbance Coefficients

Label	Description	NNW	NW	W
C1	Outer Channel	0.78	0.57	0.21
C2	Inner Channel	0.18	0.12	0.31
T1	Turning Circle	0.16	0.12	0.17
B1	Berth 1	0.10	0.07	0.06
B2	Berth 2	0.10	0.08	0.07
B3	Berth 3	0.15	0.10	0.14

Using these coefficients, a representative mean significant wave height (Hm0, mean) can be estimated by multiplication of the wave disturbance coefficient of the location with the incident significant wave height (Hm0). Wave disturbance coefficients estimated from the study suggests that the maximum of 0.15 m of wave will reach berth locations if incident wave of 1 m approach the port. While, wave height of 0.16 m, 0.12 m and 0.17 m are estimated at the turning circle for 1 m incident wave from NNW, NW and W directions respectively.

The proposed port will handle bulk cargo, operation at these berths withstand significant wave height up to 0.6 m. thus considering the wave disturbance coefficients the cargo handling operations can be effectively undertaken until incident wave height of about 4.0 m.

Based on the percentage exceedance of waves at 14 m contour, it is assessed that waves exceeding 3 m are less than 1% at Belekeri and hence it may be safely concluded that downtime at the port with proposed layout is practically nil under the normal wave conditions.

7.2 Onshore Facilities

The onshore facilities for port operations and cargo storage are located in the reclaimed land. The cargo storage for the breakbulk cargo has been earmarked contiguous to the multipurpose berth for operational ease. However, the storage area for bulk cargo is located close to shore on the reclaimed land, where the material shall be transferred from the bulk berth using the conveyor system.

While arriving at the onshore layout adequate space has been earmarked for the railway lines to be provided within the port area.

7.3 Breakwaters

7.3.1 Basic Data for Breakwaters Design

7.3.1.1 Design Wave Height

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.

Based on the available data in the region having similar water depths upto which the breakwater extends, the design wave height adopted is 5.5 m for the head and truck sections located in deeper waters. For sections closer to shore the design wave height shall be governed by corresponding breaking wave height in that water depth, whichever is critical.

7.3.1.2 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.

7.3.1.3 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.

7.3.1.4 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 7,000 T/day by end on dumping method including the quantity of rock that 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 7.2 K_D Values for Breakwater

Breakwater Portion	K_D values for Accropodes
Trunk	15
Head	12

The typical cross section of the breakwater is presented in **Drawing DELD15005-DRG-10-0000-CP-BLR1008**.

7.3.3 Geotechnical Assessment of Breakwaters

The seabed level at the breakwaters increases from +2.0 m CD near the shore to a maximum of –7.0 m CD. The crest level of breakwater is assumed at the maximum depth is about +8.5 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 likely to be on a good founding strata overlaying rock.

7.3.4 Rock Quarrying and Transportation

7.3.4.1 Location of Quarries

It is understood during the site visit, the the environmental ministry has imposed ban on rock quarrying due to the sensitivity of the western ghats. The rock for the construction of breakwater works need to sourced out from the government approved quarries in the area.

7.3.4.2 Transport to Site

The quarry material will have to be transported in through dumpers. Some localise road improvement measures will need to be undertaken near the quarries and near the project site to enable moving of the large quantity of stones by road using trucks.

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-BLR1007**. Ideally the Container / 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 high dredging requirement at the berth locations, it is proposed to provide the bulk and multipurpose berth away from the shore and some portion of backup area is created behind multipurpose berth for transit storing and backup area near the shore to which the connection shall be by approach bund/trestle.

7.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +5.0 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

The structural design of the bulk and 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 7.3** below:

Table 7.3 Characteristics of Design Ships

Commodity	Design Ship Size (DWT)
Coal	200,000
Multipurpose	80,000
Containers	4,000 TEUs

7.4.3.1 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -21 m CD.

7.4.3.2 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:
  - *Loads due to Gantry type unloaders with rail centres at 20 m c/c on bulk berth*
  - *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*

- **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 40 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 below:

Table 7.4 Details of Berthing Energy, Fender and Berthing force applied at Berths

Parameters	Bulk Berth	Container cum Multipurpose Berth
Berthing Energy	2975 kNm	1234 kNm
Fender	Trelleborg Cell Type Fenders SCK 2500H E1.1 or equivalent	Trelleborg Cell Type Fenders SCK 2000H E1.0 or equivalent
Rated Berthing Force	2711 kN	1397kN

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.

7.4.3.3 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.

7.4.3.4 Materials and Material Grades

Concrete of minimum grade M40 and high corrosion resistant thermo-mechanically treated bars of Fe500 grade shall be used for berth construction.

7.4.4 Proposed Structural Arrangement of Berths

7.4.4.1 Dry Bulk Berths

The cargo complexion under dry bulk includes thermal/ coking coal and iron ore for the port at Belekeri. 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 bund/ trestle in the lee of south breakwater connecting the berths to the reclaimed land.

A common system is proposed to handle thermal coal, coking coal and iron ore at 2 bulk berths. The berths shall be provided with a conveyor system which will carry the dry bulk from the berth and transfer to the conveyor provided over the approach bund/ 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 30m. 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 8.0 m c/c in the longitudinal direction. The piles will be founded in substrata at levels beyond -40 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 300 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 conveyor supports are provided in the rear side of the berth at a spacing not exceeding 24 m. The typical cross section of bulk berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1009**.

7.4.4.2 Container cum Multipurpose Berths

The container cum multipurpose berth is connected to land by means of approach trestle. Due to the requirement of placing the ship's hatch covers additional area has been created by reclaiming the land behind the berth and hence the width of the berth is taken same as that of bulk berth i.e. 30 m.

The structural arrangement of the berth is based on the design criteria. The proposed scheme consists of four rows of vertical bored cast-in-situ RCC piles of 1.2 m diameter, spaced at 8.0 m c/c in the longitudinal direction. The piles will be founded in subsea strata at levels beyond -40 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 third 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.

The berth is connected to the shore by means of 980 m long and 15 m wide approach bund to back up area. The approach shall be either in the form of bund or a trestle supported over three rows of 1.1 m diameter bored cast in situ piles. The typical cross section of bulk berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-BLR1010**.

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 **16.4 million cum** required for handling panamax size ships. Nearly half of the dredged material shall be used for reclamation and balance shall be disposed off at a suitable location offshore at about 30 m contour.

7.5.2 Maintenance Dredging

As the harbour area is located in deeper waters and there is no river estuary nearby bringing in large sediments. Therefore the annual maintenance dredging volumes are expected to be very low and limited to about 700,000 cum per annum only including the littoral drift material that could find way to the channel.

7.6 Reclamation

7.6.1 Areas to be Reclaimed

It is proposed that the area behind the bulk and container cum multipurpose berths shall be reclaimed to provide the space for transit storage and area along the shore line to create the backup area for storage and operation. The reclamation level is proposed to be +4.5 m CD and the total quantity of reclamation fill is estimated as **8.6 Mcum** which can be carried out through suitable material from capital dredging.

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 +1.9 m CD. Between the elevations + 2 to +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.

7.7 Material Handling System

7.7.1 Bulk Import System

7.7.1.1 General System Description

A fully mechanized common ship unloading system is planned at the bulk berths to handle thermal/ coking coal and iron ore. The system is designed for a rated capacity of 4,000 TPH to ensure faster turnaround of vessels at berth.

The major components of the mechanized bulk import system are:

- Ship unloaders
- Stacker cum Reclaimer units at stackyard
- Wagon Loading System
- Connected Conveyor system

7.7.1.2 Ship Unloaders

The bulk 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 panamax 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.

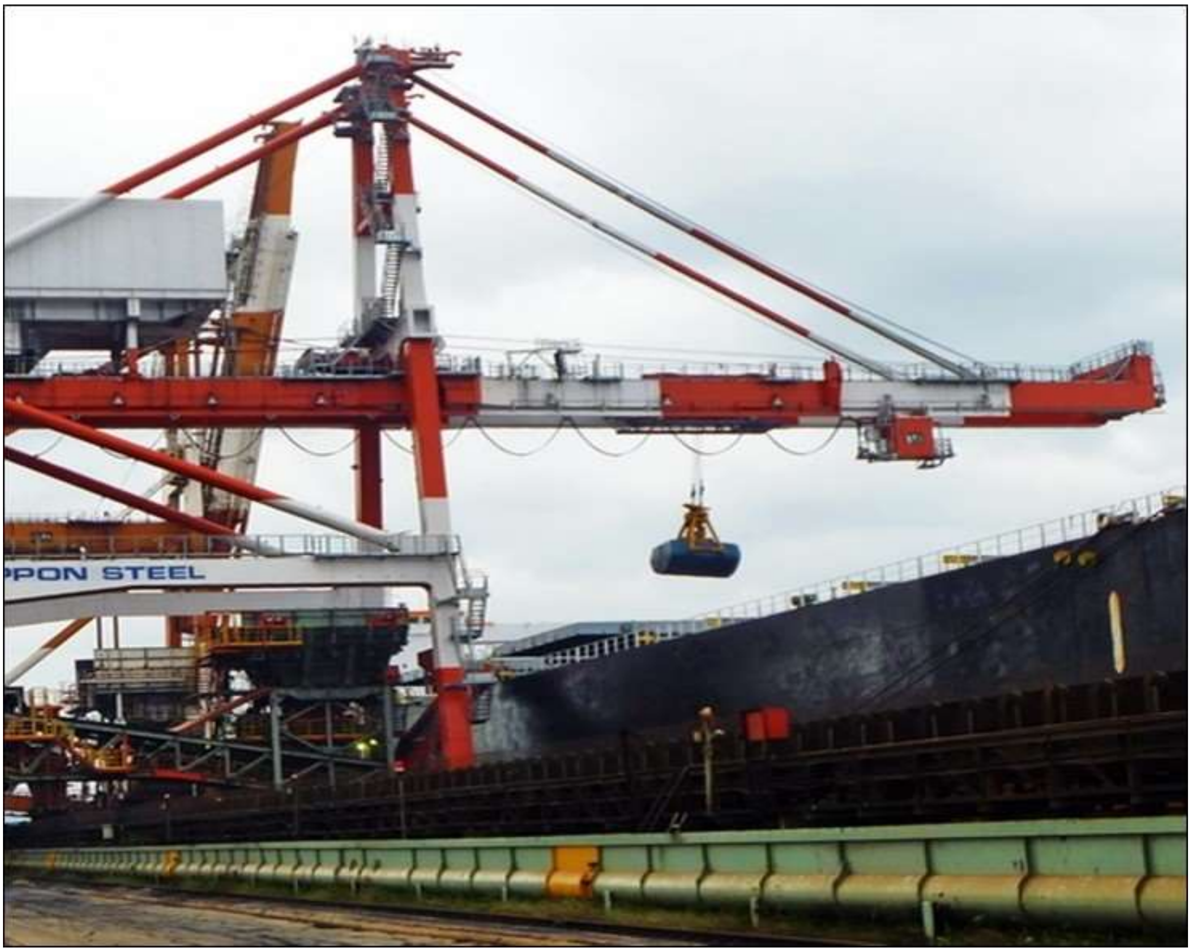

Figure 7.7 Typical Ship Unloader

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

The same system is proposed to handle thermal/ coking coal and iron ore cargo by means belt cleaning arrangement. The system consists of suitable pump, storage tank, nozzles for belt cleaning at discharge / feeding points of belt conveyors at each transfer tower for efficient belt washing system.

In addition to above suitable spray system shall also be provided at ship unloader, coal stackyard and wagon loading station.

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 four stacker-cum-reclaimer units at the stackyard. This equipment shall be used to receive thermal/ coking coal and iron ore from the ship and stacking in different rows in the yard. The same equipment shall also be utilised to reclaim these cargoes from stackyard for further transportation by conveyor 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.

7.7.2 Break Bulk Handling System

7.7.2.1 Container

The projected container traffic is in the initial phase of development is only 25,000 TEUs per annum in the initial phase which increases to 53,000 TEUs per annum in the year 2035. In view of the limited throughput, it is proposed to handle the containers at the multipurpose berth. Mobile Harbour Cranes (MHCr) fitted with the spreader attachment are well proven for the efficient handling of containers.

Figure 7.8 Mobile Harbour Crane with Spreader Arrangement

This arrangement will have benefit in the sense that the cranes can also be used to handle breakbulk cargo.

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 7.9** shows an E-RTG in operation.

Figure 7.9 Typical E-RTG for Yard Operation

Figure 7.10 Typical Details of Electric Buss Bar Arrangement for E-RTG

7.7.2.3 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 7.11 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.

7.7.2.4 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 7.12 Snapshot of Typical Reach Stacker Handling

Considering the throughput of the import export containers of gateway traffic, it is proposed to provide one numbers of Reach Stackers for train loading/unloading and handling in the stackyard.

7.7.2.5 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 7.13 Typical ITV for Handling Containers

7.8 Road Connectivity

7.8.1 External Road Connectivity

As discussed in section 2.10.2, roads connecting to NH 17 from project site passes through a dense population at Ankola town and any upgradation of road will lead to displacement of people and related R&R issues. A new road alignment is proposed in order to have minimal R&R as shown in **Figure 7.14**.

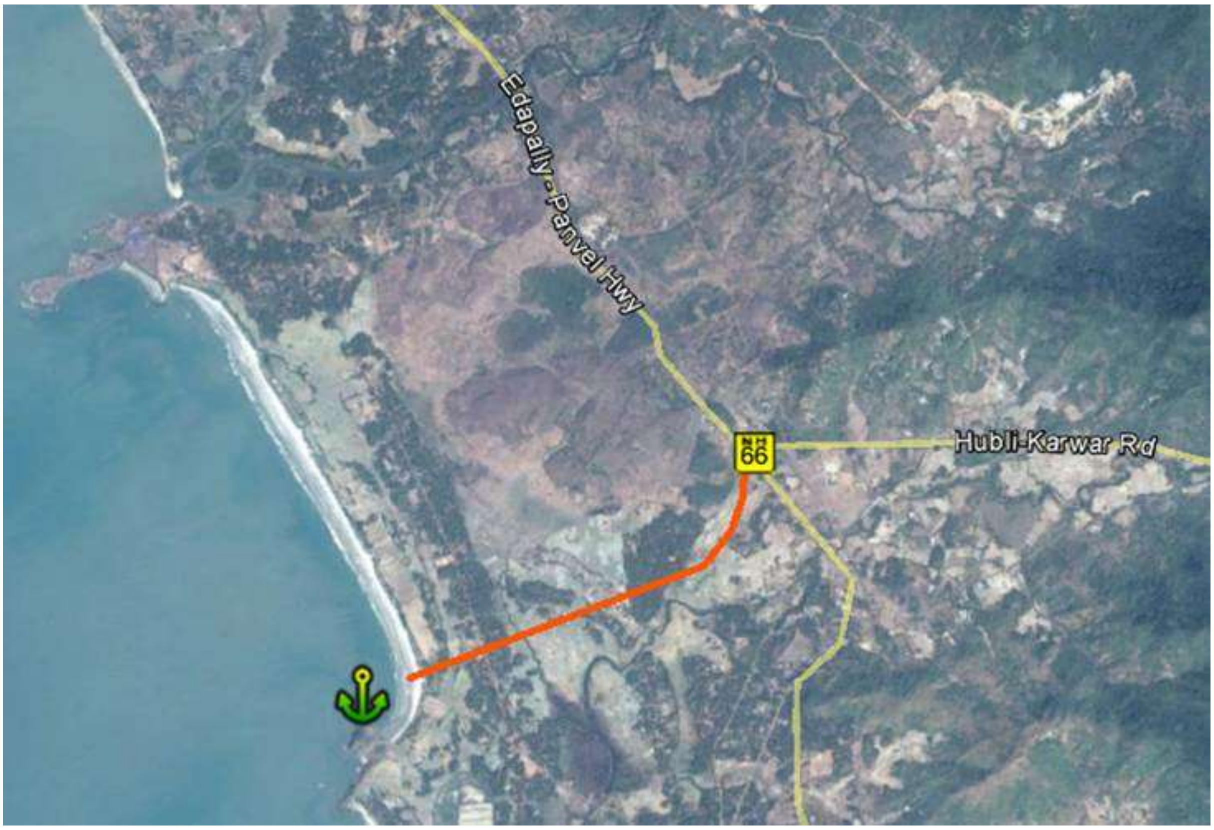

Figure 7.14 Proposed Alignment of External Road Connectivity

7.8.2 Internal Roads

The main approach road to the port shall be located parallel to the backup area. 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.

7.9 Rail Connectivity

7.9.1 External Rail Connectivity

Three alternatives alignments were analysed to provide rail connectivity to the port as shown in **Figure 7.15**.

Figure 7.15 Alternative Rail Alignment to Port at Belekeri

Option 1: The route is about 4.2 km and traverse through Bhavikeri village. It also passes through a hill.

Option 2: This option provides a route length of about 6.6 km along the creek and is provided to avoid habitation of Bhavikeri village. It also traverses though a hill. This route will need 3-4 bends, which may present technical challenges for rail alignment.

Option 3: This route is largest of the three (8 km) and was assessed to avoid population and sharp bends in alignment. This would require passing through two hills and will need 1 minor bridge.

Out of the three options, Option 1 is found to be most suitable as it is shortest, requires lesser land acquisition, and does not involve construction of any major bridge.

However options 1 and 2 are very close to the navy boundary and would hinder any expansion plans of Navy that may be needed to increase the runway length in future. There are no documented details available of area that will be required but this must be duly taken into account at the DPR stage. In case of expansion plans of Navy go through, options 1 and 2 will not possible and hence only alignment that will be possible is Option 3. Both rail and road will have to follow this option for connectivity, which will require higher capital cost as compared to the suggested options.

7.9.2 Internal Rail Links

The internal rail lines will be developed so that the rakes for bulk cargo could be taken to the wagon loading system. It shall be ensured that their location does not obstruct the movement of port vehicles. At the bulk import yard two rail sidings shall be provided including one engine escape line. A separate siding for the handling of breakbulk and containers shall be provided.

7.10 Port Infrastructure

7.10.1 Electrical Distribution System

7.10.1.1 Introduction

The handling systems for bulk loading and unloading are power intensive and hence require considerable high tension electrical power for their operation. 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. The various terminals within port will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

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 19 MVA over the proposed master plan horizon.

7.10.1.3 Source of Power Supply

Power supply to Port at Belekeri shall be tapped from the existing grid. It is proposed that the transmission lines be tapped off and extend up to the proposed location of the main receiving substation at the port.

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 the substations. The distribution of power in the terminals shall be through this substation.

The substations will be equipped with a 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. The substation shall be equipped with capacitor banks for automatic power factor correction and for maintaining a PF of not less than 0.9.

7.10.1.6 Standby Power Supply

It is proposed to install one diesel generator of 2 MVA in the 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 & Lightning 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 0.97.

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 100 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 Unloaders, MHCr, 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 proposed port will have the following objectives:

- Establish one common IT infrastructure that is based on 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
- 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 Port at Belekeri 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.

7.10.4 Water Supply

7.10.4.1 Water Demand

The water demand for the Port at Belekeri Port has been worked out in the **Table 7.6** below:

Table 7.6 Estimated Water Demand for proposed Port at Belekeri

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	908	1,840
2.	Potable Water (KLD)	42	51
Total Water Demand at Port (KLD)		**950**	**1892**

7.10.4.2 Sources of Water Supply

The water requirement for the port shall be sourced from Honnaili Water Supply Scheme which is 10 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 1000 cum located at the port boundary which is equivalent to one day 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 50 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 500 cum capacity each located near the stackyard. The secondary sump at multipurpose terminal shall be split into three compartments of 200 cum, 200 cum and 100 cum. The compartment of 200 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 200 cum will provide water for dust suppression system in the bulk import terminal.

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 and other dry storage area 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 20 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 vessels four harbour tugs of 50 T bollard pull capacity are required initially, including tug for standby/ emergency.

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 Phase 1 development of port of Belekeri are given in **Table 7.7** below.

Table 7.7 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 50 T bollard pull	4
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 has a total length of 12 km from the breakwater head which require 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 mile. In addition some buoys are proposed in the harbour basins as well. IALA maritime buoyage system as per region A, in which Belekeri 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 long and 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 breakwater head is proposed to 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. For Belekeri Port, 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.

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 cum 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 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.

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 Bhavikeri about 4 km south of Belekeri. 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

Bhavikeri is located in Ankola Taluka of Uttara Kannada District in the state of Karnataka. As per Census of India 2011 it has total population of 8160 from 1911 households. Total male population is about 4058 as compared to 4102 females. Average Sex Ratio of Bhavikeri village is 1011 which is higher than Karnataka state average of 973. Bhavikeri village has higher literacy rate of 83.66%, where 90.52% males and 76.91% of females are literate.

Rain-fed agriculture activities are prevalent in the area where rice and groundnut are sown predominantly. Other crops that are grown in this area are coconut, Arecanut, Cashew, Banana, Water Melon and other leafy vegetables.

8.3 Site Setting

A Greenfield port is planned to be developed on the coast near the Bhavikeri village. The waterfront identified for port development has a small village Keni in the immediate vicinity, while Bhavikeri village is about 500 m east of the sea coast (**Figure 8.1**).

About 100-120 households were found to be located in the village Keni and a total population of about 2000 has been reported. The villagers are mainly involved in small scale fishing and also agricultural activities.

The coast has rocky outcrops and is also demarcated as stable (**Figure 8.2**).

	
Proposed site with coconut plantation in the backdrop	**Proposed site with habitation of Keni Village and Hill in the backdrop**
	
Habitation at Keni	**Agriculture fields behind Keni Village**

Figure 8.1 Location of the Proposed Site

Figure 8.2 Coastal Stability Map of Uttara Kannada District

[Source: ChenthamilSelvan et al, 2014[1]]

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	No forest land is involved in the project.	MoEF&CC; Department of Forest, GoK

[1] ChenthamilSelvan et al, 2014, Assessment of Shoreline Changes along Karnataka Coast India, using GIS and Remote Sensing Techniques, Indian Journal of Marine Science, Vol 43(7).

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
		• Permission for tree felling		
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	Pulicat Lake Bird Sanctuary is within 10 km radius	Chief Conservator of Wildlife, Wildlife Wing, Forest Department, GoK; 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	Karnataka 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	Karnataka Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Karnataka 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.	Karnataka State 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, GoK
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. • Construction of breakwater	• 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. • Shoreline changes	• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• Shoreline changes due to permanent breakwater structures • 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	• Operation of vehicles and construction machinery • Quarrying and transportation of material to the site.	• Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery Including stand-by generators	• Increase in noise • Health impacts on workers

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 • Influx of outside workers/ population	• 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	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **Positive Impacts** • 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 proposed port is planned on reclaimed land between shoreline to 5 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 from 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 to a designated solid waste collection point.

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 Honnalli Water Supply scheme, for which all the required permissions from the state authorities will be sought.

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 stored 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 sea or 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 KPCB 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 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.
- 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 Karnataka 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.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.

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.

Mitigation Measures

- 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

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.

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 on reclaimed land.

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 stack yard 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 waste 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 coastguard personnel 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 at proposed 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 stack yard & 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, 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 stackyard shall be installed.
- In addition to all the above measures, a 10 m wide greenbelt will be developed for dust arresting proposes.
- 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 shall 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.

Due to maintenance dredging, some 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 first quarter of 2016.
- 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 are for the facilities created during Phase 1 and Master plan phase only.

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

A. Port Development Cost Only

S. No.	Item	2020	2035	Total
1.	Project Preliminaries and Site Development	30	15	45
2.	Dredging	327	370	697
3.	Reclamation	142	10	152
4.	Breakwater	426	-	426
5.	Berths	353	90	443
6.	Buildings	29	9	38
7.	Stackyard and Other Backup Area	48	28	75
8.	Internal Roads and Railway	50	30	80
9.	Equipment	677	333	1,011
10.	Utilities and Others	166	59	224
11.	Navigational Aids	8	2	10
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**2,256**	**945**	**3,201**
13.	Contingencies @ 10%	226	94	320
14.	Engineering and Project Management @ 5%	113	47	160
Incremental Capital Cost (Rs. In Crores)		**2,595**	**1,086**	**3,681**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	2020	2035	Total
1.	**Port Development Cost**	**2,595**	**1,086**	**3,681**
2.	**External connectivity including land acquisition**			
	Rail	**110**	-	**110**
	Road	**115**	-	**115**
	Total Cost (INR in Crores)	**2,820**	**1,086**	**3,906**

These capital cost estimates do not include the following:

- 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.

9.2.2 Repair and Maintenance Costs

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

- 5% of 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 200 increasing to about 300 in the master plan 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 - Rs. 4.50 per unit plus Rs. 225 per kVA of demand rate per month
- Water Charges - Rs. 50 per kilolitre
- Diesel - Rs. 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 Firefighting & 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 Port at Belekeri are summarised below in **Table 9.2** below:

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

S. No.	Item	2020	2035	Total
1.	REPAIR AND MAINTENANCE COSTS	51.0	23.2	74
2.	OPERATION COSTS	81.0	34.9	116
3.	TOTAL	132.0	58.0	190
4.	Contingencies (Rites, @ 10%-Aecom)	13.2	5.8	19
5.	Administrative Expenses @ 5%	6.6	2.9	10
Incremental O & M Costs (Rs. In Crores) per annum		152	67	219

The above O&M costs do not include the repair and maintenance of external rail and road connectivity.

9.3 Implementation Schedule for Phase 1 Port Development

9.3.1 General

The main components for the development of Belekeri Port comprise of construction of breakwater, capital dredging for approach channel and manoeuvring basin, reclamation, 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, dredging and reclamation have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 3 million tonnes of rock is required for the construction of the proposed breakwater. The major quantity of rock required for armour and sub armour layers would be obtained from identified quarry sites.

It is proposed to construct the breakwater 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, beyond about -4m CD contours. 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 7,000 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 breakwaters could be completed in a period of about 27 months duly accounting for weather downtime.

9.3.3 Dredging and Reclamation

The overall dredging quantity is estimated to be about 16.4 Mcum. Initially the reclamation bunds shall be built to receive the suitable material from the dredging operations and then dredging activity can commence in the fair weather season. While the dredging by cutter suction dredger would be limited during fair weather season the same using TSHD shall be carried out round the year. The overall duration of the dredging and reclamation is expected to be 22 months. However in case some rock patches are found in the dredging area the duration will increase.

9.3.4 Berths

As bulk berths are not proposed to be contiguous to the land, construction of these berths would be independent of the dredging. However the construction of multipurpose berth having backup area would need to be synchronised with dredging and reclamation.

Considering the berths are located a distance of about 3.1 km from shore, the construction of berths could be either undertaken using floating equipment or by launching the gantries from the partly completed breakwater. The latter option is most likely as it would involve lesser downtime due to weather and relatively lower cost of construction.

The berth piling would be commenced using piling gantries installed from the completed portion of the breakwater. 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 Belekeri port is likely to take over 40 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 Belekeri Port is shown in **Table 9.3**.

Table 9.3 Implementation Schedule

10.0 FINANCIAL ANALYSIS FOR ALTERNATIVE MEANS OF PROJECT DEVELOPMENT

10.1 Assumptions for Financial Assessment

The following assumptions have been made while making the financial assessment of the project and arriving at the suitable means of project development:

- Due to the minimal incremental traffic the financials have been worked out assuming the there is no expansion after Phase 1 development of port. However, any subsequent expansion would improve the project viability.

- Based on the profiling of competing ports following tariff has been assumed
  - Coal - Rs. 200 per tonne
  - Containers - Rs. 4500 per TEU

- The cost of Debt is assumed as 11% for PPP operator.

- The cost of Debt for the SPV, in case of Landlord model, is assumed at 4%.

10.2 Option 1 – By Project Proponents

In this option, the project shall be executed by the public sector entity, i.e., (New Mangalore Port Trust and/or State Government/SDC), who shall also arrange funds for the project financing, manage and operate the port.

The financial analysis has been carried out considering the overall capital investment of Rs. 2820 crores for Phase 1 port development. The project IRR in this scenario works out to about 11.5%.

10.3 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.

In this case the costs towards External Rail and Road Connectivity to port and land acquisition for connectivity and port facilities shall be borne by the government entities.

Therefore the capital investment for the private operator shall be limited to Rs. 2595 crores only. However, in this case also the project IRR for the private developer works out to about 12.4% even after considering that the developer does not do any revenue sharing with government.

10.4 Option 3 – Landlord Model

In this option a Special Purpose Vehicle (SPV) shall be formed comprising of New Mangalore Port Trust and other government entities which may include Karnataka State Government, Sagarmala Development Corporation etc. The exact composition of SPV and the % share of the entities could be decided once the decision to go ahead with the project is taken. The following shall be modalities for development under this option:

1. The basic infrastructure in terms of Breakwaters, capital dredging, reclamation, access rail and road, water and power connection, harbour crafts etc. shall be arranged by SPV. Apart from that, the SPV shall also be responsible providing external rail and road connectivity to port including any land acquisition for connectivity and port development. In addition SPV shall also be 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 authorities and administering subleases for the various marine terminals leased to users, terminal operators as applicable.
2. The cargo handling terminals and associated facilities comprising of berths, stackyard development, equipment, utilities etc. will be developed with private participation on PPP mode. PPP Concessionaire would be responsible for terminal operations and maintenance and sharing of its revenue with SPV as per the concession agreement.

In the proposed implementation model the cost split between the project proponents and the terminal operators is estimated as below in **Table 10.1**:

Table 10.1 Estimated Cost Split

A. Port Development Cost Only

S. No.	Item	SPV	Concessionaire	Total
1.	Project Preliminaries and Site Development	18	12	30
2.	Dredging	327	-	327
3.	Reclamation	129	13	142
4.	Breakwater	426	-	426
5.	Berths	-	353	353
6.	Buildings	20	9	29
7.	Stackyard and Other Backup Area	-	48	48
8.	Internal Roads and Railway	25	25	50
9.	Equipment	-	677	677
10.	Utilities and Others	82	84	166
11.	Navigational Aids	8	-	8
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**1,036**	**1,221**	**2,256**
13.	Contingencies @ 10%	104	122	226
14.	Engineering and Project Management @ 5%	52	61	113
Capital Cost of Phase 1 Port Development (Rs. In Crores)		**1,191**	**1,404**	**2,595**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	SPV	Concessionaire	Total
1.	**Port Development Cost**	**1,191**	**1,404**	**2,595**
2.	**External connectivity including land acquisition**			
	Rail	**110**	-	**110**
	Road	**115**	-	**115**
	Total Cost (INR in Crores)	**1,416**	**1,404**	**2,820**

For the limiting project IRR of 15% for the PPP operator, he can share maximum 36% of revenue with the SPV. Basis this revenue an overall IRR of about 9.9% for SPV is estimated which is though low but could still be manageable in case SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall reduce. This could be worked out in during project structuring to be carried out at DPR stage.

11.0 WAY FORWARD

With the projected traffic, there is a strong case for development of port at Belekeri on landlord model. However the entire port development is dependent on the completion of Hubli Ankola rail link. It is also suggested that the proposed Hubli Ankola Rail link be extended till Belekeri as a single project to get synergy and also provide competitive multi-modal transport to the destination. It is further proposed that all efforts must be directed to get environmental clearance for this connecting rail link before undertaking any further study or work for the proposed port.

In case it is decided to pursue the project, the following action plan is recommended:

1. The current road blocks to the completion of development of Hubli Ankola rail need to be removed with active participation from State and Central government.
2. An SPV for development of the port may be formed.
3. Once it is certain that Hubli Ankola rail link would be completed in a given time frame start for the process of port development by initially appointing a consultant for preparation of detailed project report.
4. The detailed project report shall use the present TEFR as a base document and refine it further by:
    a. Carrying out marine geotechnical investigations
    b. Real Time Ship Navigational Studies
    c. Engineering of the Marine Structures, material handling system and onshore infrastructure to further refine the cost estimates
    d. Two and three dimensional model studies for design of breakwaters.
    e. Mathematical model studies on the updated layout, if any, for further optimisation. Apart from that model studies for dispersal of dredged plume at the proposed disposal site would be needed as per the requirement of MoEF.
    f. Updated financial analysis
5. Approvals from SFC/ EFC/ PIB/ PPPAC/ CCEA
6. Preparation of EIA report and approval of MoEF
7. Preparation of tender documents for Selection of contractors for the works to be undertaken by project proponents (PPT)
8. Start the construction of Breakwaters, reclamation, dredging and basic onshore infrastructure
9. Selection of Transaction Advisor and bidding for the selection of operator(s) for the terminal development
10. Terminal development works by the BOT operator

11. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

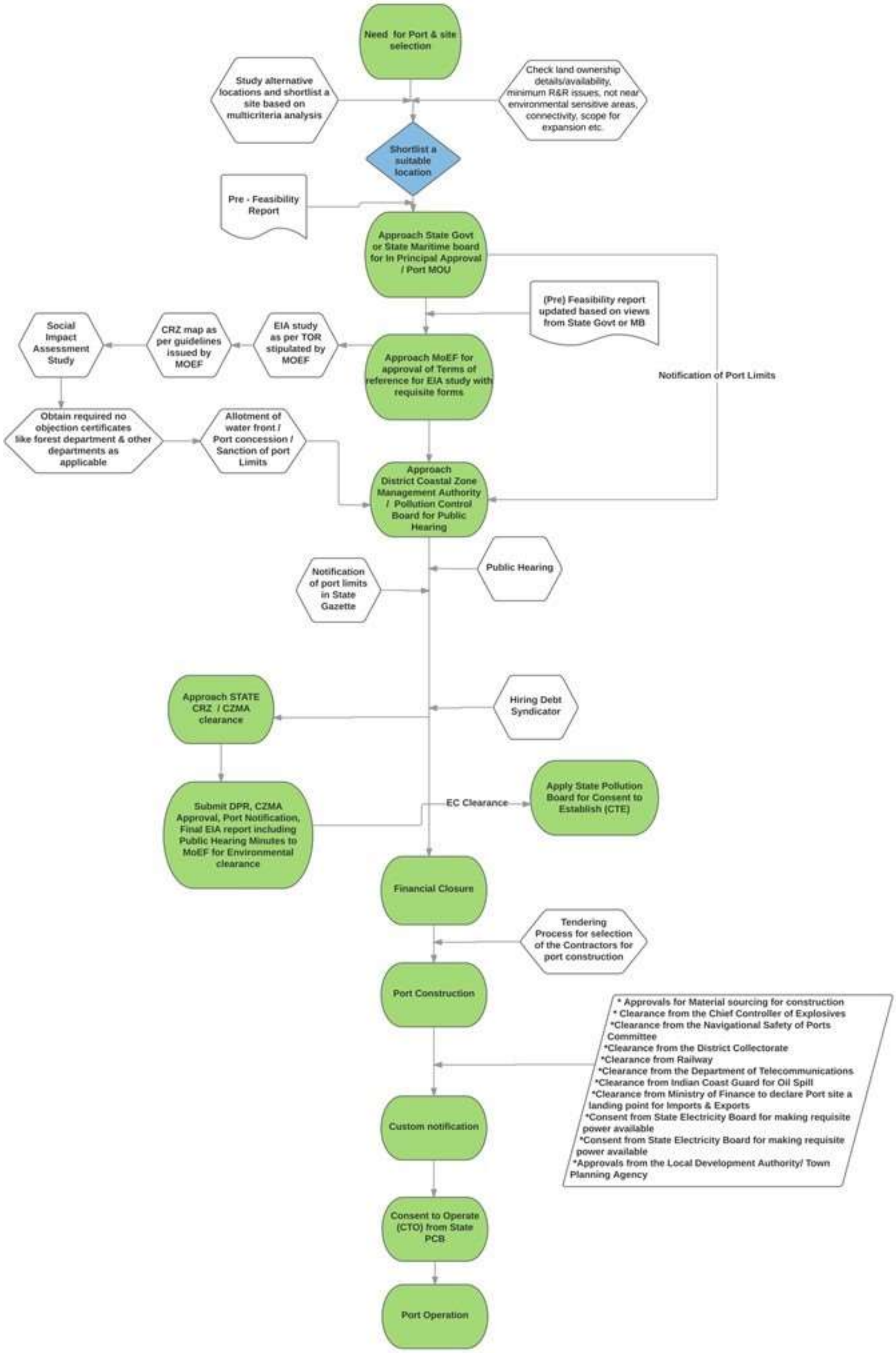

Figure 11.1 Process for the Greenfield Port Development

Techno-Economic Feasibility Report for Development of Port at Sagar Island

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Ministry of Shipping / Indian Ports Association

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EXECUTIVE SUMMARY

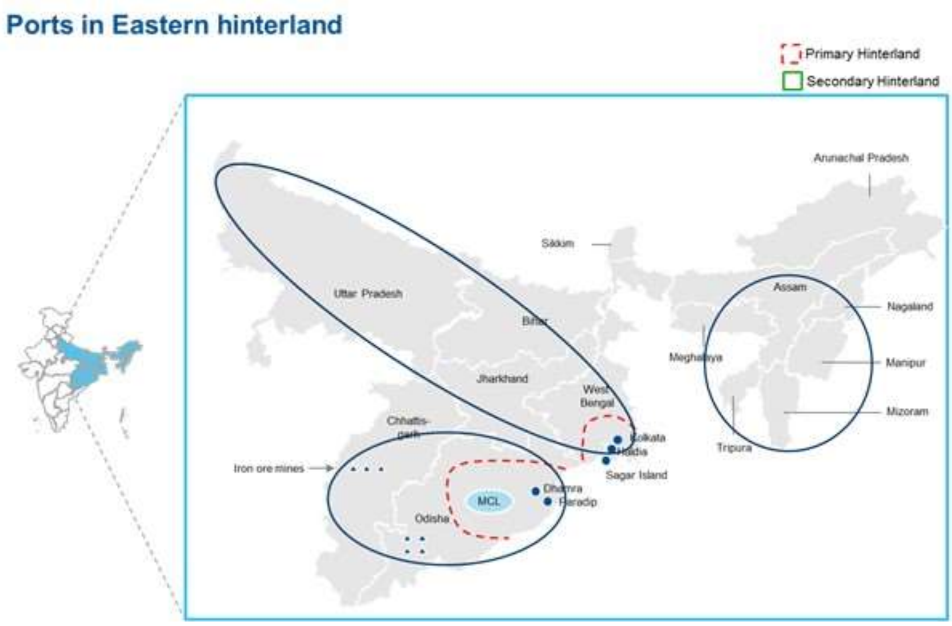
Introduction

Currently, the Haldia Dock Complex and the Kolkata dock handle cargo traffic of around 41 MTPA, primarily thermal coal, coking coal, POL and general cargo from the hinterland. The ports/docks have been facing the challenges in terms of draft limitations, limited headroom for expansion and efficiency. These serious constraints at the ports of Kolkata & Haldia has necessitated the need to look for a new port nearer to the sea, avoiding long river navigation with limitations in draft due to high dredging costs.

The Sagar Island has been selected for a detailed study for locating a mega port. The Sagar Island is the southernmost Island of the Hooghly Estuary and forms one of the biggest deltas in Sunderban group. It is located 100 km downstream of Kolkata and separated by Muriganga River from mainland. The island is 30 km in length and has a maximum width of 12 km. Presently there is no rail-road connectivity to Sagar Island with the mainland and rail-cum-road bridge across the Muriganga River has been proposed to provide connectivity.

Traffic Projections for the Proposed Port

A port in Sagar will share the hinterland of the Haldia and Kolkata ports, particularly the power and steel plants in the eastern region, and containers from the eastern parts of India (Western UP, Odisha, Jharkhand, Chhattisgarh, etc.) and neighbouring landlocked countries – Nepal and Bhutan.



According to the landed-cost analysis of the imported cargo for bulk, the natural ownership of cargo for the Sagar port is limited due to the proximity of the Haldia, Paradip and Dhamra ports to plants in the hinterland and the established evacuation infrastructure as could be seen from the above figure.

Analysis reveals that while Sagar port does not come out as the cheapest port of call for any of the existing steel and upcoming power plants, the landed cost of coking coal/ thermal coal at Sagar port is only marginally expensive in case of a 9 m draft (Sub- panamax vessel). In case of 13.5 m draft Sagar port becomes comparable to Haldia port in landed cost. Thus, Sagar port can become a viable alternative to serve as for spill-over cargo, specifically non-POL bulk from the Haldia dock complex.

Containers will be the major cargo commodity handled at the Sagar port. This is primarily due the paucity of capacity and the inability to expand the Haldia and Kolkata ports, which is causing an overflow of containers that can be handled at the Sagar port.

The traffic for the Sagar port is projected to be around 3.5 MTPA in 2020 increasing to around 27 MTPA in 2035.

Port Development Plan

It is assessed that at Sagar anchorage an additional draft ranging from 1.4 m to over 2.0 m is available as compared to Haldia and Kolkata Ports respectively. Accordingly the phasing of dredging for Sagar port has been proposed as given below:

Phase 1 - To handle vessels with draft of 9.0 m with tidal advantage

Ultimate Phase - To handle vessels with draft of 13.5 m with tidal advantage

The vessel size for Phase 1 is carefully chosen so that no capital dredging is needed in the long eastern approach channel. This would still enable carrying about 30,000 T of parcel size of bulk in panamax ships round the year with minimum waiting time. The recommended port master plan layout is as shown in **Figure** below.

It is imperative that the road bridge is built before the Sagar port is made operational i.e. by year 2020. The rail connectivity is assumed to be provided by Phase 2 development of the port i.e. year 2025.

State of the art material handling system shall be provided to ensure faster turnaround of ships. In the Phase 1 a 600 m quay length is provided which shall go upto 2000 m in the master plan phase.

The recommended port master plan layout is shown in **Figure** below and it shall be developed in various phases as per the built up of traffic. The entire area for port operations and storage shall be created by way of reclamation. It is proposed to reclaim an area of 96 Ha in Phase 1 and that 197 Ha in master plan stage of the port. The engineering for the major port facilities such as dredging and reclamation, Revetment, berths, material handling system has been carried out in compliance with the applicable codes and standards.

The width of eastern channel navigational channel is proposed to be 450 m and that for Sagar channel is proposed as 400 m to allow two-way navigation of ships.

Cost Estimates

The capital cost of overall port development upto the master plan phase is expected to be INR 5,971 crores. The capital cost for Phase 1 development is expected to be INR 1,161 crores. The major exclusions in cost estimates are Road and Rail Bridge across river Muriganga, External linkages for rail, road beyond river Muriganga, Cost of land acquisition, Financing and Interest Costs.

Financial Appraisal

The base case traffic of container and break bulk overflow from Kolkata port has been considered to calculate the financial viability of the project. The project IRR was worked out for various scenarios of development and it is observed that the scenario where the port development is limited to Phase 1 works out to be the most financially viable option. It is therefore recommended that only the infrastructure of Phase 1 as suggested in this TEFR is built for now (at total capital investment of INR 1,161 crores) and traffic handling capacity be limited based on the infrastructure developed in Phase 1.

The project is recommended to be developed as per Landlord model, wherein the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the Special Purpose Vehicle (SPV) between KoPT and Govt. of West Bengal, at total estimated cost of INR 421.85 crores funded by a multilateral loan at 5% payable over 15 years. PPP concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc. at an estimated cost of INR 739 crores.

It is assessed that the Concessionaire shall provide the revenue share to SPV to cover debt servicing of multilateral loan (interest and repayment) and O&M costs borne by SPV. With an assumed 70:30 Debt/Equity ratio at 12% cost of debt and 20% VGF, the Concessionaire has an estimated pre-tax equity IRR of about 16.31%.

Recommendations

It is recommended that initially Phase 1 of the project be built under landlord model as per the details mentioned in financial appraisal in para above.

The following are the key enablers for the success of Sagar Port:

- Limiting Greenfield investments in Haldia port complex; to create overflow for Sagar Port
- No expansion in container handling capacity at Kolkata Dock Systems
- Guaranteed Viability Gap Funding of minimum 20% from the State/Central Govt.
- Road connectivity to the port and bridge at River Muriganga to be constructed before port becoming operational
- Land Acquisition for rail, rail connectivity and offsite rail yard
- Establishment of industrial cluster/hinterland near Sagar port for enabling cargo flow
- Widening of NH-117 for road connectivity
- Expansion of mainland railway connectivity from Kashinagar to main routes

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 economies 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 Port 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 by 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.

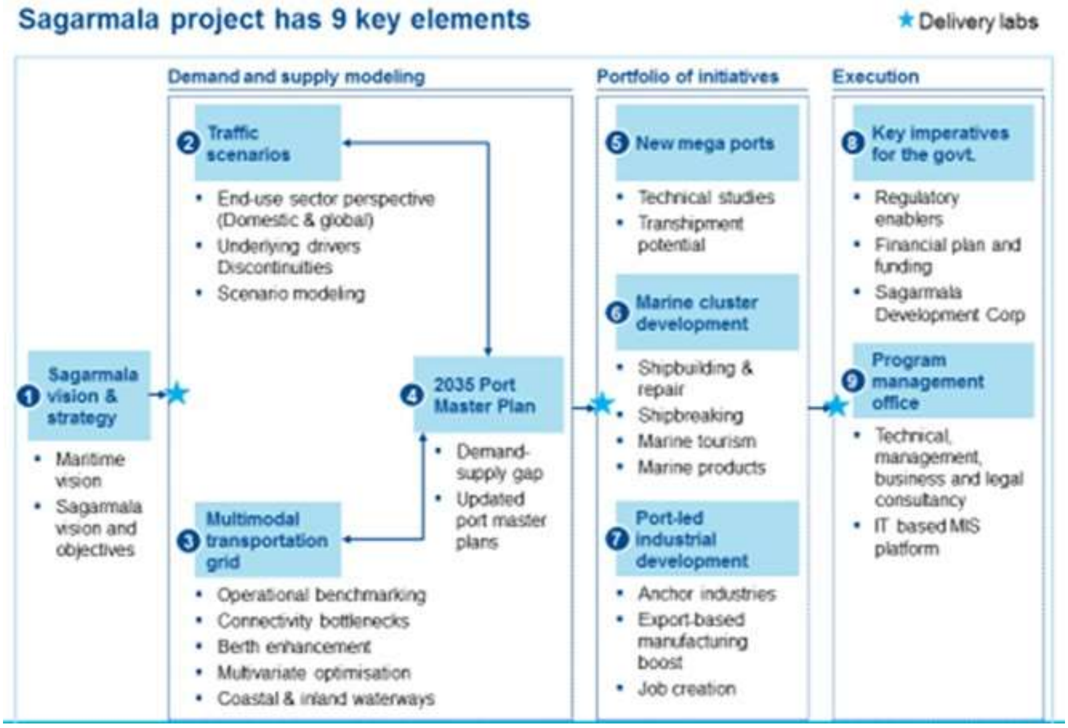


Figure 1.2 **Governing Principles of our Approach**

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 Sagar Island

1.3.1 General

At present Haldia port and Kolkata port are the only ports in West Bengal handling significant cargo. They share the same navigational facilities and are under the management of KoPT. These ports serve the vast hinterland in northeast India. However, both are riverine ports located along the Hooghly River at a distance of 121 km and 232 km from respectively from the sea. Hence, they are severely constrained by the reduced parcel size of the vessels due to the limited water depths in the long approach channel, which are being maintained after significant annual dredging.

1.3.2 Limitations of Haldia/Kolkata Port

The port of Haldia is a Riverine port and the designated berths for bulk cargo are located within the impounded dock system. The entrance to the dock system is controlled by lock gates and the river passage of 70 nautical miles from the sea known as SANDHEADS is governed by the available draft depending on the tide of the day and is negotiated under the guidance of port pilots.

The pilotage distance to Haldia is 121 km comprising 46 km of river and 75 km of sea pilotage. The Port maintains a pilot Vessel/Station at Sagar Roads. The River Pilot embarks on inwards bound vessels at Middleton Point and proceeds up the river. At Haldia the pilot bringing the vessel from Middleton point hands over the vessel at the lock entrance to the Berthing Master but all vessels bound for oil jetties are taken alongside by the same Pilot. The following constraints are notice at the Haldia Port:

- Average river draft gradually falling over the last few years, resulting in reduced parcel size of ships with increased operating costs
- Reduced parcel sizes result in increased number of ships for the same cargo traffic causing congestion at the lock gates
- Port has limitations in handling bigger ships due to navigational constraints and draft limitations.
- High annual maintenance dredging costs for maintaining the channel

Kolkata Port, which is still farther away from the sea, is also facing similar constraints on account of smaller parcel sizes and high costs of maintenance dredging.

1.3.3 Need for a New Port

The aforesaid serious constraints at the ports of Kolkata & Haldia has necessitated the need to look for a new port nearer to the sea, avoiding long river navigation with limitations in draft due to high dredging costs.

The idea of a deep-draft port in West Bengal was floated in 2010, and a Feasibility Report was completed by RITES in 2012. Sagar was suggested as a complementary location for Kolkata Port Trust. Subsequently the state government and the Centre for development have signed a memorandum of understanding for a new port in West Bengal.

Accordingly, the Sagar Island has been selected for a detailed study for locating the new port.

1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for development of the port at Sagar Island, West Bengal. This report is organised in the following sections:

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

2.0 Site Conditions

2.1 Alternative Sites Considered

Three sites were considered for the proposed new port development in West Bengal.

- Digha
- Rasulpur and
- Sagar

These site locations are as shown in the **Figure 2.1**.

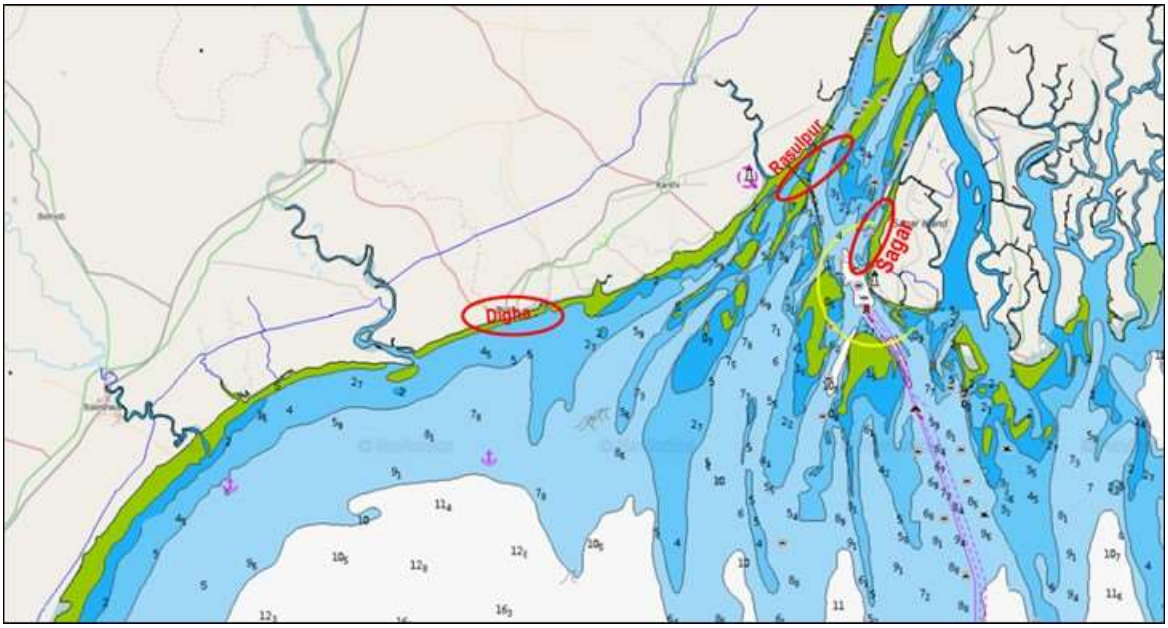


Figure 2.1 Prospective Site Locations

These sites were evaluated based on the available site data for the following parameters:

- Technical suitability for port development
- Hinterland connectivity
- Capital and Maintenance costs of development
- Potential for expansion to cater to bigger vessels
- Time for construction
- Environmental aspects

The comparison and site evaluation was carried out considering the various factors and the outcome of the evaluation is given in **Figure 2.2**.

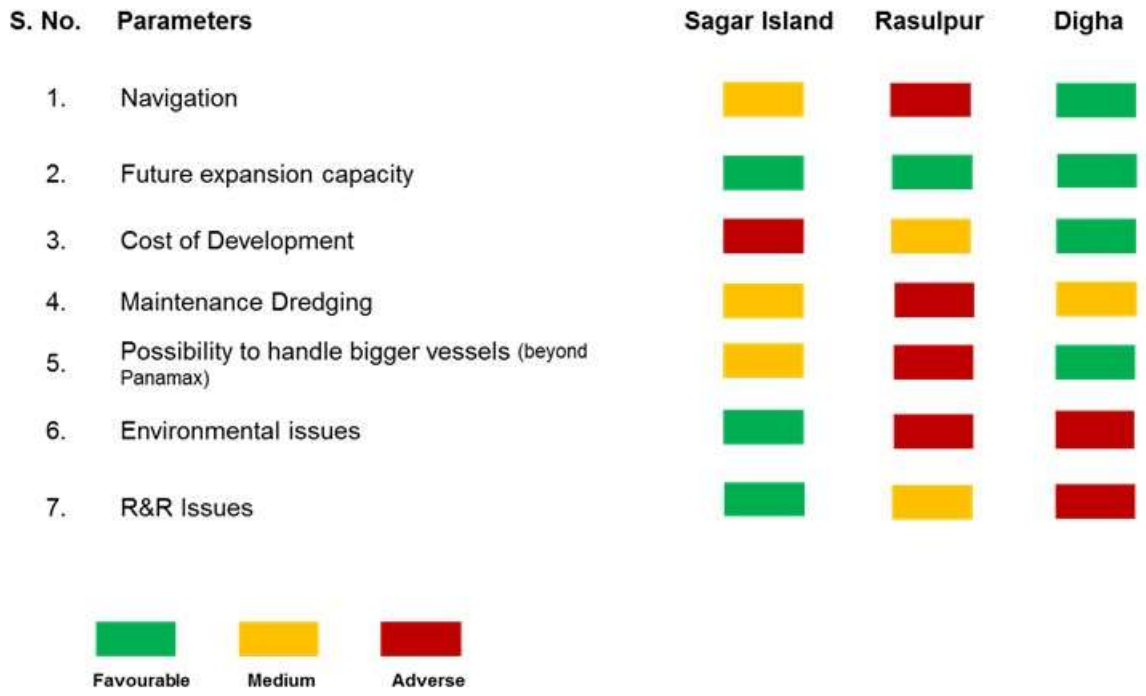


Figure 2.2 **Multicriteria Analysis of Alternative Locations**

While the site at Digha might be better from the technical aspects, due to associated serious environmental and R&R issues it is not preferred site for port development. The port site at Sagar scores better than at Rasulpur and Digha on overall considerations for technical, environmental and financial parameters and thus selected for further detailed evaluation.

2.2 Port Location at Sagar Island

The Sagar Island is the southernmost Island of the Hooghly Estuary and forms one of the biggest deltas in Sunderban group. It is located 100 km downstream of Kolkata and separated by Baratola River / channel creek /Buriganga River from main land. On the north is Ghoramara Island. On west side is Bedford channel while on southern side are sand heads of Hooghly River. The Sagar Island can presently be accessed by ferry only from Harwood point to Kachubaria having an approximate distance of 3.5 km. The island is 30 km in length and has a maximum width of 12 km.

The location plan of proposed Sagar Port is shown in **Figure 2.3**.

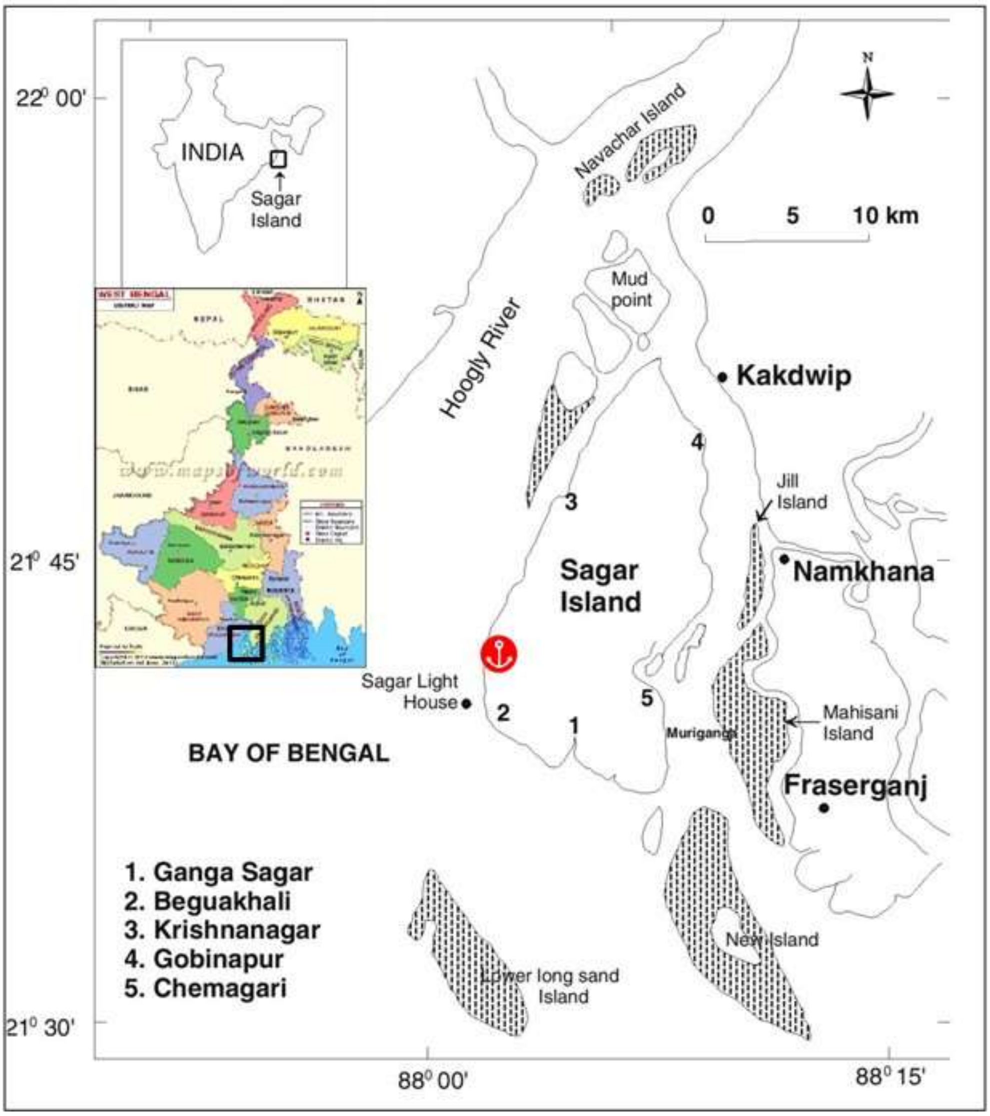


Figure 2.3 Location of Sagar Island in West Bengal

Two sites (Site A and Site B) were considered by RITES in their study along the western bank of the island (**Figure 2.4**) to carry out the port site evaluation based on factors such as,

- wave tranquillity,
- availability of adequate back up area for port infrastructure,
- proximity of deep water contour,
- magnitude of tidal window etc.

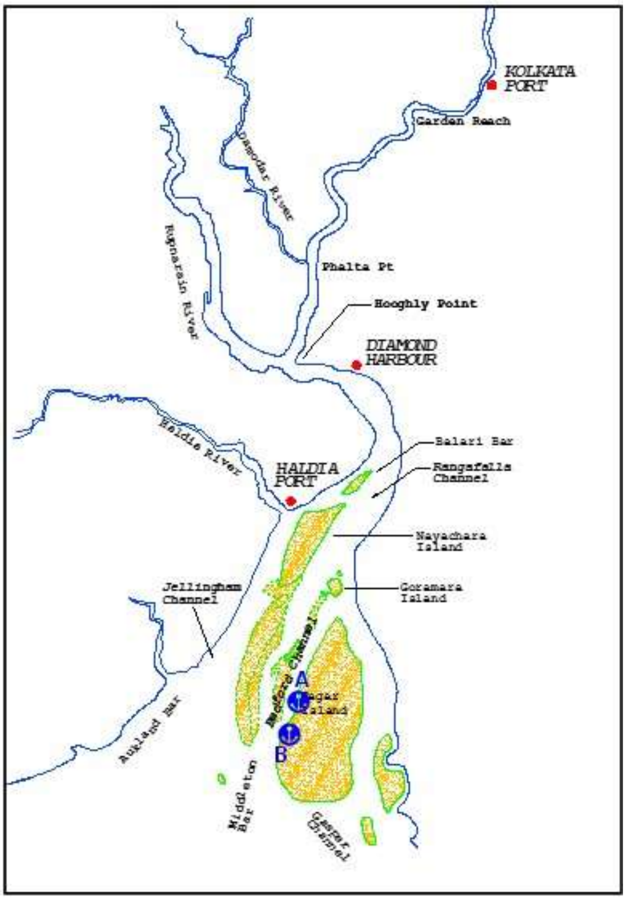
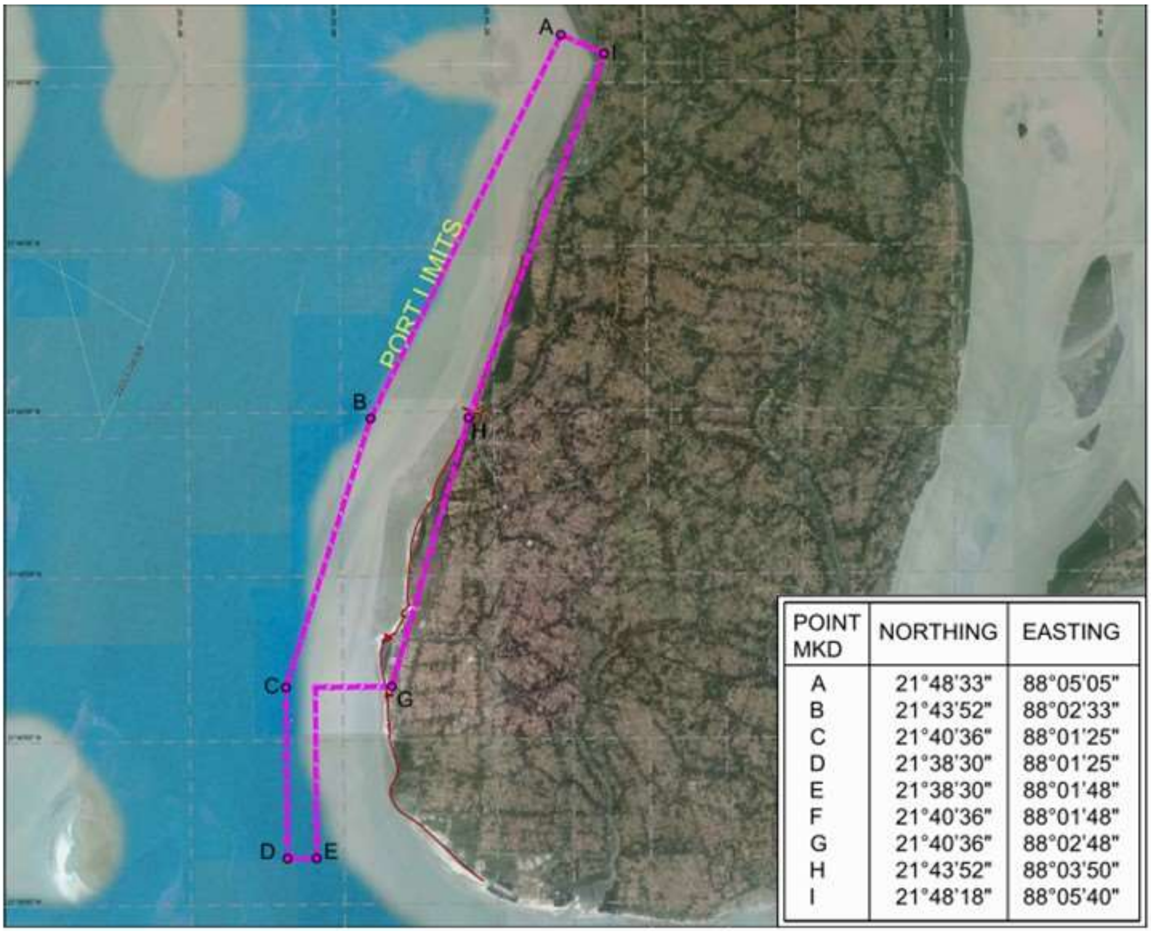


Figure 2.4 **Port Development Locations (Site A & B) at Sagar**

Based on these parameters, the Site B area at the south of Sagar Island was preferred for the port development.

The proposed port limits for Sagar port are as shown below.



POINT MKD	NORTHING	EASTING
A	21°48'33"	88°05'05"
B	21°43'52"	88°02'33"
C	21°40'36"	88°01'25"
D	21°38'30"	88°01'25"
E	21°38'30"	88°01'48"
F	21°40'36"	88°01'48"
G	21°40'36"	88°02'48"
H	21°43'52"	88°03'50"
I	21°48'18"	88°05'40"

Figure 2.5 Existing and Proposed Port Limit of Sagar

2.3 Field Survey and Investigations for Sagar Port Development

For planning of the port facilities, RITES in 2011 conducted the following surveys and investigations at Sagar Island as part of the Techno-economic feasibility studies. The following surveys and investigations were conducted both on the western as well as the eastern fringe of the island.

- Hydrographic and Hydraulic survey
- Topographic survey
- Geotechnical Investigation
- Wind and Wave measurements

2.4 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.

2.5 Meteorological Data

2.5.1 Wind

Wind data were measured in the months of May, June, July and August in 2011 at the location (21° 37' 59.53" Lat. and 88° 07'03.50" Long.). The data were analysed and the wind rose diagrams from May 2011 to August 2011 are presented in **Figure 2.6**. Predominant wind directions at the location are from the sector between WNW to SW with average wind speed of about 6m/s to 8m/s.

During southwest monsoon, winds are from SW, SSW and S with maximum speed of 68 km/hr, while northeast monsoon winds are from N, NNE with maximum wind up to 50 km/hr. During non-monsoon season, winds are from SSW, S, SSE and SE with maximum wind speed of 54 km/hr.

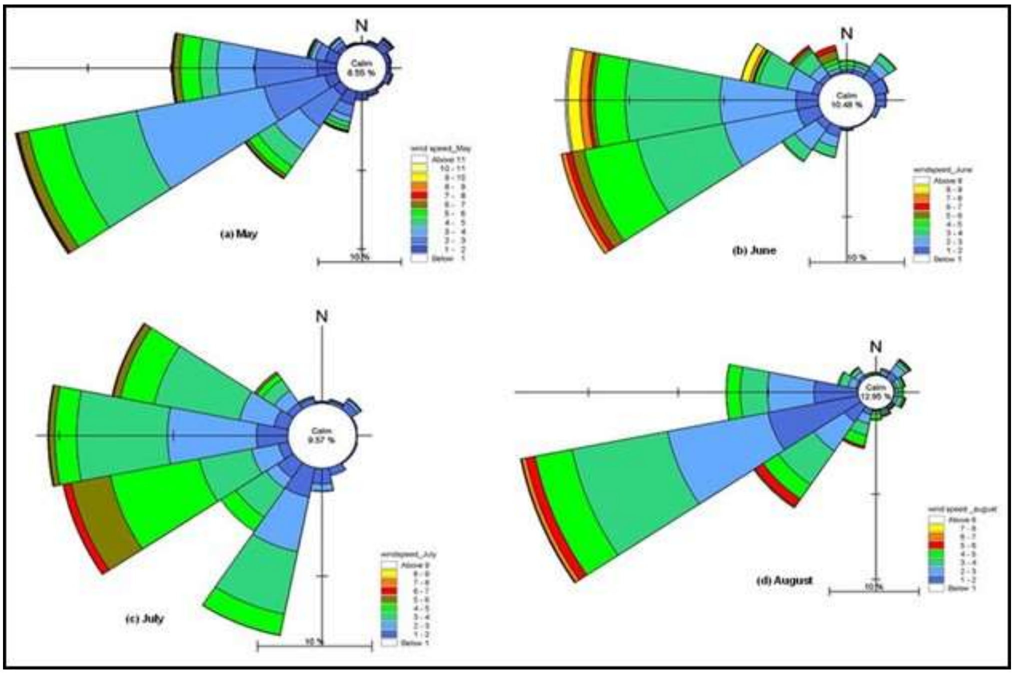


Figure 2.6 Measured Wind Rose Diagram in May to August 2011

Sagar Island experiences a mean annual wind speed of 8.24 km/ hr. Maximum wind speed was observed in April (13.2 km/hr), while minimum wind speed was observed in November (4.51 km/hr).

2.5.2 Rainfall

As per the study of 1982-2010 data done for Sagar island area, it receives annual rainfall of 1735.9mm. Maximum, minimum and mean rainfall distribution is as per the **Table 2.1** shown below.

Table 2.1 Rainfall data of Sagar Island 1982-2010

Month	Maximum	Minimum	Mean
January	87.60	0.10	11.44
February	72.1	1.00	20.74
March	271.7	0.40	21.39
April	163.3	1.10	40.44
May	471.2	1.00	121.12
June	363.3	0.80	251.24
July	700.5	134.9	372.51
August	380.5	101.8	303.64
September	741.8	78.8	344.27
October	498.1	24.2	182.85
November	307.7	0.40	61.44
December	33.2	0.10	4.84

2.5.3 Temperature

As per study of climate data between 1982 – 2010, average monthly temperature was highest during May (29.8°C), and lowest in January (20.43°C). Mean (of 29 years) maximum and minimum temperatures recorded were 33°C (in May) and 22°C (in January).

The highest maximum temperature experienced by the island was 43.1°C (June 2010), and the lowest minimum temperature was 11.6°C (January 2010).

2.5.4 Relative Humidity

Relative humidity is generally high and rises to about 87% during the monsoons in the month of August.

2.5.5 Visibility

Throughout the year visibility is good except during rains and squalls, the visibility deteriorates. While navigation in channel gets affected rarely, berthing of vessels may not be possible for about 10 days in a year.

2.6 Site Seismicity

The site is in Zone IV of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a high risk seismic intensity zone.

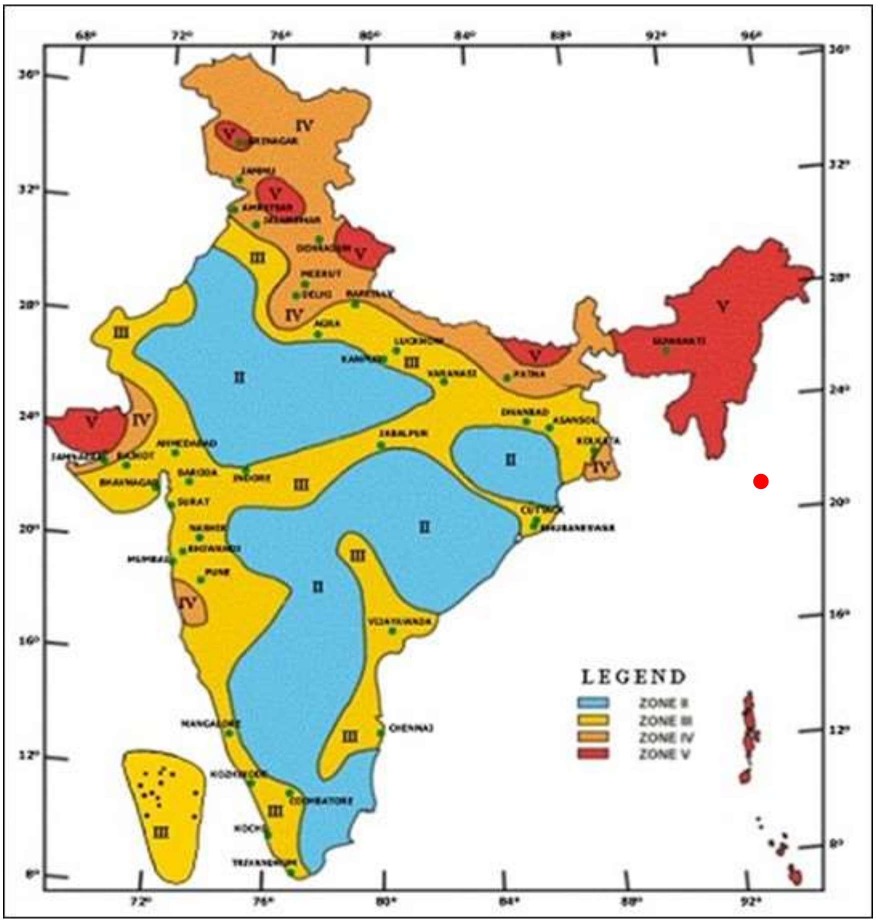


Figure 2.7 Seismic map of India as per IS-1893 Part 1-2002

2.7 Oceanographic Information

2.7.1 Bathymetry

Sagar Island is separated from the mainland by two channels with Jellingham channel on the west and Rangafalla channel on the east. Deep drafts are available along the southern tip and midstream lighterage operation of ships is being carried out at Sagar Anchorage for the last 40 years. Towards the western side of the waterfront of the proposed port location, natural water depth of about 8.0 to 10m below chart datum exists.

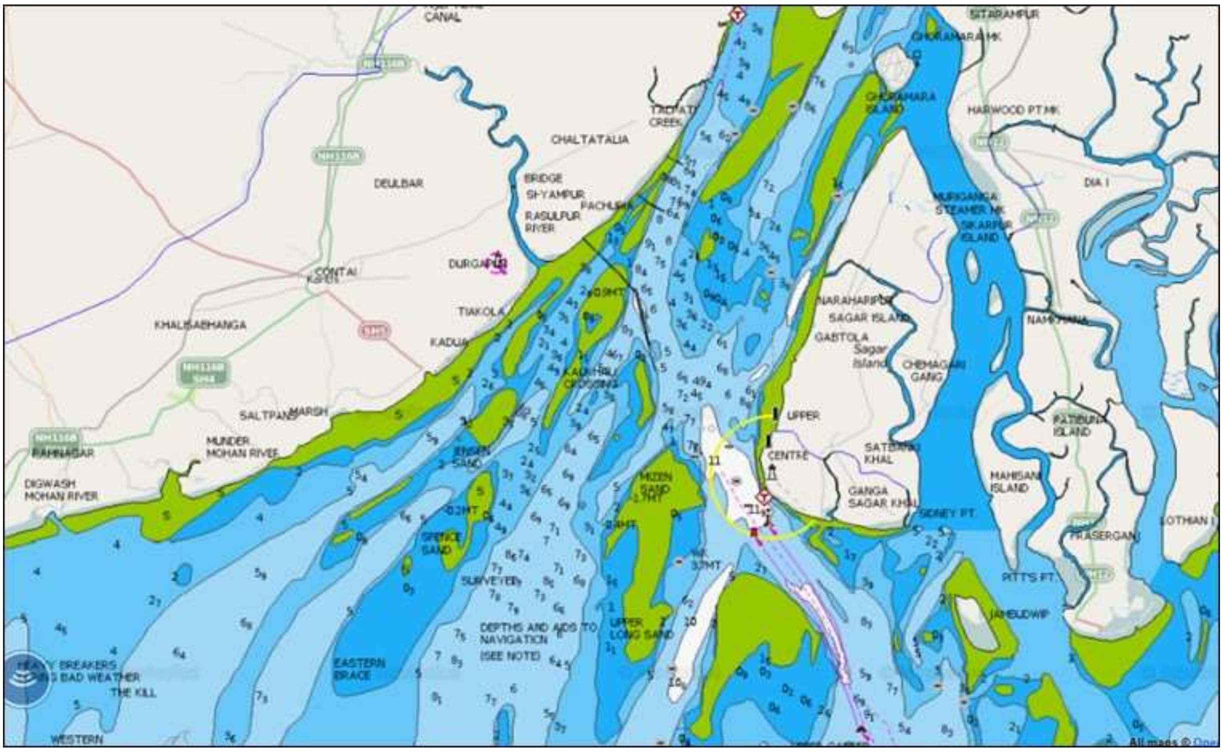


Figure 2.8 **Sagar Island Bathymetry Information**

The hydrographic survey data for the western fringe of Sagar Island is being collected by Kolkata Port Trust periodically. The hydrographic survey chart is presented in **Figure 2.9**.

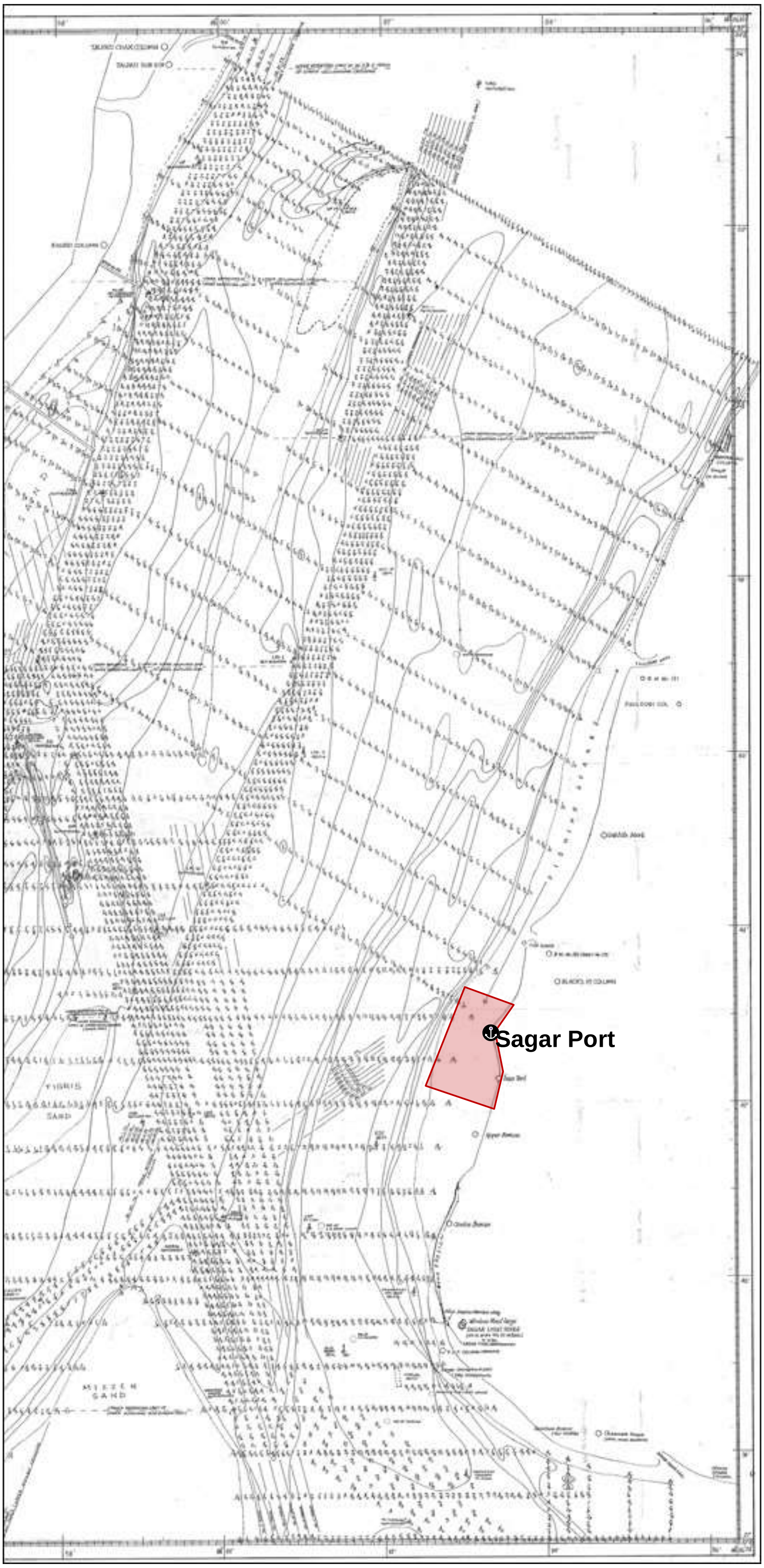


Figure 2.9 Hydrographic Chart provided by KoPT

2.7.2 Waves

2.7.2.1 Offshore Wave Data

The offshore wave data reported by India Meteorological Department (IMD) as observed from ships plying in deep waters off Sagar (Latitude 20° N to 25°N, Longitude 85°E to 95°E) for 33 years from 1968 to 2001 were analysed. The frequency distribution of wave heights from different directions during different seasons and entire year for the above offshore data were presented in the form of the wave rose diagrams presented in **Figure 2.10**. It is seen from the deep water data that the predominant wave directions in the deep sea off Sagar are from WSW to SSE. It may be noted that the wave height based on ship observed data closely corresponds to significant wave height, which represents average energy of the random wave train.

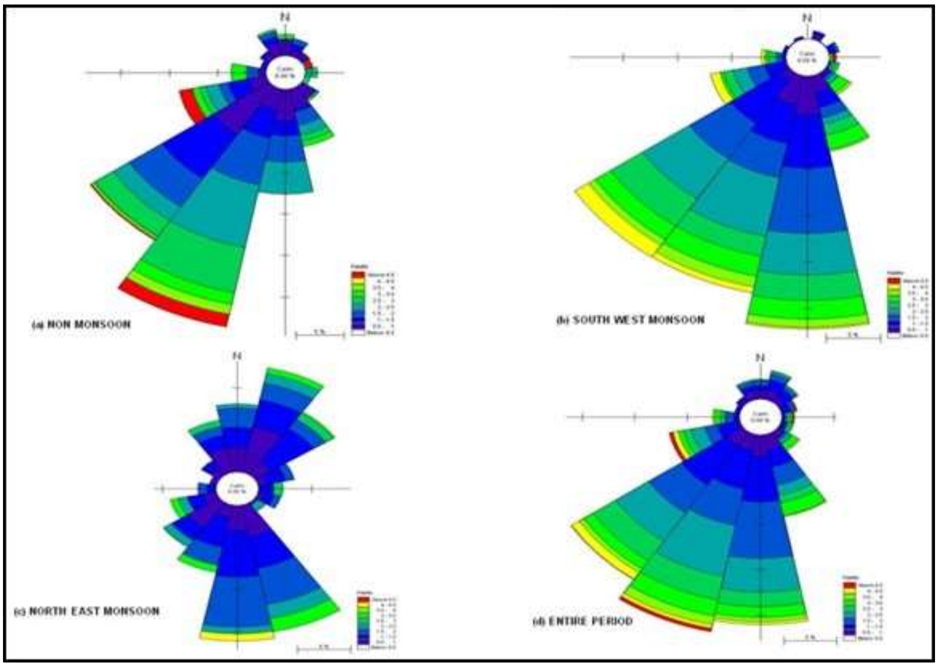


Figure 2.10 Offshore Wave Rose Diagrams

2.7.2.2 Measured Wave Data

The wave data were measured for months of June, July and August 2011. The results are presented in **Table 2.2** below:

Table 2.2 Percentage Occurrence of Measured Wave Heights (m) during SW Monsoon

Month	Significant Wave height (m)		
	0.0 - 0.5	0.5 - 1.0	1.0 - 1.5
June	82.97	17.03	0
July	77.26	22.74	0
August	67.77	32.08	1.14

2.7.2.3 Nearshore Wave Transformation

As waves travel from deep sea to shallow coastal waters, they undergo changes in direction and height due to the processes of refraction and shoaling. MIKE21 SW models is a spectral wind wave model based on unstructured mesh and it simulates the growth, decay and transformation of wind – generated waves and swell in offshore and coastal areas. In the present case, MIKE21 SW was used to assess these transformations of offshore wave conditions to the proposed port location.

The offshore data reported by India Meteorological Department (IMD) as observed from ships plying in deep waters off Sagar (Latitude 20° N to 25° N, Longitude 85° E to 95° E) for 33 years from 1968 to 2001 were analysed and used as input to the model. In addition, wave data collected on the southern tip of Sagar Island for months of June, July and August 2011 was also considered for the study.

The analyses of the offshore data suggested that the predominant wave directions in the deep sea off Sagar are from WSW to SSE (**Table 2.3**).

Table 2.3 Percentage Occurrence of Wave Height & Direction off Sagar Island for Entire Period (Jan-Dec)

Height (m)	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	TOTAL
DIRECTION								**CALM**	**%**	**5.47**
22.50	1.13	1.02	0.59	0.25	0.00	0.14	0.00	0.00	0.00	3.14
45.00	0.58	1.06	0.33	0.00	0.18	0.04	0.00	0.00	0.02	2.20
67.50	0.18	0.74	0.36	0.00	0.05	0.00	0.00	0.00	0.16	1.50
90.00	0.00	0.31	0.00	0.18	0.31	0.18	0.00	0.00	0.18	1.16
112.50	0.14	0.33	0.14	0.14	0.29	0.14	0.00	0.00	0.00	1.19
135.00	0.67	0.09	0.27	0.43	0.09	0.65	0.18	0.00	0.00	2.39
157.50	1.64	1.78	2.01	1.04	0.82	1.38	0.11	0.00	0.00	8.78
180.00	2.18	4.83	5.95	3.56	1.49	1.13	0.47	0.29	0.00	19.91
202.50	1.72	4.10	3.92	5.43	2.52	1.73	0.95	0.36	0.36	21.09
225.00	1.72	4.99	3.55	3.55	2.5	1.02	0.47	0.85	0.04	18.69
247.50	0.33	1.82	1.10	1.26	0.67	0.51	0.00	0.50	0.33	6.50
270.00	0.18	0.36	0.72	0.13	0.36	0.54	0.00	0.18	0.00	2.48
292.50	0.14	0.29	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.51
315.00	0.43	0.31	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.78
337.50	0.99	0.49	0.4	0.00	0.16	0.05	0.00	0.00	0.00	2.09
360.00	0.90	0.51	0.49	0.11	0.00	0.13	0.00	0.00	0.00	2.13
Total	**12.94**	**23.02**	**19.92**	**16.08**	**9.47**	**7.64**	**2.18**	**2.18**	**1.08**	**100.00**

It is evident from the above analysis that about 95% of the time wave height is less than 3m.

Nearshore wave transformation of the offshore wave conditions was carried out and the results were extracted at every 1000 m at 18 locations opposite the waterfront of Sagar Island, as shown in **Figure 2.11** below.

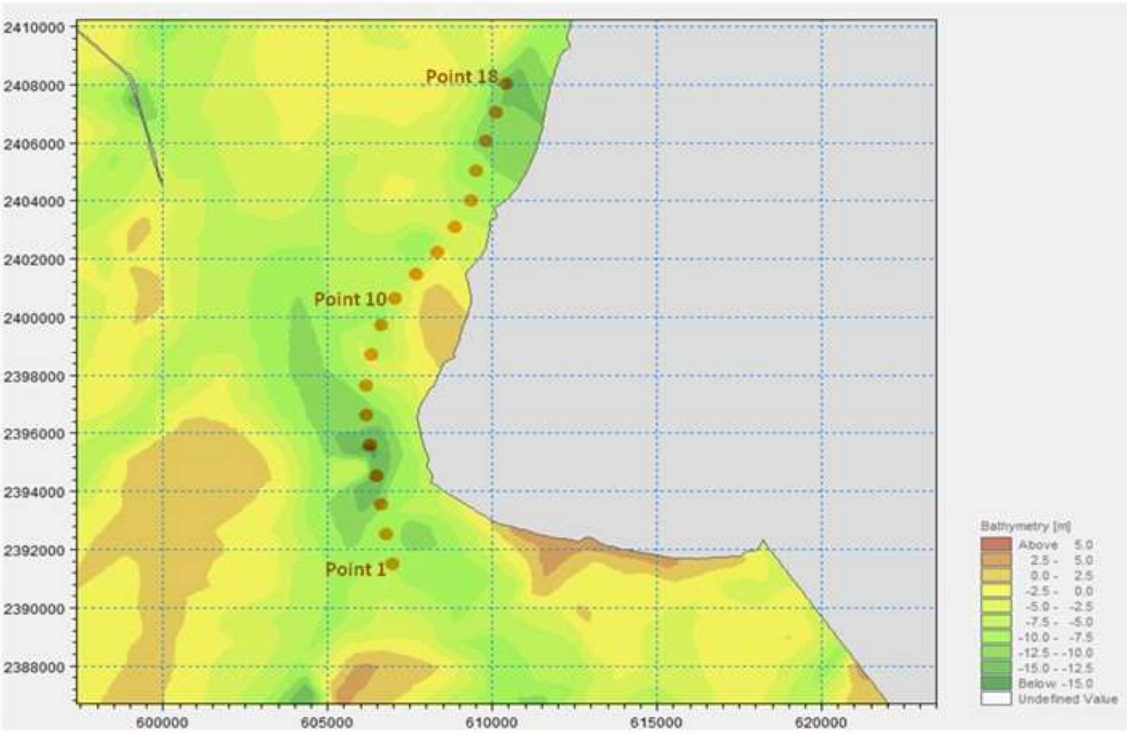


Figure 2.11 Locations of Extraction of Wave Height along the Approach Channel

Points 12 to 15 represent the waterfront of the proposed port location at Sagar Island. Nearshore wave transformation studies were carried out for an offshore wave height of 3 m offshore and the resultant wave heights from various incident directions have been arrived at as presented in **Table 2.4,** below:

Table 2.4 Wave Heights along the Sagar Waterfront with respect to 3 m Offshore Wave Height with High Water from various directions

Locations	Incident Wave from SSE	Incident Wave from S	Incident Wave from SSW	Incident Wave from SW
1	0.62	0.27	0.82	0.77
2	0.64	0.33	0.82	0.78
3	0.66	0.35	0.75	0.76
4	0.66	0.35	0.73	0.75
5	0.66	0.37	0.71	0.77
6	0.65	0.39	0.72	0.78
7	0.64	0.38	0.74	0.77
8	0.56	0.34	0.73	0.77
9	0.50	0.33	0.72	0.76
10	0.41	0.29	0.72	0.73

Locations	Incident Wave from SSE	Incident Wave from S	Incident Wave from SSW	Incident Wave from SW
11	0.32	0.22	0.67	0.66
12	0.27	0.16	0.60	0.59
13	0.26	0.14	0.59	0.57
14	0.25	0.13	0.58	0.56
15	0.25	0.14	0.57	0.55
16	0.24	0.13	0.59	0.54
17	0.23	0.13	0.58	0.55
18	0.22	0.13	0.57	0.54

It is concluded that wave heights at the proposed port location remain below the permissible limits for port operations and the weather downtime would be limited to during the cyclonic events only.

2.7.3 Tides

Tidal and current measurements were carried out continuously a period of 1 lunar month covering the tidal and current time history for a complete tidal cycle. Also, the bed samples and water samples were also collected in order to establish the characteristics of seabed and suspended silt content in the project area.

Tidal levels at Sagar Island are presented in **Table 2.5** as per the NHO chart 301. The levels mentioned below are with respect to Chart Datum (CD).

Table 2.5 Tide levels at Sagar Island

Description	Tide Levels
Mean high water spring	+5.2m CD
Mean high water neap	+3.9m CD
Mean sea level	+3.0m CD
Mean low water neap	+2.2m CD
Mean low water level spring	+0.9m CD

2.7.4 Currents

The current measurements have been carried out at 3 locations using FSI 2D-ACM self-recording current meter. The Current meter flow quest ADCP was lowered at location C1 at water depth of 8.7 m, 2DACM Current meter was lowered at location C2 at the water depth of 9.5 m & the Velport 106 was lowered at location C3 at the water depth of 4.9 m in the survey area. The Current speed in the region varies from 0.01 m/s to 1.15 m/s. The surface currents are found to be higher as compared to the velocities near the bottom.

However the recent measurements undertaken by KoPT at the proposed port location indicate the maximum current speed of about 2.5 m/s.

2.7.5 Water and Bed Samples

The Seawater samples were collected at 56 locations in the open sea. The water samples were collected using Aqua Trap water sampler. The samples collected were analysed for silt, grain size distribution of suspended load and salinity. The samples tested indicated that the water was slightly acidic with a high concentration of dissolved solids.

The coastal areas prone to tidal floods may have acid sulphate soils. Seabed samples were collected at 20 locations using a Van Veen grab sampler. The collected samples were then tested in the laboratory after being dried and sieved.

2.8 Geotechnical Conditions

The field investigations were carried out during June and August 2011 at proposed locations and consist of total 20 nos. of Boreholes. Refer **Figure 2.12** for borehole location map. About 9 boreholes were carried out near the proposed location of the port. The boreholes were terminated at a maximum depth of 30m.

Soil profiles for all the boreholes were developed as shown in **Figure 2.13** and **Figure 2.14** to study the distribution of the sub strata. According to the particle size distribution, the soil in boreholes MBH 1 to 9 consists of mostly silty sand.

Figure 2.12 Topographic and Geotechnical Survey Locations

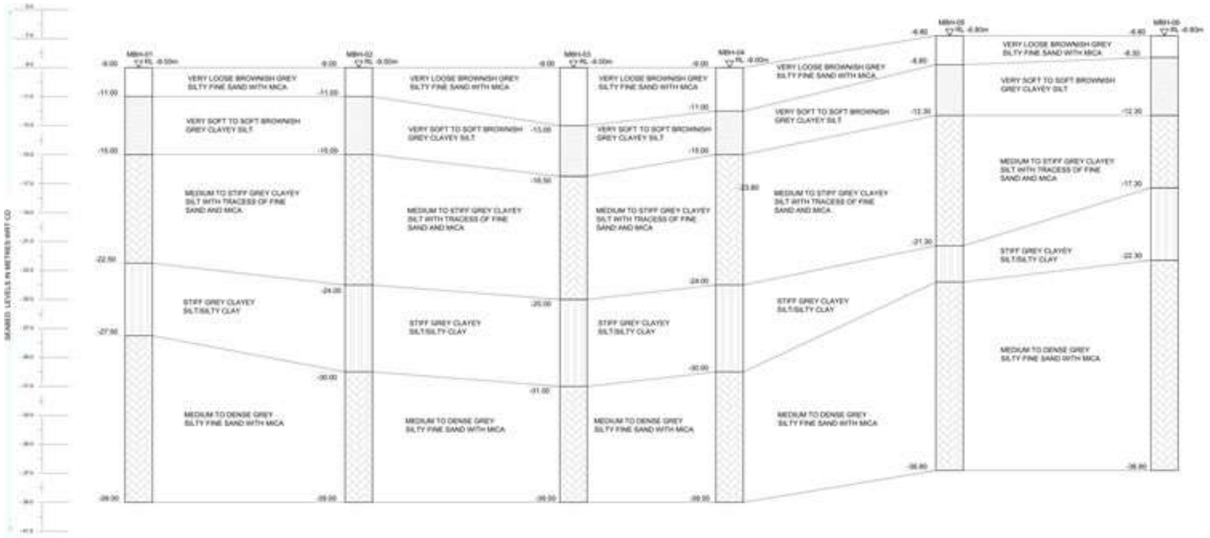


Figure 2.13 Soil Profiles of Boreholes MBH 1 to MBH 6

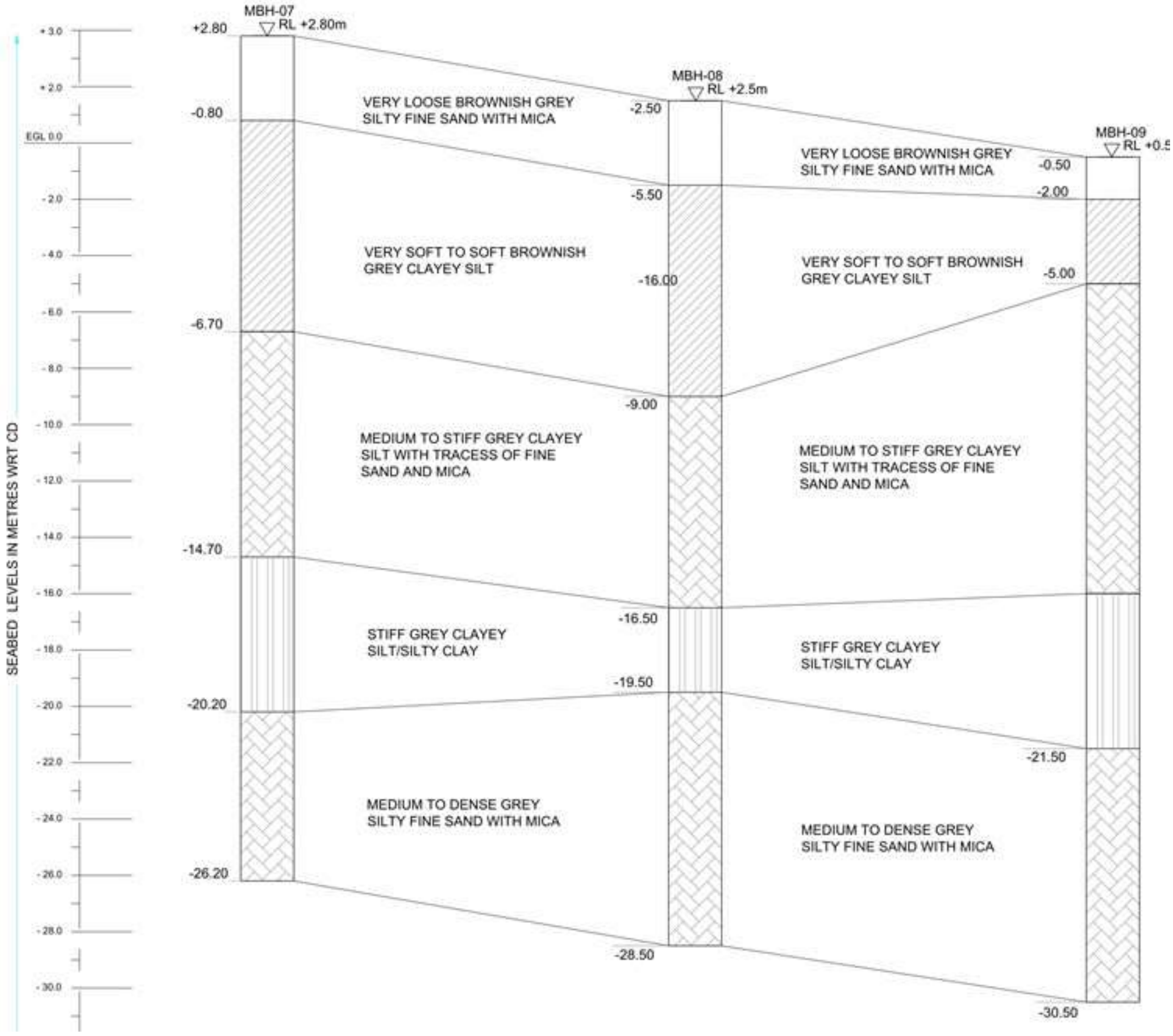


Figure 2.14 Soil Profiles of Boreholes MBH 7 to MBH 9

2.9 Topographic Information

Topographic survey was carried out at project site, covering an area of 4 km^2, by levelling/traversing and mapping. Spot levelling was carried out at a spacing of 50 m.

The topographic survey carried out were presented in the form of topographic survey maps as shown in **Figure 2.15** the elevations are marked WRT, mean sea level, which is (+) 3.00m CD.

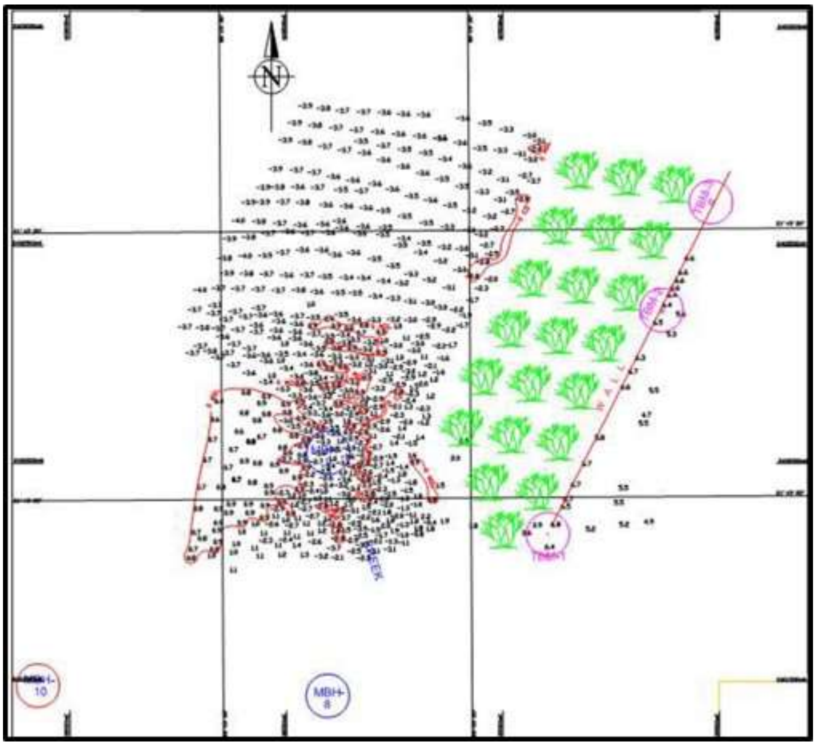


Figure 2.15 Topographic Survey chart

2.10 Connectivity of Port Site

2.10.1 Rail Connectivity

Eastern Railways has taken up the project of Rail connectivity as a feeder route to Eastern Dedicated Freight Corridor (DFC) from Kashinagar to Dankuni. Presently, there is no rail-road connectivity to Sagar Island with the mainland. It will be connected to the mainland by a proposed rail-cum-road bridge across the Muriganga River.

The utilization of the different sections between Dankuni and Namkhana via Dum Dum – Ballygunge - Baruipur and Laxmikantapur, capacity is marginally available between Kankurgachi and Ballygunge section to accommodate additional trains. In rest of the sections the line capacity is saturated and will get further deteriorated in future with the introduction of additional suburban trains. As only EMU rakes are in operation in all the sections, induction of any goods train with higher trailing load shall affect the existing line capacity since suburban trains are quicker in operation. In this context, introduction of any new freight train on this section will require laying of additional tracks throughout the section for carrying the projected traffic generated at the proposed port. Also providing any additional line particularly between Jadavpur and Ballygunge may not be feasible as no spare railway land is available and at the same time the area is thickly populated with residential buildings immediately after the railway boundary. Besides, movement of any additional freight traffic through Dum Dum station may be difficult. Similarly, movement of projected freight trains between Dum Dum and Dankuni may not be possible because no additional track can be laid on this section in view of land constraints and Vivekananda Bridge on river Hooghly. The proposed flyover at Dum Dum shall be mainly used for movement of trains to and from Bongaon section avoiding surface crossing at Dum Dum Junction. Considering these limitations, it would be necessary to plan a new dedicated route for movement of port traffic.

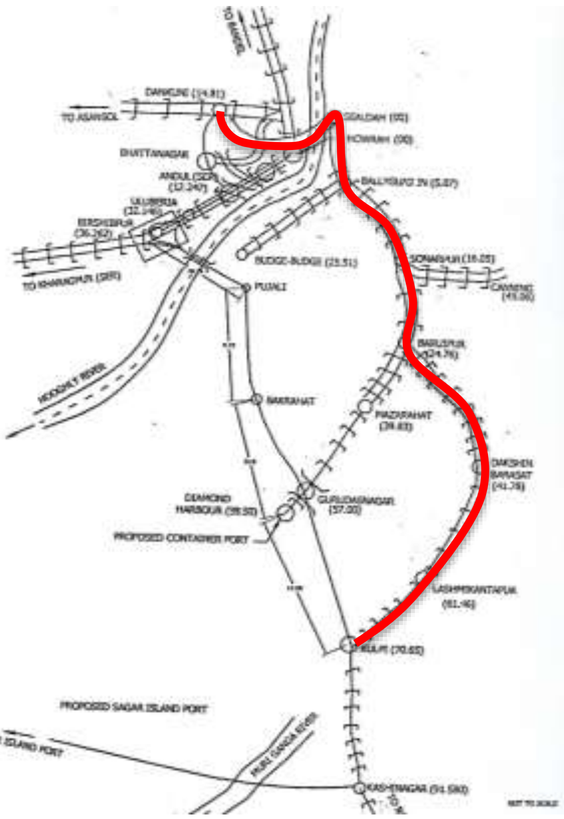


Figure 2.16 **Currently Operating Alignment**

2.10.2 Road Connectivity

NH-117 runs through Kolkata-Diamond harbour – Kulpi – Kakdwip – Namkhana. Sagar Island can be connected with NH-117 near Kakdwip through the proposed bridge across the waterway. Sagar main road which is running from north to south of Sagar Island needs to be widened in order to facilitate the movement of anticipated traffic from/to the Port. In the island, the proposed road connecting the bridge and port location is intersected with Sagar main road, to serve the general public for their movement to main land. **Figure 2.17** shows West Bengal state road connectivity map and Sagar Island location with respect to existing NH-117 alignment.

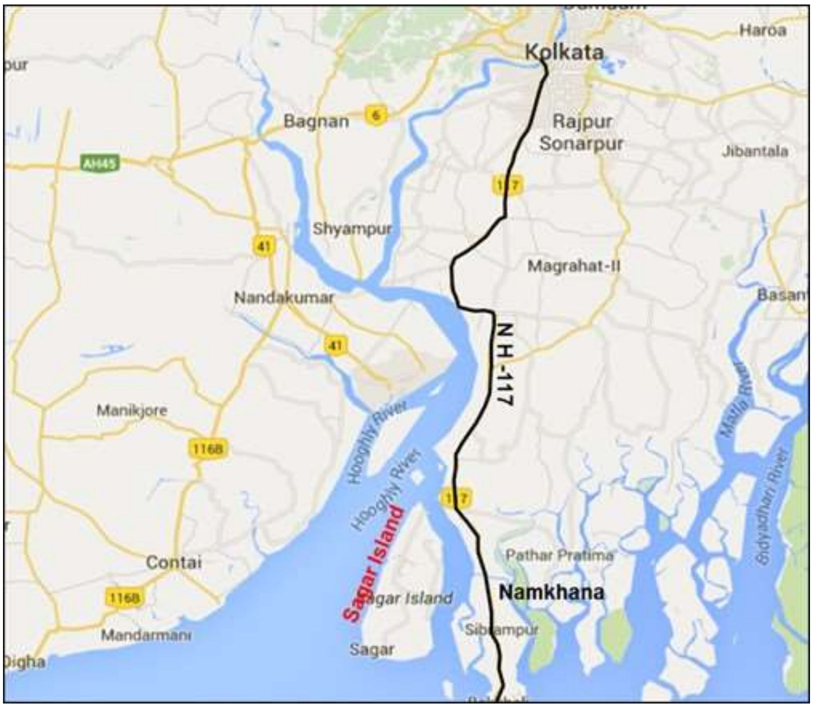


Figure 2.17 **NH-117 Connecting Kolkata-Namkhana**

3.0 Traffic Projections for Sagar Port

3.1 General

A port in Sagar will share the hinterland of the Haldia and Kolkata ports, particularly the power and steel plants in the eastern region, and containers from the eastern parts of India (Western UP, Odisha, Jharkhand, Chhattisgarh, etc.) and neighbouring landlocked countries - Nepal and Bhutan.

This section covers traffic projections for the proposed Sagar Port.

3.2 Hinterland Identification and Cargo Potential

Assessment of past traffic at Haldia & Kolkata port, interviews with industry bodies (West Bengal Industrial Development Corporation), and interviews with manufacturing units in the hinterland as well as port authorities have been conducted to assess traffic for Sagar port.

Cargo potential at Sagar has been estimated based on the following sources of information:

1. Assessment of past traffic at Haldia & Kolkata port
2. Landed cost economics analysis for relevant hinterland plants
3. Interviews with industry bodies (West Bengal Industrial Development Corporation)
4. Interviews with Port Authorities

Existing traffic (2014-15 in the eastern region in India is around 132 MTPA (**Figure 3.1**), with coal and POL being the primary commodities along with other general cargo (around 28 MTPA) consisting of limestone, manganese ore, food grains, vegetable oil, agro-products etc.

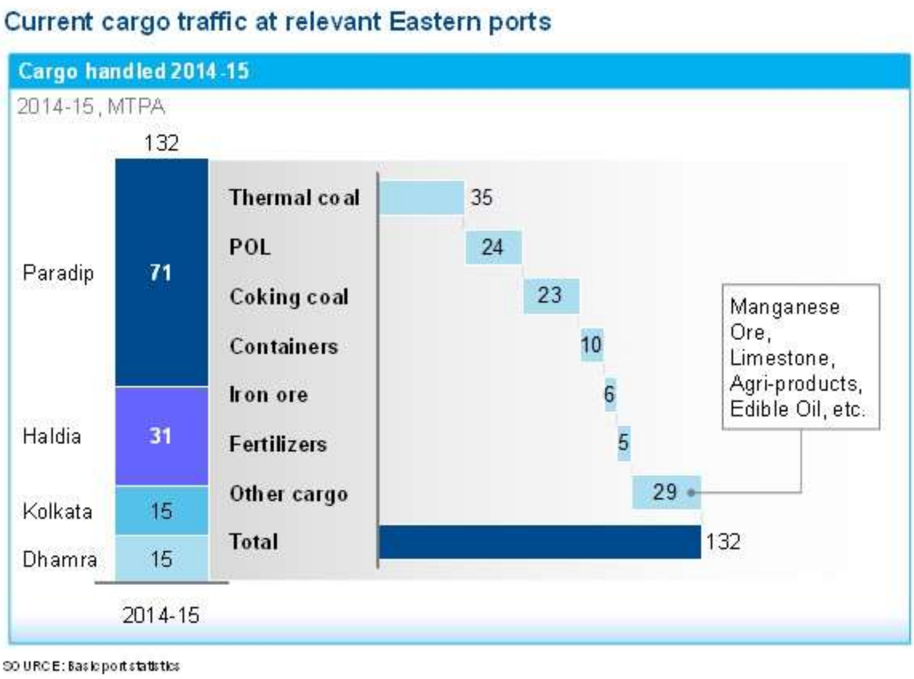


Figure 3.1 **Traffic at Relevent Eastern Ports**

The primary hinterland for the Haldia and Kolkata ports (for containers) is manufacturing units and agri-based cargo in the vicinity; the secondary hinterland is large with , Bihar and Jharkhand, serves the North-Eastern studies of Assam, Meghalaya, Nagaland, Tripura, Mizoram, Arunachal Pradesh and Sikkim as well as parts of Orissa, Chhattisgarh, Uttar Pradesh, Madhya Pradesh and the northeast (**Figure 3.2**).

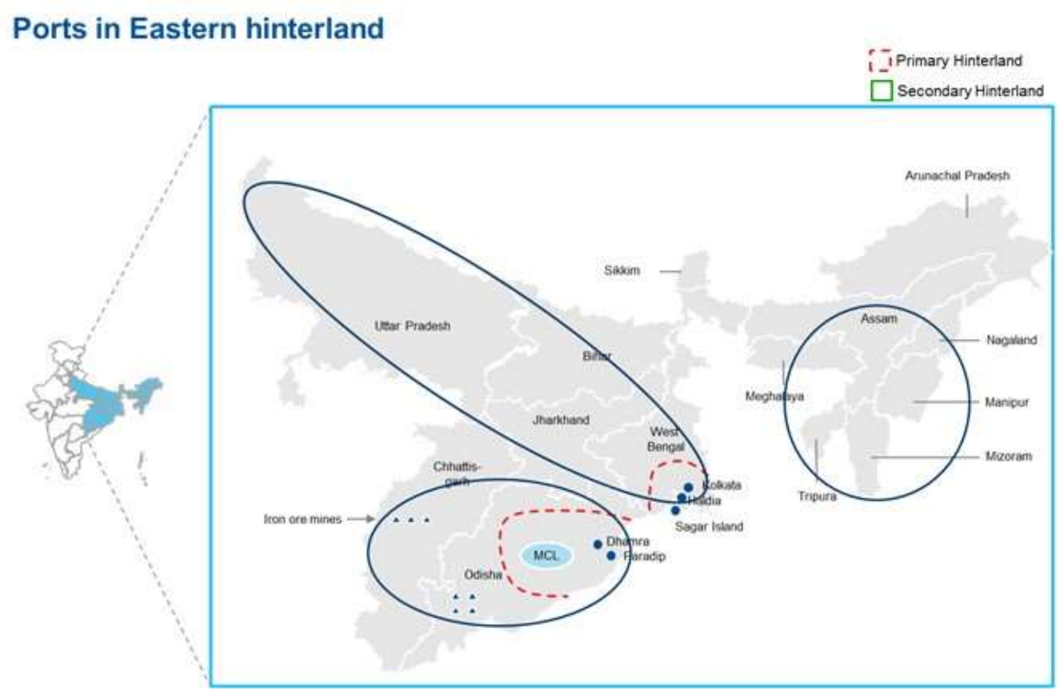


Figure 3.2 **Hinterland to the Eastern Ports**

Based on the origin-destination analysis of key commodities and industrial growth in the eastern hinterland, cargo is projected to grow up to around 440 MTPA by 2025 (**Figure 3.3**).

Eastern Hinterland: Kolkata Dock System, Haldia Dock Complex, Paradip, and Dhamra port

Key commodities for the cluster	Current – 2014-15 (MMTPA)	2020 (MMTPA)	2025 (MMTPA)	2035 (MMTPA)	Growth drivers for the next 5-10 years
Thermal Coal	35.3	129.0	196.7	291.2	Uijamala: Paradip and Dharma port to be used as loading ports for coastal shipping
Coking Coal	23.0	37.8	47.5	78.8	Increased coking coal imports due to capacity expansion of steel plants (Meramandali & Patratu) and greenfield plant at TATA, Kalinganagar
Iron Ore	5.7	3.9	5.3	9.4	Linear growth in exports/imports due domestic mining regulation and low global export spot prices
Fertilizer	5.4	10.0	12.6	18.9	Business as usual growth for finished and fertilizer raw material. No major upswing identified
POL	24.1	40.1	53.4	88.5	Operations start of IOCL Paradip. increasing the volume of crude imports at Paradip
Containers (nm. TEU)	10.1	17.2 (1.1)	26.6 (1.7)	34.5 (2.3)	Increased containerization, port led development and increased export competitiveness
Cement	0.4	8.0	30.7	50.9	Coastal shipping of Steel, Creation of New Steel clusters as part of port led development
Steel	0.0	8.4	20.9	34.6	Coastal shipping of Cement, Creation of New Cement clusters as part of port led development
Others	28.3	57.0	72.4	112.9	
TOTAL	**115.6**	**294.2**	**439.5**	**719.0**	

Figure 3.3 Projected Traffic in Eastern Hinterland

Most of the increase in cargo will be contributed by:

a) Coastal shipping of thermal coal (around 100 MTPA), **this traffic is relevant only for Paradip and Dhamra**
b) Coking coal (12 MTPA increase) to serve new upcoming plants of Tata Kalinganagar, JSPL Patratu, etc. and capacity expansion projects at SAIL, Bokaro etc.
c) Containers due to a rise in containerization and manufacturing boost
d) Growth in general cargo due to industrial growth in the region

The existing capacity of the four primary ports in the hinterland - Paradip, Dhamra, Haldia and Kolkata is around 190 MTPA. This capacity - meets the current need of the hinterland cargo. However, the future capacity projection based on existing port expansion plans and the headroom available for growth at four port locations will fall short of cargo projections by 2030.

Port capacity combined at all four locations will become equal to capacity available in 2030–2032, as the projected hinterland traffic in 2030 will be around 524 MTPA compared to the available capacity of around 530 MTPA.

While Paradip and Dhamra ports have the potential for expansion due to the availability of waterfront, land and draft (**Figure 3.4**), the Kolkata Dock System and Haldia Dock Complex have limited headroom for expansion. KDS is constrained by limited waterfront availability and HDC will need to create a new lock or new berths.

Thus, an additional deep water port in West Bengal would be required by 2030.

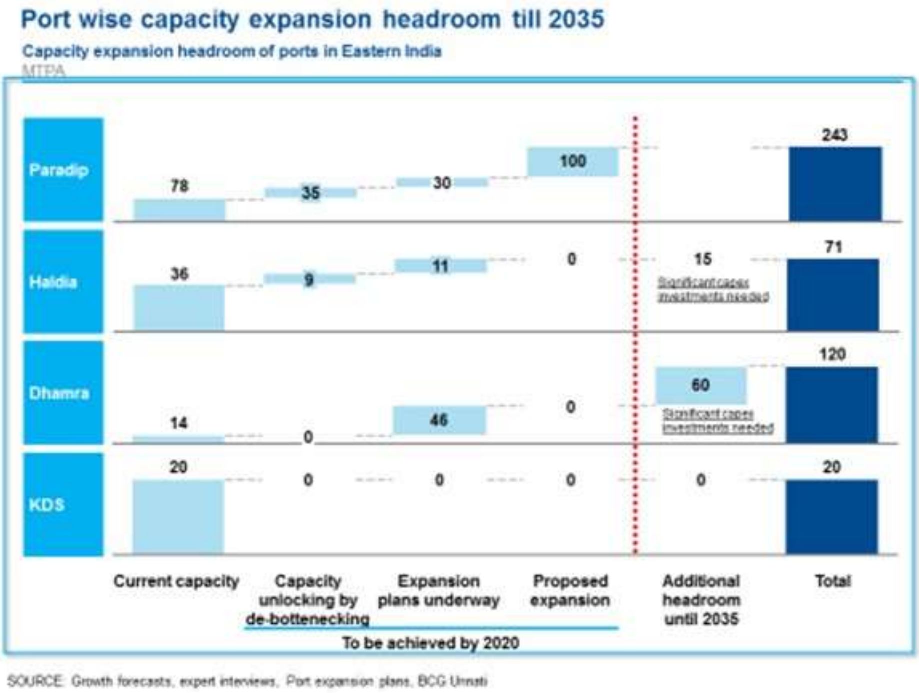


Figure 3.4 Capacity Expansion Headroom of Eastern Ports

Paradip and Dhamra ports have a large primary hinterland mostly centred on natural resources and the location of steel and power plants. Logistics costs for bulk cargo for these plants is the lowest through Paradip and Dhamra, hence this cargo is unlikely to shift to the Sagar port.

The Sagar port will share the hinterland cargo currently being serviced by the Haldia and Kolkata ports. Looking at the profile of cargo being handled at Haldia & Kolkata port the likelihood of cargo types spilling over from Haldia/Kolkata is the following (**Figure 3.5**)

- **Petroleum, Oil & Lubricants:** The products/crude imported at Haldia port currently is consumed within a radius of 100-300 km. Most of the consumption centres are already connected to the Haldia refinery and dock based storage through existing pipeline infrastructure. Thus it is unlikely that this cargo would shift to Sagar.
- **Coal:** A detailed analysis of relevant steel plants (SAIL, TATA, JSPL and others) and thermal plants on the basis of landed logistics cost, from Australia (coking coal) and Indonesia (thermal coal) has been undertaken. The data reveals that only SAIL, Durgapur will have comparable cost savings (~48 INR /tonne), for all the other plants in the hinterland Dhamra port and Paradip port will have natural ownership of the coking coal cargo. Thus, this will not shift to Sagar port.
- **Containers:** Apart from traffic originating in the immediate hinterland, the KDS and HDC handle container traffic from Bihar, Orissa, North-East, part of Uttar Pradesh and NCR besides the neighbouring Countries of Nepal and Bhutan. Capacity at HDC can reach 0.3-0.4 million TEU. At KDS current capacity is 0.8 million TEU but headroom for further expansion is limited. As the container traffic volume increases, overflow traffic from KDS could potentially move to Sagar.
- **Iron Ore:** The volume of Iron Ore exports has been on a decline and as per the origin-destination study conducted the Iron Ore volumes will remain muted and hence, the probability of shifting to Sagar port is low.
- **Fertilizers**: The imported fertilizers finished products and fertilizer raw materials, moved by rail travels to various locations in the hinterland such as Birgunj, Birbhum/ Burdwan/ Murshidabad, and Eastern UP and Bihar-Gorakhpur, Samstipur, Darbhanga, etc. for

processing and consumption. Haldia dock complex currently has the business environment and set –up for relevant processing units hence only spill over cargo can move to Sagar port.

- **Other Cargo:** Most of the other cargo (Vegetable oil, Manganese Ore, Limestone etc.) is generated or consumed within 100-300 km of the existing port and thus, has an established business environment; Interviews conducted with manufacturing units in the vicinity of Haldia confirm that handling this cargo in Sagar would result in significantly higher costs and would not be economically viable.

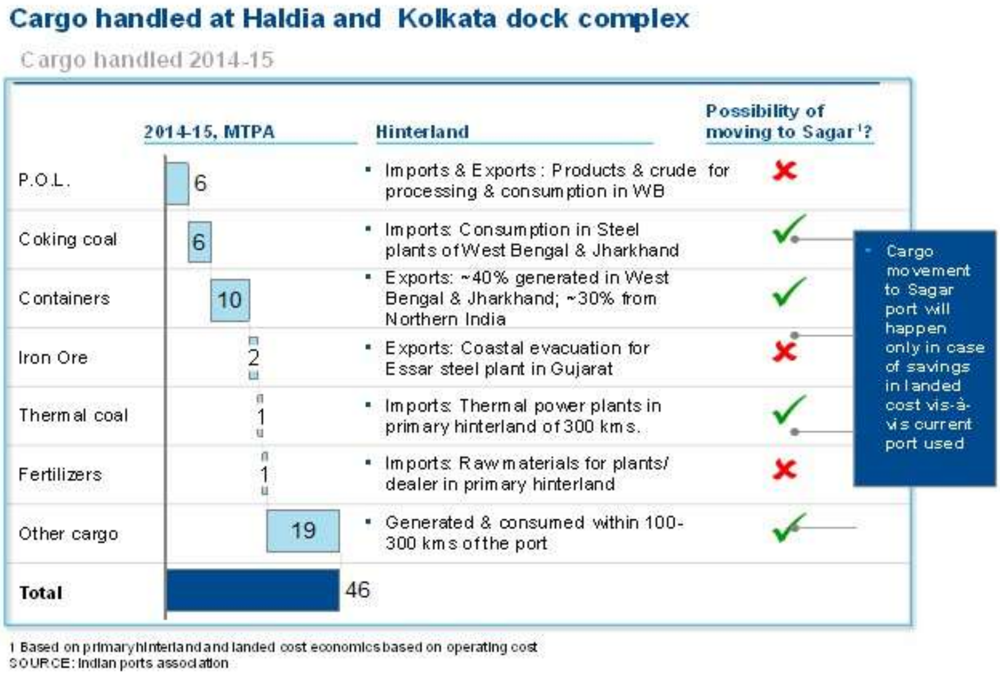


Figure 3.5 **Cargo handled at Haldia and Kolkata Dock Complex**

Also, the Sagar port does not have a natural hinterland and ownership of any cargo due to limited levels of industrialisation in eastern West Bengal and Ganga Sagar Island. We have conducted interviews with West Bengal Industrial Development Corporation, which confirmed that there are no existing plans for establishing an industrial zone for the Ganga Sagar Island. Thus, the potential for growth in cargo from Sagar Island remains muted, Also, Eastern West Bengal the level of industrialization and presence of manufacturing units is low to generate enough for Sagar port.

3.3 Competitive Analysis and Possible Diverted Cargo

An end-to-end landed-cost analysis for around 20 relevant steel and power plants in the hinterland was conducted to ascertain the natural cargo ownership of the Sagar port.

For importing cargo, any plant in the hinterland has six choices across four ports:

- Importing through the Haldia port with a sub-Panamax vessel or a part-load Panamax vessel;
- Importing through a cape-sized vessel and conducting transloading at the Paradip anchorage using a 10,000–15,000 DWT vessel from anchorage to the Haldia dock;
- Importing at the Dhamra port in a Panamax vessel in case of a smaller throughput (<2 MTPA);
- Importing at the Dhamra port in a cape-sized vessel in case of a bigger throughput (>2 MTPA);
- Importing at the Sagar port in a Panamax/Sub- Panamax vessel, and
- Importing at the Paradip port in a Panamax vessel.

The components of landed cost have been taken as:

a) Ocean freight (from Australia in case of coking coal and Indonesia in case of thermal coal) and
b) Railway freight, based on actual rail kilometres.

Analysis reveals that the Dhamra port is economical for most plants, as it is able to handle cape-sized vessels in case of an annual cargo throughput more than 2 MTPA (**Table 3.1**). Further, as per the proposal, the Paradip port would also start constructing an outer harbour for handling cape size ships, thus reducing the landed cost at the Paradip port as well with enabling a cape- size vessel.

The Sagar port can attract around 1.9 MTPA of coking coal cargo for the SAIL Durgapur plant currently. Although, while Sagar port does not come out as the cheapest port of call for any of the existing steel and upcoming power plants, the landed cost of coking coal/ thermal coal at Sagar port is only marginally expensive in case of a 9 m draft (Sub- panamax vessel). In case of 13.5 m draft Sagar port becomes comparable to Haldia port in landed cost (**Table 3.1** and Figure 3.6).

Thus, Sagar port can become a viable alternative to serve as for spill-over cargo, specifically non-POL bulk from the Haldia dock complex.

Table 3.1 Ocean Freight Analysis to Eastern Ports

		Types of Ship	Lightered Panamax	Capesize/ Panamax	Sub-Panamax	Panamax
Commodity	**Volumes (MMTPA)**	**Points in hinterland**	**Haldia**	**Dhamra**	**Sagar**	**Paradip**
	6.20	TISCO	1,407	1,079	1,544	1,535
	2.40	SAIL, Bokaro	1,564	1,241	1,627	1,697
	2.50	SAIL, IISCO	1,502	1,179	1,516	1,635
	3.32	SAIL, Rourkela	1,627	1,299	1,746	1,521
	1.90	SAIL, Durgapur	1,490	1,513	1,452	1,683
	0.60	Bhushan steel, Sambalpur	1,791	1,479	1,867	1,370
	6.80	Tata steel, Kalinganagar, Orissa	1,525	721	1,670	1,060
Coking Coal	1.70	Bhushan steel, Meramandali	1,715	1,194	1,808	1,085

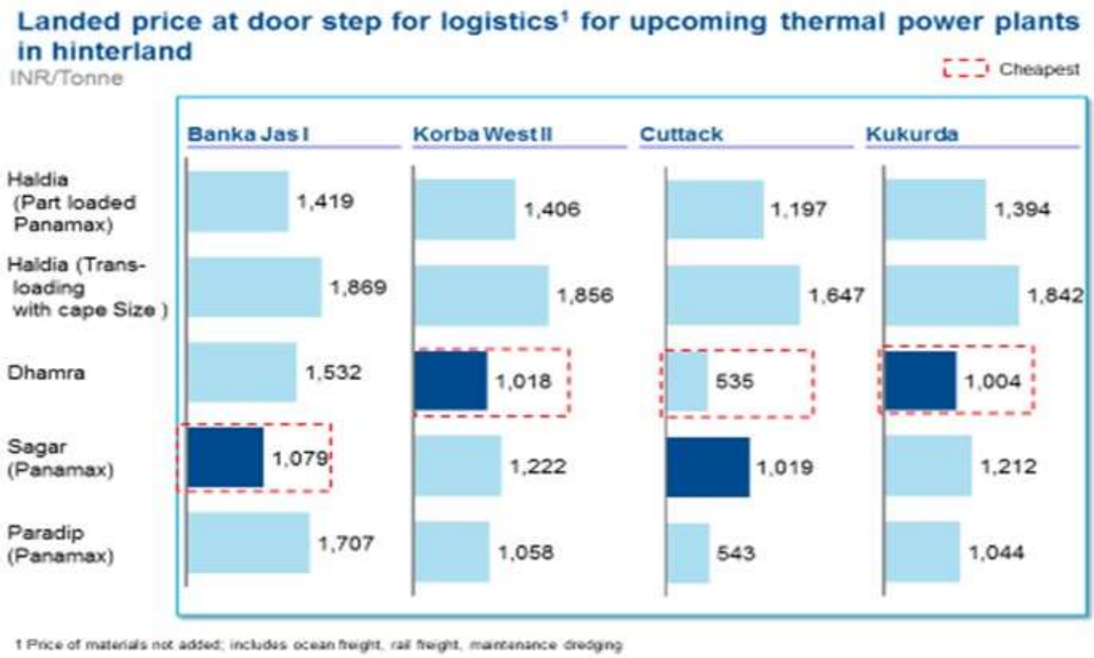


Figure 3.6 Logistics Cost for the upcoming Power Plant

Landed cost includes ocean freight, rail freight, handling cost and in the case of trans-loading, trans-loading charge and extra barging cost.

3.4 Haldia Port Capacity Expansion Scenario

Haldia port has a lock based system with an estimated capacity of 30 MTPA, with lock gate being the main limiting factor currently in increasing capacity further. There is potential to further expand the capacity outside the lock either by creating another lock or through use of Trans-loading systems with barge handling berths outside the lock and additional riverine jetties.

The port is currently operating at only ~24 MTPA within the lock due to low productivity operations on the berth. As part of Project Unnati, a detail set of initiatives have been proposed to unlock the capacity and enable the port to reach 34 MTPA capacity. Basis this analysis, it looks quite feasible to increase cargo throughput from 24 MTPA to 34 MTPA without significant incremental capex.

Also, currently the port has 3 berths outside the locks for handling oil cargo. These berths currently handle 7 MTPA of oil cargo. There are plans to develop additional riverine jetties outside the lock and it is expected that the port will be able to handle about 50 MTPA of cargo.

In order to further expand capacity, the port will need to make investments in building new berths / jetties at Shalukhali. They will also have to establish road / rail linkages with the current port network.

A detail analysis will be required to estimate the maximum capacity can be created through this route, though a total port capacity of > 60 MTPA should be feasible. Alternatively, in case of Greenfield investments the port can also explore the possibility of creating another lock system basis commercial feasibility and this can take the port capacity beyond 60 MTPA.

For container traffic the Haldia Dock Complex has a current capacity of 0.6 Mn. TEU which cannot be extended beyond that in the existing complex. Thus, in order to cater to container cargo other than 0.6

Mn. TEU Haldia port complex will need to make a Greenfield capex investment of around INR 2,000-2,500 crores in Haldia – II, which will offer a draft of 6-8 m compared to 9 m (in Phase 1) at Sagar port.

Thus, for Sagar port to generate any traffic from Haldia cargo spill over, a decision on whether Greenfield investments in Haldia should be continued has to be made.

3.5 Final Traffic Forecast Figures adopted for Port Planning

As it is clear from the preceding analysis, Sagar port does not have a natural hinterland or ownership of cargo. Most of the bulk cargo will continue to move through the existing four ports in the eastern region until such time that the ports run out of capacity. A new hinterland could develop for Sagar through increased industrial activity in West Bengal but as of now, there are no confirmed plans from the state government.

Any cargo from the hinterland of the Dhamra or Paradip ports will not shift to the Sagar port, due to relative distance and increased landed cost. The Dhamra and Paradip ports serve the evacuation of natural resources and import of raw materials for plants in the hinterland. The Sagar port is around ~200-270 km away from both the ports and thus, cargo evacuation through Paradip and Dhamra is the economical choice.

For traffic projections of the Sagar port, we have considered **container and non-POL bulk overflow from Kolkata and Haldia port**: The Kolkata Dock System cannot handle/expand more than its current capacity of 0.8 Mn. TEU's due to water front constraints although the container traffic in the Eastern Ports cluster (Paradip, Dhamra, Kolkata, Haldia) etc. is projected to be ~2.3 Mn. TEU. Thus, the growth of container cargo generated in the hinterland will be evacuated from Sagar port. (**Table 3.2**)

The Kolkata port currently handles around 0.54 Mn. TEU and according to the hinterland growth of around 8 percent would reach capacity (0.8 Mn. TEU) by 2020 and hence the overflow of containers will start to Sagar port. It may be noted, that at Haldia port, with the current plans of floating jetties outside the lock, the non POL bulk capacity can potentially reach 50-55 MTPA. With this capacity, the spill over of non POL bulk from Haldia is only expected after 2035.

Table 3.2 Base Case - Container and Bulk Cargo for Sagar Port

Base Case	Cargo overflow from Kolkata Port Trust - Containers & Break Bulk		
Year	Total Traffic (in MT)	Container (in MT)	Break Bulk (in MT)
2020-21	3.42	0.52	2.90
2021-22	4.09	0.71	3.38
2022-23	5.44	1.55	3.89
2023-24	7.41	2.99	4.42
2024-25	9.53	4.55	4.98
2025-26	11.14	5.81	5.33
2026-27	12.84	7.15	5.69
2027-28	14.64	8.57	6.07
2028-29	16.52	10.07	6.45

Base Case	Cargo overflow from Kolkata Port Trust - Containers & Break Bulk		
Year	**Total Traffic (in MT)**	**Container (in MT)**	**Break Bulk (in MT)**
2029-30	18.52	11.67	6.85
2030-31	20.05	12.80	7.25
2031-32	21.64	13.97	7.67
2032-33	23.29	15.19	8.11
2033-34	25.00	16.45	8.55
2034-35	26.78	17.77	9.01
2035-36	26.78	17.77	9.01

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 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 Sagar 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 322,000 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.

Considering the draft limitations on account of the likely maintenance dredging required at the proposed port at Sagar, the size of the dry bulk ships is proposed to be limited to Panamax carrier (80,000 DWT).

4.3 Break Bulk 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

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	15000 TEU	16000 TEU	Triple E	18300 TEU
Nominal Capacity	1000	2000	4000	6000	9000	14500	15000	16000	18000	18300
LOA (m)	160	200	290	320	350	365	397	400	400	400
Beam (m)	22	32	32	42	45	50	56	54	59	59
Loaded Draft (m)	10.0	11.0	13.5	14.0	15.0	16.0	15.5	15.5	15.0	15.5

[Source: Lloyds Fairplay Database]

Considering the location of Sagar Island, only feeder ships will call. However, provision should be made to handle larger direct-call ships (4000 TEUs) at a later date.

4.5 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed Sagar 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	13.5
Break Bulk	10,000	9,000	125	19	8.1
	20,000	18,000	160	25	10.0
	40,000	200	200	28	11.3
Containers	1000 TEUs	700 TEUs	160	22	10.0
	4000 TEUs	1,200 TEUs	290	32	13.5

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.

Presently, ships going to Haldia and Kolkata are brought through the eastern channel. The daily draft forecast for every month, for vessels going to Haldia dock, Kolkata port and Sagar Roads is intimated by KoPT in advance so that appropriate scheduling of vessel could be made. Analysing this data it has been observed that for vessels going to Sagar roads an additional draft ranging from 1.4 m to over 2.0 m is available as compared to Haldia and Kolkata Ports respectively. This information has been utilised to propose the phasing of dredging for Sagar port as given below:

Initial Phase - To handle vessels with draft of 9.0 m with tidal advantage

Ultimate Phase - To handle vessels with draft of 13.5 m with tidal advantage

The vessel size for Phase 1 is carefully chosen so that no capital dredging is needed in the long eastern approach channel. This would still enable carrying about 30,000 T of parcel size of bulk in Panamax ships round the year with minimum waiting time.

It may further be noted that in Phase 1 itself, for about 109 days in a year, it would be possible to navigate vessels with draft of over 9.5 m.

The dredging of the eastern channel and Sagar Channel could be undertaken in phased manner so as to achieve adequate water depths to handle the design draft of 13.5 m, as per the trade requirements.

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 post panamax Rail Mounted Quay Gantry Cranes (RMQC) on berths. 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

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

However, considering the minimal traffic of bulk import commodities in Phase 1, it is proposed to handle this cargo at the multipurpose berths using mobile harbour cranes. Although the traffic is limited, it is proposed to provide mobile hoppers with the connected conveyor system at the multipurpose berth and stackers at the stackyard in the subsequent phases. The rail loading of bulk cargo is proposed to be through front end loaders only.

5.2.2.3 Break Bulk cargo

The forecast of other dry bulk cargoes at Sagar Port comprise of iron and steel, non-metallic goods, Sugar 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)			
		2020	2025	2030	2035
1.	Coal and ore	12,000	15,000	15,000	15,000
2.	Other Bulk	12,000	15,000	15,000	15,000
3.	Fertilizer, Food Grain, Sugar	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)	1,200	1,500	2,000	2,000

5.2.4 Operational Time

As the proposed site has adequate wave tranquillity, round the year operations are possible. 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 Sagar Port

S. No.	Type	Total Berths Needed			
		2020	2025	2030	2035
1	Multipurpose Berths	2	3	4	5
2	Container Berths	1	2	3	4
	Total Berths	**3**	**5**	**7**	**9**

The requirements of subsequent stages would depend on how best the proposed port is able to meet the requirements of the customers. Therefore while preparing the master plan it shall be ensured that the proposed initial port facilities could be expanded so as to meet the traffic beyond the master plan phase.

5.2.8 Port Crafts Berth

For the initial stage development, the port would require 4 tugs with a capacity of 40 T bollard pull, 3 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.

Therefore for planning the berths, the profile of vessels visiting the Kolkata port and Haldia ports were analysed and maximum, minimum and average vessel sizes for the various commodities were compiled. The berth lengths for the initial phase were worked out on that basis. As for subsequent phases when deepening of Sagar port would take place in phased manner it is assumed that average LOA of the ships using the port would also go up and accordingly the berth lengths for future phases have been worked out.

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

	Phase of Port Development			
	2020	2025	2030	2035
Total Berth Length (m)	**600**	**1100**	**1500**	**2000**

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,
- 20 days for export 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 15 Ha increasing to 65 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.

Currently there is a proposal to provide only a two lane road bridge across river Muriganga. This has to be ready before the first phase of the proposed port is commissioned i.e. by year 2020. Along with Road Bridge, the widening of NH117 shall also be taken up from bridge location till Kolkata. It is also assumed that the work for Rail Bridge shall be undertaken in the next phase i.e. by year 2025. These form the key assumptions while arriving at the traffic forecast for Sagar Port and planning of the port facilities.

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

Table 5.4 Evacuation Pattern for Various Cargo

S. No.	Commodity	2020		2025		2030		2035	
		Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share
		%	%	%	%	%	%	%	%
1.	Thermal Coal	100%	0%	5%	95%	5%	95%	5%	95%
2.	Other Bulk	100%	0%	5%	95%	5%	95%	5%	95%
3.	Fertilizer	100%	0%	75%	25%	65%	35%	50%	50%
4.	Iron and Steel	100%	0%	75%	25%	65%	35%	50%	50%
5.	Containers	100%	0%	75%	25%	65%	35%	50%	50%

5.5.2 Port Access Road

The access road from bridge across Muriganga till the proposed port shall be the only means for receipt and evacuation of cargo during Phase 1. However, subsequently with the construction of a rail bridge the evacuation of key cargo shall also be by rail. Based on the traffic forecast the total PCU movement are estimated to be about 4,000 per day increasing to about 11,000 per day over the master plan horizon, which indicates adequacy of two lane access road to port.

5.5.3 Rail Connectivity

Similar to above, the assessment of rail movements in the port has been carried out for different phases of the project. Total daily incoming and outgoing rakes are estimated to be 6 in the initial phase (from the offsite rail yard) increasing to 36 over the master plan horizon.

In the absence of any rail bridge across river Muriganga in the Phase 1 development of port, an offsite rail yard for the port shall be located near Kashinagar railway station and adequate rail sidings shall be provided at that location. Subsequently this yard shall be utilised as an R&D yard for the port.

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 development will be around 0.1 MLD increasing to about 0.3 MLD in the long term.

5.7 Power Requirements

HT and LT power supply at the port would be required for Handling Equipment, 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 3.5 MVA increasing to about 10.5 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at various berths.

6.0 Preparation of Sagar 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
- 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 Sagar Island.

6.2.1 Potential Traffic

The potential traffic that a new port could attract forms the first and foremost requirement of the project. In case there is significant traffic that could be captive to the port e.g. coal for the nearby power plant or cargo from nearby SEZ /industrial areas, the viability of the port increases. According to the landed-cost analysis of the imported cargo for bulk, the natural ownership of cargo for the Sagar port is limited due to the proximity of the Haldia. Containers will be the major cargo commodity handled at the Sagar port. This is primarily due the paucity of capacity and the inability to expand the Haldia and Kolkata ports beyond a certain limit, which is causing an overflow of containers that can be handled at the Sagar port.

6.2.2 Techno-Economic Feasibility

<u>6.2.2.1 Design Ship Size</u>

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. Considering the site conditions, it is proposed to increase the draft at port in phases so as to phase the capital investment with growth in traffic.

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. At Sagar port the soil comprises silty sand and silty clay for a depth of about 22m below bed level followed by a layer of stiff/ dense silty clay up to 30m. This soil condition allows carrying out dredging at competitive rates as well as moderate cost of building the structures.

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 Sagar Port site it is observed that the location remain tranquil round the year under normal conditions.

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 Sagar, it is assessed that most of the material for reclamation could be obtained from the capital dredging. However, rock would have to be brought from Pakur, which is about 350 Km from the port site. Similarly other construction material would also have to be brought from mainland through boats/barges as the bridge connecting the Sagar Island with mainland would not be ready during the port construction 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. Therefore it is proposed to limit the draft of design ship so as to minimise the cost.

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 Sagar, it is therefore proposed that backup area of cargo storage and port operations be planned on reclaimed area in the intertidal zone.

Another aspect which needs to be considered carefully is that only a two lane road bridge across river Muriganga shall be built initially and the rail bridge shall be built in later phases. Therefore suitable land parcel for off-site rail yard would also need to be identified at mainland preferably near Kashinagar station (from where the rail connectivity to Sagar shall be provided in future). This land parcel shall need to be adequately sized so as to provide sufficient storage space for transit cargo, loading unloading facilities and rail lines.

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. In this particular case of Sagar the Bridge across river Muriganga is a prerequisite for the port construction.

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 Sagar Roads and then take the ship to the port location through Sagar 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 Breakwater

The mathematical studies on the nearshore wave transformation studies reveal that the proposed port site is naturally protected to allow round the year operations and there is no need for breakwater protection.

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 **Table 5.3**.

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 6.2**.

Table 6.2 Assessment of Channel Width

The calculated channel width for various design ship sizes is indicated below in **Table 6.3**.

Table 6.3 Particulars of Navigational Channel for Design Ships

Design Ship Size	Beam	Outer Channel Width		Inner Channel width	
		One way Channel	Two way Channel	One way Channel	Two way Channel
80,000 - Bulk Carrier	32	200	415	150	310
4,000 - TEUs Container Carrier	32	200	415	150	310

The eastern channel has natural water depths available to receive the 9.0m draft vessels planned for Phase 1 and is wide enough to allow two way passage of the design ships. However, in the ultimate stage when 13.5 m draft vessels are proposed to be handled, significant dredging would need to be carried out over a width of about 450 m to allow two way passage of design ships.

As regards to the Sagar Channel, it is fully protected and therefore it is proposed to provide a channel width of 400 m to allow two way movements of 32 m beam ships.

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.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship. The calculated values are given in **Table 6.4** below:

Table 6.4 Dredged Depths in Approach Channel to Sagar Port

Location	Vessel Size	Design Draft of vessel (m)	Depth of Channel Required (m below CD)	Tidal Advantage (m)	Design Dredged Depth (m below CD)
Sagar Channel	Phase 1 2020	9.00	9.90	3.00	6.90
	Phase 2 2025	11.70	12.87	3.00	9.87
	Phase 3 2030	12.50	13.75	3.00	10.75
	Phase 4 2035	13.50	14.85	3.00	11.85
Eastern Channel	Phase 1 2020	9.00	10.35	3.50	6.85
	Phase 2 2025	11.70	13.46	3.50	9.96
	Phase 3 2030	12.50	14.38	3.50	10.88
	Phase 4 2035	13.50	15.53	3.50	12.03

Considering the above it is recommended that in the initial phase the eastern channel should be utilised in the present condition, with no capital dredging. However, the Sagar channel shall be dredged to a level of -8.0 m CD to allow for navigation of about 10.0 m draft vessels (which may be possible during few days in a year) and berth pockets shall be dredged to -11.0 m CD. The structural design of berths shall be carried out to the design dredged level of -15.0 m CD to cater to fully loaded Panamax ship.

6.3.5 Elevations of Backup Area and Berths

Considering the mean high water springs as +5.2 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 +8.5 m CD. It is proposed to keep the finished levels of onshore areas also at +8.50 m CD.

6.4 Recommended Master Plan Layout

Based on the traffic projections, port facility requirements and the technical requirements, the master plan layout of the Sagar Port has been developed as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1001**. It may be noted that the master plan layout is based on the traffic projections but there is significant scope for expansion of port facilities.

The ideal capacity of phase 1 of port development is assessed as **5.75 MTPA** and that for the proposed master plan at year 2035 is assessed as **26.0 MTPA**, as presented in **Table 6.5**.

Table 6.5 Berth Capacity Assessment

Capacity at Phase 1 Development

Berth Type	Commodities to be Handled Using Common Material Handling System	Import (I)/ Export (E)	Handling Rate TEUPD/TPD	Average Parcel Size T	Maximum Parcel Size T	Year 2020						Allowable Berth Occupancy	Berth Capacity (MTPA)
						Annual Throughput MTPA	Ship Calls/ Annum	Berth Days Required	Total Berth Occupancy	Berths Provided	Combined Berth Occupancy		
Multi Purpose Berth	Thermal Coal	I	12,000	30,000	70,000	0.33	11	29	105%	2	53%	65%	0.41
	Other Bulk	I/E	8,000	25,000	50,000	0.00	0	0					0.00
	Fertilizer, Food Grain, Sugar	I/E	8,000	25,000	50,000	2.52	101	332					3.11
	Iron and Steel	I/E	8,000	20,000	50,000	0.05	3	7					0.06
	Total					2.90	114.30	368.18					3.58
Berth- Containers	Containers	I/E	1,200	500	1,000	0.52	87	55	16%	1	16%	65%	2.16
	Total					0.52	87	55					2.16
GRAND TOTAL						3.42	200.97	422.90		3			5.75

Capacity at Master Plan Development

Berth Type	Commodities to be Handled Using Common Material Handling System	Import (I)/ Export (E)	Handling Rate TEUPD/TPD	Average Parcel Size T	Maximum Parcel Size T	Year 2035						Allowable Berth Occupancy	Berth Capacity (MTPA)
						Annual Throughput MTPA	Ship Calls/ Annum	Berth Days Required	Total Berth Occupancy	Berths Provided	Combined Berth Occupancy		
Multipurpose Berth	Thermal Coal	I	15,000	60,000	70,000	1.01	17	70	318%	5	64%	65%	1.03
	Other Bulk	I/E	8,000	30,000	50,000	0.00	0	0					0.00
	Fertilizer, Food Grain, Sugar	I/E	8,000	30,000	50,000	7.83	261	1023					7.99
	Iron and Steel	I/E	8,000	25,000	50,000	0.16	6	21					0.16
	Total					9.00	284	1114					9.19
Berth-Containers	Containers	I/E	2,000	1,200	2,000	17.77	1234	943	269%	4	67%	65%	17.15
	Total					17.77	1234	943					17
GRANDTOTAL						27	1518	2057		9			26

The capacities calculated above are based on the optimal berth occupancy of 65%. However with the same berthing facilities it is possible to handle additional cargo beyond the capacity e.g. phase 1 of the port development can also handle 7.5 MTPA cargo at a berth occupancy of about 85%. However this may result in higher waiting time for ships and thus reducing competitiveness of the port in long run.

6.5 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 6.6** below.

Table 6.6 Phasewise Port Development over Master Plan Horizon

Description	Total Port Facilities in Each Phase			
	Phase 1 - Year 2020	Phase 2 - Year 2025	Phase 3 - Year 2030	Master Plan - Year 2035
Maximum Ship Size				
• *Dry Bulk (DWT)*	*80,000*	*80,000*	*80,000*	*80,000*
• *Containers (TEUs)*	*2,000*	*3,000*	*4,000*	*4,000*
Total length of berths in meters				
• *Multipurpose and Container berths*	*600*	*1100*	*1500*	*2000*
Navigational Areas				
• *Length of Sagar Channel (m)*	*6500*	*6500*	*6500*	*6500*
• *Width of Approach Channel (m)*	*400*	*400*	*400*	*400*
• *Diameter of Turning Circle (m)*	*500*	*500*	*550*	*550*
• *Minimum Width of Sagar Channel (m)*	*400*	*400*	*400*	*400*
• *Minimum Width of Eastern Channel (m)*	*450*	*450*	*450*	*450*
Design Draft of the Ship (m)	*9.0*	*11.7*	*12.5*	*13.5*
Dredged Depths at Port (m below CD)				
• *Approach Channel*	*6.9*	*9.9*	*10.8*	*11.9*
• *Manoeuvring Areas*	*6.9*	*9.9*	*10.8*	*11.9*
• *Berths*	*10.0*	*13.0*	*14.0*	*15.0*
• *Incremental Dredging Quantity (million cum)*	*1.2*	*45.2*	*25.8*	*36.8*
Incremental Reclamation Quantity (million cum)	*6.6*	*6.6*	*1.9*	*1.3*
Total Reclamation Area (Ha.)	*96*	*170*	*186*	*197*

The phase wise development plan of the Sagar port is indicated in **Drawings DELD15005-DRG-10-0000-CP-WBP1002** to **WBP1004**. It is assumed that Rail Bridge across river Muriganga would be in place by Phase 2 development i.e. by year 2025 and accordingly Rail sidings are proposed within the port area at that phase.

7.0 Engineering Details

7.1 Mathematical Model Studies on Marine Layout

7.1.1 General

The mathematical model studies have already been conducted for the port development at Sagar Island by CWPRS. The findings of model study are presented in following sections.

7.1.2 Wave Transformation Studies

The site being naturally protected there is no requirement to provide the breakwater for wave tranquillity. Therefore the wave penetration studies are not required. As mentioned in section 2.7.2.3 the proposed location is suitable for round the year port operations under normal wave conditions.

7.1.3 Hydrodynamics/ Flow Modelling

The two dimensional mathematical model MIKE21 HD was used to examine the flow conditions at the berths along the western bank of Sagar Island and in the approach channel. The truncated portion of estuary from Kulpi to Sagar Roads including part of Eastern and Western channels near sand heads was included in the model. The Muriganga (Baratola) channel was also included for the study. Water levels were applied as boundary conditions at the southern boundary while the observed discharge at Kulpi was specified for Northern boundary.

To represent the conditions of the proposed developments, berths and channel, bathymetry was modified and used as an input to the model.

The hydrodynamic model simulation was calibrated for current observations at Middleton Fairway Buoy, southwest of Sagar Island observed during 03/05/2011 to 02/06/2011 (**Figure 7.1**).

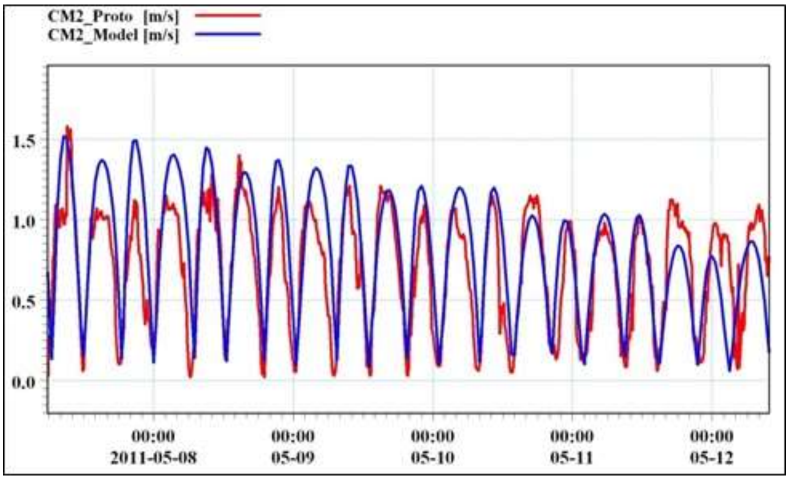


Figure 7.1 Calibration of Current

The model results i.e. current speed in the entire domain is provided as **Figure 7.2** and **Figure 7.3**. Higher magnitude current may be observed at the southern end of the Sagar Island during both ebb and flood tide. The figures clearly show that proposed berthing area and channel have higher current velocities.

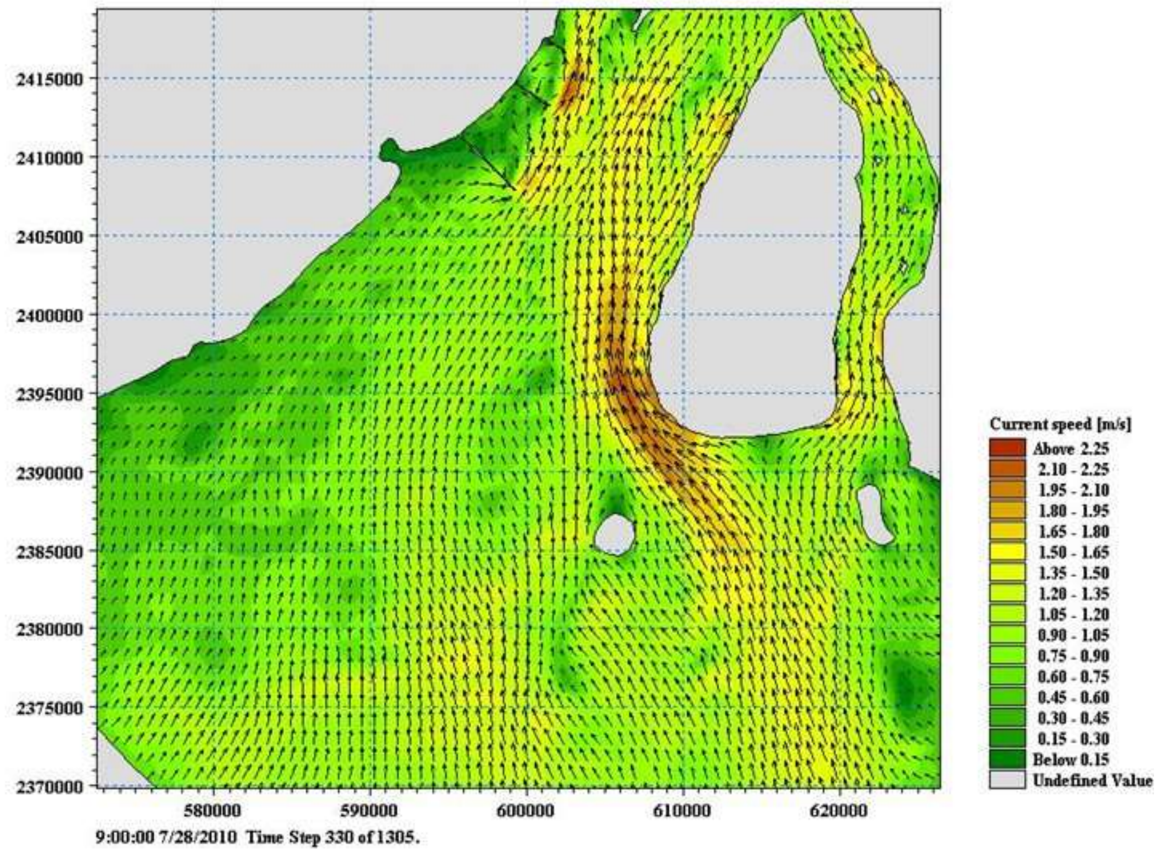


Figure 7.2 Location of Peak Flood Currents Southwest of Sagar

The current profiles were extracted from the model results at all berth locations and in the channel (Figure 7.3). At berth locations, flood currents were found to vary between 1.2 m/s and 1.4 m/s, while during ebb currents were between 0.82 and 1.08 m/s.

Similarly, current profiles were extracted at 23 locations in the channel (**Figure 7.4**). At outer channel, high current values were noticed as compared to the current strength in the inner channel and turning circle. During flood conditions, currents in the channel were found to vary between 1.2 to 2.3 m/s.

It is important to note that current profiles with the proposed channel dredging were also quite same as in existing condition at most of the locations.

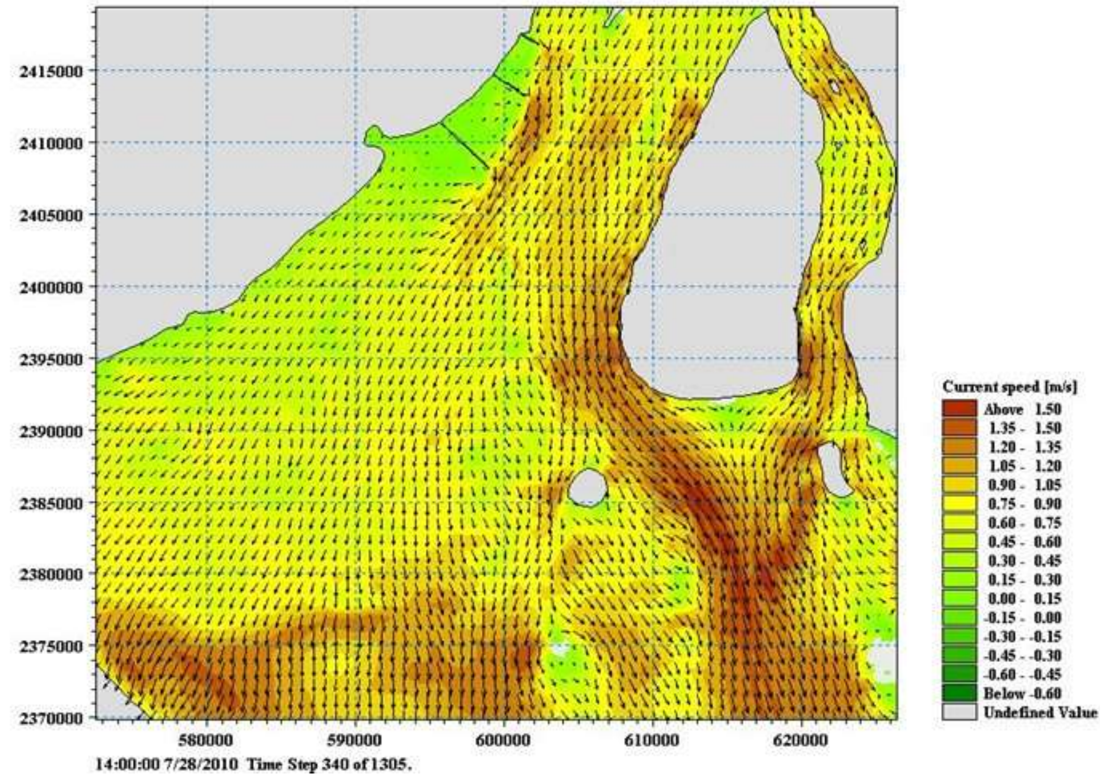


Figure 7.3 **Location of peak Ebb Currents south of Sagar**

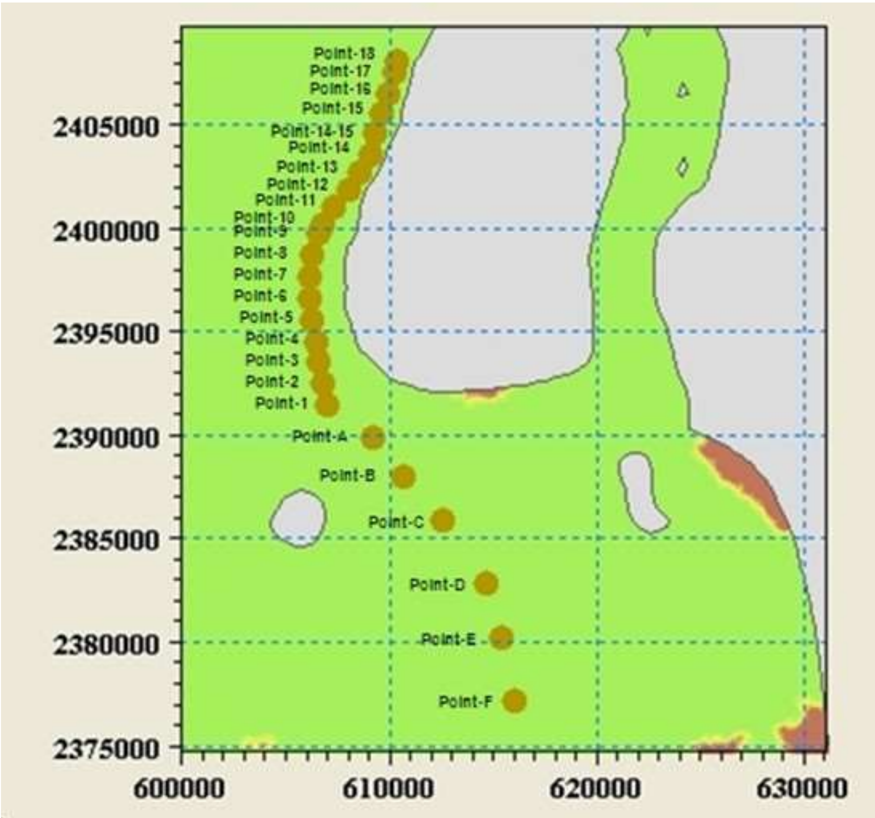


Figure 7.4 **Locations of Extraction of Current along the Approach Channel**

Table 7.1 Maximum current at berth locations for ebb and flood conditions, m/s

	Point 17	Point 15	Point 13	Point 11	Point 9	Point 7	Point 5	Point 3	Point 1	Point A	Point B	Point C	Point D	Point E	Point F
Current magnitude for existing conditions															
Ebb Tide	1.08	1.00	0.92	1.15	1.25	1.20	1.30	1.30	1.15	1.30	1.40	1.60	1.65	1.50	1.60
Flood Tide	1.44	1.40	1.20	1.60	1.80	2.00	2.30	2.20	1.85	2.30	2.25	2.00	1.85	1.70	1.65
Current magnitude with proposed channel / dredging															
Ebb Tide	1.00	0.92	0.88	1.20	1.20	1.20	1.30	1.30	1.15	1.30	1.45	1.60	1.50	1.50	1.50
Flood Tide	1.44	1.28	1.20	1.60	1.80	2.00	2.30	2.20	1.85	2.30	2.25	2.10	1.85	1.80	1.80

The results of model study corroborated that the restricted flow at lower stages of tide near the Sagar bank and the shallow Bedford sands might be helping in maintaining the depths in that region. After dredging of turning circle, berthing basin and the approach channel the flow in the region did not show any significant change in the magnitude of the flood and ebb currents.

7.1.4 Morphological Model Simulations

The MIKE21 ST module was used for simulation of sediment transport for assessing the morphological changes and likely siltation in the vicinity of the proposed berthing area and the approach channel. The hydrodynamic input was taken from the 2-D hydrodynamic model and morphological simulation was done for one month covering the monsoon period.

The model predictions provided the zones of potential siltation and erosion along the channel as shown in **Figure 7.5**.

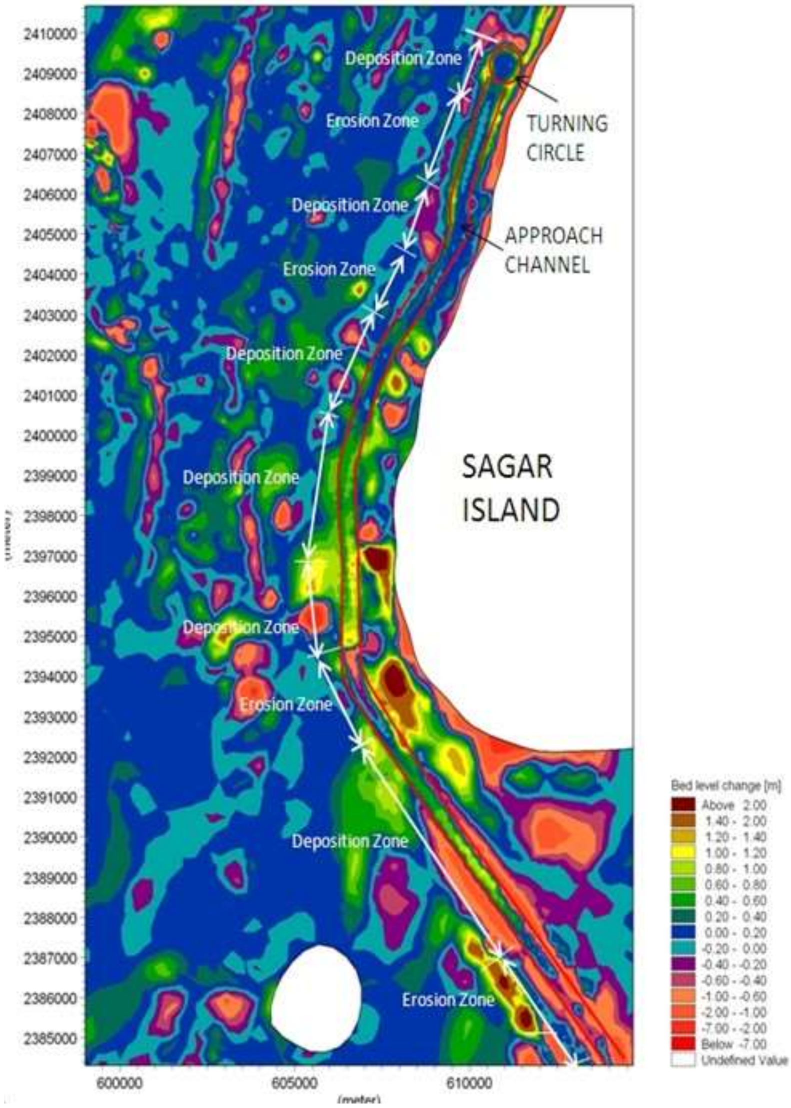


Figure 7.5 Results of Sediment Transport Model

The Upper Channel extending from turning circle to the Middleton Fairway Buoy (Ch. 0.0 to 16.0) generally observed to have siltation with a very small pocket of erosion zone in between, i.e. near the berths area.

In the Lower Channel, which extends from Ch. 16.0 to Ch. 48.0, siltation was observed in the entire channel except the end reaches where erosion was prominent.

Based on the model study results, the siltation was extrapolated for annual yield. It was observed that the overall sedimentation was about 5% of the capital dredging carried out.

The capital dredging volumes being 1.2 million cum in Phase 1, the annual maintenance dredging is expected to be 0.06 million cum only. For ultimate stage development, where the total capital dredging is calculated as 103 million cum, the annual maintenance dredging is taken as about 5.2 million cum.

7.1.5 Model Studies for Ship Manoeuvring

A numerical model NAVIGA developed at CWPRS was executed to ascertain the adequacy of the width of the channel for navigating the ship safely under the prevailing winds, waves and currents at the site. The model is based on Abkowitz (1964) formulation and upgraded based on the latest literature on ship hydrodynamics and its tracks of the centre of gravity, heading angle and the required rudder action in small time steps. The model accounts for the influence of winds, waves and currents. The wind, waves and current forces the ship to deviate from the desired path. In order to maintain the course under the influence of winds, waves and currents and also in channels having bends, proper steering actions are necessary.

For the purpose of this study, a container vessel with 210 m LOA and 30 m beam was considered. Simulations were carried out for various limiting conditions of wave, wind and currents. It was observed that channel width of 208 m would be adequate for such vessel under the critical section of the channel.

As indicated in section 6, it is proposed to provide a channel width of 400 m in Sagar channel and that 450 m in the eastern channel to allow for two way passage of design ships, as per the PIANC guidelines.

7.2 Onshore Facilities

The main consideration, in locating the facilities has been to minimise the land acquisition. Therefore the onshore facilities have been located in the reclaimed land. The areas for cargo handling and port operations have been segregated. The administrative building and other buildings catering to port users, amenities etc. are placed outside the port compound and close to the gate. They are planned as a single complex because of their inter-related functions.

While arriving at the layout it has been ensured that adequate space has been earmarked for the railway lines to be provided within the port area once the rail bridge across river Muriganga is built.

7.3 Revetment

7.3.1 Basic Data for Revetment Design

7.3.1.1 Extreme Wave Conditions at Site

Wave transformation studies were carried out at site for the operational wave conditions. Based on that it has been observed that reduction factor of waves at port location vs the offshore waves is about 25%. Analysis of cyclonic wave data observed in the region indicated that the offshore wave height could reach about 8 m in deep waters. Using the same reduction factor on a conservative side, the design significant wave height at the port location shall be around 2.0 m.

7.3.1.2 Design Water levels

Storm surges, the meteorological conditions causing the rise in water levels, occur sometimes but not always the same as those causing maximum wave attacks. In some cases the two conditions will act as independent variables; and in some other cases they can be positively or negatively related. The probability of the design wave height at structure occurring along with maximum storm surge is considered to be negligible. Therefore storm surge is generally added to MHWS to arrive at the design water level. No significant storm surge has been reported in the region and no reliable data on storm surge is available. Therefore it is proposed to use the +5.4 m CD (mean high water spring) as the design water level.

7.3.2 Revetment 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 values for K_D considered for design of revetment is 2.8.

Based on this, the assessment of revetment section would comprise of 1 to 1.5 T rock in the armour layer. The filter layer shall comprise of 50 kg to 150 kg stones. The cross section of revetment is as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1005**.

7.3.3 Rock Quarrying and Transportation

7.3.3.1 Location of Quarries

It is understood that the rock for the construction works in the mainland opposite Sagar Island is brought from Pakur to Farakka by road and from Farakka it is taken to various marine sites through barges.

7.3.3.2 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 barges.

The proposed quarry site is located at about 30 km from Farakka. Considering the quantum of rock needed it may work out to be economical that rock be brought through the river to the proposed port site where a temporary jetty shall be built to receive the construction material. The location of quarry sites is as shown in **Figure 7.6**.

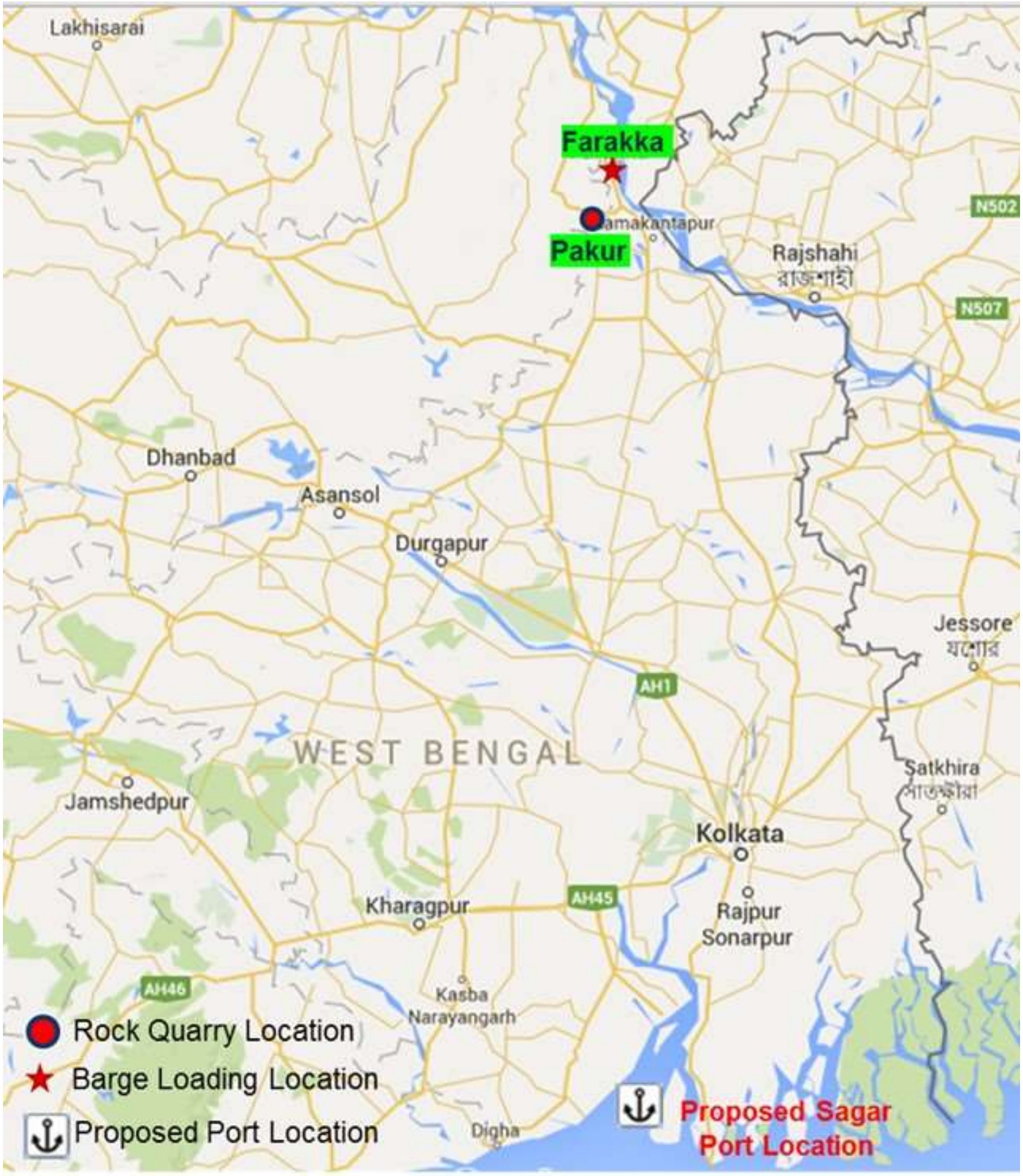


Figure 7.6 **Location of Quarry Site**

Figure 7.7 describes the transportation process assumed for rock required for armour layer of revetment.

Figure 7.7 **Logistics Flow diagram from Quarry to Port Site**

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-WBP1002**. 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. However, considering the soil conditions and also the requirement to carry out deepening of berth pockets in stages, it is proposed that all berths shall be located away from backup area to which the connection shall be by approach trestles provided at intervals along the quay length.

7.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +8.50m 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 7.2** below:

Table 7.2 Characteristics of Design Ships

Commodity	Design Ship Size (DWT)
Coal*	80,000
Multipurpose**	80,000
Containers	4000 TEUs

* The berth designed for fully loaded Panamax ship can also cater to the loads of light loaded cape size ships.

** It may be noted that the multipurpose berths shall be designed such that during later stages, there is a flexibility to convert these to container berths.

7.4.3.2 Design Dredged Level

The structural design of the berths shall be carried out for design dredged level of -15.0 m CD.

7.4.3.3 Geotechnical Criteria for Design of Berth Piles

The preliminary design of the berths' foundation has been carried out based on the subsoil profiles discussed in section 2.

7.4.3.4 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 LMH400 or equivalent*
  - *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 (except for the exclusive bulk 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 3.0 m/s.

- **Wave Loads** shall be computed considering maximum wave height of 3.6 m (~ 1.8*2.0) for the design of the berths on a conservative side.

- **Mooring *Loads*** shall be calculated considering 150 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 80,000 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 below:

Table 7.3 Details of Berthing Energy, Fender and Berthing Force applied at Berths

Parameters	Value
Berthing Energy	153 Tm
Fender	Trellborg Cell Type Fenders SCK 2000 or equivalent
Berthing Force	174 T

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.

7.4.3.5 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.

7.4.3.6 Materials and Material Grades

Concrete of 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/ Multipurpose Berth

The berth shall have a provision to provide a conveyor system, to be provide in future if required, for carrying the dry bulk from the berth and transfer to the conveyor provided over the approach trestle. **Drawing DELD15005-DWG-10-0000-CP-WBP1006** presents the general arrangement of Phase 1 berths. **Drawing DELD15005-DWG-10-0000-CP-WBP1007** presents the cross section of multipurpose berth and approach trestle.

The minimum width of the berth, keeping in view the rail span of the coal unloaders (only future provision), service ducts and the end clearances should be about 25m.

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 founded at a level of -40 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.

The bulk berth is connected to the shore by means of 105 m long and 16 m wide approach trestle to back up area. The approach trestle shall be supported over three rows of 1.0 diameter bored cast in situ piles. The structural arrangement of the approach trestle would be similar to that of the bulk berth.

7.4.4.2 Container and Multipurpose Berths

The container and multipurpose berths are connected to land by means of approach trestle. Due to the requirement of placing the ship's hatch covers on the berths the width of the berth is taken as 40 m.

The structural arrangement of the berth is based on the design criteria. The proposed scheme consists of five rows of vertical bored cast-in-situ piles of 1.2 m diameter, spaced at 7 m c/c in the longitudinal direction. The piles will be founded at a level of -45.0 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 third 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.

The berth is connected to the shore by means of 90 m long and 16 m wide approach trestle to back up area. The approach trestle shall be supported over three rows of 1.1 m diameter bored cast in situ piles. The structural arrangement of the approach trestle would be similar to that of the container and multipurpose berth.

Drawing DELD15005-DWG-10-0000-CP-WBP1008 presents the cross section of container and multipurpose berths.

7.5 Dredging and Disposal

7.5.1 Capital Dredging

Considering the design draft of the ships chosen for Phase 1 development, no capital dredging in the eastern channel is required to be carried out. The entire capital dredging for Phase 1 development shall be limited to the Sagar Channel only and is estimated to be around 1.2 million cum only. The phase wise incremental capital dredging quantity is indicated in **Table 7.4** below:

Table 7.4 Estimated Quantity of Capital Derdging (cum)

S. No.	Location	2020		2025		2030		2035	
		Design draft of Ship	Capital Dredging	Design draft of Ship	Capital Dredging	Design draft of Ship	Capital Dredging	Design draft of Ship	Capital Dredging
1	Eastern Channel	9.00	-	11.70	42,056,093	12.50	23,998,113	13.50	33,320,091
2	Sagar Channel	9.00	1,072,398	11.70	2,025,641	12.50	1,079,610	13.50	2,024,920
3	Harbour Area	9.00	108,000	11.70	816,309	12.50	692,034	13.50	1,143,033
	Total Incremental (Phase Wise)		**1,180,398**		**44,898,042**		**25,769,758**		**36,488,043**

Most of the dredging in the approach channel and harbour basin shall be carried out using trailing suction hopper dredger. It is anticipated that about 0.9 million cum of material could be utilised for reclamation and balance shall be dumped offshore at the designated disposal area.

The dredging for subsequent phases shall be undertaken as per the demand of the users and cost benefit analysis.

7.5.2 Maintenance Dredging

Based on the outcome of model studies the expected annual maintenance dredging volumes are estimated to be about 60,000 cum only for Phase 1. The maintenance dredging volumes being minimal it is suggested that maintenance dredging to be carried out on annual basis by deploying suitable trailing suction dredgers. However, in the subsequent phases with the deepening of water depths significant maintenance dredging is anticipated. At the master plan stage development with dredged depths adequate to receive the fully loaded Panamax ships the annual maintenance dredging is expected to be about 6.0 million cum.

7.6 Reclamation

7.6.1 Areas to be reclaimed

The backup area for the proposed berth shall be reclaimed using the suitable dredged material and also the borrowed fill.

7.6.2 Reclamation Process

The reclamation process comprises creating bunds in the reclamation areas of suitable heights to receive the dredged material. Considering that most of the fill will be placed in intertidal zone and it could be undertaken without the requirement of reclamation bunds, except behind the proposed locations of berths.

As the required reclamation quantity of 6.6 Mcum in phase 1 development is significantly higher than the suitable material available from dredging the Sagar channel, borrowed fill would be needed. Currently, over 9.0 million cum dredging is being carried out in Auckland bar to maintain the navigational route to Kolkata and Haldia ports. Instead of disposing the material at offshore disposal site, the suitable material could be brought to the proposed port site. The material shall be disposed off by TSHD using rain bowing technique. Alternatively the dredger may discharge material using pipeline to reclamation area for which a temporary jetty with connecting pipelines and couplers would be provided. The dredged material being silty sand, ground improvement shall be carried out using band drains.

7.7 Material Handling System

7.7.1 Bulk Import System

<u>7.7.1.1 General System Description</u>

Due to low throughput a partly mechanized ship unloading system is planned at one of the multipurpose berths (bulk berth).

The major components of the mechanized bulk import system are:

- Mobile Harbour Crane(s)
- Mobile Hoppers
- Stackers at stackyard
- Connected Conveyor system

7.7.1.2 Mobile Harbour Cranes

Mobile harbour crane is versatile equipment and can be used to handle variety of cargo ranging from bulk, breakbulk, containers etc. utilising different attachments like grab, sling or spreader. For unloading the bulk cargo it is proposed to provide two cranes at one of the multipurpose berths (bulk berth). These cranes shall unload the bulk from ships and transfer to the mobile hopper. The mobile hoppers are rail mounted and provided over conveyor placed at ground level at berth for carrying the material to stackyard. The system details are shown in **Figure 7.8**.

Figure 7.8 Typical Mobile Harbour Cranes with Mobile Hoppers

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 2000 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

It is proposed to provide two stackers at the stackyard. This equipment shall be used to receive coal from the ship and stacking in the yard.

The stacker will have limit switches and controls to restrict the stockpiles to their planned boundaries. The equipment shall be used to stack coal to 12 m height.

7.7.1.5 Reclaiming and Wagon Loading

Due to very limited cargo throughput it is proposed to use front end loaders for cargo reclaiming from stackyard and loading the wagons. Should the throughput goes up reclaimer in the stackyard with conveyor to rapid loading system shall be provided.

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 42 m. 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 7.9**.

Figure 7.9 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 7.10** shows an E-RTG in operation.

Figure 7.10 Typical E-RTG for Yard Operation

Figure 7.11 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 7.12 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 7.13 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 7.14 Snapshot of Typical Reach Stacker Handling

Considering the throughput of the import export containers of gateway traffic, it is proposed to provide two numbers of Reach Stackers for train loading/unloading.

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 7.15 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 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.

The typical section of container and bulk yard is as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1009** and **DELD15005-DRG-10-0000-CP-WBP1010**.

7.8 Port Infrastructure

7.8.1 External Rail Connectivity

7.8.1.1 Proposed New Rail Alignment

A subcommittee was constituted by Chief Secretary, Govt. of West Bengal to finalise the railways alignment connecting the future Sagar port to the dedicated freight corridor. The final unanimously recommended route by the committee is as under:

1. *Sagar Port – Kasinagar : New Line*
2. *Kasinagar – Kulpi : Existing Line*
3. *Kulpi – Gurudasnagar – (Diamond Harbour) – Bakrahat – Chak Gopalpur – Nangi : New Line*
4. *Nangi – Majerhat : Existing Line*
5. *Majerhat – Kidderpore – Takta Ghat : Existing Line (Circular Railways)*
6. *Takta Ghat – Shalimar : New Line on new bridge over the Hoogly river*
7. *Shalimar – Santragachi – Dankuni : Existing Line*

The railway alignment, consisting of existing rail corridors and proposed new lines, has to be capacity augmented to cater to the DFC standards. A schematic diagram of the railway alignment is presented in **Figure 7.16**.

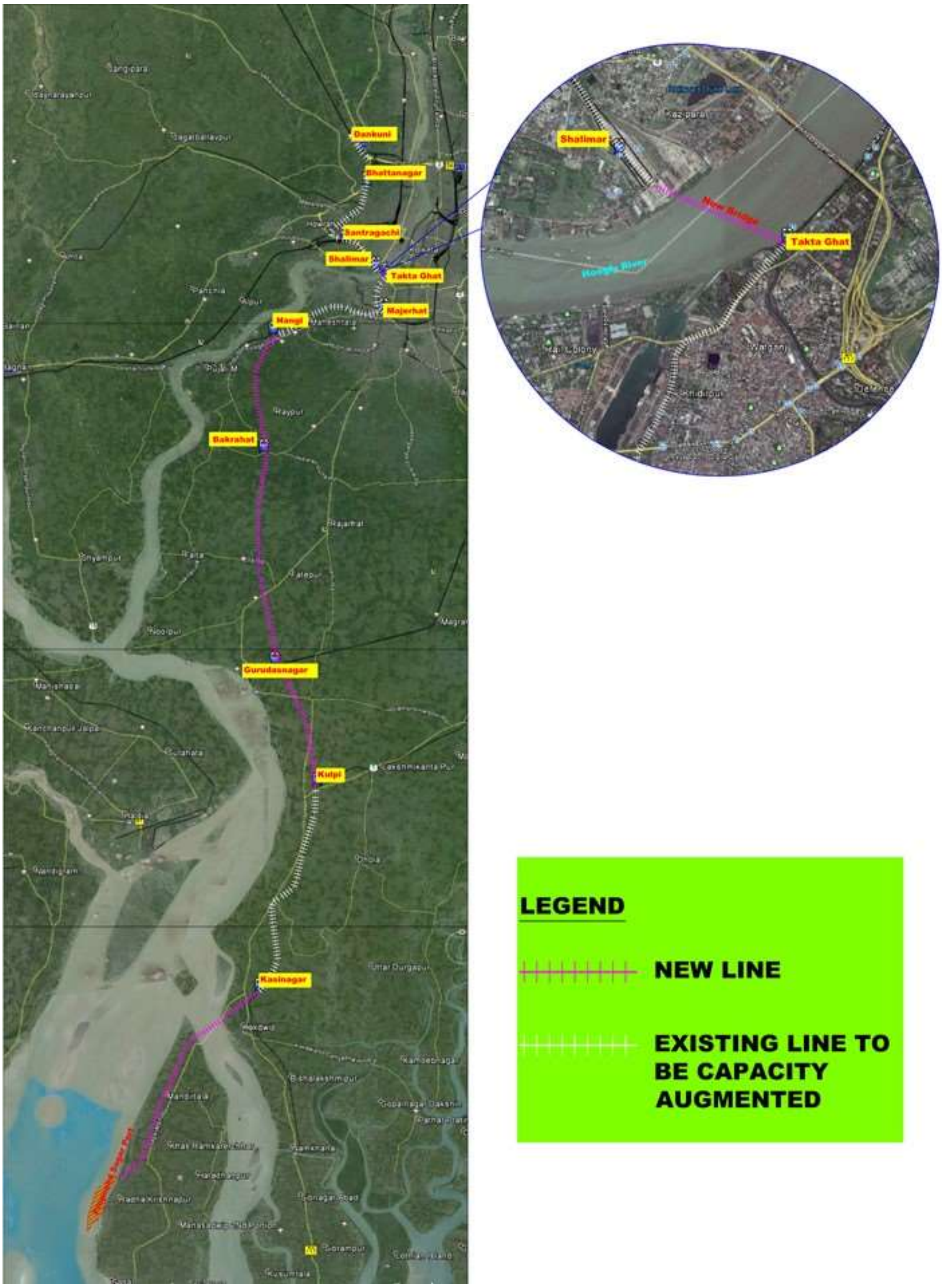


Figure 7.16 Proposed New Rail Alignment till Dhankuni

7.8.1.2 Offsite Rail Yard

As mentioned in section 7.8.1, an offsite rail yard shall be built near Kashinagar railway station from where a branch rail line is taken to the yard. Initially three sidings shall be built in the yard for loading and unloading of the cargo.

The cargo between the port and the offsite rail yard shall be transferred by means of tractor–trailers /dumpers/trucks. Adequate storage space shall be provided in the offsite yard for storage of transit cargo. The typical layout of the offsite rail yard is shown in **Figure 7.17**.

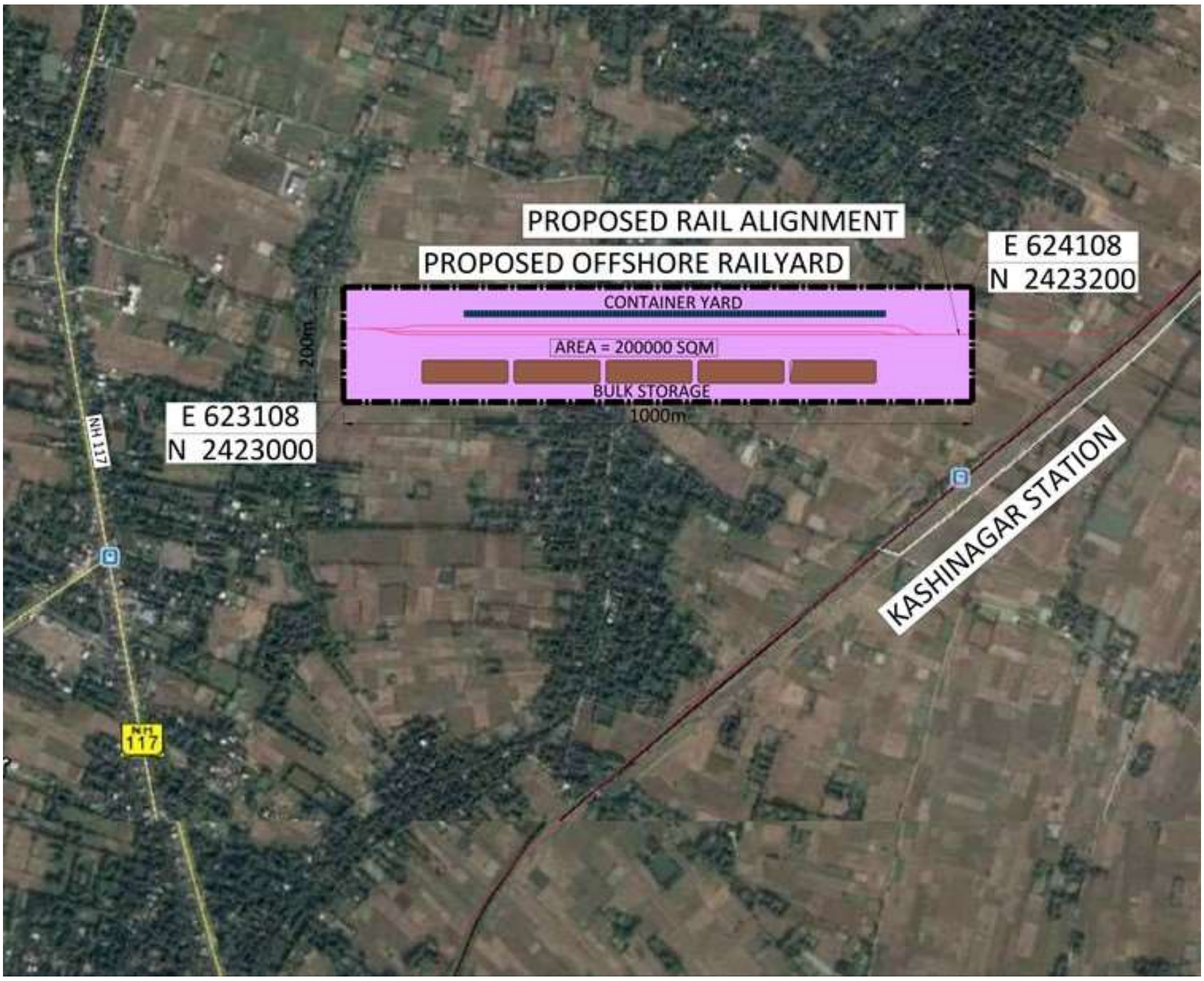


Figure 7.17 Typical Layout of Offsite Rail Yard

7.8.1.3 Take off station for Rail Connectivity

The rail bridge across river Muriganga is expected to be built by the year 2025 and then port shall be connected to main railway network. The main line of broad gauge that passes through Kakdwip – Kashinagar – Kulpi – Laxmikantapur – Dakshin Barasat – Sealdah – Dankuni is approximately 25 km from the Sagar Port location. It is proposed to take off a rail link from the Kashinagar station for the proposed port.

7.8.1.4 R&D Yard

Since block loads of trains or point to point trains are proposed to be run to and from the port, only a Receipt & Despatch (R&D) yard is required to be provided. Provision for a separate siding for sick wagons needing repairs and a loco shed for attending to minor repairs of shunting locomotives with fuelling arrangement is also required.

It is proposed that the offsite railyard be used as R&D yard. In the ultimate stage it would have about 6 full length lines, out of which one line will be kept exclusively for engine movement. Apart from this, a loco line of short length for parking locomotives and another short siding for detaching sick wagons will be provided.

7.8.2 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. One silo for in motion wagon loading shall be located at the main rail track.

7.8.3 External Road Connectivity

7.8.3.1 Introduction

The road connectivity at Sagar is as discussed in section 2.10.2. Once the road bridge on river Muriganga is constructed, the island can be connected to the mainland and thereafter to NH 117, which runs through Kolkata-Diamond harbour – Kulpi – Kakdwip – Namkhana.

7.8.3.2 Road Connectivity between Sagar Port to Muriganga Bridge

Sagar main road which is running from north to south of Sagar Island needs to be widened in order to facilitate the movement of anticipated traffic from/to the Port.

For the road connectivity from future Sagar port, KoPT has already initiated the land acquisition process for around 102 Ha of land as per RITES alignment (schematically presented in **Figure 7.18**) and hence further option study in this regard is not envisaged.

Figure 7.18 Road Alignment between Sagar Port and Muriganga Bridge

However, the following few important points have to be ratified during preparation of detailed design of the road corridor:

- The spur connecting the Kasinagar Stackyard (approximate length – 0.85km) to the junction of NH-117 and the road to Lot no. 8, was not part of the RITES report. Hence the alignment option study in this regard has to be done during detailed design stage.
- The land width being acquired is 25m for new alignment and 15m for existing alignment, which is not adequate as per 4 lane standards. However, the projected traffic is only 8000 PCU after 20 years, which is well within the traffic capacity of 15,000 PCU for 2 lane roads. Hence, since the proposed dualisation is only for traffic safety enhancement, the 4 lane road can be accommodated within the 25m RoW, with some deviations from standard cross sectional elements. The proposed cross sectional elements in this regard are as under :
  - Median : 1.5m
  - Carriageway with Kerb Shyness : 7.5m
  - Earthen Shoulder : 1.5m

  However, detailed analysis of all parameters has to be done during the detailed design phase to finalise the road cross sectional elements.

- Since the road is located in the vicinity of the Bay of Bengal and the area was severely affected by the cyclonic storm “Aila” in May 2009, detailed investigations and analysis have to be done while finalising the road design to ensure sustainable connectivity to the future port.

7.8.3.3 Road Connectivity between Muriganga Bridge to Offsite Railway Yard

Option 1

The proposed connectivity option is about 3.48 km. It follows existing road and get connected with the Railway yard with a level crossing at NH 117. The road capacity augmentation will be required.

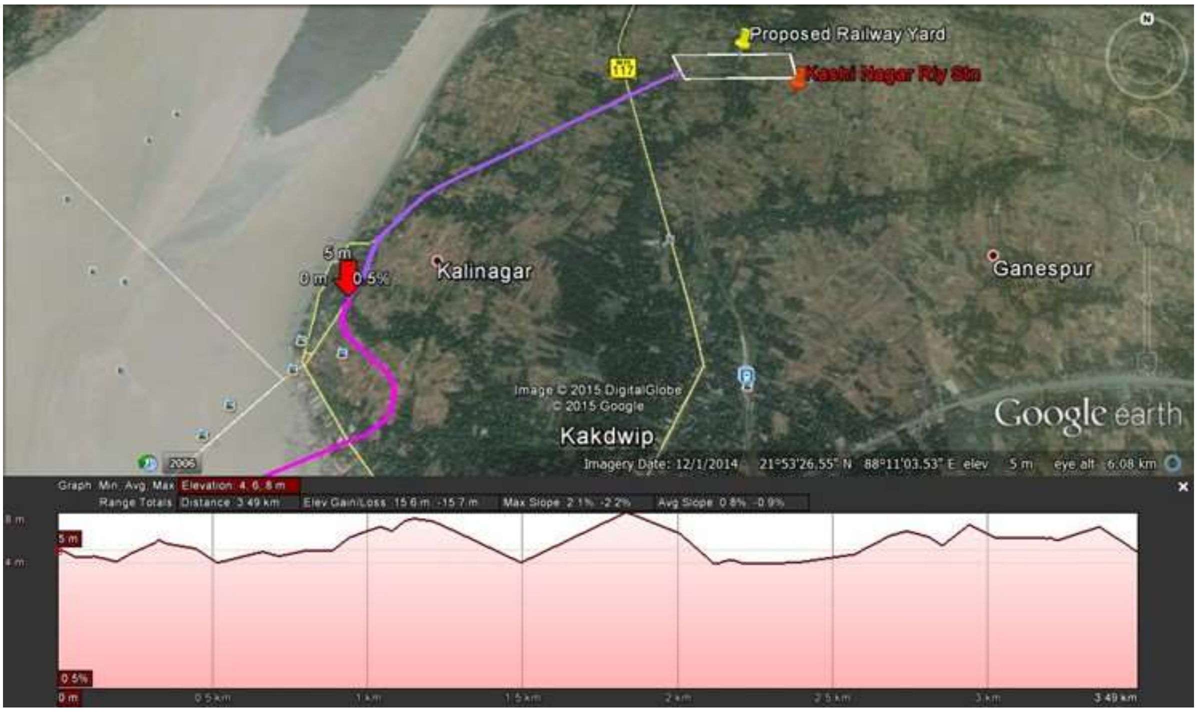


Figure 7.19 Option 1 – Road Connectivity to Proposed Rail Yard from Muriganga Bridge

Option 2

The proposed connectivity option is about 4.46 km and a Greenfield Alignment. It will also have a flyover over NH 117. But it will have more social and environmental issues.

Figure 7.20 Option 2 – Road Connectivity to Proposed Rail Yard from Muriganga Bridge

<u>Preferred Alignment</u>

Option 1 is preferred as the project length is less and is following the existing road.

7.8.4 Rail cum Road Bridge across Muriganga

The bridge across river Muriganga has to be taken up separately by a government agency and the above options are indicated to help in decision making process.

However, AECOM carried out assessment of various options of development of Rail cum Road Bridge for a span of 3 km across Muriganga. The following were the options which were considered from cost point of view.

- **Option 1**: Extradosed Bridge (2 Track + 4 lane Road)
- **Option 2**: Steel Truss (2 track + 3 lane)
- **Option 3A**: Fully welded Steel composite Truss (2 track +3 Lane)
- **Option 3B**: Fully welded Steel composite Truss (2 track + 4 Lane)
- **Option 4**: Fully welded Steel composite Truss (1 track + 2 Lane) Sub structure for double track and 4 lane Road with Super structure provision
- **Option 5A**: Steel Truss (1 track + 2 Lane)
- **Option 5B**: Fully welded Steel composite Truss (1 track + 2 Lane)

Following are the assumptions for the determination of Block cost

- The span length for the main bridge is considered 125m
- Foundation is assumed to be well

Table below summarises cost comparison of different options.

Table 7.4 Rail-Road Bridge Option Comparison

Options	Bridge Type	Cost (INR in Crores)
Option 1	Extradosed Bridge (2 Track + 4 lane Road)	**1,841**
Option 2	Steel Truss (2 track + 3 lane)	**2,494**
Option 3	**A:** Fully welded Steel composite Truss (2 track +3 Lane)	**3,203**
	B: Fully welded Steel composite Truss (2 track + 4 Lane)	**3,417**
Option 4	Fully welded Steel composite Truss (1 track + 2 Lane) Sub structure for double track and 4 lane Road with Super structure provision	**2,221**
Option 5	**A:** Steel Truss (1 track + 2 Lane)	**1,746**
	B: Fully welded Steel composite Truss (1 track + 2 Lane)	**1,922**

These costs include the cost of elevated approach to the bridge at both the ends.

7.8.5 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. Within the terminals internal roads shall be planned based on the cargo handling and storage plans.

7.8.6 Electrical Distribution System

7.8.6.1 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.

7.8.6.2 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 3.5 MVA. This is expected to go up to 10.5 MVA over the proposed master plan horizon.

7.8.6.3 Source of Power Supply

Power supply to Sagar Island is being managed by West Bengal Electricity Distribution Company. Currently, transmission line carrying power at 33 KV is passing near the proposed port location. The power shall be tapped from Rudranagar Electric Substation 33/11 KV which is approximately 5km from the proposed port site.

7.8.6.4 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. This outdoor switch yard will have SF 6 type circuit breakers and will have necessary lightening arresters, current transformers etc. required for protection and metering. The outgoing cables from the two transformers are designed to be of 300 sq mm size leading to the indoor switching station.

The power from the 33/11 kV switch yard is drawn through twin 11 kV feeders each of 3 core XLPE cables to the substation.

All the low tension loads meant for illumination, office buildings etc. are drawn through a 11 KV/415 V transformers.

7.8.6.5 Distribution of Power

Two no. of 33 KV / 11 KV, 5 MVA, HT transformers will be installed at the main receiving substation. 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 for the initial phase.

11 KV feeders from main receiving substation will feed to two secondary substations; one for bulk 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 a 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. The substation shall be equipped with capacitor banks for automatic power factor correction and for maintaining a PF of not less than 0.9.

7.8.6.6 Standby Power Supply

It is proposed to install one diesel generator of 1 MVA each in container and bulk handling substations. These would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

7.8.6.7 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

Area	Lux Level
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.

7.8.6.8 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.

7.8.6.9 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.

7.8.6.10 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.

7.8.7 Communication System

7.8.7.1 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.

7.8.7.2 Telephone System

To meet the total port requirement, an EPABX of 100 lines capacity will be installed. Suitable telephone instruments to suit the site requirement with adequate protection will be provided.

7.8.7.3 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.

7.8.7.4 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.

7.8.8 Computerized Information System

7.8.8.1 Overall Objectives

The computerised information system proposed for Sagar 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.

7.8.8.2 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
- Operations Equipment Control (OEC)
- Cargo Control (CC)
- Yard Planning, gate delivery and receipt control
- Landside planning processes
- Enterprise Resource Planning

7.8.8.3 Technology Infrastructure

The IT Infrastructure of Sagar 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.)

7.8.9 Water Supply

7.8.9.1 Water Demand

The water demand for the Sagar Port has been worked out in the **Table 7.6** below:

Table 7.6 Estimated Water Demand at Sagar Port

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	38	223
2.	Potable Water (KLD)	15	42
Total Water Demand at Port (KLD)		**53**	**265**

7.8.9.2 Sources of Water Supply

It is understood that ground water is being utilised to meet the requirements of local population. As the water requirements for the proposed port are very much limited, bore wells shall be installed for the receipt ground water and transferred to an underground reservoir located near the port entrance. This water after chlorination shall be distributed for potable purposes.

7.8.9.3 Storage of Water

It is proposed to provide an underground water tank of 250 cum at the port boundary. 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 50 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 bulk terminal. The secondary sump at bulk 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/multipurpose 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.

7.8.10 Drainage and Sewerage System

7.8.10.1 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.

7.8.10.2 Solid Waste Management

For the buildings complex having administration building and port user buildings, a small sewage treatment plant of 20 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.

7.8.11 Floating Crafts for Marine Operations

7.8.11.1 Tugs

For berthing / un-berthing of the design coal carriers a minimum of three harbour tugs of 40 T bollard pull capacity are required initially. In addition, a tug is also required for standby/ emergency.

7.8.11.2 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. Though Sagar Port has a short channel, the vessel arrival and departure shall take place during high water time and hence queueing of vessels is expected. Therefore at least two pilot vessels would be required. In addition one standby vessel is proposed. This will also take care of requirements of routine maintenance and emergency break down/ repairs as well as security purposes.

7.8.11.3 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.

7.8.11.4 Harbour Crafts

The requirements of Harbour Crafts for the first phase of the Sagar Port development are given in **Table 7.7** below.

Table 7.7 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 40 T bollard pull	4
2.	Pilot cum Security Vessels	3
3.	Mooring Boats	2

7.8.12 Navigational Aids

7.8.12.1 General

It is envisaged that navigation will be carried out throughout the year, by day and night, except during cyclonic weather. 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 for safe and regulated navigation in channels, anchorages, berths and docks. It is proposed to use the existing VTMIS at Sagar Island for this port as well.

The aids to navigation proposed to be provided at port are shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1011** and are detailed below:

7.8.12.2 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 mile. In addition some buoys are proposed in the respective berthing area as well. IALA maritime buoyage system as per region A, in which Sagar Port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

7.8.12.3 Leading / Transit Lights

Considering the channel being 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.

7.8.13 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.

7.8.14 Fire Fighting System

7.8.14.1 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.

7.8.14.2 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.

7.8.14.3 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.

7.8.15 Pollution Control

7.8.15.1 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

7.8.15.2 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 Environmental Setting

Sagar Island is one of the largest river island and is 30 km long and 12 km wide. The major coastal geomorphological landforms identified around the island during the field survey were barrier beaches, spits, bars, tidal flats, mud flats, sand dunes, and marshy and swampy zones.

The site for the development of Greenfield port is proposed at Chandipur Village on the South-West side of the island. The selected site has about 500 m of tidal flats beyond which sparse habitation and paddy fields may be observed (**Figure 8.1**). On the shoreline some tree plantation was observed which was reported to be under afforestation program.

Tidal flat	Habitation near the selected site

Figure 8.1 Landside area behind proposed Port Site

The prime activity in the vicinity was observed to be agriculture, where rice is the main crop. Coconut plantation is also practised widely. No fishing or aquaculture activities were observed near the proposed site.

The region is found to have good provisions of electricity and drinking water.

8.2 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, GoWB
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, GoWB; 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	West Bengal 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	West Bengal Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	West Bengal 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.	Yes, All vehicles shall comply with these provisions	State Motor Vehicle Department

S. No.	Act/Rule/Notification, Year	Relevance	Applicability	Implementing Agency
		• Issuance of Pollution Under Control (PUC) certificate to vehicles used in		
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.	West Bengal 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, GoWB
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.

8.3 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 break water • 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	• 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	• Operation of vehicles and construction machinery	• Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery	• Increase in noise
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 • 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 •	• Discomfort to nearby communities due to noise, air and water pollution • Loss of land/	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and

		livelihood in case of rail and road development • Relocation of CPR and utilities for rail and road development • Increased traffic movement • Occupation health issues		water pollution **Positive Impacts** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

8.4 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.

8.4.1 Impacts on Land and Soil

The proposed port is planned on reclaimed land between low and high water line. It does not have much of vegetation except some afforestation carried out by forest department. The present vegetation in the areas is planned to act as wind breakers and as a shield during cyclonic conditions. Moreover, this plantation also protects erosion of the shoreline. Thus, vegetation clearing may lead to erosion.

Soil contamination 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 contactor 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.

8.4.2 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 ground and treated to be used for port activities. Thus, water availability to the locals from the existing Rudrapur water supply plant will not be impacted.

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 KLD 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 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 project, the following measures need to be implemented:

- Bore wells, if required to source water during 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 '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 WBPCB 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:
    - Dredged disposal site shall be identified 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.

8.4.3 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 and this arrangement shall continue to reduce the consumption of diesel;
- 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 West Bengal 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.

8.4.4 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.

Mitigation Measures

- 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.

8.4.5 Impacts on Ecology

As discussed earlier the proposed site is devoid of any vegetation except the small area where Afforestation has been carried out by forest department. Thus, impact of terrestrial ecology is limited.

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

However, it is well documented that sediment concentration of the Hoogly river is quite high and thus is categorised as low productive region in terms of presence of marine life forms. No fishing activity is been observed near the proposed location. Thus, damage to marine life due to the increase of turbidity would be minor, localized, temporary and reversible.

Mitigation Measures

- All care shall be taken that trees shall be protected as far as possible while site clearing.
- 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.

8.4.6 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

- Detail survey 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 wellbeing of affected families and panchayats.

8.5 Impacts during Operation Phase

8.5.1 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 off 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 in Sagar Port area for prevention of marine pollution.

8.5.2 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.

8.5.3 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 and 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.

8.5.4 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.

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.

8.5.5 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 and Job Trainings
- Environmental Services and climate resilience.

8.6 Environmental Monitoring Plan

This section presents the environmental monitoring framework for the project where parameters, frequency and locations for the environmental monitoring are suggested in **Table 8.3** below:

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	03-Apr
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	03-Apr
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 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	04-May

8.7 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 $ = INR 65/-
- Provision towards 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 6.6** 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

S. No.	Item	2020	2025	2030	2035
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	6	3	3	3
2.	DREDGING AND RECLAMATION	313	1,136	587	797
3.	BERTHS	256	176	162	151
4.	BUILDINGS	72	24	7	5
5.	STACKYARD AND OTHER BACKUP AREA	69	94	46	54
6.	ROADS AND RAILWAY	66	70	23	14
7.	EQUIPMENTS	230	332	411	305
8.	UTILITIES AND OTHERS	93	88	41	50
9.	PORT CRAFTS AND AIDS TO NAVIGATION	2	0	0	0
10.	Total (1+2+3+4+5+6+7+8+9)	**1,106**	**1,923**	**1,279**	**1,379**
11.	Engineering and Project Management @ 5%	55	96	64	69
Incremental Capital Cost (Rs. In Crores)		**1,161**	**2,019**	**1,342**	**1,448**

These capital cost estimates do not include the following:

- Road and rail bridge across river Muriganga, which shall be provided by Government agency.
- External linkages for rail, road from port to river Muriganga and beyond to hinterland
- Cost of land acquisition for rail/road corridors, offsite rail yard/exchange yard
- Port crafts, as these are proposed to be leased out
- Contingencies, 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 325 increasing to about 900 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 RTGCs and 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 Firefighting & Pollution Control - 3% per annum

9.2.5 Annual Operation and Maintenance Costs

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

Table 9.2 Annual Operation and Maintenance Costs

S. No.	Item	2020	2025	2030	2035
1.	REPAIR AND MAINTENANCE COSTS	21.9	26.4	27.2	21.8
2.	OPERATION COSTS	49.8	66.1	47.4	57.5
3.	TOTAL	**71.7**	**92.5**	**74.7**	**79.3**
4.	Contingencies @ 10%	7.2	9.3	7.5	7.9
5.	Administrative Expenses @ 5%	3.6	4.6	3.7	4.0
Incremental O & M Costs (Rs. In Crores) per annum		**82**	**106**	**86**	**91**

9.3 Implementation Schedule for Phase 1 Port Development

9.3.1 General

The main components for the Development of Sagar Port comprises of 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 Berths

The construction of berth shall be commenced on priority. The berths being offshore the contractor would need to build some bunds perpendicular to the shore till the berth side boundary of backup area so as to move the construction equipment and piling gantries. The berth piling would be commenced using piling gantries installed from the bunds. The superstructure would be mainly built using precast concrete elements to avoid soffit shuttering. The construction of berths is expected to take about 30 months.

9.3.3 Dredging

The dredging quantity for Phase 1 is only about 1.2 million cum and could be completed within a time frame of less than six months. The dredging may need to be carried out with the deployment of one trailing suction and if required a one cutter suction dredger for dredging the shallow areas. Considering the low volumes it is proposed to carry out dredging activity to match with the commissioning of the project.

9.3.4 Reclamation

For berth construction, the contractor would need to create bunds perpendicular to the shoreline on which the piling gantries shall be launched. The reclamation activity will be commenced subsequently with the disposal of dredged material within the reclamation bund. It is anticipated that the material obtained from the maintenance dredging in Auckland bar would be utilised for the reclamation purposes and therefore this activity shall take about 2 years. The top layers of the backup area shall be made by borrowed fill. The reclamation fill shall be placed in layers of small thickness and compacted before placement of next layer.

9.3.5 Revetment

The reclaimed land would need protection from wave attack under the cyclonic conditions. For this purpose an armour layer of rock shall need to be laid all over the boundary of the reclamation fill. This shall be undertaken once the backup area is fully reclaimed but before start of the yard development and onshore utilities.

9.3.6 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.

9.3.7 Implementation Schedule

The construction of Phase 1 development of the Sagar port is estimated to take about 39 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 Sagar Port is shown in **Table 9.3**.

Table 9.3 Implementation Schedule

10.0 Financial Analysis for Sagar Port

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.

10.2 CAPEX Plan

The capex spending for entire phase 1 development has been planned over 4 years with phasing of investment as 9 percent (first year), 25 percent (second year), 32 percent (third year) and 34 percent (fourth year). For other phases the implementation time is assumed to be 2 years and investment phasing assumed as 50% each year.

The incremental capital cost over master plan horizon is given in **Table 10.1**.

Table 10.1 Incremental Cost (INR in Crores) Over the Master Plan Horizon

Item	2020	2025	2030	2035
Incremental Capital Cost	**1,161**	**2,019**	**1,342**	**1,448**
Incremental Capital Cost – Without increasing draft beyond 9 m	**1,161**	**1,115**	**826**	**712**

10.3 OPEX Estimates

The operations and maintenance cost has been ascertained based on industry standards and includes maintenance dredging needed for the port (**Table 10.2**).

Table 10.2 Incremental O&M Costs (INR in Crores) Over the Master Plan Horizon

Item	2020	2025	2030	2035
Incremental O&M Costs	**82**	**106**	**86**	**91**
Incremental O&M Costs – Without increasing draft beyond 9 m	82	61	60	54

10.4 Sagar Port Tariff

Fixing proper tariff and port charges is one of the critical components of the financial analysis since the success of the project depends on the competitiveness and acceptability of the tariff to be charged to the users.

The rationale underlying the fixation of tariff for Sagar is as follows:

- Prevailing tariff levied by East coast ports, specifically Haldia and Kolkata Dock complex
- Competitiveness/Cost advantage compared to East Coast ports
- Adequate revenue to meet the debt service requirement, operation and maintenance costs including revenue share and lease rent to be paid to the Government and generate cash surplus for payment of dividend to the shareholders and funds for additional capacity expansion when required.

Though the aforementioned rationale is useful in determining a competitive tariff, in order to arrive at the desired tariff the following points should also be considered.

- Port Tariff is generally revised every 3 years due to escalation in cost of materials and the effect of the wage revision for the port employees.
- Prevailing rates should merely be limited to serve as a guideline. The new port should be able to charge a premium for the facilities superior to the competing ports.
- Tariff for newer ports should be higher than old ports, as an older port can afford to charge less owing to their comparative low investment and the fact that over the years it has paid for itself. However the tariff has to be competitive so as not to lose the share of traffic that has been projected to be handled at the new port.

It is therefore proposed that Sagar port charges ~INR 300 per Metric tonne of cargo (current prices), which is comparable to the port tariff charged by Haldia and Kolkata Ports as well as Paradip Port.

10.5 Financial Viability of the Project

The base case traffic of container and break-bulk overflow from Kolkata port has been considered to calculate the financial viability of the project (**Table 10.3**).

The pre-tax IRR has been calculated for 28 years i.e. 15 years from the last tranche of capex spending.

Also, since the profile of cargo anticipated at the port has containers- which are feedered to Colombo for transhipment and around 60 percent of general cargo, the parcel size of each commodity will be anticipated at 15,000-25,000 tonnes and hence, while dredging might enable Panamax ships to call at the port, most of the cargo can be evacuated by Sub-panamax ships, thus, the port can function without the dredging for draft of 13.5 m.

Table 10.3 Base Case Traffic Overflow from Kolkata Dock System

Base Case	Cargo overflow from Kolkata Port Trust - Containers & Break Bulk		
Year	Total Traffic (in MT)	Container (in MT)	Break Bulk (in MT)
2020-21	3.42	0.52	2.90
2021-22	4.09	0.71	3.38
2022-23	5.44	1.55	3.89
2023-24	7.41	2.99	4.42
2024-25	9.53	4.55	4.98

Base Case	Cargo overflow from Kolkata Port Trust - Containers & Break Bulk		
Year	Total Traffic (in MT)	Container (in MT)	Break Bulk (in MT)
2025-26	11.14	5.81	5.33
2026-27	12.84	7.15	5.69
2027-28	14.64	8.57	6.07
2028-29	16.52	10.07	6.45
2029-30	18.52	11.67	6.85
2030-31	20.05	12.80	7.25
2031-32	21.64	13.97	7.67
2032-33	23.29	15.19	8.11
2033-34	25.00	16.45	8.55
2034-35	26.78	17.77	9.01
2035-36	26.78	17.77	9.01

While building scenarios for financial modelling, following parameters have been taken as variables:

1. The cost of bridge is not considered in the capital cost of port development.
2. No VGF vs VGF of 20% or 40% on the Phase 1 CAPEX only
3. Tariff per tonne of INR 300 or INR 325 or INR 350
4. Both the revenue and OPEX are grown at 5% annually in the model and the inflated CAPEX at the time of investment is considered

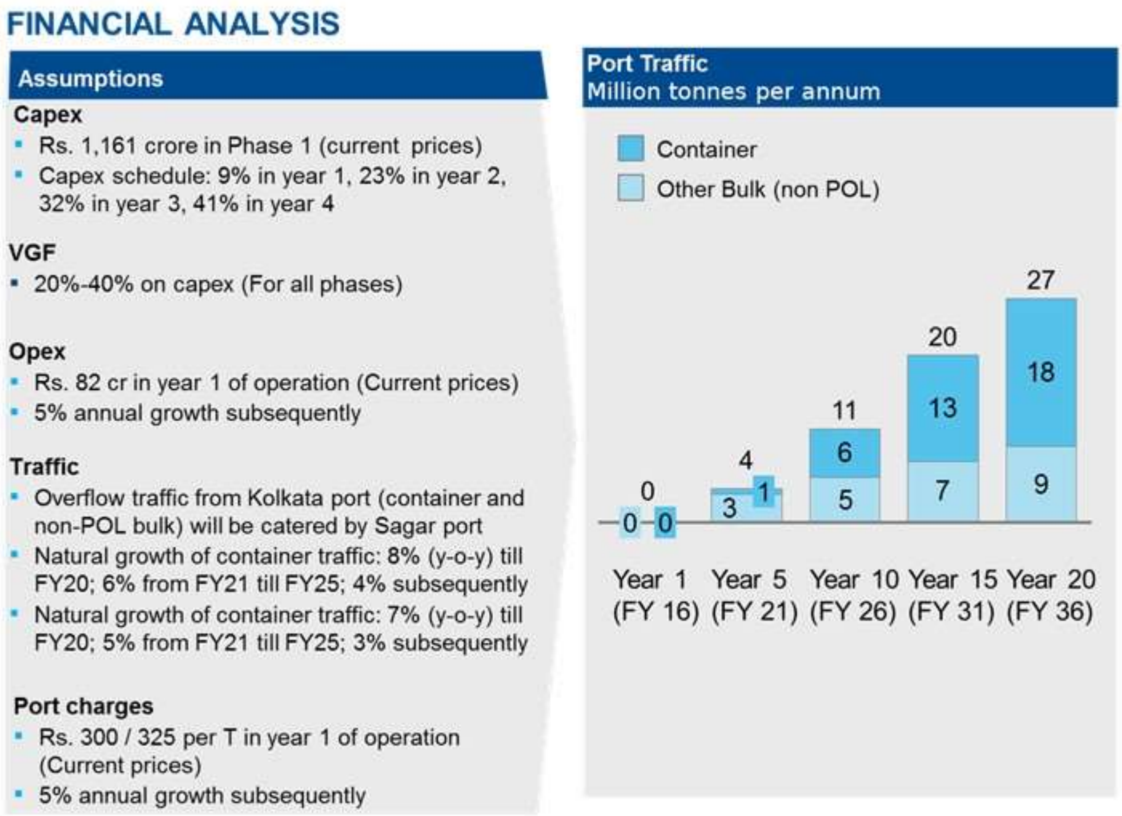


Figure 10.1 Sagar Port Financial Analysis details

The project IRR has been evaluated for various scenarios as mentioned below:

1. Scenario – 1: The port is developed as per the phase-wise development details considered in the report with incremental increase in the design draft.
2. Scenario – 2: Same as scenario 1 but design draft of the ships limited Phase 1 draft only i.e. 9.0 m, over master plan horizon
3. Scenario – 3: In this scenario it is assumed that the port development shall be limited to the facilities created in Phase 1 only. The traffic growth at the port shall be capped at a point when the berth occupancy goes upto 85% (i.e. about 7.5 MTPA).

The matrix of the project IRR calculations is presented in Table 10.4 below:

Table 10.4 Project IRR for Various Scenarios

%of VGF	No VGF			20% VGF			40% VGF		
Scenario	**Tariff @300/T**	**Tariff @325/T**	**Tariff @350/T**	**Tariff @300/T**	**Tariff @325/T**	**Tariff @350/T**	**Tariff @300/T**	**Tariff @325/T**	**Tariff @350/T**
Scenario 1 (Base Case) - Design Draft of Ship increases from 9.0 m to 13.5 m in phased manner	**6.20%**	**7.60%**	**8.90%**	**6.60%**	**8.10%**	**9.40%**	**7.00%**	**8.60%**	**10.00%**
Scenario 2 - Design Draft of Ship remains at 9.0 m for all phases	**12.45%**	**13.75%**	**14.96%**	**13.35%**	**14.74%**	**16.05%**	**14.45%**	**15.97%**	**17.40%**
Scenario 3 - No port development beyond Phase 1 excluding the incremental bridge cost	**12.56%**	**13.88%**	**15.11%**	**14.84%**	**16.31%**	**17.67%**	**18.25%**	**199.97%**	**21.57%**

The equity IRR for pre-tax and post-tax can be worked out once the mode of funding is decided but these would not have any impact on the viability projections of the project.

The scenario 3 presented in **Table 10.4** above has project IRR of 16.31% with tariff of Rs. 325/- per tonne and VGF of 20%.

It may be noted that the project IRR improves to 17.67% with a tariff of Rs. 350 per tonnes, which is still considered competitive considering the draft advantage offered by Sagar Port as compared to Haldia and Kolkata docks.

10.6 Alternative Means of Project Development

10.6.1 Option 1 – SPV Model

In this option the entire project shall be executed by the Special Purpose Vehicle (SPV) between KoPT and Govt. of West Bengal, who shall also arrange funds for the project financing.

10.6.2 Option 2 – Full PPP Model

In this option the project shall be executed through the partnership of SPV and one or more private sector companies.

In this option the private party provides the project and assumes substantial financial, technical and operational risk in the project. SPV contributions to a PPP may be in the form of transfer of land, creating transport linkages etc. In some other cases, the government may support the project by providing revenue subsidies, including tax breaks or by removing guaranteed annual revenues for a fixed time period.

While the port is suitable for development under this model as the SPV's investment in the project would be minimal. However there could be potential competitive issues in a situation where KoPT is fully saturated.

10.6.3 Option 3 – Landlord Model

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

10.6.4 Recommended Option

The project is recommended to be developed as per Landlord model, wherein the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the SPV. PPP Concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc.

10.7 Financial Analysis of Recommended Option

Based on the roles and responsibilities of the SPV and the Concessionaire, the breakup of cost estimates for the Phase 1 of the project development is worked out as shown in **Table 10.5**.

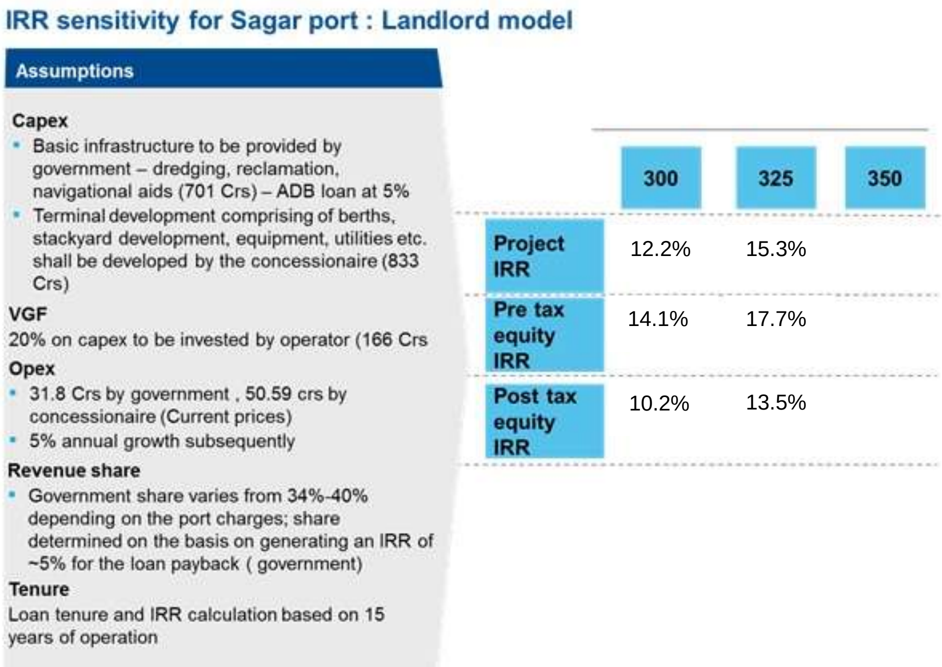
Table 10.5 Cost Split Between SPV and Concessionaire

Cost (Rs. In Crores)	SPV	Developer
Capital Costs	421.85	739.01
O&M Costs	31.84	50.59

Phasing of CAPEX	Cost (Rs. In Crores)	Cost (Rs. In Crores)
Year 1	103.41	5.07
Year 2	188.40	72.56
Year 3	101.01	250.23
Year 4	29.03	411.15

It is assumed that the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the SPV at total estimated cost of Rs. 421.85 crores funded by a multilateral loan at 5% payable over 15 years. PPP concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc. at an estimated cost of Rs. 739 crores.

The summary of the financial appraisal for the concessionaire is provided below:



11.0 Conclusions and Recommendations

11.1 Conclusions

The proposed port site at the Sagar Island along the coastline of West Bengal is technically suitable for development of a port. Considering its advantageous position over Haldia and Kolkata ports in terms of draft, it has a potential to attract customers for using this port for import and export of their cargo.

It is recommended that the project be taken up as per Landlord model. Initially phase 1 of the project shall be taken up i.e. a quay length of 600 m (suitable to handle 2 or 3 ships simultaneously), required backup area, associated infrastructure and dredging to handle 9 m draft ships.

The Sagar Port development shall involve the following broad activities as mentioned in paragraphs below. The process of port development is outlined in **Figure 11.1** attached.

11.2 Project Enablers

Given the borderline economics of Sagar Port substantial government interventions would be needed for generating private participation. The following are the key factors to make the Sagar Port successful:

- Limiting Greenfield investments in Haldia port complex; to create over flow for Sagar
- No expansion in container handling capacity at Kolkata Dock Systems
- Guaranteed Viability Gap Funding of minimum 20% from the State/Central Govt.
- Road connectivity to the port and bridge at River Muriganga to be constructed before port becoming operational
- Land Acquisition for rail, rail connectivity and offsite rail yard
- Establishment of industrial cluster/hinterland near Sagar port for enabling cargo flow
- Widening of NH-117 for road connectivity
- Expansion of mainland railway connectivity from Kashinagar to main routes

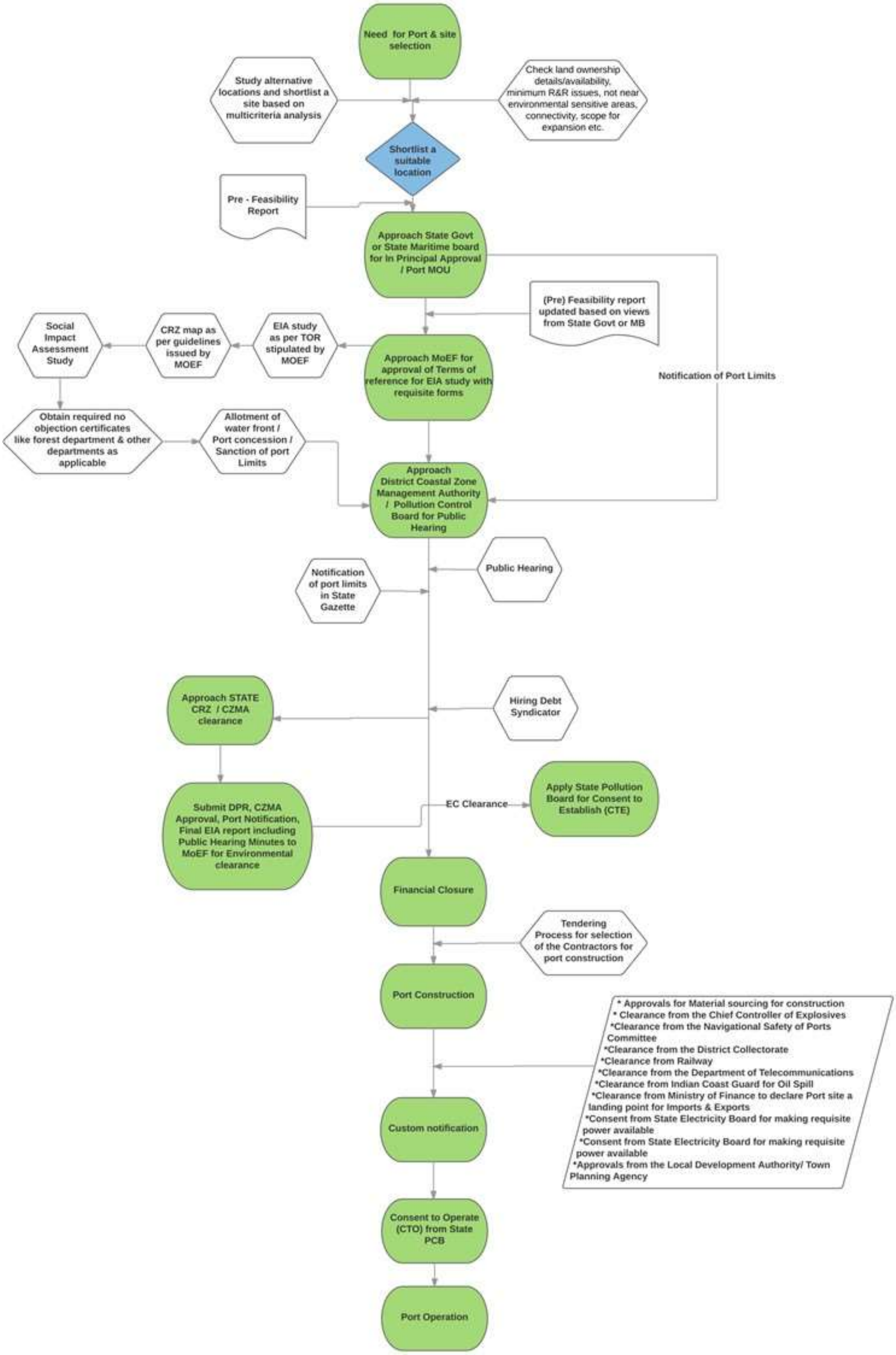


Figure 11.1 Process for the Greenfield Port Development

11.3 Way Forward

The action plans for the Sagar Port development project are as follows:

1. Appointment of Transaction Advisor for the Project
2. Preparation of tender documents for selection of private entity for the terminal development and operations as per the landlord model.
3. Tender documents (either EPC contract or Item rate contract basis) for selection of the contractor for the development of basic port infrastructure would also need to be prepared alongwith associated engineering works.
4. Appointment of consultant for EIA studies and approval of MoEF
5. Simultaneously award the work for construction of bridge across river Muriganga and upgrading the rail road connectivity in the hinterland.
6. The selected operator shall take the following actions for project development:
   a. Appointment of consultant for preparation of detailed project report for terminal development
   b. Coordination with state government for external infrastructure linkages like water, power, rail, road and also land needed for the offsite rail yard.
   c. On receipt of DPR, coordination with financial institutions for financial closure.
   d. Appointment of consultant for detailed engineering/EPC tendering for construction of terminal facilities
   e. Appointment of contractor(s) for construction of terminal facilities
   f. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

Techno-Economic Feasibility Report for Development of Port at Sirkazhi

Prepared for

Ministry of Shipping
Government of India

Ministry of Shipping / Indian Ports Association

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1.	25.08.2016		Comments on Draft Report	Shashank Yadav Engineer II

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EXECUTIVE SUMMARY

Introduction

To make best use of economies of scale, increased global trade and to achieve efficient management of supply chain, larger sized ships are being built (cape size vessels for moving bulk cargoes) to ply on international routes and as well as coastal. This benefits the cargo owners with lower freight costs which eventually lead to low cost of final product for the end user. With this in mind, it is envisaged by Ministry of Shipping that all major ports in India shall have infrastructure and equipment capable of handling such large ships that will be at par with their global peer group.

Port at Sirkazhi

Based on judicial directive, Chennai Port has been restrained from handling dirty cargo like coal and iron ore which have been shifted to Kamarajar Port (Ennore). The next coal handling port in Tamil Nadu is Karaikal in the Union Territory of Pondicherry at a distance of 280 km (156 nautical miles). Therefore, the concept of satellite port for Chennai Port has emerged, which aims at providing a Greenfield port along the Tamilnadu coast that serve the requirements of secondary hinterland of ChPT and also overcoming constraints of handling dirty cargo adjacent to the city. The development of satellite port in Sirkazhi would be a catalyst in aiding for speeding development of the region by providing the employment opportunities, industrialisation, cheaper end products to user etc.,

Based on the Origin–Destination studies carried out under Sagarmala assignment, it has been assessed that there is a good potential of about 58 MTPA of traffic for coastal movement of thermal coal from Sirkazhi to power plants located in the North & South Tamilnadu e.g. SRM, IL&FS, NLC, Sindhya & TANGEDCO etc. These industries can be better served by setting up a port close to proximity of the power Plants. In addition to diversion of traffic, Sirkazhi port can also build upon the industrial growth of Tamilnadu, which is considered one of India's most industrialised states, comprising large public sector industrial undertakings as well as privately-owned industries e.g. steel, sugar and textiles. The state has also evolved as the base for some of the largest public sector industries in India.

It is assessed that the proposed port shall cater to the total traffic volumes of 18 MTPA in Phase I and increasing upto 58 MTPA in Master Plan phase (year 2035).

Port Development Plan

It is proposed that the port facilities shall be developed in a phased manner commensurate with traffic growth. Considering that the coal would be the primary commodity for the port, it is proposed that the port facilities will be able to handle capsize vessels upto 200,000 DWT. As the proposed port has to compete with the adjacent port at Karaikal which can currently handle mini-cape size ships of 120,000 DWT (draft 16.5 m), it would be important that the proposed port at Sirkhazi be planned to handle cape size ships at initial stage of development itself.

Under Phase 1 development of the port it is proposed to provide 2 coal berths. In view of the cost economics and minimal impact on shoreline it is proposed to provide only one offshore breakwater initially to provide the required tranquillity. The estimated capital dredging for phase 1 development is about 17.2 Mcum. It is proposed that the coal for NLC power plant shall be directly taken to their power plant. For coal of other power plants stackyard has been proposed in the port boundary from where it shall be loaded into rail wagons through in- motion wagon loading system. Fully mechanised bulk import system shall be provided at the port with 2 × 2400 TPH capacity Grab Unloaders and 4,800 TPH conveyor system at each of the two coal berths.

Additional berths, equipment, other infrastructure and additional breakwater shall be added in staged manner till the ultimate stage development.

The estimated capital cost of Phase 1 port development is INR 2,446 crores. Additional INR 423 Crores would be needed for the rail/road connectivity to the port and land acquisition. Phase 1 of port development would have an implementation time of about 34 months.

It has to be noted that when the port is commissioned, it can readily capture 7 MTPA of thermal coal for TNEB Mettur Power Plant and 4 MTPA of imported coal for IL&FS Parangipettai Power Plant. If NLC power plant is commissioned by that time, an additional 6 MTPA of imported coal will have to be handled.

Assessment and Recommendations

The viability analysis for the project has been carried out considering three alternative models for port development i.e. development by project proponents, by full-fledged concession to private operators and landlord model.

In the project proponent model the project shall be executed by a Special Purpose Vehicle (SPV), which may include ChPT and other government entities. SPV shall arrange funds, manage and operate the port. The IRR for project proponent model works out to 12.5%.

In the second model in which the entire project is given to private developer and costs towards external rail/road connectivity, land acquisition for connectivity and port facilities shall be taken up by the government entities. In this case IRR for the private entity works out to 14.5% considering the private entity does not share the revenue with the government.

In the third model, SPV shall be responsible for providing the entire basic infrastructure for the port including the external connectivity and land acquisition to the port. The cargo handling terminals and associated facilities shall be developed by PPP operator, who shall be responsible for terminal operations & maintenance and also sharing the revenue with the SPV. Limiting the project IRR to 15% for the PPP operator, he can share about 50% of the revenue with the SPV with an overall IRR of 11.5 % for SPV. The estimated IRR for SPV can further improve if SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall reduce.

From these thorough analyses of the development of port at Sirkazhi, it can be concluded that the port has a great potential and can be developed under Landlord model.

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.

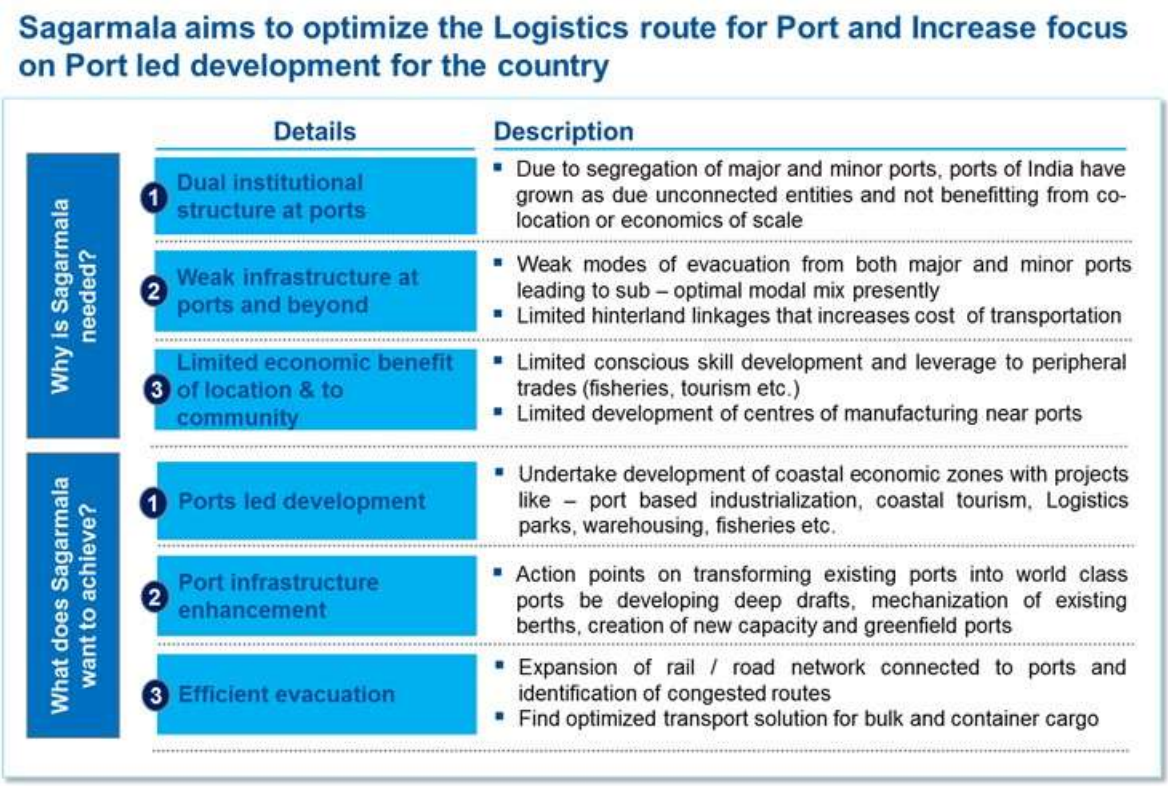


Figure 1.1 Aim of Sagarmala Development

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

The team of McKinsey and AECOM distilled learnings from the experience in port-led development, the major engagement challenge to develop a set of governing principles for our approach is shown in **Figure 1.2**.

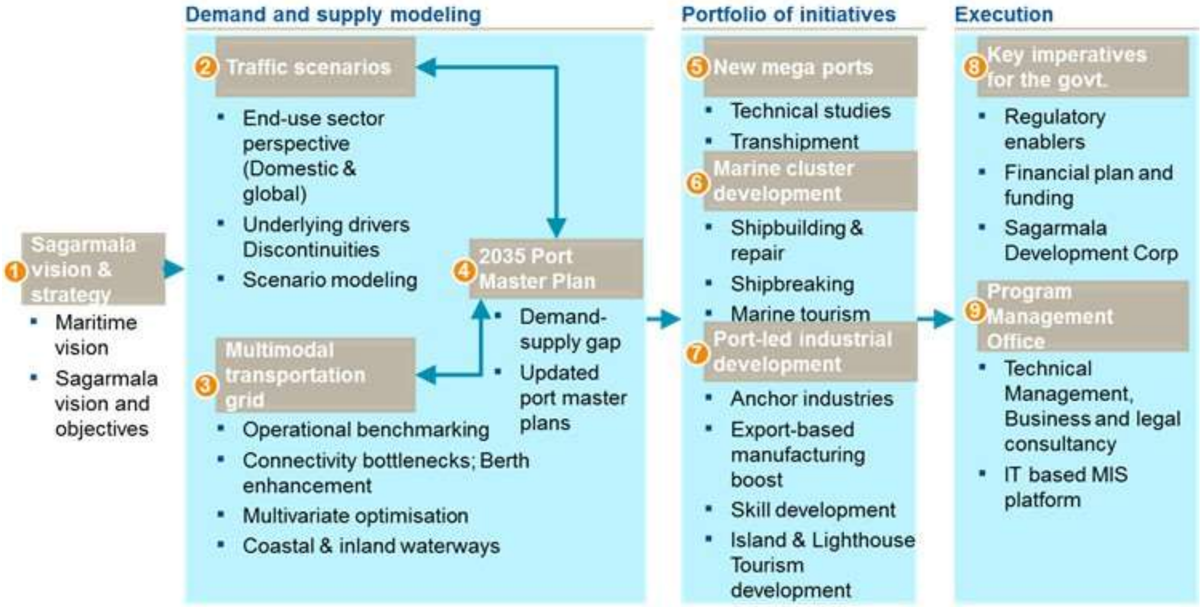


Figure 1.2 Governing Principles of Our Approach

As indicated above, the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports have been 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 another Major Port in Tamil Nadu

Based on judicial directive, Chennai Port has been refrained from handling dirty cargo like coal and iron ore which have been shifted to Kamarajar Port (Ennore). The next coal handling port in Tamil Nadu is Karaikal in the Union Territory of Pondicherry at a distance of 280 km (156 nautical miles). Hence, it has been proposed to set up another major port in between Ennore and Karaikal with a focus on handling coal for industries and thermal power plants.

1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for “Development of Port at Sirkazhi”, Tamil Nadu. This report is organised in the following sections:

Section 1	: Introduction
Section 2	: Site Selection
Section 3	: Site Conditions
Section 4	: Traffic Projection for Sirkazhi Port
Section 5	: Design Ship Sizes
Section 6	: Port Facility Requirements
Section 7	: Preparation of Port Layout
Section 8	: Engineering Details
Section 9	: Environmental Settings and Impact Evaluation
Section 10	: Cost Estimates and Implementation Schedule
Section 11	: Financial Analysis for Alternative Means of Project Development
Section 12	: Way Forward

2.0 SITE SELECTION

2.1 Present Status of Ports of Tamil nadu

The ports under the control of Tamil Nadu Maritime Board (TNMB) in Tamil Nadu are shown in **Figure 2.1**.

GOVERNMENT PORTS	CAPTIVE PORTS (C.P)		PORT UNDER PROCESS (Yet to be declared)
1. CUDDALORE	1. KATTUPALLI	9. VANAGIRI	1. PANAIYUR (Kanchipuram District)
2. NAGAPPATTINAM	2. ENNORE MINOR PORT	10. TIRUKKADAIYUR	
3. PAMBAN	3. MUGAIYUR	11. THIRUKKUVALAI	
4. RAMESWARAM	4. THIRUCHOPURAM	12. PUNNAKKAYAL	
5. VALINOKKAM	5. SILAMBIMANGALAM SHIPYARD	13. UDANGUDI	
6. KANYAKUMARI	6. PARANGIPETTAI	14. MANAPPAD	
7. COLACHEL	7. PY-03 OILFIELD	15. KOODANKULAM	
	8. KAVERI	16. CHETTINAD THARANGAMBADI	

Figure 2.1 Various Ports in Tamil Nadu

Among these ports, Cuddalore and Nagappattinam are Government ports. All others are captive ports. Among captive ports, Kattupalli, Mugaiyur and Semmbimangalam are for shipyards and ship repair facilities. Thiruchopuram, PY-03 and Thirukkadaiyur are for handling liquid cargo. The rest are linked to power plants and are to handle thermal coal.

The present status of these captive ports is presented hereunder:

- **Panaiyur - Cheyyur Port:- (Gazette Notification Not Yet Issued)**

The Government of India has proposed to develop a 4,000 MW Ultra Mega Power Plant (UMPP) at Cheyyur, near Marakkanam, in Villupuram district. A SPV, namely M/s. Coastal Tamil Nadu Power Limited (M/s. CTNPL) has been established for this purpose. In order to handle the coal required for this power plant, the company has been granted an in-principle approval to establish a port in a location called Panaiyur, south of Mudaliyar kuppam Boat House. ***Till date there is no progress at site.***

- **Parangipettai Port :- (Gazette Notification Issued During May, 2010)**

M/s. IL&FS Ltd. has proposed to develop a Captive Port to handle the coal required for their proposed 4,000 MW Power Plant at Parangipettai, in Cuddalore District. ***Till date no progress at site for the port. However, the 1st Phase of power plant (1200 MW) has been commissioned during October, 2015 and is sourcing coal through Karaikal port.***

- **Kaveri Port: (Gazette Notification Issued During January, 2010)**

M/s. PEL Power Limited had proposed to establish a jetty near Poombuhar in Nagappattinam District for handling coal for their proposed 1,320 MW Power Plant. ***Till date there is no progress at site.***

- **Vanagiri Port: (Gazetted Notification Issued During July, 2009)**

M/s. NSL Power Limited had proposed to establish a jetty in Sirkazhi taluk of Nagappattinam district for handling coal for 1,500 MW Power Plant. However, it is understood that this power plant has been shifted to Odisha. ***Till date there is no progress at site.***

- **Tharangambadi Port (Gazetted Notification Issued During January, 2012)**

Chettinad Tharangampadi Port: M/s. Chettinad Power Corporation Ltd. has proposed to set up a 1,320 MW Thermal Power project at Tharangampadi taluk in Nagappattinam District. ***Till date there is no progress at site.***

- **Thirukkuvalai Port: (Gazetted Notification Issued During April, 2008)**

M/s. Tridem Port and Power Company Private Ltd. had proposed to establish a captive port at Nagappattinam District to handle coal required for proposed 2,000 MW Merchant Power Plant. ***Till date there is no progress at site.***

It is also understood that Neyveli Lignite Corporation Ltd. is planning to set up a thermal power plant of 1,600 MW (2 × 800 MW) at Thirumullaivasal / Vettangudi (Sirkazhi site). This will be further expanded to an ultimate capacity of 4,000 MW (5 × 800 MW). The land for the power plant is understood to have been identified and NLC is taking it up with the State Govt.

Considering the locations of these proposed power plants and their present status, it is suggested that the new major port could be located at a suitable location so that it is able to cater to the needs of these plants as and when they come up. Instead of having many captive jetties along the coast, it is prudent to have a centralised coal handling at a specific area so as to ensure better management of environment.

Another advantage of the proposed port location at Sirkazhi is its proximity to Mettur and Parangipettai where thermal power plants are already in operation.

Mettur Thermal Power Station is operated by TANGEDCO. It has 4 units each of 210 MW and 1 unit of 600 MW which was commissioned recently giving its total capacity as 1,440 MW. Its annual thermal coal requirement is about 7.0 MTPA which is sourced from Mahanadi Coal Fields and routed through Paradip and Kamarajar Ports.

As indicated earlier, IL&FS have recently commissioned their 1,200 MW Power Plant at Parangipettai and they are sourcing their coal from Indonesia and are presently routed through Karaikal port as their captive port has not yet been taken up.

The nearest station to the proposed new port is Sirkazhi. By opting for this new port, both the power plants can reduce their railway haulage by about 100 km each. In fact, Parangipettai is only about 30 km away as compared to Karaikal at about 130 km. The relative locations of Sirkazhi, Parangipettai and Mettur are shown (*blue circle*) in the southern railway map given in **Figure 2.2**.

With this locational advantage, it is possible to kick-start this new port immediately with a starting traffic of about 17 MTPA. It will be a win-win situation for the power plants as well as for the new port.

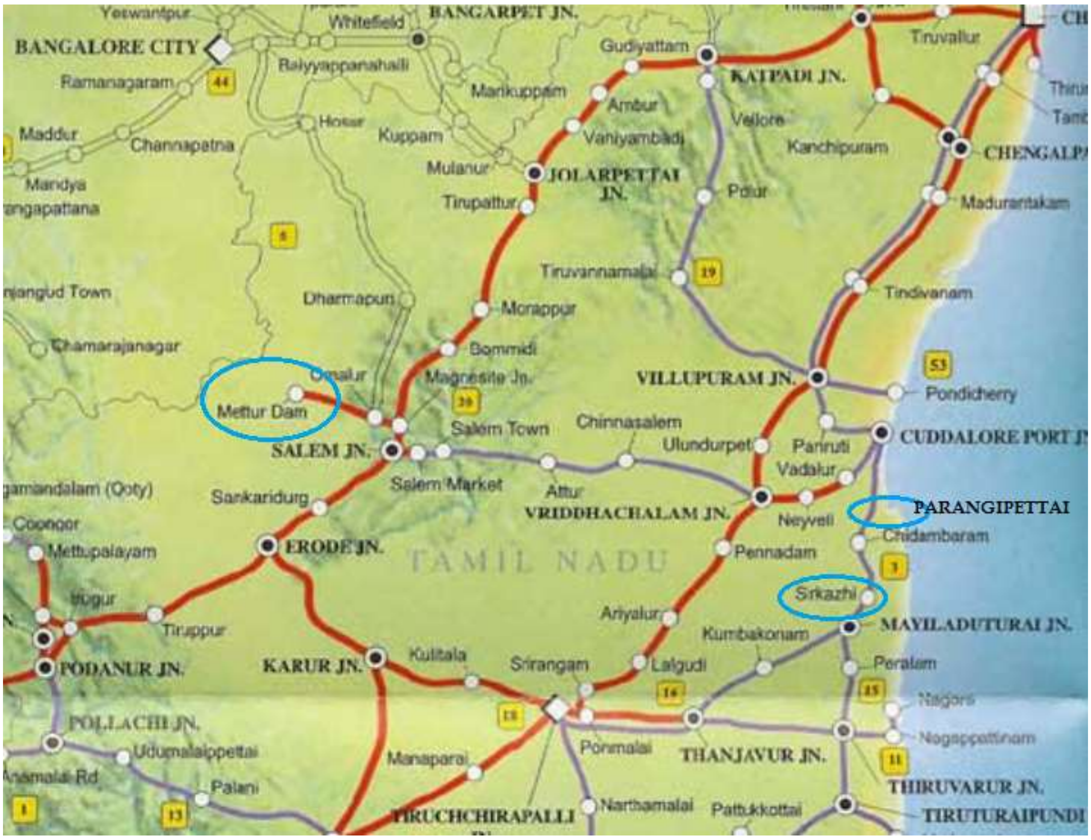


Figure 2.2 Relative Locations of Sirkazhi, Parangipettai & Mettur

2.2 Selection of Port Site

Considering the proposed locations of all these power plants, their capacities and the present status, it is proposed that the new port could be located east of Vettangudi where the power plant of Neyveli Lignite Corporation has been planned. This power plant could be the anchor client to the proposed port. Accordingly the exact location of the proposed port is examined hereunder.

The identified land for the NLC power plant lies almost in between Collidam River and Uppanar River as shown in **Figure 2.3**.

Figure 2.3 Tentative Location Identified for NLC Power Plant

On the northern side (about 7-8 km) at the mouth of Collidam River, there is a well-developed Pazhaiyar fishing harbour with about 400 fishing operational boats. On the southern side approximately 5 km at the mouth of Uppanar River is Thirumullaivasal, where a relatively small fish landing centre is operational. On the eastern side, there is a coastal stretch of about 3 km free of any habitation as marked as ‘A’ & ‘B’ in the **Figure 2.3**. A blow up image of this area is as shown in **Figure 2.4**.

Figure 2.4 Proposed Port Location

This coastal stretch has been examined by Chennai Port through the National Centre for Sustainable Coastal Management. It has concluded that this selected stretch is a stable coast. The finding is presented in the **Figure 2.5**.

Figure 2.5 Coastal Stability at the Location of Proposed Port

Considering the nearest rail head, this port is proposed to be named as **Sirkazhi Port**.

3.0 SITE CONDITIONS

3.1 Location of Project Site

The Satellite port to Chennai is proposed to be located near Sirkazhi in Tamil Nadu. The port site is 4 km north of Thirumullaivasal (a fishing village) while the latter is 14 km east of Sirkazhi town. All lie with in Nagappattinam District.

The site is bounded by the sea on the eastern side, Buckingham canal on the western side, a canal on the northern side and is about 1 km away from Thoduvaai village on the southern side. There is almost 2 km stretch of stable coastline at this location as discussed in **Chapter 2**. The site is free of habitation and there are casuarina plantations around. The location of the proposed thermal power plant of Neyveli Lignite Corporation is bound by Vettangudi on the west, Kooliyar village on the northern side and Radhanallur on the southern side. The co-ordinates of the site are 11° 18' N and 79° 50' E. Site location is as shown in **Figure 3.1**.

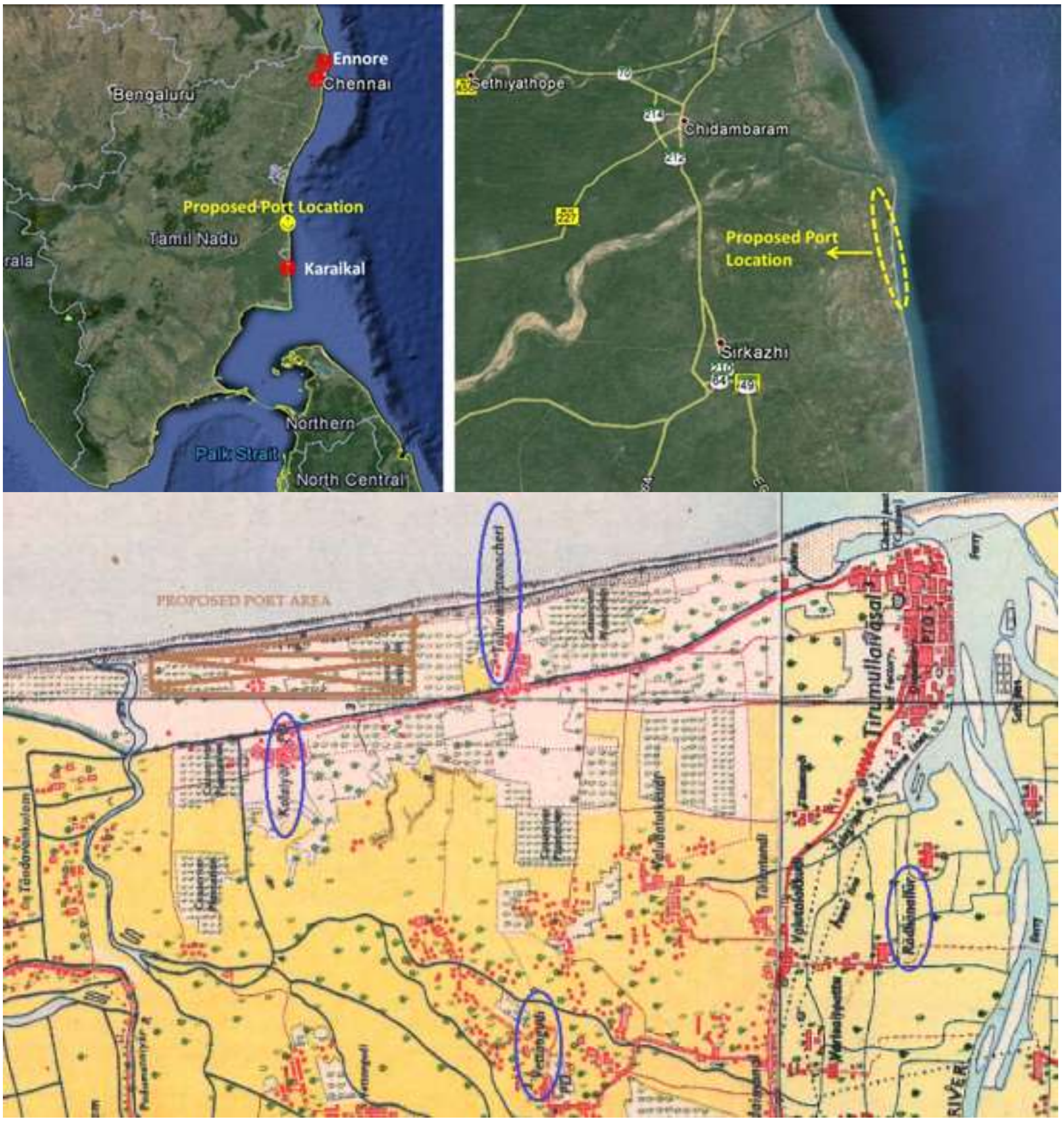


Figure 3.1 Location of Project Site

There is a clear distance about 800 m from the high water line up to the edge of Buckingham canal. This space is sufficient for locating the required port facilities.

Figure 3.2 Area Available for Port Facilities

Approximately 3,000 m of water front area is available for the proposed port development, which can be utilized for handling various cargoes. The port site is endowed with natural depths of 20 m within a distance of approximately 3,600 m from the shore.

The waterfront identified for the development of proposed port has a village named Thoduvaai in the immediate vicinity, while the other village Kooliyar is about 900 m west. The village has got a population of 8,000 and the main occupation involves mostly around small scale fishing and agriculture (rice, groundnut, cashew and mango).

3.2 Meteorological Data

3.2.1 Climate

The climate of the region is characterised by two seasonal monsoons viz. NE and SW. NE monsoon occurs between November and January and is characterised by predominant north-easterly winds. During this period the risk of a tropical storm or cyclones is higher than in most months. SW monsoon extends from June up to September and is characterised by occurrence of rain, with predominantly south-westerly winds.

3.2.2 Rainfall

The annual rainfall is in the order of 1,400 mm, about 65% occurring in the period October to December.

3.2.3 Relative Humidity

The climate of the area is tropical in nature with mean relative humidity around 75% reaching a maximum of almost 100%.

3.2.4 Temperature

March to June is the summer season with maximum temperature touching around 42º C. December to February is the winter season with minimum temperature falling to around 18° C.

3.2.5 Visibility

Throughout the year visibility is good as the fog is infrequent at sea in all seasons.

3.3 Oceanographic Data

3.3.1 Bathymetry

The Admiralty Chart No. 2069 suggests that 5 m contour is at around 0.7 km while 10 m contour is about 1.5 km and 20 m contour is 3.6 km away from the coast.

3.3.2 Tides

The tides in the region are semi diurnal in nature with two high tides and two low tides in a day. The various tidal levels at Sirkazhi port with respect to Chart Datum (CD) are as follows:

Mean High Water Springs (MHWS)	+ 1.1 m
Mean High Water Neaps (MHWN)	+ 0.9 m
Mean Low Water Neaps (MLWN)	+ 0.6 m
Mean Low Water Springs (MLWS)	+ 0.3 m
Mean Sea Level (MSL)	+ 0.7 m

3.3.3 Currents

The current during the NE monsoon is southwards and during SW monsoon is northwards. The current velocities are in the range of 0.1 m/s to 0.5 m/s.

3.3.4 Wind

The average wind speed does not exceed 20 kmph for almost 90% of the time during a year but during monsoon season, winds of up to 60 kmph speed are experienced. The annual average wind climate exhibits two distinct peaks in its directional distribution, centered approximately on SW and NE. Examination of the seasonal climate tables shows that these corresponds to the (SW) monsoon period and the post-monsoon (also referred to as northeast monsoon) period, respectively. Wind rose diagram for a period of 10 years is as shown in **Figure 3.3**.

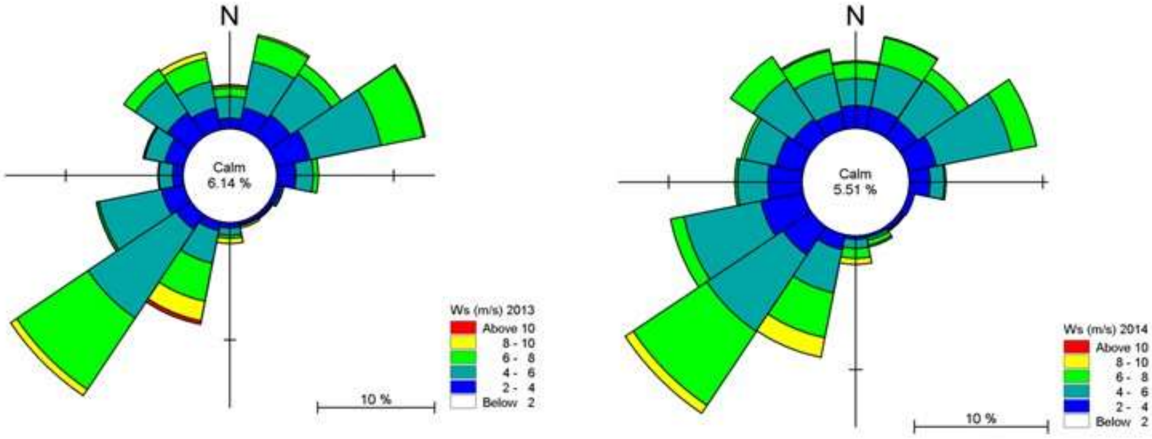


Figure 3.3 Wind Rose Diagram

Non-cyclonic offshore wind speeds for different return periods are as mentioned in **Table 3.1**.

Table 3.1 Non-Cyclonic Extreme Wind Speeds (m/s)

S. No.	Return Period (Years)	N-ENE	ENE-SSE	SSE-WSW	All Directions
1.	1	12.40	9.10	13.50	13.50
2.	50	14.50	11.60	15.50	15.50
3.	100	14.80	12.00	15.80	15.80
4.	200	15.10	12.30	16.10	16.10

3.3.5 Cyclones

East Coast is prone to cyclonic storms round the year but mostly these occur prior to SW monsoon i.e. in May and after SW monsoon i.e. in October and November. Tropical cyclones generated in the Bay of Bengal hit the coast between Nagappattinam and Chennai. The data relating to cyclones which crossed the areas within 200 Km from Sirkazhi between 1975 and 2013 is presented in the **Table 3.2**.

Table 3.2 List of Severe Cyclones Hitting the Site Shoreline

S. No.	Date	Maximum Wind Speed (Knots)	Duration (Days)	Type of Cyclone
1.	27.10.1975	33	1	D
2.	20.10.1976	47	1	SS
3.	29.11.1976	33	1	D
4.	12.11.1978	33	1	D
5.	25.11.1979	47	1	S
6.	18.10.1982	63	2	SS
7.	16.11.1984	47	2	SS
8.	01.12.1984	63	1	SS
9.	12.11.1985	33	1	D
10.	14.12.1985	47	1	S
11.	29.10.1991	33	1	D
12.	14.11.1991	47	1	S
13.	22.11.1993	63	2	SS
14.	04.12.1993	63	1	SS
15.	20.12.1993	33	1	D
16.	31.10.1994	63	1	SS
17.	06.05.1995	33	1	D
18.	14.10.1996	20	1	D
19.	29.11.2000	63	1	SS
20.	10.12.2005	43	1	S
21.	30.12.2011	63	1	SS
22.	16.11.2013	30	1	D
D – Depression; S – Storm; SS – Severe Cyclone				

3.3.5.1 Storm Surge

Surge levels were also assessed for the Thirumullaivasal shoreline. The assessment shows that the wind driven water surge towards the shoreline at shallow waters turns to be higher as shown in **Table 3.3**.

Table 3.3 Surge Levels Based on Extreme Cyclonic Storms (m) wrt CD

S. No.	Return Period (Years)	(-5 m)	(-10 m)	(-15 m)	(-20 m)
1.	1	0.40	0.30	0.30	0.30
2.	50	0.70	0.60	0.50	0.50
3.	100	0.80	0.70	0.60	0.60
4.	200	0.90	0.70	0.70	0.70

3.3.6 Wave

The offshore wave data obtained from secondary sources (UKMO) based on the hindcasting using the synoptic chart and statistical analysis has been considered to Sirkazhi site and is presented in the subsequent tables. The annual average offshore wave rose diagram is shown in **Figure 3.4**.

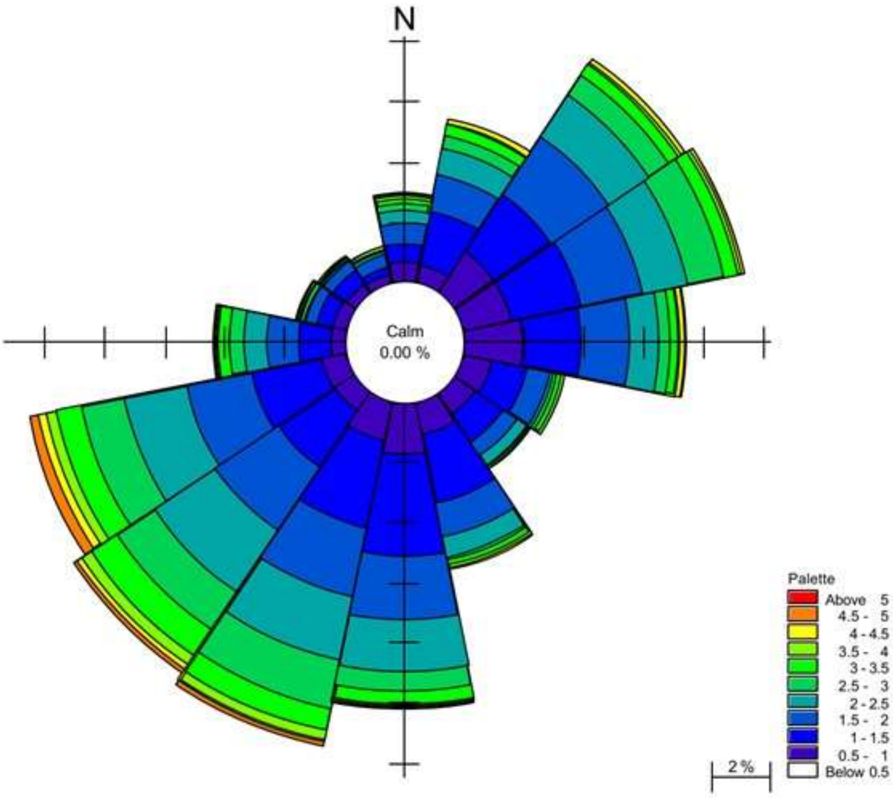


Figure 3.4 Annual Offshore Wave Rose Diagram

3.3.7 Nearshore Wave Transformation

Based on the past records for the offshore wave data mentioned above its respective nearshore transformed wave rose plot is shown in **Figure 3.5**, and nearshore wave characteristics for different return periods are provided in **Table 3.4**.

Table 3.4 Wave Characteristics for Return Periods wrt CD

S. No.	Return Period (Years)	(-5 m)		(-10 m)		(-15 m)		(-20 m)	
		Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1.	1	2.6	6.2	2.8	6.1	3.0	6.2	3.0	6.2
2.	50	3.7	8.4	3.9	8.2	4.1	8.2	4.1	8.1
3.	100	3.8	8.9	4.2	8.7	4.3	8.7	4.3	8.6
4.	200	3.8	9.4	4.4	9.3	4.5	9.2	4.5	9.1

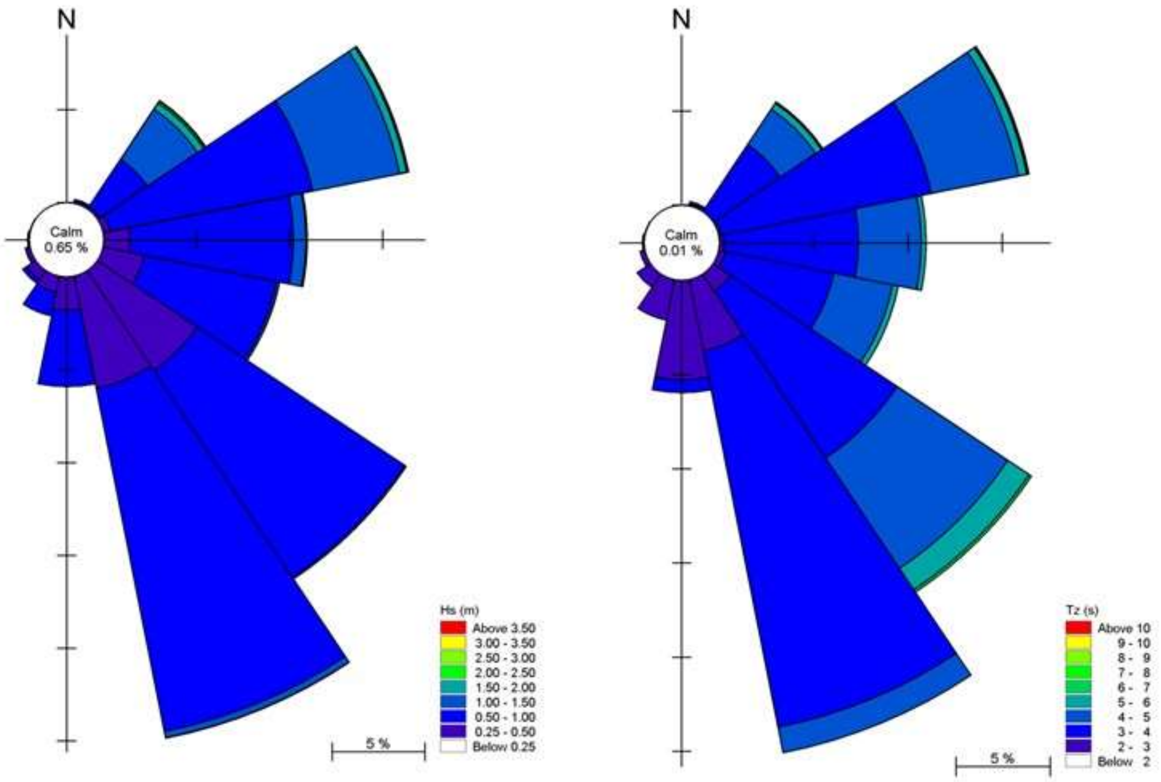


Figure 3.5 Nearshore Wave Rose Diagram

3.3.8 Littoral Drift

The east coast is subjected to the phenomenon of littoral sediment transportation, which is from south to north during SW monsoons and in the reverse direction during NE monsoons. The net annual littoral drift at a particular location depends upon the orientation of the coastline and also the nearshore wave climate at that location. The net drift towards north has been generally observed to increase as one moves up along the coast in the north direction, with values of as high as 0.75 Mcum in Visakhapatnam and 1.0 Mcum in Paradip. However, the observed net drift is much smaller in the ports located towards south such as V.O.Chidambaranar.

The site specific mathematical model studies on siltation were carried out near the proposed site. It has been observed that the gross annual littoral drift towards north and south are quite balanced and are 298,000 cum and 125,000 cum respectively. The net drift works out to only 150,000 cum per annum only towards north.

3.4 Site Seismicity

Sirkazhi is in **Zone II** of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone (**Figure 3.6)**.

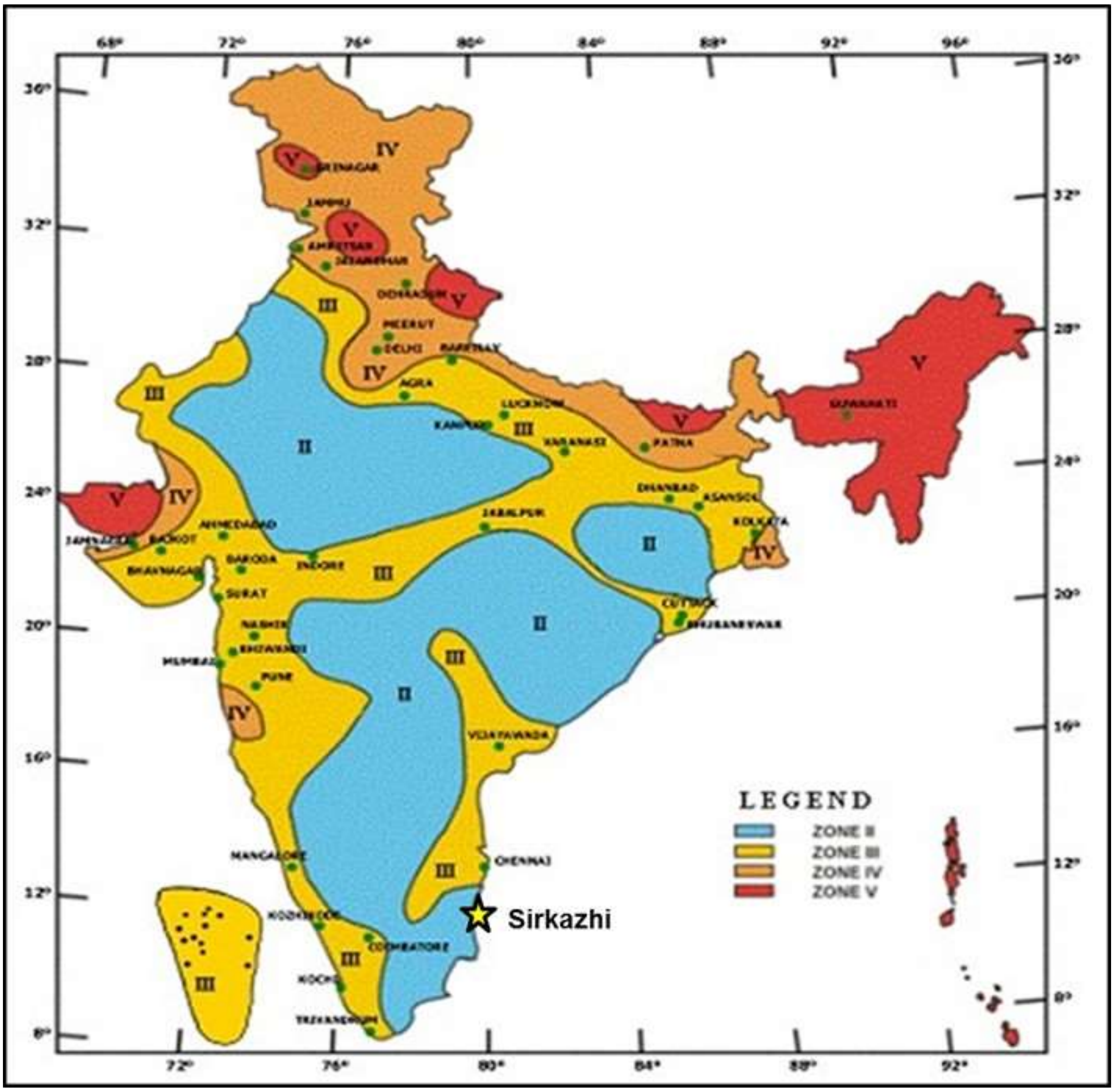


Figure 3.6 Seismic Zoning Map of India as per IS-1893 Part 1 – 2002

3.5 Geotechnical Data

Based on the available site data and information collected during the site visits, the geotechnical data indicates absence of any hard stratum like rock and presence of soft strata like dense fine silty sand along the seabed strata. The top layer is very loose to medium dense silty fine sand with less percentage of clay content. This stratum is followed with the layer of medium dense fine sand with the presence of silt. The depth of this layer varies from 15 m close to the shore. This layer is underlain with dense silty sand followed with the layer of very dense fine to medium course sand.

3.6 Topography

The proposed area for cargo storage and port operations shall be located along the stretch of 3 km of port waterfront area. Along this stretch Casuarina trees were observed along the shoreline covering almost entire 3 km stretch. The topographic details of the onshore area for port operation and storage have been extracted from source like Google Earth and processed through ArcGIS software. This information has been completed using the available land charts of the region. Proposed area of development is mostly flat with average ground elevations of varying from 1 m along the shore to 5 m. An average ground elevation of +1.5 m CD is considered.

The topographic details of the area are as shown in **Figure 3.7**.

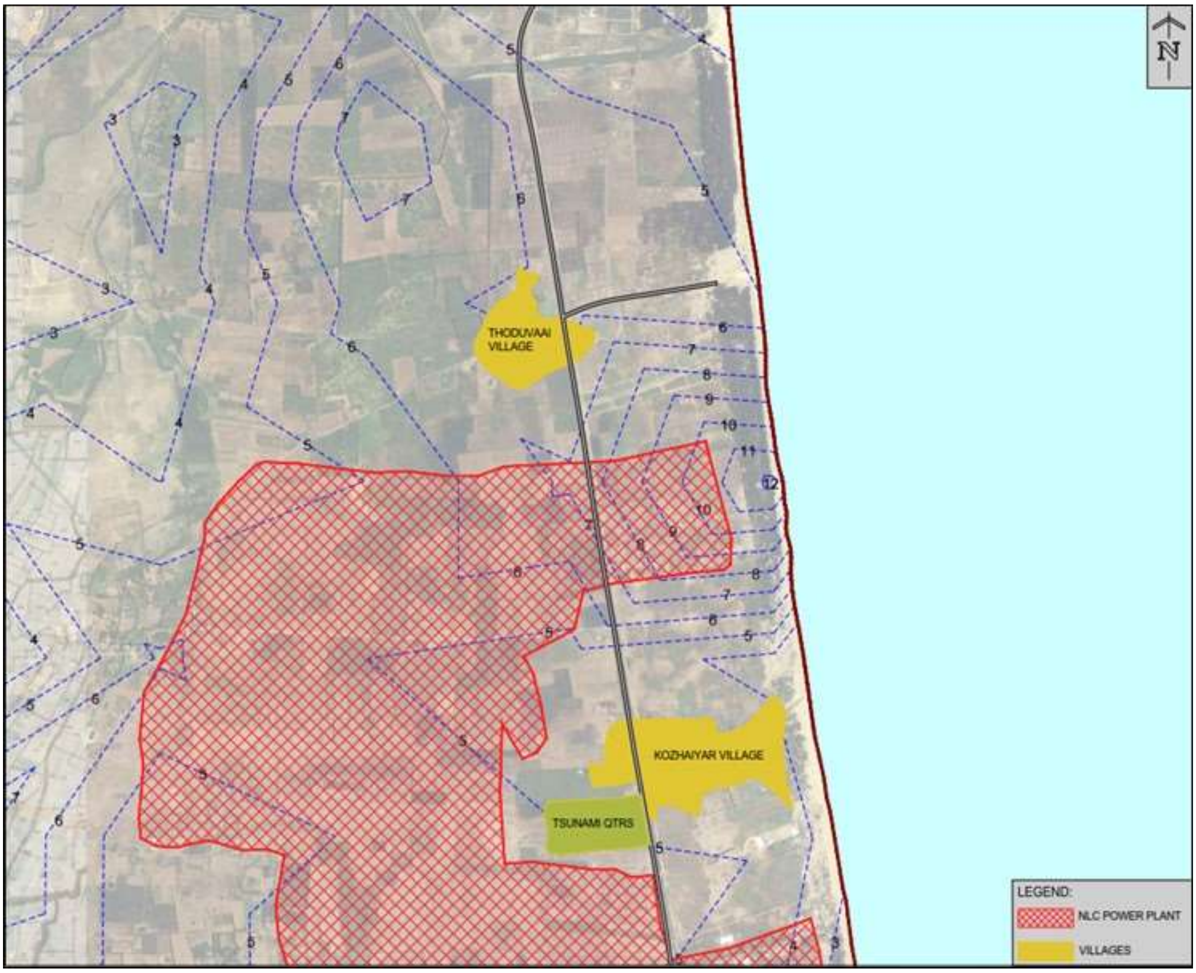


Figure 3.7 Topographic Details of the Proposed Sirkazhi Port Area

3.7 Connectivity of Port Site

3.7.1 Existing Rail Connectivity

The nearest railhead is at Sirkazhi (**Figure 3.8**) at a distance of about 14 km from the proposed port location. This location can be considered for rail head where the railway siding to the port site can be established. The station area shall include a secondary stackyard and siding facilities.

Figure 3.8 Sirkazhi Railway Station at Present

The existing rail network to Sirkazhi area is as shown in **Figure 3.9**

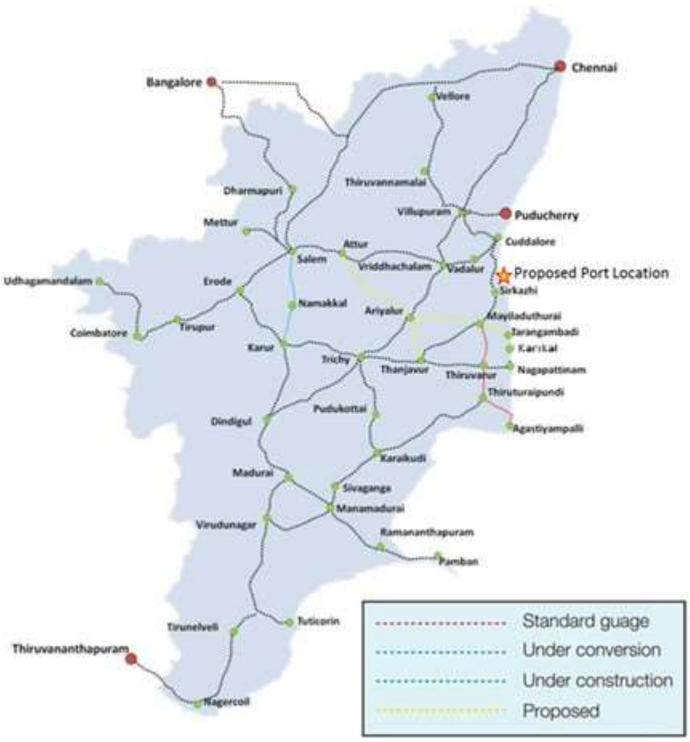


Figure 3.9 Existing Rail Connectivity

3.7.2 Existing Road Connectivity

The proposed port location is approximately 14 km from the East Coast Road (NH-45A), which passes through Cuddalore and links the proposed port to northern hinterland right up till Chennai. In addition to the national highways, a network of state highways connects Sirkazhi to other industrial centres of Tamil Nadu.

NH-67 starting from Nagappattinam (Approx. 60 km from the proposed port location and south of Karaikal) traverses Central Tamil Nadu in a near straight line connecting the major industrial areas such as Thiruchirapalli, Karur and Coimbatore as well as onward linkages to other industrial areas such as Salem, Erode and Mettur.

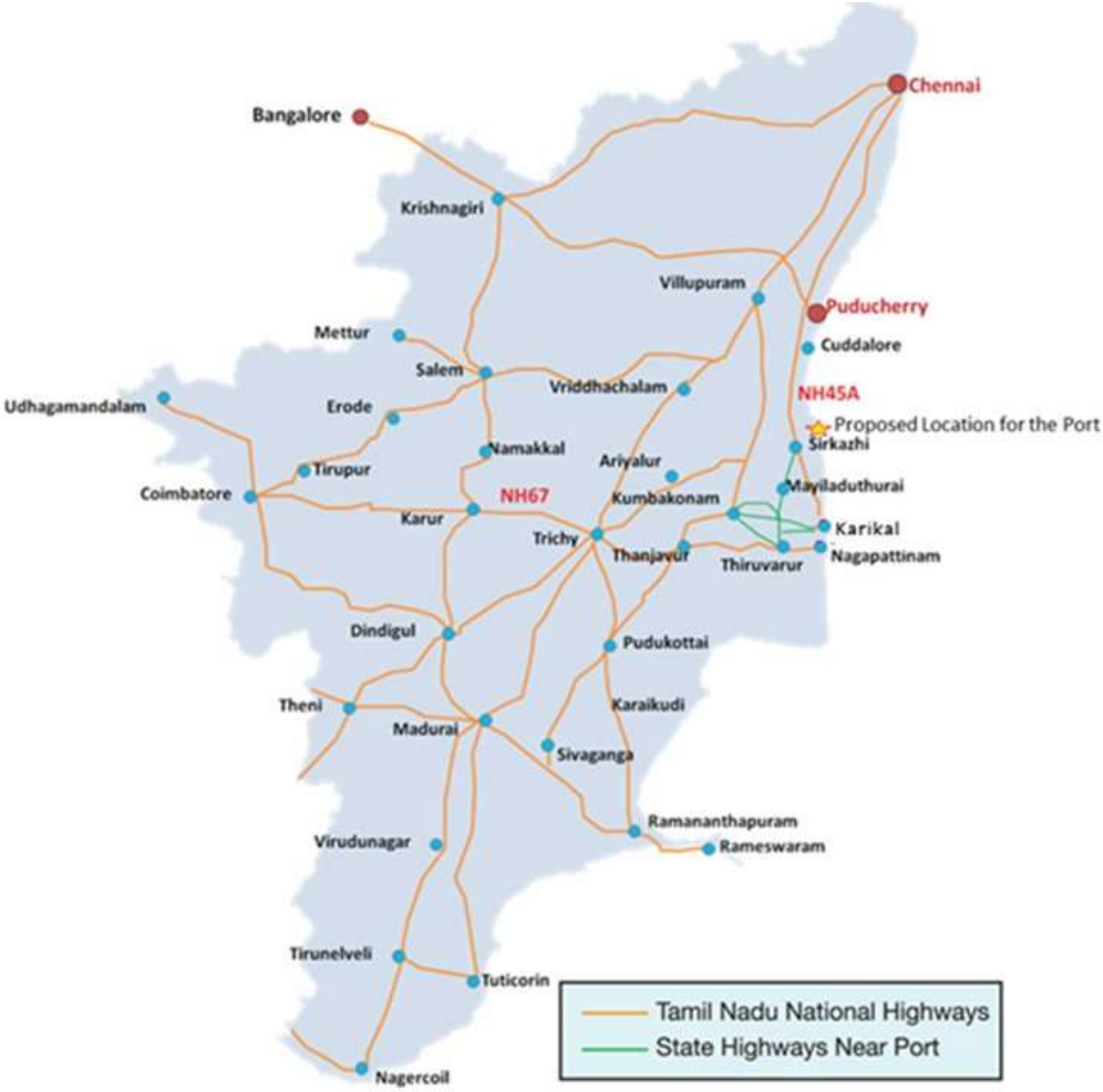


Figure 3.10 Existing Road Connectivity wrt Proposed Port

The proposed port location is connected via single lane road covering a total length of 14 km from Sirkazhi to Thirumullaivasal (about 6 km from proposed port location).

Figure 3.11 Road from Sirkazhi to Thirumullaivasal

3.8 Water Supply

The Madanam and Palaypalayam L&T water supply station supplies water to the adjoining 140 villages in the surrounding area, Thoduvaai also comes under its domain. This pumping station has a pumping capacity of 500,000 liters per day. The pumps are of 20 HP capacity and it is serving Thirumullaivasal village and its surroundings. To this pumping station additional water is pumped from Pannagattakudi borewells near Sithamalli village. Further additional water can be pumped from Collidam River, if required. Ground water table near Thoduvaai is good and available within 20 feet.

Figure 3.12 Existing Water Supply Station

To meet the water demand in the port area during the construction phase, water can be sourced from Collidam River. However, during operational phase of the port the water supply will be from the desalination plant.

3.9 Power Supply

33/11 KV substation is located at Edamanal (**Figure 3.13**) which is about 10 km away from the proposed port location (recently upgraded to HT substation). The substation has got 3 feeder lines which are at Thettai feeder, Kooliyar feeder and Thozilga feeder. The substation is working with 8,000 KVA capacity which can be enhanced suitably as per the requirement.

Figure 3.13 Electrical Substation at Edamanal

4.0 TRAFFIC PROJECTIONS FOR SIRKAZHI PORT

4.1 General

The origin-destination of key cargo for port at Sirkazhi and development of traffic scenarios for a period of 20 years, i.e. upto 2035 has been carried out by **McKinsey & Co.** as mandated for this project.

The proposed port site of Sirkazhi lies on the Southern coast of India in Tamil Nadu. It has operational major ports of Chennai and Ennore on the north and major port of Tuticorin on the south. Tamil Nadu would be the primary hinterland of the port. Considering the location of the proposed site and the presence of other ports in proximity, Sirkazhi port would have to compete for the same hinterland with ports of Ennore, Chennai, Karaikal, Tuticorin and Katupalli.

4.2 Major Commodities and their Projections

Thermal coal, coking coal, POL and containers would be the key commodities that can be catered to by the proposed port. Thermal coal, which is the major commodity for the port, would be diverted away from the existing ports of Ennore and Tuticorin. It has to be noted that all identified traffic is only potential and traffic commitments may be needed for final go-ahead.

4.2.1 Coal

The port is expected to divert part of the traffic currently handled by Ennore and Tuticorin ports. Neyveli Lignite Corporation, IL&FS and Mettur (TANGENCO) would be the key plants in the hinterland ideally placed to take supplies through the Sirkazhi port. These plants are closer to Sirkazhi port as compared to Ennore and Tuticorin ports.

In the case of IL&FS, as Sirkazhi cuts distance to the plant by 100 km, it is reasonable to expect this traffic at Sirkazhi port. In addition, Mettur plant can take coal from the proposed Sirkazhi port as it is also ~100 km nearer as compared to the next nearest port.

In 2020, it is also understood that Neyveli Lignite Corporation Ltd. is planning to set up a thermal power plant of 1,600 MW (2 × 800 MW) at Thirumullaivasal / Vettangudi (Sirkazhi site). As the proposed Sirkazhi port is the nearest port, it is expected that incremental ~6.6 MTPA of coal will be handled at Sirkazhi port in 2020.

In 2025, setting up of a power plant by SRM Energy in Cuddalore can also result in incremental traffic of ~6.1 MTPA for the proposed port. In the 2025 optimistic case, ~10 MTPA of coal traffic for upcoming plants of Patel Energy (Tirumalai) and 2 power plants of Sindhya Power at Nagappattinum has been accounted for in the projections. In addition, the 2025 optimistic case also assumes IL&FS to handle its coal traffic at the Sirkazhi port considering the port is the nearest to its power plants.

In 2035, the port is expected to handle, 6.1 MTPA of traffic for Mettur plant, 6.1 MTPA of traffic for SRM energy plant, ~10 MTPA of traffic for the plants of Patel energy and Sindhya power. In addition going forward in 2035, Phase II expansion of Neyveli Lignite Corporation can add an incremental traffic of ~6.7 MTPA. The 2035 optimistic case also assumes IL&FS to handle its coal traffic at the Sirkazhi port considering the port is the nearest to its power plants.

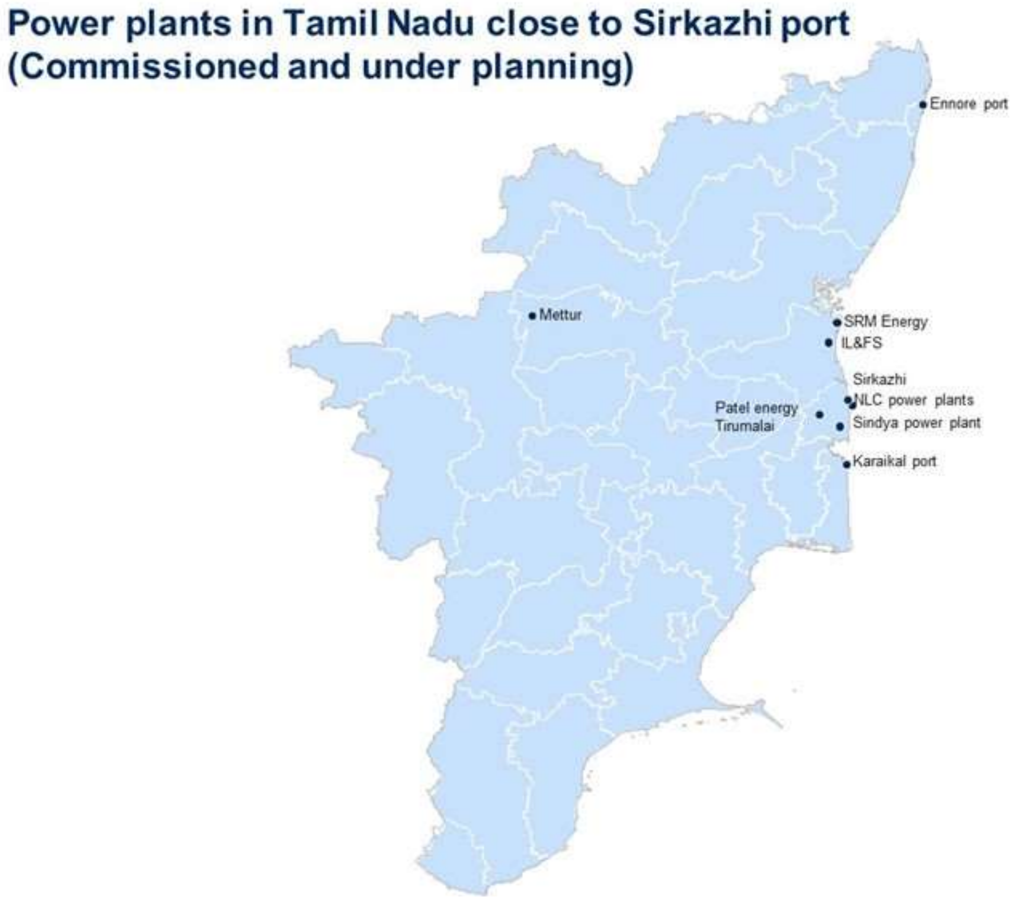


Figure 4.1 Location of Power Plants Close to Sirkazhi Port

Also, JSW Salem plant with a capacity of 1 MTPA is expected to add traffic of ~0.7 MTPA of coking coal to the proposed port.

4.2.2 Containers

The proposed port is expected to attract traffic of ~60,000 TEUs by 2020 primarily from the hinterlands of central Tamil Nadu. This traffic would be diverted mainly from the ports of Ennore and Chennai on the north and Tuticorin in the south. This traffic is expected to be generated from the hinterlands of Namakkal, Karur and Salem. The GDP of these hinterlands are expected to grow at a CAGR of 9-11% resulting in estimated traffic of ~80-97,000 TEUs by 2025.

In the case of a new transhipment hub coming up on the Southern tip of the country the potential traffic is expected to significantly decline owing to the fact that part of the Tamil Nadu containers will go directly to the transhipment hub.

4.2.3 POL

Tamil Nadu is expected to face a deficit of around 10 MTPA of MS/HSD deficits in the next 10 years. This deficit is proposed to be met by coastal shipping of product from Cochin refinery or other refineries on east coast of India (Vizag, Paradip etc.). The proposed port would be best positioned to serve the demand arising from the closest hinterland districts of Cuddalore, Ariyalur, Perarbelur etc. in the longer term it is proposed that a Greenfield refinery be set up in Central Tamil Nadu. Hence it has been assumed in the optimistic case, that a 10 MTPA Greenfield refinery will come up in Central Tamil Nadu and the refinery will use the port to meet its crude demand. The refinery capacity is proposed to go up to 20 MTPA by 2035 in order to meet the demand and consequently the crude traffic at port is expected to go up to 15-20 MTPA by 2035 in optimistic case.

4.2.4 Other Cargo

Other than the above mentioned commodities, break bulk and coastal cargo is expected to form a significant share of the total traffic owing to the rich hinterland of the proposed port site. Cuddalore, Ariyalur, Perarbelur, Tiruchirapalli, Salem, Namakkal, Karur and Erode are the key districts in the primary hinterland of the port. Proposed port of Sirkazhi is ideally located to serve the break bulk requirements of these districts. Consequently, the break bulk and coastal cargo traffic is expected to be ~2.7 MTPA by 2020 and 4-7.6 MTPA by 2025.

The overall commodity wise projections for the port are as shown in **Table 4.1**.

Table 4.1 Traffic Projection of Sirkazhi Port

Sirkazhi Port - Traffic Projections

Units: MMTPA (except Containers)

xx Base Scenario | xx Optimistic Scenario

Commodity	2020	2025 (Base)	2025 (Optimistic)	2035 (Base)	2035 (Optimistic)
Dry and Break Bulk Cargo					
Thermal Coal (Unloading)	22.5	28.6	38.6	45.4	45.4
Coking coal	0.7	0.7	0.7	0.7	0.7
Containers and other Cargo					
Containers ('000 TEUs)	57.6	79.5	97.2	188.3	275.9
Others	2.7	3.9	7.6	7.6	10.8
Liquid cargo					
POL	1.5	1.5	10	2	15
Total (MMTPA)	**28.3**	**35.9**	**58.4**	**58.5**	**76.0**

Conversion Factor Used for Containers Projections: 1 TEU = 15 Tons

The others cargo split are given in **Table 4.2**.

Table 4.2 Other Cargo Split - Traffic Projection of Sirkazhi Port

Sirkazhi Port - Traffic Projections (Others)

Units: MMTPA (except Containers)

xx Base Scenario xx Optimistic Scenario

Commodity	2020	2025		2035	
Others cargo					
Steel	0.4	0.5	0.5	1.0	1.0
Cement	0.3	0.4	1.9	0.9	2.3
Fertiliser	0.1	0.1	0.1	0.2	0.2
Food grains	0.6	0.7	0.7	1.0	1.0
Break bulk[1]	1.4	2.1	4.4	4.5	6.3
Total (MMTPA)	**2.7**	**3.9**	**7.6**	**7.6**	**10.8**

1 Break bulk assumes 10% of overall cargo

4.3 Cargo Considered for Proposed Port at Sirkazhi

For planning of Port at Sirkazhi, the phase wise traffic as shown in **Table 4.3** has been considered.

Table 4.3 Projected Cargo for Port at Sirkazhi

Cargo Handled	I/E	Projected Traffic (MTPA)		
		2020	2025	2035
Coal	I	17.7	28.6	46.1
Breakbulk & Containers	I/E	0.0	5.1	10.4
POL	I	0.0	1.5	2.0
Total		**17.7**	**35.9**	**58.5**

As the port would be developed primarily for handling coal and other traffic like breakbulk and containers may take to get built up, it is proposed that phase 1 be planned only for coal traffic. This would minimise the initial capital investment. Depending upon the user requirements other facilities could be added in later phases of development.

5.0 DESIGN SHIP SIZES

5.1 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 of annual traffic to be handled and the likely parcel size as per the requirements of the users

Coal is the main commodity to be handled at the proposed Sirkazhi Port. However, there will also be some potential for handling breakbulk and containers.

5.2 Dry Bulk Ships

Coal being the main cargo commodity proposed to be handled at the proposed port at Sirkazhi. 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.

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

Presently, the coastal shipping of thermal coal to southern states is carried out using ship sizes limited to Panamax. However, more and more facilities are being built in the southern states to receive vessels up to cape size and ports further north can handle vessels of 200,000 DWT. The coastal shipping in cape size carrier offer additional cost advantage for many of the users and it would be prudent, if the proposed port should also have unloading facilities for cape size ships.

5.3 Containers

Container ships are classified into six broad categories viz. Feeder, Feedermax, Handy, Sub-Panamax, Panamax and Post-Panamax. The following **Table 5.1**, which has been compiled through the Shipping Register of Lloyds Fairplay database, gives a broad outline of the principal dimensions of the ships under the different categories. The **Table 5.1** 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 its other facilities.

Table 5.1 Dimensions of the Smallest and Largest Ship

Parameters	1,000 TEU	2,000 TEU	4,000 TEU	6,000 TEU	9,000 TEU	14,500 TEU	16,000 TEU	Triple E	20,000 TEU
Nominal Capacity	1000	2000	4000	6000	9000	14500	16000	18000	20000
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	16.0	16

[Source: Lloyds Fairplay database]

In view of its location, the port at Sirkazhi is expected to handle feeder vessels only and therefore the design ship size for container is likely to be limited to 4,000 TEUs.

5.4 POL

The liquid cargo mainly involve the product handling facility, the berth may be required to handle small tankers on exigencies. Hence, for laying out jetty the ship size ranging from 20,000 DWT to 80,000 DWT is considered for planning purpose.

5.5 Break Bulk Ships

The general cargo commodities such as steel, fertilizers, food grains, cement etc. are likely to be handled in ships, which range from 10,000 DWT to 65,000 DWT.

5.6 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed port is presented in **Table 5.2**.

Table 5.2 Parameters of Ship Sizes

Commodity	Design Ship Sizes (DWT)	Maximum Parcel Size (T)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Dry Bulk	80,000	72,000	240	32	14.5
	120,000	110,000	260	40	16.5
	200,000	200,000	300	50	18.3
Container	1,000 TEUs	700 TEUs	160	22	10.0
	4,000 TEUs	1,200 TEUs	290	32	13.5
POL	60,000	54,000	230	32	12.5
Break Bulk	65,000	60,000	240	32	14.5

[Source: Lloyds Fairplay database]

6.0 PORT FACILITY REQUIREMENTS

6.1 General

The layout of the master plan of any port should be based on the expected traffic at different timelines, size of ships, facility requirements in terms of number and length of berths, navigational requirements, material handling system, storage area required for each type of cargo, road and rail access for the receipt, evacuation of cargo, and other utilities and service facilities. The layout of the proposed port at Sirkazhi is prepared based on these.

The vessel size for Phase 1 needs to carefully chosen so that the capital investment commensurate with the traffic forecast. Accordingly, it is proposed to consider the following options for phasing of depths in approach channel and harbour basin:

1. Initial development for panamax size ships having draft of 14.5 m.
2. Initial development for cape size ships of draft up to 18.3 m.
3. Initial development for panamax size ships and deepening of the channel and harbour basin to handle cape size ships in phase-wise manner as per the market demand.

As the proposed port has to compete with adjacent port at Karaikal which can currently handle mini-cape size ships and can be deepened further upto -18.0 m dredged depth to handle 120,000 DWT cape size ships (draft 16.5 m), it would be Prominent that the port be planned to handle cape size ships at initial stage of development itself.

6.2 Berth Requirements

6.2.1 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.

6.2.2 Cargo Handling Systems

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

6.2.2.1 Dry Bulk Import

For bulk cargo, it is proposed to provide a fully mechanised coal handling system comprising of gantry type coal unloaders, conveyor system, stacker, reclaimers and in motion wagon loading system etc. It is expected that with the proposed handling arrangement about 45,000 T coal can be unloaded per day at one berth on an average.

6.2.2.2 Breakbulk and Containers

It is proposed to be handled through mobile harbour cranes with spreader arrangement. For handling at the container yard, suitable number of Rubber Tyred Gantry Cranes (RTGC's) shall be provided. At the railway yard reach stacker shall be provided for loading and unloading of rakes.

6.2.2.3 POL

The POL products are unloaded from the tankers by means of marine unloading arms and transferred to the tank farms through the pipelines. The unloading rates mainly depend upon the capacity of the on-board ships provided the matching capacity of unloading arms and pipelines are provided. The average handling rates achieved at berth for POL products is about 8,000 TPD.

6.2.3 Operational Time

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.

6.2.4 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.

6.2.5 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, 65% for 2 berths and higher for 3+ berths for similar commodity. This shall reduce the pre-berthing detention of ships and offer reduced logistics cost to the shippers.

6.2.6 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 6.1**:

Table 6.1 Berths Estimates for Port at Sirkazhi

S. No.	Berth Type	Commodities to be Handled	Import (I) / Export (E)	Total Berth Provided		
				2020	2025	2035
1.	Bulk Import	Coal	I	2	3	4
2.	Multipurpose Terminal	Break Bulk/ Containers	I/E	0	3	5
3.	POL	Liquid	I	0	1	1
	Total			**2**	**7**	**10**

6.2.7 Port Crafts Berth

For the initial stage development, the port would require 4 tugs (3 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 berth for berthing of port crafts initially. An exclusive berth for the port crafts could be provided in the later phases.

6.2.8 Length of the Berths

Length of a single berth for a commodity depends upon 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.

The proposed length of isolated berth for the different design ships are presented in **Table 6.2**.

Table 6.2 Total Berth Length

Berth Type	Design Ship Size	Design Ship's LOA (m)	Minimum Berth Length (m)
Bulk Berths	80,000 DWT	240	290
	120,000 DWT	260	310
	200,000 DWT	300	350
Breakbulk/ Containers	4,000 TEUs	250	300
	65,000 DWT	240	290

6.3 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.

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 per berth so as to allow faster turnaround and/or avoid delays to unloading of the ship.

For containers, the dwell time at port is a deciding factor. However, for some of the cargo, the annual throughput is relatively small as compared to the parcel sizes and hence the frequency of vessel calls will be low to moderate. This will, most likely allow for the clearance of the stored cargo prior to the arrival of the next shipment. Further, during cargo handling operations at the multi-purpose berths, part of the cargo is likely to be directly evacuated without passing through the storage area. Under these circumstances, the storage areas could be optimised at least for the initial stages of development. As far as thermal coal is concerned the main requirement is for the power plants in the near vicinity. It is therefore expected that this cargo would be moved out of the port through direct conveyor system or dedicated rail corridor.

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 16 Ha increasing to 85 Ha over the master plan horizon. This does not take into account the area of coal stackyard required for the proposed NLC power plant, which shall be located within the power plant boundary itself.

6.4 Buildings

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

6.4.1 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

6.4.2 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.

6.4.3 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.

6.4.4 Gate Complex

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

6.4.5 Substations

One substation is envisaged to be provided for coal terminal, apart from the main receiving substation at the terminal boundary.

6.4.6 Worker’s Amenities Building

This shall provide locker and store rooms. It will also include bath and lavatory facilities. Separate buildings are envisaged based on various terminals to be developed.

6.4.7 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.

6.4.8 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

6.5 Receipt and Evacuation of Cargo

6.5.1 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 Sirkazhi, as shown in **Table 6.3**.

Table 6.3 Cargo Evacuation Pattern from Proposed Port at Sirkazhi

S. No.	Commodity	2020		2025		2035	
		Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share
		%	%	%	%	%	%
1.	Bulk Import*	0%	100%	0%	100%	0%	100%
2.	Breakbulk & Container	100%	0%	100%	0%	80%	20%
3.	POL	100%	0%	100%	0%	100%	0%

* This does not include coal for NLC, which shall be directly evacuated from berth to the power plant through conveyor

6.5.2 Port Access Road

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

6.5.3 Rail Connectivity

The port shall be connected to the nearest rail link for effective evacuation of cargo.

6.6 Water Requirements

Water would be needed at the port for use of port personnel's, potable water for ships calling at this port, dust suppression, firefighting and miscellaneous uses.

It is estimated that the average water requirement for the initial phase development will be around 0.71 MLD increasing to about 2.10 MLD in the master plan phase.

6.7 Power Requirements

HT and LT power supply at the port would be required for handling equipment, 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 12 MVA increasing to about 33 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at coal berths.

6.8 Land Area Requirement for Port at Sirkazhi

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 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 6.4**.

Table 6.4 Land Area Requirement for Port at Sirkazhi

S. No.	Commodity	Allocated Area (sqm)		
		2020	2025	2035
1.	Storage Space for various Cargoes	1,59,629	4,89,967	8,51,211
2.	Internal Roads and Circulation Space in Storage areas @ 25%	39,907	1,22,492	2,12,803
3.	Rail and Road Corridor	1,97,000	6,04,673	10,50,487
4.	Port Building Complexes including parking	5,000	11,630	16,652
5.	Landscaping, Green belt and other for Expansion	1,32,507	4,05,491	7,03,281
	Total Land Area (Sqm)	**5,34,044**	**16,34,254**	**28,34,434**
	Total Land Area (Acres)	**132**	**404**	**700**
	Total Land Area (Hectares)	**53**	**163**	**283**

The master plan details have been worked out based on traffic studies only up to 2035. However, ports are normally planned for 50 to 70 years of growth and hence there is need to provide at least double the area over the area requirement assessed for the year 2035.

7.0 PREPARATION OF PORT LAYOUT

7.1 Layout Development

The key considerations that are relevant for the establishment of layout for the proposed port at Sirkazhi 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
  - Ability to cater for Littoral Drift
  - 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 and R&R issues related to development.

7.2 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 Sirkazhi.

7.2.1 Potential Traffic

The potential traffic that the proposed 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 Port development at Sirkazhi.

As indicated earlier, Sirkazhi port will immediately cater to the needs of three power plants, viz. Parangipettai (IL&FS), Mettur (TANGEDCO) & Vettangudi (NLC). Therefore, there is assured cargo in the Phase 1 port development itself.

7.2.2 Techno-Economic Requirements

7.2.2.1 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. The Karaikal port which is a potential competitor located towards south is close to this port location and can cater to small cape size ships, it would be important that the proposed port at Sirkazhi be designed for handling cape size ships.

7.2.2.2 Geotechnical Characteristics of the Site

The geotechnical characteristics of the site could be a key factor in capital cost of port development. Based on the information available, the seabed strata mainly comprise of loose to medium dense silty fine sand. Only part of the suitable dredged material shall be used for site grading and reclamation. The sea bed level indicates good founding strata for piled foundations. Therefore the geotechnical conditions at the proposed site are considered favourable for preliminary design purposes, but to be verified by marine SI in the later stages.

7.2.2.3 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. The ports located along east coast are subject to waves from NE direction during NE monsoons and that from SE direction during SW monsoon period. The orientation of the breakwaters would need to be decided accordingly.

7.2.2.4 Ability to Cater for Littoral Drift

The phenomenon of littoral drift of sediments along the east coast of India is well known. The drift of sediments along the coast is caused by the action of waves impinging on the coastline at an angle, and this slowly drives the material in the direction of the waves. This is predominantly from south to north along the east coast of India, but there is some reverse drift in the NE monsoon season.

7.2.2.5 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 and breakwater. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. As per the information obtained during site visits, there are no quarries available for breakwater rock in Nagappattinam district and rock have to be brought from at least over 150 km away from Villupuram district. Any additional sources of rock shall need to be identified during detailed study.

7.2.2.6 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 operation.

7.2.2.7 Scope for Expansion Over the Initial Development

With the costly basic infrastructure like breakwaters, 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.

7.2.2.8 Flexibility for Development in Stages

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

7.2.2.9 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. Same is the case for reducing the area required to be reclaimed in the initial phase.

7.2.2.10 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 2035 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing beyond 2035. Therefore in comparing the merits of different alternatives for Master Plan layout, preference should be given to those that allow space for further development.

7.2.3 Land Availability

7.2.3.1 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.

The area demarcated for the NLC power plant is as shown in **Figure 7.1**.

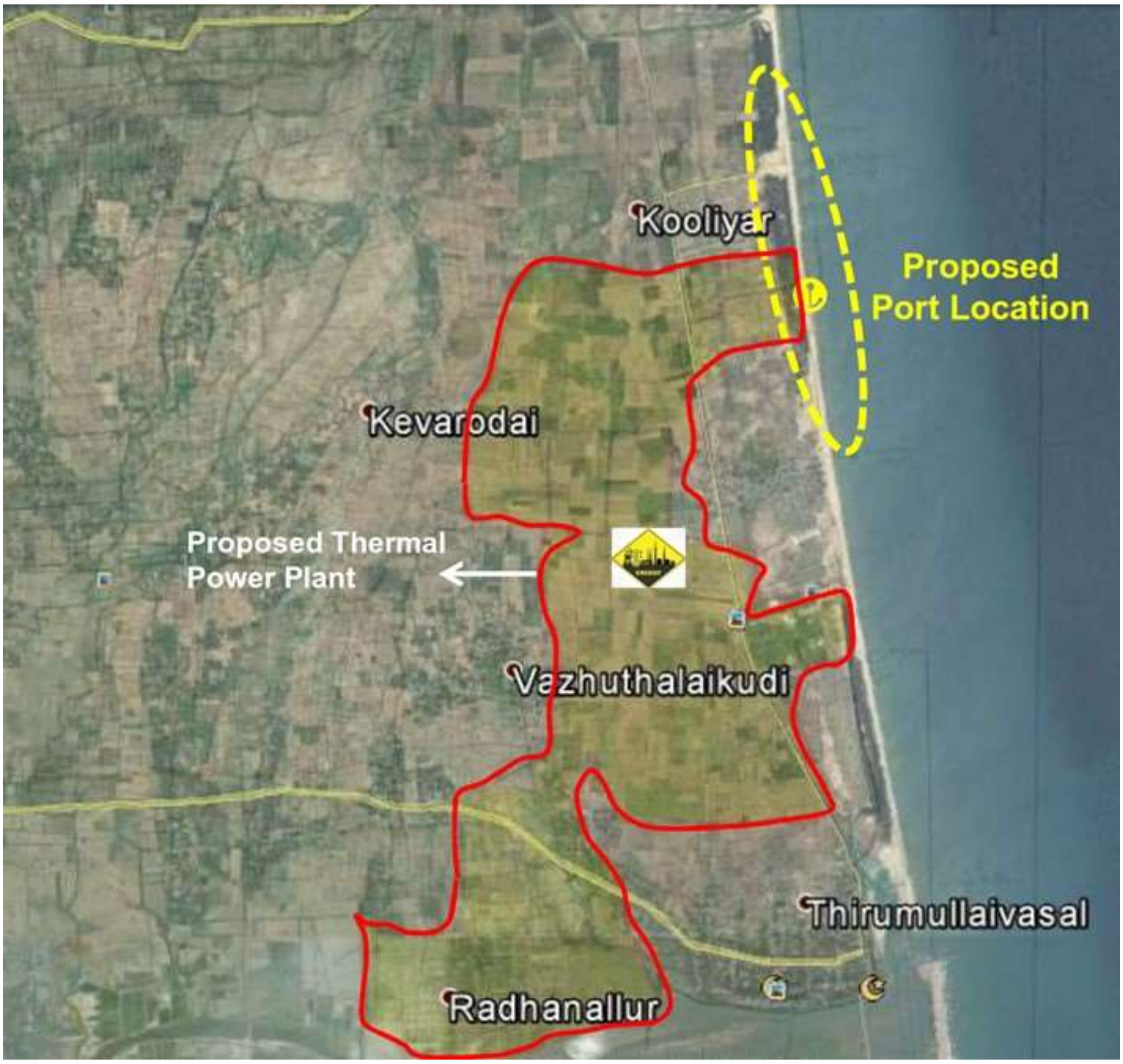


Figure 7.1 Land Area Demarcation of Proposed Neyveli Thermal Power Plant and Port

The area to the north of the power plant area along the coastal stretch of about 3 km is free of any habitations. The backup land of this area shall be utilised for locating the onshore facilities for the port. At the same time it shall also be ensured that the land acquisition is kept to minimal.

7.2.3.2 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. 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 and avoid conflicts with local traffic (if any).

7.2.4 Environmental Issues

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

7.3 Planning Criteria

7.3.1 Limiting Wave Conditions for Port Operations

7.3.1.1 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 seawards of the navigational channel then take the ship to the harbour or at the outer anchorage if it has to wait for a berth. 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.

7.3.1.2 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 H_s=1.0 m to H_s=1.5m depending on the type of tugs used.

7.3.1.3 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 ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for 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 wave conditions exceed 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) for different wave directions for coal unloading operations are summarised in **Table 7.1**.

Table 7.1 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
Containers	0.5 m	0.5 m
Break bulk	1.0 m	0.8 m

7.3.2 Breakwaters

In view of the two monsoon seasons, it is possible to get the required tranquillity in the open sea for a limited period in a year only. This is determined by wave exceedance studies in the mathematical model. Handling the required number of ships during the limited number of operational days would require vast storage area to allow for the period of downtime. Hence there is a need for breakwaters to ensure the port is operable throughout the year.

The purpose of breakwater is to provide tranquil conditions inside the port under normal wave conditions. Breakwater is to be planned for predominant waves coming from southeast, east and northeast direction. This would require a south breakwater to protect harbour from the waves coming from southeast direction and a north breakwater to protect the harbour from North east waves. Final length and alignment of the breakwaters has to be decided based on the mathematical model studies for harbour tranquillity and the length shall be kept minimum, to limit the overall capital expenditure.

7.3.3 Navigational Channel Dimensions

The dimensions of the navigation channel to the terminal are dependent on the vessel size, and 1 or 2 way operation, the behaviour of the vessel when sailing through the channel, required tidal advantage, the environmental maritime conditions (winds, waves, currents) and the channel bottom conditions.

7.3.3.1 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 7.2**.

Table 7.2 Assessment of Channel Width

The calculated channel width for various design ship sizes is summarised below in **Table 7.3**.

Table 7.3 Particulars of Navigational Channel for Design Ships

Design Ship Size (DWT)	Beam (m)	Channel Width (m)				Loaded Draft (m)
		Straight Channel		Curved Channel		
		One Way	Two Way	One Way	Two Way	
2,00,000	50	240	400	250	410	18.3
80,000	32	150	320	160	330	14.5

The channel length for handling 2,00,000 DWT ships works out to approximately 3.4 km and therefore the transit time of the ships in the channel will be about 0.3 hours at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1.3 hour, maximum of 18 ship movements per day (9 in and 9 out) could be accommodated with one set of tugs. Taking an average of about 16 ship movements per day in the channel, a one way channel can handle about 2,920 ship calls per year using one set of tugs. Considering the projected traffic and consequent ship movements, one way channel would be adequate for the proposed port.

7.3.3.2 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.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship as calculated in **Table 7.4**:

Table 7.4 Dredged Levels at Port for the Design Ships

Ship Size	Draft (m)	Approach Channel Outside Breakwater (m CD)	Inner Channel and Manoeuvring Area (m CD)	At Berths (m CD)
80,000 DWT	14.5	16.7	16.0	16.0
2,00,000 DWT	18.3	21.0	20.1	20.1

It may however be noted that above values are arrived at considering the design ship navigates the channel and harbour basin during low water levels and therefore without the advantage of tide. There is a opportunity to reduce the dredging quantity at the implementation stage.

7.3.4 Elevations of Backup Area and Berths

Considering the mean high water level as +1.1 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 proposed as +4.5 m CD. The finished levels of onshore areas will be kept at around +4.0 m CD.

7.4 Alternative Marine Layouts

Two basic layouts for the port development have been considered for the Port at Sirkazhi, keeping in view various considerations discussed above. These are discussed below:

Alternative Layout 1 involves offshore harbour option where the harbour area is located away from the shore. The master plan and Phase 1 development of this is alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-SRK1001** and **SRK1002** respectively. The breakwater in this alternative extends up to 15 m contour. This alternative involves higher cost for breakwaters but less for dredging. Also the berths are away from shore resulting in higher cost of approach trestle and conveyor system. It is proposed to provide only a south breakwater with two berths in its lee for Phase 1 development. This arrangement is likely to provide adequate protection to the berths and harbour area for round the year operations. The root of south breakwater is located towards the southern boundary of the NLC plot. The channel orientation at harbour entrance is from NNE direction and after some distance from entrance it take a turn towards ENE direction to minimise the length to reach 20 m contour.

Alternative Layout 2 is a coastal harbour option with berths located closer to the shore as compared to alternative layout 1. The breakwater extends only up to 11 m contour and therefore shorter in length. However, dredging quantity would be higher. The master plan and Phase 1 development of this is alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-SRK1003** and **SRK1004** respectively. The channel orientation is similar to that in alternative 1. The port location in this layout is shifted towards north by about 2 km to check its suitability as compared to location in alternative 1. Therefore root of the south breakwater is located towards northern boundary of the NLC plot and the onshore and reclaimed back-up areas are better integrated.

7.5 Evaluation of the Alternative Port Layouts

7.5.1 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, approach trestle and Equipment are of minor cost difference while some of the items such as Stacking areas, Internal Roads and Railway, Port Crafts, Navaids, Utilities, Buildings etc. are of negligible cost difference for both alternative layouts. Therefore, for cost comparison for these two alternative port layouts, items of major cost difference need to be considered, as presented in **Table 7.5**.

Table 7.5 Cost Differential (Rs. in Crores) of Key Items for Alternative Layouts

Item	Phase 1 Development		Master Plan Development	
	Layout 1	Layout 2	Layout 1	Layout 2
Breakwaters	832	505	1208	711
Dredging*	75	180	465	477
Reclamation	92	92	195	182
Total	**1000**	**778**	**1868**	**1371**

* In above table it is assumed that dredging for cape size ships shall be carried out for master plan layout. However in case dredging is carried out for cape size ships in phase 1 development the cost of dredging would be Rs. 177 crores and Rs. 344 crores respectively for layout 1 and 2.

7.5.2 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 7.6**.

Table 7.6 Estimated Rock Quantity and Construction Time of Breakwater

Alternate	Estimated Rock Quantity (MT)	Estimated Construction Time (months)
Alternative 1	5.4	45
Alternative 2	3.2	34

7.5.3 Available Land for Phased Development

The selected port layout should be able to expand in a phased manner to meet the market demand. Considering a patch of state government land right opposite the waterfront, it is required that limited land could be reclaimed utilising the suitable dredged material for the required cargo storage and operational areas.

7.5.4 Expansion Potential

It is observed that alternative layout 1 offer higher number of berths as compared to alternative 2. However, considering the traffic projections, the number of berths available in alternative 2 are considered adequate.

7.6 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 7.7**.

Table 7.7 Multi-Criteria Analysis of Alternative Layouts

S. No.	Factor Description	General	Alternative 1	Alternative 2
1.	**Soil Profile**	The soil characteristic would dictate the cost of dredging and marine structures.	The soil comprises of loose to medium dense silty sand and thus easy to dredge. Also it provides a reasonable founding strata for breakwaters and piled foundation	Same as Alternative 1.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	Part of the dredged material could be used for reclamation.	Same as Alternative 1.
3.	**Protection to the Berths from Waves and Swell**	The predominant wave direction is from ENE and ESE	The proposed breakwaters provide adequate tranquility to the berths	Same as Alternative 1.
4.	**Ability to Cater to Littoral Drift**	The scheme should be able manage littoral transport so as to minimize the shoreline changes	Sand trap could be provided along the south breakwater to manage littoral drift	Same as Alternative 1.
5.	**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 receipt / evacuation of cargo and also provide separation between dirty and clean cargo	Storage area much further from the bulk berths, requiring longer conveyors. Clear segregation of cargo.	Effective utilization of backup area. Clear segregation of cargo.
6.	**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	Suitable rail and road connectivity can be provided in the land proposed to be acquired for port development	Same as Alternative 1.
7.	**Environmental issues Related to Development**	Pitchavaram Mangroves forest	Proper EMP needs to be prepared to avoid any impact of proposed development.	Same as Alternative 1.
8.	**Potential Reclamation Area**	The higher reclamation area could be used to meet the storage and operation requirements of master plan stage	Reclamation area has to be minimum to reduce the cost. Already adequate land required for storage and port operations in phase 1 is available.	Same as Alternative 1.

S. No.	Factor Description	General	Alternative 1	Alternative 2
9.	**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
10.	**Expansion Potential**	Maximum number of berths possible in the harbour so as to meet the demand at least for master plan horizon	Total 11 berths possible with potential for more berths	Only 9 berths would be possible

7.7 Proposed Port Master Plan Layout

Based on above assessment it is observed that alternative 2 involving shorter breakwaters involves lower capital investment and implementation time and therefore recommended to be taken up. The recommended port master plan layout is shown in Drawing **DELD15005-DRG-10-0000-CP-SRK1006**.

7.8 Recommended Phase 1 Layout

From **Table 7.5**, it may be noted that the difference of cost of dredging for panamax and capesize facilities is only Rs. 164 Cr, it is recommended to develop capesize facilities in Phase 1 itself in order to be competitive with the neighbouring ports.

Drawing **DELD15005-DRG-10-0000-CP-SRK1007** presents, Phase 1 layout of the recommended master plan layout of the port. In this recommended alternative, it is suggested that only offshore portion of the south breakwater be built first. This will have the following advantages:

1. The rock quantity required to build the breakwater will reduce resulting in some cost reduction.
2. The breakwater not being connected to shore will not block the littoral movement of the sediments and hence minimise any shoreline changes.
3. The harbour area being sufficiently away from shore the sedimentation would be very much limited and also shadow effect (Tombola effect) due to offshore breakwater is not expected.

7.9 Phasing of the Port Development

The key port facilities that shall be developed in the phased manner over the master plan horizon are indicated in **Table 7.8**.

Table 7.8 Phasewise Port Development over Master Plan Horizon

Description	Total Port Facilities in Each Phase	
	Phase 1 Year 2020	Master Plan - Year 2035
Maximum Ship Size		
Number of Berths (Total length of berths in meters)		
• *Dry Bulk (DWT)*	*200,000*	*2,00,000*
• *Breakbulk (DWT)*	*0*	*65,000*
• *Containers (TEUs)*	*0*	*4,000*
• *POL (DWT)*	*0*	*60,000*
Navigational Areas		
• *Bulk Berths*	*2*	*4*
• *Multipurpose berths*	*0*	*4*
• *POL berths*	*0*	*1*
Breakwaters		
• *Length of Approach Channel (m)*	*3.4*	*3.4*
• *Width of Approach Channel (m)*	*240*	*240*
• *Diameter of Turning Circle (m)*	*600*	*600*
Design Draft of the Ship (m)	18.3	18.3
• *South Breakwater (m)*	*1700*	*3400*
• *North Breakwater (m)*	*0*	*1200*
Dredged Depths at Port (m below CD)		
• *Approach Channel*	*21.0*	*21.0*
• *Manoeuvring Areas*	*20.1*	*20.1*
• *Berths*		
○ *Bulk*	*20.1*	*20.1*
○ *Breakbulk/Containers*	*0*	*14.5*
○ *POL*	*0*	*14*
Incremental Dredging Quantity (million cum)	*17.2*	*6.7*
Incremental Reclamation Quantity (million cum)	*4.6*	*4.5*
Total Reclamation Area (Ha)	*0*	*70*

8.0 ENGINEERING DETAILS

8.1 Mathematical Model Studies on Marine Layout

8.1.1 Model Inputs

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.

The model bathymetry was created using the breakwater configuration and the approach channel shown in **Figure 8.1**. All the numerical simulations of the wave agitation were carried out with a water level corresponding to the Chart Datum (CD).

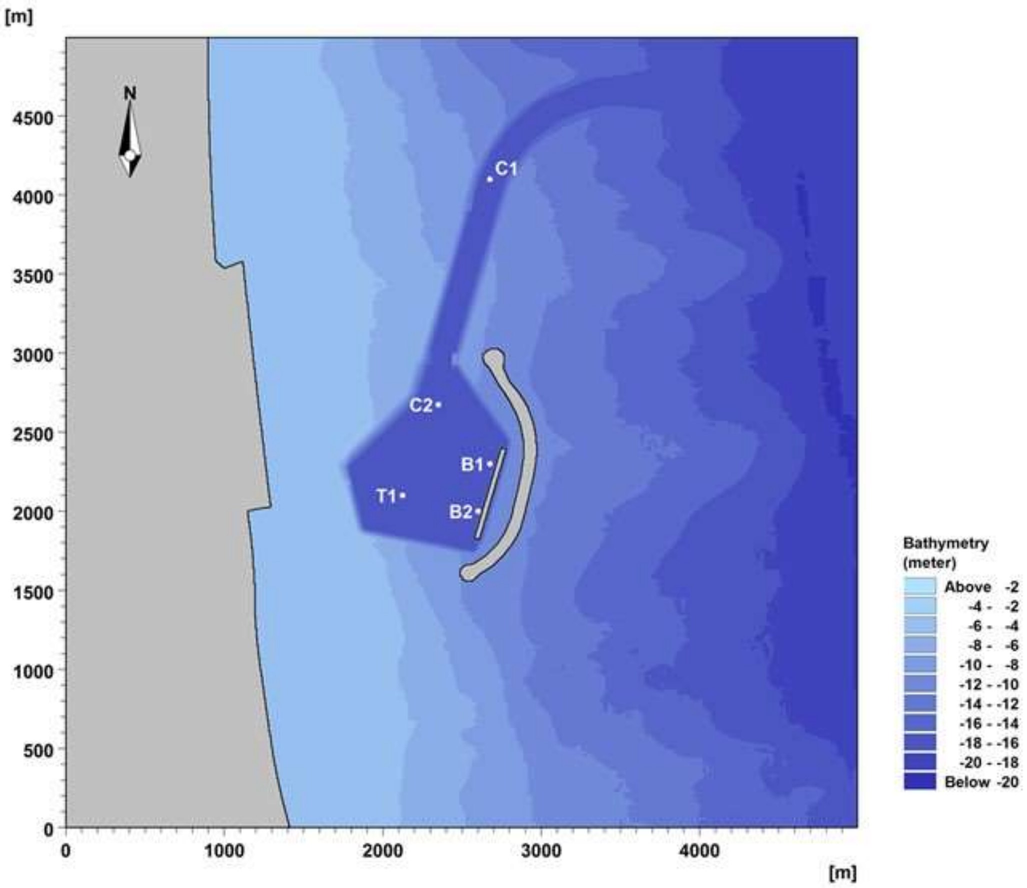


Figure 8.1 Bathymetry Used for the BW

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 closed boundaries (**Figure 8.2)**.

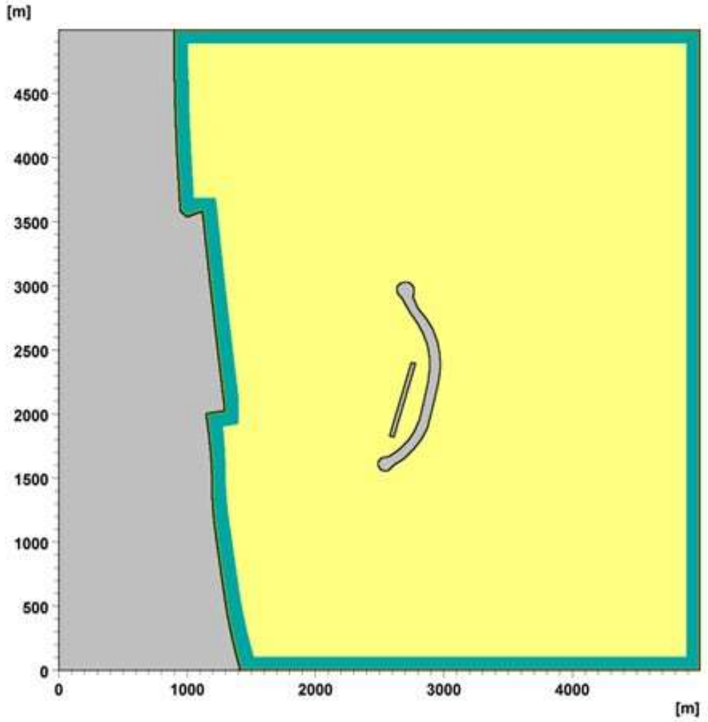


Figure 8.2 Sponge Layers (in Green) along the Non-Reflecting Boundaries

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 8.3**). For the present study, the porosity coefficient for the breakwater has been taken as 0.5 while that for berths a value of 0.8 has been considered.

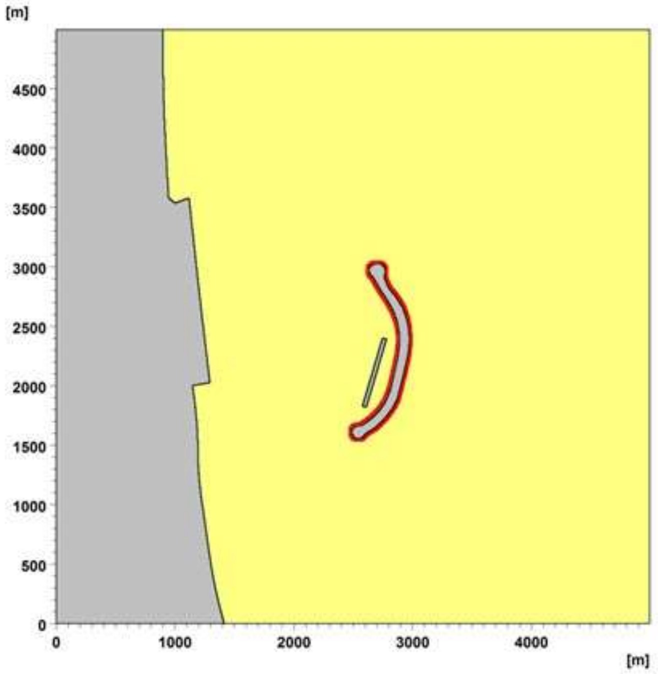


Figure 8.3 Porosity Layers (in Red) along the Port Structures

The proposed layout provides effective protection from E, SE, SSE and partially from the NE and NNE. 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 6.5 s.

8.1.2 Model Results

Figure 8.4 to **Figure 8.6** provides wave diffraction patterns after encountered within the breakwater from NNE, NE, E, SE and SSE directions respectively. In order to access the wave impact on entire breakwater the grid is been tilted about 45 degrees for the above mentioned respective directions except E direction.

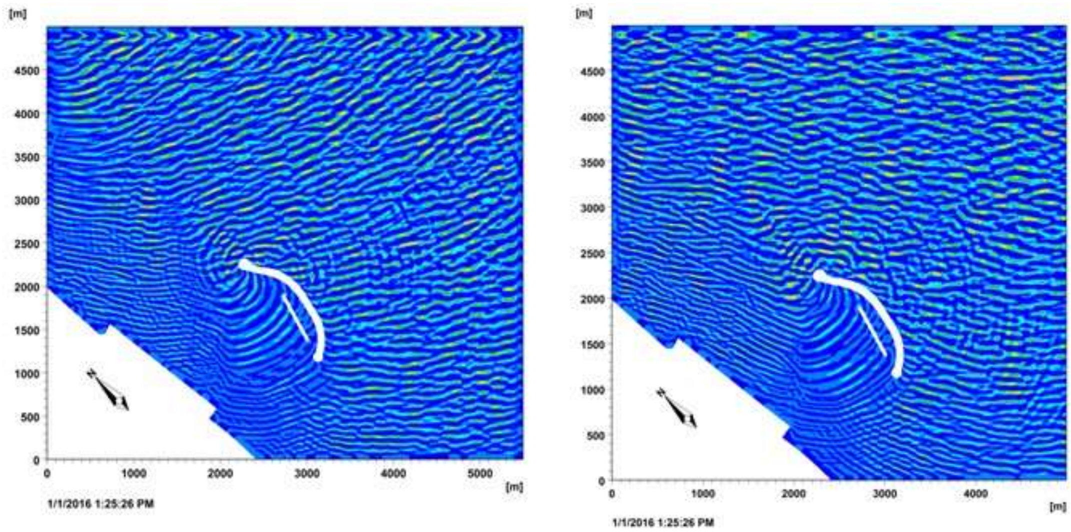


Figure 8.4 Wave Diffraction Patterns after Breakwater from NNE (Left) and NE (Right)

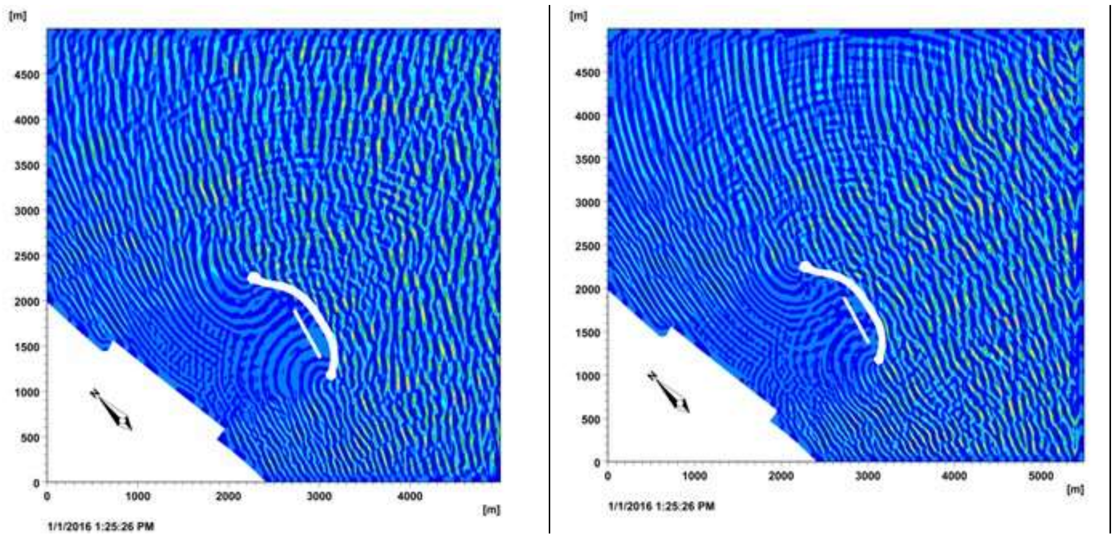


Figure 8.5 Wave Diffraction Pattern after Breakwater from SE (Left) and SSE (Right)

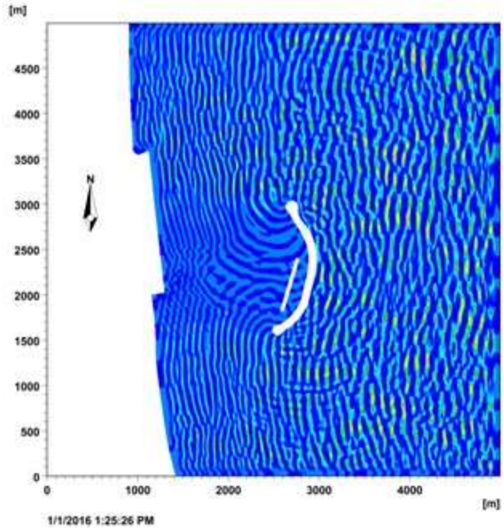


Figure 8.6 Wave Diffraction Pattern after Breakwater from E

Figure 8.7 to **Figure 8.11** provides wave height that may be encountered within the harbour under the impact of 1 m waves from NNE,NE, E, SE and SSE directions respectively. It may be observed that the wave entering the harbour have maximum impact at the berth locations and turning circle, while NE, E, SE and SSE waves are attenuated at the breakwater.

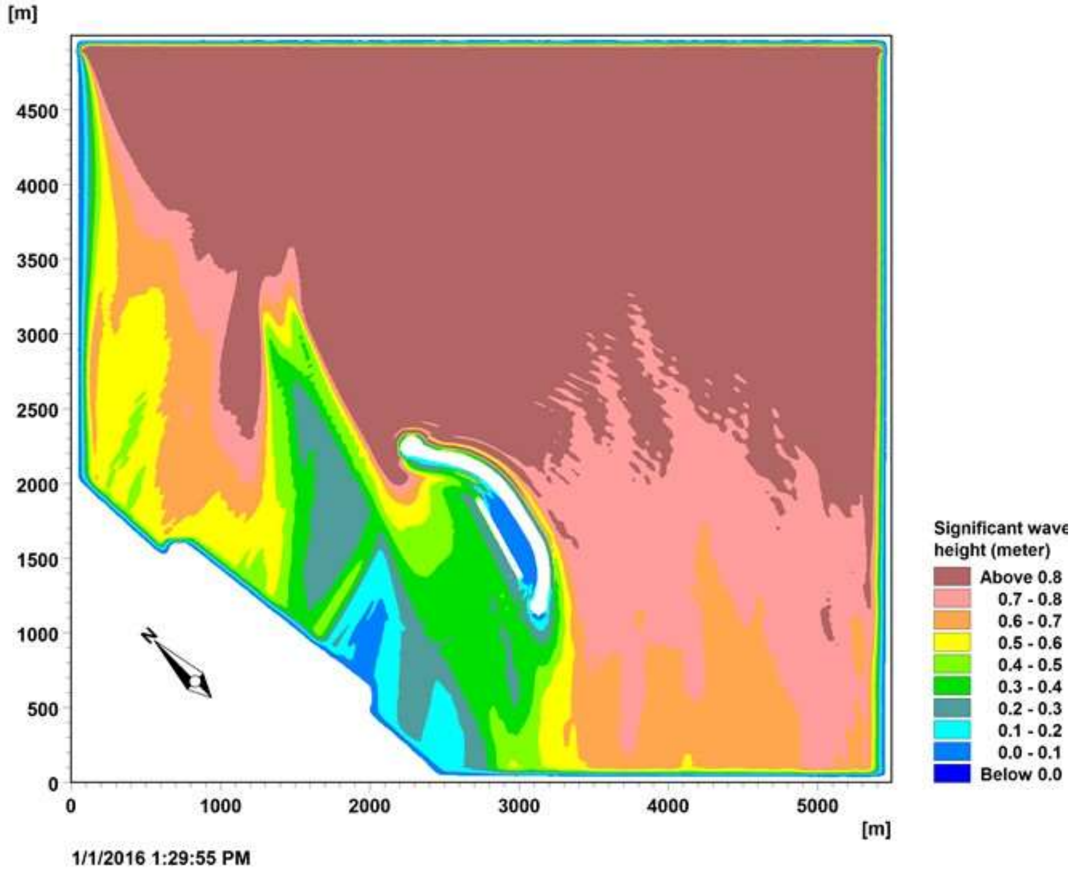


Figure 8.7 Wave Tranquility Assessment for Waves from NNE Direction

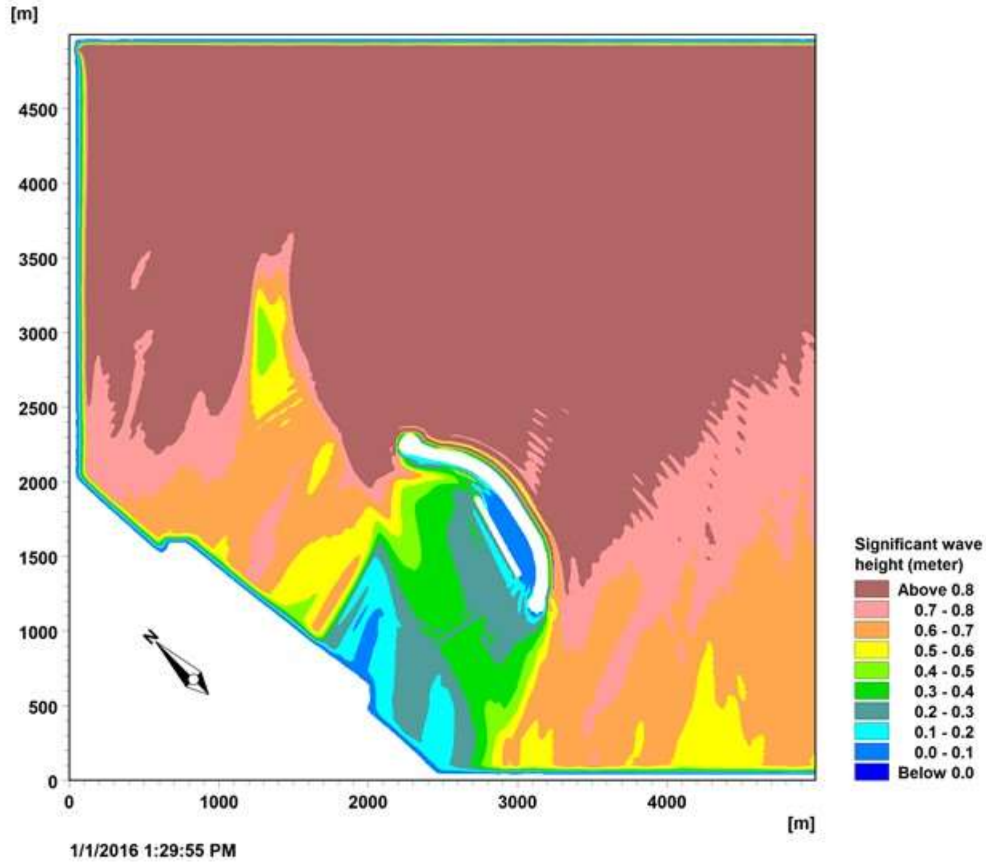


Figure 8.8 Wave Tranquility Assessment for Waves from NE Direction

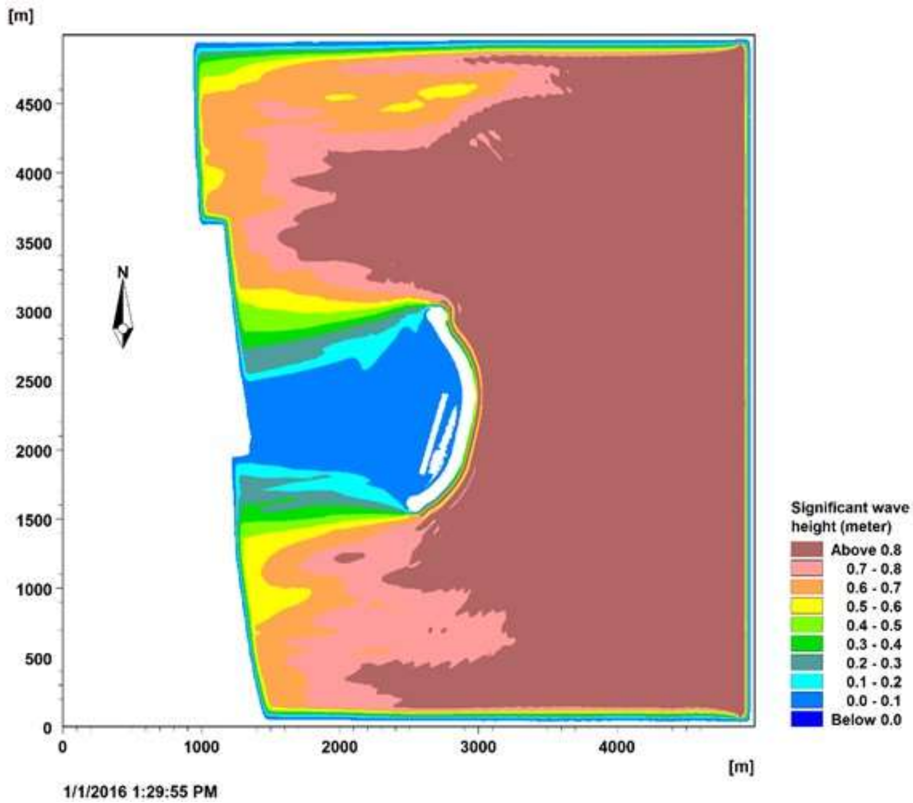


Figure 8.9 Wave Tranquility Assessment for Waves from E Direction

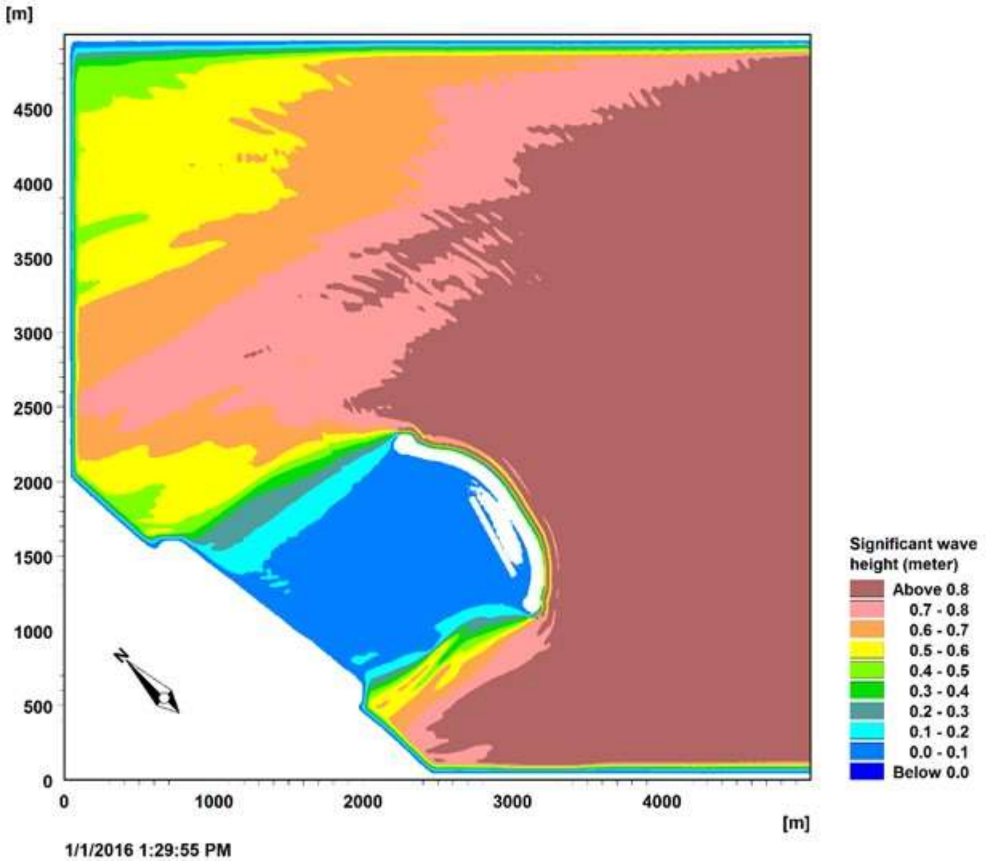


Figure 8.10 Wave Tranquility Assessment for Waves from SE Direction

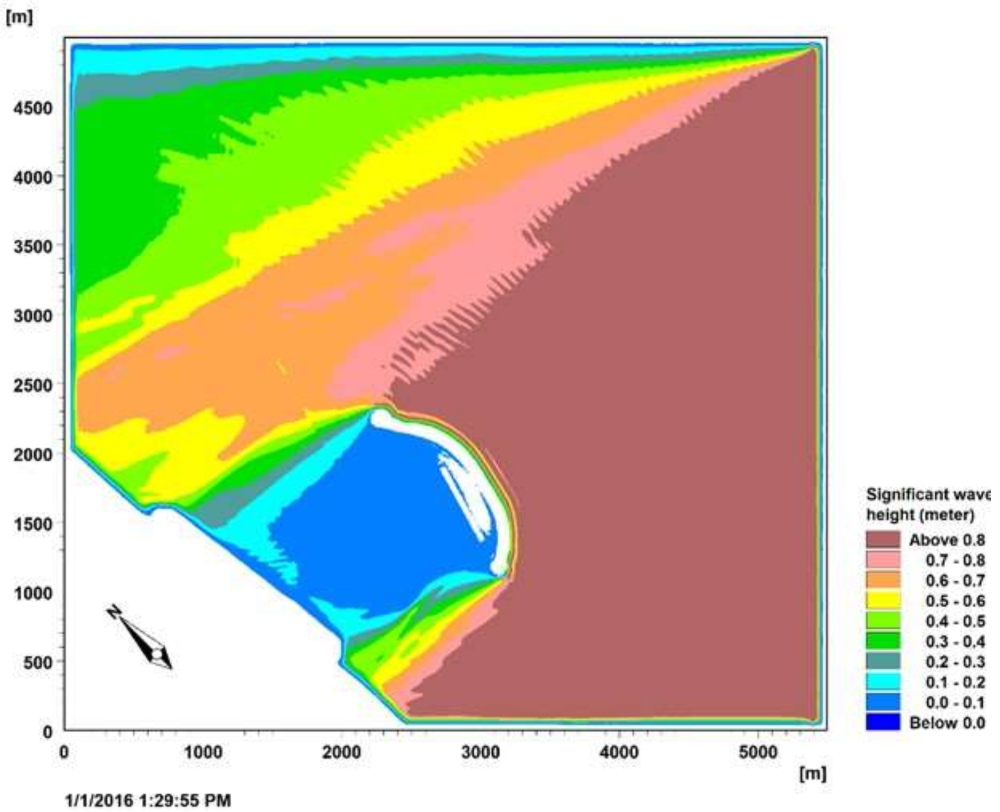


Figure 8.11 Wave Tranquility Assessment for Waves from SSE Direction

Based on the model runs carried out for the above conditions the wave disturbance coefficients i.e. ratio of H_{mo} (Site)/H_{mo} (incoming), are calculated at the locations of proposed berths and turning circle (**Table 8.1**).

Table 8.1 Wave Disturbance Coefficients

Label	Description	NNE	NE	E	SE	SSE
C1	Outer Channel	0.6	0.6	0.9	0.8	0.6
C2	Inner Channel	0.6	0.5	0.1	0.04	0.04
T1	Turning Circle	0.4	0.3	0.1	0.1	0.04
B1	Berth 1	0.2	0.2	0.03	0.03	0.02
B2	Berth 2	0.2	0.2	0.05	0.03	0.02

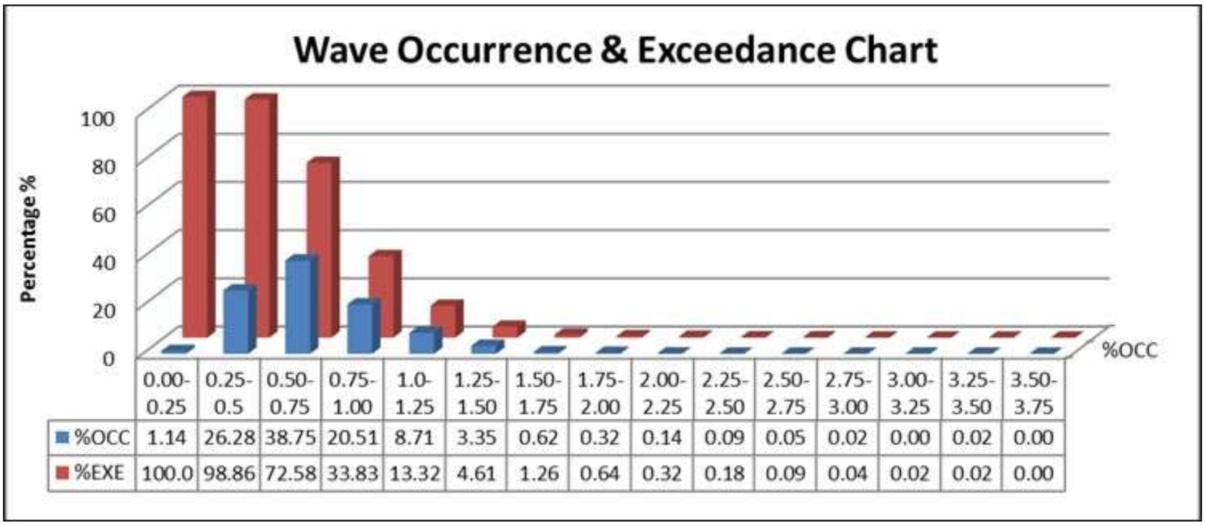
Using these coefficients, a representative mean significant wave height (Hm0, mean) can be estimated by multiplication of the wave disturbance coefficient of the area with the incident significant wave height (Hm0) outside. As may be seen from the **Table 8.1** above, coefficient of only 0.2 reaches location B1 if incident wave of 1 m approach the port from NE direction.

8.1.3 Outcome of Model Studies

Considering that the berths under consideration are for handling bulk cargo, cargo handling operations can be effectively undertaken for a significant wave height of 1.0 m, which corresponds to an offshore incident wave height of more than 2.5 m.

Based on the percentage exceedance of waves at 20 m contour (**Table 8.2**), it is assessed that waves exceeding even 2m are negligible and hence it may be safely concluded that downtime at the port with proposed layout is practically nil under the normal wave conditions.

Table 8.2 Percentage of Wave Occurrence and Exceedance



8.2 Onshore Facilities

The main consideration, in locating the facilities has been to minimise the land acquisition. Therefore, while the initial onshore facilities have been located on a narrow strip of land along the shoreline, the land needed for future expansion has been located on reclaimed land.

While arriving at the layout, it has been ensured that adequate space has been earmarked for the railway lines to be provided within the port area.

8.3 Breakwater

8.3.1 Basic Data for Design of Breakwater

8.3.1.1 Design Wave Height

The probable significant wave heights off Sirkazhi coast for different return periods have been discussed in **Section 3**.

AECOM analysed the historic cyclone data close to project site. Extreme values associated with cyclone events viz. the wind speeds, significant wave heights and peak periods were predicted by fitting a Weibull probability distribution to the results of historical storms.

8.3.1.2 Design Wave Height

The wave heights to be considered for the breakwaters design would depend upon the extreme wave conditions for 1 in 10, 1 in 50 and 1 in 100 years return periods for the respective depths in which breakwaters are located from considerations of over topping and section design respectively.

The estimates derived from the extreme value analyses of wave height during cyclonic conditions were found to be about 5.5 m at 10 m contour. Thus, the significant wave height for the breakwater design is taken as 6.0 m in the offshore section and 4.0 m for nearshore sections or the breaking wave height whichever is lesser.

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

8.3.1.3 Design Water Levels

The storm surge of 0.7 m is expected at this site based on the mathematical model study. 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 is considered to be negligible. It is therefore proposed to use +1.8 m CD (Mean High Water Springs i.e. +1.1 m CD plus 0.7 m storm surge), as the design high water level for the breakwater design.

- Other Design Assumptions
- Stones up to 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.

8.3.1.4 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.

8.3.1.5 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 Core-loc or Xblock.

8.3.2 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 years 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 8.3 K_D Values for Accropodes

Breakwater Portion	K_D values for Accropodes
Trunk	15
Head	12

The typical cross section of the breakwater is presented in **Drawing DELD15005-DRG-10-0000-CP-SRK1008**.

8.3.3 Geotechnical Assessment of Breakwaters

The breakwaters would be built on existing sea bed, so dredging areas need to be sufficiently far away to avoid endangering the foundations, allowing for the cape size depths.

The seabed level at the proposed offshore breakwater increases from -10 m CD to a maximum of -11 to -12.0m CD level. The crest level at the maximum depth is about +9.0 m CD.

The stability of the breakwater foundation needs to be analysed for the subsoil conditions. This would be more relevant for the sections in deeper water. Based on the subsoil data observed along the coast, the top layer of soil could be loose to medium dense sand for which breakwater toe may have to be wider for safety. At this stage it is assumed that there will not be any requirement of soil replacement which would increase the cost for breakwater significantly. However, any shortfall in the stability found at the detailed engineering stage could be managed by increasing the toe width and/or toe depth while maintaining a safe distance from the adjacent dredged area, allowing for future design depth.

8.3.4 Rock Quarrying and Transportation

8.3.4.1 Location of Quarries

It is understood that there are no suitable quarries are located for breakwater construction in Nagappattinam district. The rock for the construction of breakwater works need to sourced out from the quarries located at distant places in Villupuram district, which are approximately 150 km from the proposed site.

AECOM visited various quarry sites as shown in **Figure 8.12**. Considering the requirement of stones for the proposed breakwater, the quarries close to the proposed port site are located in Villipuram district.

Three different quarries are available at Kunnam near Thindivanam in Villupuram district. Two quarries are located in Kunnam which are at a distance of 3 km from Perumpakkam and one quarry in Perumpakkam itself of Thindivanam taluka in Villupuram district. The total distance from the proposed site to the quarry is about 146 km.

The approach to these quarry sites is through the WBM road which meets NH-45A. The distance of the quarry from the highway is about 2 km. The port site can be reached through NH-45A from Kunnam – Pondicherry – Cuddalore – Pudupettai. As far as rail link is concerned, the nearest place from the quarry site is Kutteripattu which is at a distance of 18 km.

The quarry is located by the side of the state highway which joins NH 45 at a distance of 19 km.

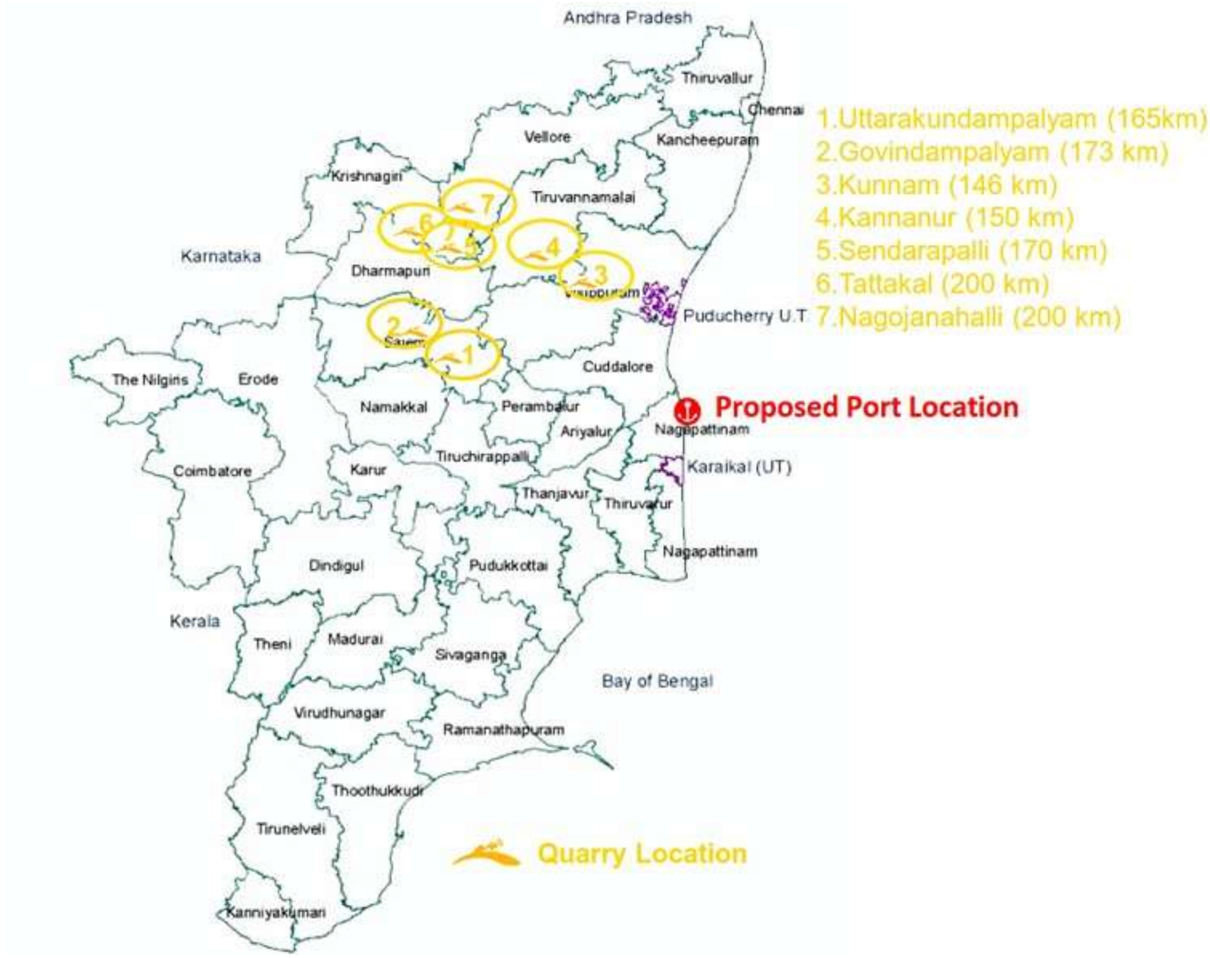


Figure 8.12 Location of Quarry Sites

Figure 8.13 Quarries at Villipuram

8.3.4.2 Transport to Site

These quarry sites are well connected to the proposed port through road network. The approach to the port site is well connected to the NH 45. The quarry material will have to be transported in through dumpers. Some localised road improvement measures will need to be undertaken near the quarries and near the project site to enable moving of the large quantity of stones by road using trucks.

8.4 Berthing Facilities

8.4.1 Location and Orientation

The location and orientation of the proposed berths is shown **Drawing DELD15005-DRG-10-0000-CP-SKZ1007**. The bulk berths are located away towards south of the harbour and connected to shore by means of an approach trestle. The multipurpose berths proposed to be provided in later phases are located in the lee of north breakwater and are located close to shore.

8.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +4.5 m CD. This deck elevation will prevent the waves slamming the deck during cyclones. This level will also ensure adequate clearance to the deck during operational wave conditions.

8.4.3 Design Criteria

8.4.3.1 Design Ships

The structural design of the bulk berths shall be carried out for the maximum size of the ships expected to be handled at these berths at the ultimate phase.

The structural design of the bulk berths shall be carried out for 200,000 DWT ships.

8.4.3.2 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -21 m CD.

8.4.3.3 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:

    - *Loads due to Gantry type unloaders with rail centres at 20 m c/c on bulk berth*
    - *Class AA or 70R vehicle loads on deck of berth and approach trestle*

- **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 55 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 PIANC 2002 guidelines and 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 for the bulk berths. 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 below:

Table 8.4 Details of Berthing Energy, Fender and Berthing Force Applied at Berths

Parameters	Bulk Berth
Berthing Energy	2975 kNm
Fender	Trelleborg Cell Type Fenders SCK 2500H E1.1 or equivalent
Rated Berthing Force	2711 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.

8.4.3.4 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.

8.4.3.5 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.

8.4.4 Proposed Structural Arrangement of Berths

The access from the coal berths to the backup area is provided through a 13 m wide approach trestle. 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.

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 30 m. The total length of the two bulk berths provided is 600m on the assumption that two cape size ships may not berth simultaneously. If required a mooring dolphin on either end could be provided at a later stages.

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 6.0 m c/c in the longitudinal direction. The piles will be founded in the substrata at levels beyond -40 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 300 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 conveyor supports are provided in the rear side of the berth at a spacing not exceeding 24 m. The typical cross section of Bulk berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-SRK1009**.

8.5 Dredging and Disposal

8.5.1 Capital Dredging

The capital dredging for Phase 1 of the port development is estimated to be around **17.2 Mcum**. Only part of the suitable dredged material shall be used for site grading during Phase 1 development and balance shall be disposed of at a suitable location offshore at about 30 m contour.

8.5.2 Maintenance Dredging

Based on the mathematical model studies on siltation, only 50,000 cum per annum of siltation is expected at the channel entrance and the harbour basin. This material is expected to be primarily silt and will have to be disposed of at the offshore dumping ground after carrying out periodic maintenance dredging.

As in the initial phase only offshore breakwater is proposed there is unlikely to be any accretion or erosion along the coastline. Also as the harbour basin and berths are located beyond 5m contour, there is unlikely to any sedimentation in the harbour area as a result of littoral movement of sediments.

However, once the north breakwater is built in the later stages of development there would be an accretion towards its south. The accreted material being sand shall be suitable for creating the reclaimed land to provide backup area for proposed multipurpose berths. Along-with the north breakwater built for the port, a groyne towards north of the mouth of canal shall also be built to prevent closure of mouth due to deposition of littoral sediments.

It is expected that annually about 150,000 cum of material shall be accredited towards south, which would need to be periodically removed by way of excavation/dredging and bypassing to the northern side of the port by means of a pipeline and a booster pump to nourish the beach.

8.6 Site Grading

The existing average ground level at the project site is about +1.5 m CD and there would be a need to raise the formation level at site to about +4.0 m CD to allow for planning of better drainage system at site and also for protection against flooding due to the raised water levels during storms.

It is proposed that this area shall be raised to provide the space for transit storage and area along the shore line to create the backup area for storage and operation. The ground level is proposed to be +4.0 m CD and the total quantity of fill is estimated as **4.6 Mcum** which can be sourced through suitable material from capital dredging.

8.7 Material Handling System

8.7.1 Coal Handling System

The principal components of the coal handling system are:

- Ship unloaders
- Conveyors
- Stackyard
- Stacker cum Reclaimers
- Railway sidings with silos for in-motion wagon loading for evacuation

Each of these components is described hereunder.

8.7.1.1 Ship Unloaders

Gantry grab type ship unloaders: This is a versatile type of unloader suitable for all types of materials whether lumpy or powdery and materials of different bulk densities. The machine is easy to maintain and have a large population in India. The grabs are easy to maintain and the operational skills are well available. But they can cause spillage if not properly operated and maintained. Their initial cost is competitive as compared to the other type of unloaders and is manufactured by a number of competing companies. The gantry grab type unloaders can be fitted with grabs of different sizes to suit different materials of varying bulk densities. The disadvantage with this type of unloading system is that the percentage of material that can be unloaded by prime digging is less as compared to continuous unloaders. In other words the amount of material that needs to be accumulated using pay loaders after prime digging inside the hatch is more. As such the downstream conveyor system will carry more material during cream digging operation and less later.

The gantry grab type unloaders shall be designed for unloading different types of thermal coal with a bulk density of 0.8 T/m^3 and with moisture content up to 12%. They shall have a rated capacity of 2000 TPH each and a free digging capacity of 2400 TPH.

There will be two unloaders for each berth. The capacity of the unloaders shall ensure an average unloading rate of 45,000 TPD on a sustained basis and a peak unloading rate of not less than 60,000 TPD of thermal coal with the two unloaders in operation together.

Figure 8.14 Typical Gantry Type Ship Unloader

<u>8.7.1.2 Conveyor System – Berths to Shore</u>

As has been indicated earlier, the coal from the berths will have to be sent to three Power Plants – one on the shore and two farther away. While the coal for the on-shore Power Station will be directly transported to the plant stockyard, the coal for the other two Power Stations will have to pass through the transit stockyard within the port limits. Hence the conveyor system will be designed and provided in such a way that the coal can either be directly conveyed to the on-shore Power Station or conveyed to the port transit stockyard. For this purpose, there will be two streams of conveyors for the two berths so as to ensure flexibility in operation. The coal unloaded by the two gantry grab unloaders will be discharged into two streams of jetty conveyors proposed for the two coal berths. Since both the berths will be in line, the orientation of the berth conveyors will follow the berth alignment.

The berth conveyors will be ground level conveyors and will be located within the gantry track. Also these will run horizontally for the entire length of the two berths without any elevation and each conveyor will be designed to cater to coal unloaded by two gantry grab unloaders. Thus each of the two jetty conveyors will have a nominal capacity of 4000 TPH and a designed capacity of 4800 TPH.

While running along the approach trestle, the conveyors will run on an elevated closed structure to avoid pollution of the environment.

A junction tower will be provided at the landfall point which will be a junction point of the cross country conveyor to the power plant and the stockyard conveyor. Whenever required, the coal from the ship will be diverted to the stockyard at this junction tower.

8.7.1.3 Stackyard

Out of the total traffic of 17.0 MTPA during the 1st Phase, 5.5 MTPA required for the Vettangudi Power station will be taken directly to the plant stackyard through conveyors. 7.0 MTPA required for the Mettur Power Station and 4.5 MTPA for the Parangipettai Power station will have to move through the port stockyard and evacuated through rail. This will later increase to 14.0 MTPA for Parangipettai and 7.0 MTPA for Mettur during the 2nd Phase. The direct transfer to Vettangudi will also increase to 14.0 MTPA. Hence the port stockyard at the foreshore will be initially designed to handle about 12.0 MTPA during the 1st Phase and 21.0 MTPA during the 2nd Phase. The stockpiles have to be segregated for these two power stations.

It is proposed to plan the storage at port equivalent to 15 days of throughput. This would mean that in the initial phase about 0.5 MT and in the final phase about 0.9 MT of coal would need to be stored at port. The layout of stackyard and its dimensions have been planned accordingly.

8.7.1.4 Stackers & Reclaimers

The stackyard shall be provided with stackers cum reclaimer units for receipt and despatch of coal through conveyor system. Total 4 units shall be provided initially and shall be augmented to commensurate the traffic in the later stages of development. This will ensure independent operations for receipt from the ship as well evacuation through rail. The stacker will have 4000 TPH capacity capable of stacking up to 15 m high. The reclaimer will also have 4000 TPH capacity and capable of operating with stacks of 15 m high. The typical stacker cum reclaimer unit is presented in **Figure 8.15**:

Figure 8.15 Typical Stacker cum Reclaimer

8.7.1.5 Railway Sidings with Silos for In-Motion Wagon Loading

As indicated earlier, the coal for Mettur and Parangipettai will be moved through railways. Accordingly, about 7 rakes for Mettur and about 5 rakes for Parangipettai have to be handled daily during the 1st Phase. Presently, Indian Railways permit a free time of 5 hours for turning around a rake. However, it is understood that they are actively contemplating to reduce it to 3 hours. In such an eventuality, the actual loading time should be less than 1.5 hours as about 1.5 hours will be required for peripheral activities like placement of empty rake at the loading station and for rehauling it to the yard after loading. This could be done only with a rapid wagon station with a silo.

Accordingly, the proposed system will consist of a concrete silo of about 2000 T holding capacity and fitted with a rapid loading chute with electronic pre-weighing bins, sensors and a cascade chute. Prior to the placement of the rake below the silo, the silo will be preloaded to its capacity so that at least half a rake of material is already available and once the loading from silo starts, the conveyor system feeding the silo is started and filling carried out to be in line with the commensurate requirement. As the first wagon of the rake in-motion is positioned under the silo, the flood loading starts and each wagon gets filled in less than a minute. The only consideration is that the locomotive that propels the full rake has to move in a fairly controlled speed.

A typical rapid wagon loading system is presented in the **Figure 8.16** hereunder.

Figure 8.16 Typical Rapid Loading System

For this purpose, it may be necessary to have three railway sidings with two provided with rapid loading silos and the third for engine escape. The total length of the sidings will be minimum 1400 m each with the silos located at the centre.

8.7.2 Container Handling System

8.7.2.1 Mobile Harbour Crane

This port is primarily being developed as a bulk handling port. However, in the later stages of the port, the port is expected to cater breakbulk and containers as well. Based on the forecasted traffic, the expected traffic at the port is around 188,000 TEU. In view of the limited throughput for container, it is proposed to handle the containers using Mobile Harbour Cranes (MHCr) fitted with the spreader attachment which is a well proven arrangement for the efficient handling of containers.

Figure 8.17 Mobile Harbour Crane with Spreader Arrangement

This arrangement will have benefit in the sense that the cranes can also be used to handle breakbulk cargo using appropriate grab or hook attachment.

8.7.2.2 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 8.18** shows an E-RTG in operation.

Figure 8.18 Typical E-RTG for Yard Operation

Figure 8.19 Typical Details of Electric Buss Bar Arrangement for E-RTG

8.7.2.3 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 8.20 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.

8.7.2.4 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 8.21 Snapshot of Typical Reach Stacker Handling

Considering the throughput of the import export containers of gateway traffic, it is proposed to provide two numbers of Reach Stackers for train loading/unloading.

8.7.2.5 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 8.22 Typical ITV for Handling Containers

8.8 Road Connectivity

8.8.1 External Road Connectivity

The proposed port location is approximately 14 km away from the East Coast Road (NH-45A) which passes through Cuddalore and links the proposed port to northern hinterland right up till Chennai. In addition to the national highways, a network of state highways connects Sirkazhi to other industrial centres in Tamil Nadu.

NH-67 starting from Nagappattinam (Approx. 60 Km away from the proposed port location) traverses Central Tamil Nadu in a near Straight line connecting the major industrial areas such as Thiruchirapalli, Karur and Coimbatore as well as onward linkages to other industrial areas such as Salem, Erode and Mettur.

From Sirkazhi, the port location is accessed through Thirumullaivasal and Thoduvaai villages. These roads are shown in the **Figure 8.23**.

Figure 8.23 Connectivity between Sirkazhi and the Port location

8.8.2 Internal Roads

The main approach road to the port shall be located parallel to the backup area. Within the terminal internal roads shall be planned based on the cargo handling and storage plans with 1 way circulations to avoid any criss crossings.

8.9 Rail Connectivity

8.9.1 External Rail Connectivity

The rail connectivity to the port site could be achieved either through Sirkazhi Railway Station or through Kollidam Railway Station. The total distance from Sirkazhi will be about 18 km and that from Kollidam will be about 14 km. The railway routes are marked in the **Figure 8.24** and they pass through open cultivable lands. Considering that the Power Stations at Mettur and Parangipettai are both to the north, it will be advantageous to get the connectivity through Kollidam Railway Station.

Figure 8.24 Proposed Rail Connectivity

8.9.2 Internal Rail Links

The internal rail lines will be developed so that the rakes for bulk cargo could be taken to the wagon loading system. It shall be ensured that their location does not obstruct the movement of port vehicles. Two rail sidings shall be provided including one engine escape line during the initial phase of port development.

8.10 Port Infrastructure

8.10.1 Electrical Distribution System

8.10.1.1 Introduction

The handling systems for bulk loading and unloading are power intensive and hence require considerable high tension electrical power for their operation. 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. The various terminals within port will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

8.10.1.2 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 12 MVA. This is expected to go up to 33 MVA over the proposed master plan horizon.

8.10.1.3 Source of Power Supply

Power supply to port at Sirkazhi can be tapped from the 33/11 KV substation located at Edamanal (about 10 km from port site) having a current capacity of 8 MVA which can be enhanced as per the requirement. It is proposed that the transmission lines be tapped off and extended up to the proposed location of the main receiving substation.

8.10.1.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the boundary of the proposed port, where the main substation shall be located. This outdoor switch yard will have two numbers of 33 KV transformers with 13 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.

8.10.1.5 Distribution of Power

11 KV feeders from main receiving substation will feed to secondary substation for the bulk terminal. The distribution of power shall be through this secondary substation.

The substation 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.

8.10.1.6 Standby Power Supply

It is proposed to install one diesel generator of 3 MVA at the substation. This would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

8.10.1.7 Illumination

The illumination level in various areas will be maintained as per the industry standards and shall generally be as in **Table 8.5** below:

Table 8.5 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 m 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.

8.10.1.8 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.

8.10.1.9 Earthing & Lightning 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.

8.10.1.10 Power Factor Improvement

Suitable rating HT capacitors with automatic power factor correction arrangement will be installed to maintain the overall power factor correction to 0.97.

8.10.2 Communication System

8.10.2.1 General

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

8.10.2.2 Telephone System

To meet the total port requirements, an EPABX of 100 lines capacity will be installed. Suitable telephone instruments to suit the site requirement with adequate protection will be provided.

8.10.2.3 Radio Communication

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

8.10.2.4 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.

8.10.3 Computerized Information System

8.10.3.1 Overall Objectives

The computerised information system proposed for Port at Sirkazhi 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.

8.10.3.2 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
- Operations Equipment Control (OEC)
- Cargo Control (CC)
- Yard Planning, gate delivery and receipt control
- Landside planning processes
- Enterprise Resource Planning

8.10.3.3 Technology Infrastructure

The IT Infrastructure of Port at Sirkazhi 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.

8.10.4 Water Supply

8.10.4.1 Water Demand

The water demand for the Port at Sirkazhi has been worked out in the **Table 8.6** below:

Table 8.6 Estimated Water Demand for Port at Sirkazhi

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	673	1,976
2.	Potable Water (KLD)	39	129
Total Water Demand at Port (KLD)		**712**	**2,105**

8.10.4.2 Sources of Water Supply

The water requirement for port at Sirkazhi shall be sourced from Collidam River. Alternatively providing a desalination plant at the port can also be explored during the implementation stage.

8.10.4.3 Storage of Water

The water supply from the main header shall be fed to the underground water tank of 1500 cum located at the port boundary which is equivalent to about 2 day consumption.

The water from the main sump would be pumped to secondary sump of 1000 cum capacity located near the stackyard. The sump shall be split into three compartments of 600 cum, 100 cum and 300 cum. The compartment of 600 cum will retain water permanently for firefighting; the compartment of 100 cum will be used for water supply to buildings, ships, where a small filtration unit shall be provided. The third compartment of 300 cum will provide water for dust suppression system and greenery.

8.10.5 Drainage and Sewerage System

8.10.5.1 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 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.

8.10.5.2 Solid Waste Management

For the buildings complex having administration building and port user buildings, a small sewage treatment plant of 20 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.

8.10.6 Floating Crafts for Marine Operations

8.10.6.1 Tugs

For berthing / un-berthing of the design vessels four harbour tugs of 50 T bollard pull capacity are required initially, including tug for standby/ emergency.

8.10.6.2 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.

8.10.6.3 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.

8.10.6.4 Harbour Crafts

The requirements of Harbour Crafts for the Phase 1 development of port of Sirkazhi are given in **Table 8.7** below.

Table 8.7 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 50 T bollard pull	4
2.	Pilot cum Security Vessels	2
3.	Mooring Boats	2

8.10.7 Navigational Aids

8.10.7.1 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 port. 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, and berths. VTMIS will have the requisite communication, Radar system integrated into it.

8.10.7.2 Buoys

The approach channel has a total length of about 4 km from the breakwater head which require 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 mile. In addition some buoys are proposed to mark the limits of the harbour basins. IALA maritime buoyage system as per region A, in which Sirkazhi port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

8.10.7.3 Leading / Transit lights

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

8.10.7.4 Beacons / Mole lights

Two Beacons at each end of offshore breakwater are proposed to be provided.

8.10.7.5 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. For Sirkazhi Port, 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.

8.10.8 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.

8.10.9 Firefighting System

8.10.9.1 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.

8.10.9.2 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
- Conveyors galleries

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.

8.10.10 Pollution Control

8.10.10.1 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

8.10.10.2 Dust Suppression

Dust control equipment is proposed for efficient control of dust pollution to the environment during storage and handling of 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.

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.

9.0 ENVIRONMENTAL SETTINGS AND IMPACT EVALUATION

9.1 Introduction

This section presents environmental conditions in and around the proposed port location at Sirkazhi. 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.

9.2 Site Setting

A Greenfield port is planned to be developed on the coast near Thoduvaai fishing village. A 3 km long coast line was found to be suitable for this development (**Figure 9.1**).

Around 1500 household were situated in the Thoduvaai village with a population of 8000 has been reported. The villagers are mainly involved in small scale fishing and agriculture. Rice and Groundnut are cultivated predominantly along with Cashew and Mango.

Casuarina plantation was observed all along the coast line covering almost 3 km stretch. River Mudavanaru is flowing on the North of the proposed site while Buckingham canal runs parallel to coast on the west at a distance of about 1 km.

	
Mudavanaru river	**Casuarina Plantation**
	
Fishing Activities at Thoduvaai	**Fishing Activities at Thoduvaai**

Figure 9.1 Location of the Proposed Site

9.3 Environmental Policy and Legislation

Table 9.1 presents Environmental regulations and legislations relevant to this project, along with the details of the competent authority for implementation.

Table 9.1 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 forest land is involved in the project.	MoEF&CC; Department of Forest, GoTN
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	-	Chief Conservator of Wildlife, Wildlife Wing, Forest Department, GoTN; 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	Tamil Nadu 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	Tamil Nadu Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Tamil Nadu 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

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
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.	Tamil Nadu 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, GoTN
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.

9.4 Anticipated Environmental Impacts and Mitigation Measures

Potential impacts on environment due to the proposed port project have been summarized in **Table 9.2**. 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 9.2 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.	• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• 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 • Contamination due to spillage of chemicals used during pile diving.	• 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	• Operation of vehicles and construction machinery • Quarrying and transportation of material to the site.	• Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery Including stand-by generators and ship engines	• Increase in noise • Health impacts on workers

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 • Influx of outside workers/ population • Land acquisition	• 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	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **Positive Impacts** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

9.5 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.

9.5.1 Impacts on Land and Soil

The proposed port is planned along the narrow strip of land along the coast and this land is being planned to be acquired by Chennai port. This land is devoid of any habitation and used primarily for agricultural purposes. Additional land for rail and road connectivity will also be required.

The anticipated impact of the project are soil contamination that may be caused from roadside litter, oil spillage from 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 of at designated solid waste collection point.
- Appropriate R&R will be drafted for land acquisition will be drafted.

9.5.2 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 Collidam River, for which all the required permissions from the state authorities will be sought.

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 stored 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 sea or 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 TNPCB or MoEF.
- No construction activity will be undertaken during monsoon period in the sea or near coast.
- 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 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, the activities during dredging and disposal of spoils should be monitored regularly.
    - 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.

9.5.3 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.
- 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 Andhra Pradesh 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.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.

9.5.4 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.

Mitigation Measures

- 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.

9.5.5 Impacts on Ecology

The core area of Pitchavaram, one of the biggest mangrove reserved forest, is more than 10 km North of the site and this project is not envisaged to cause any disturbance to that area. However, exact boundaries of the Pitchavaram must be ascertained during the detailed EIA report.

The land requirement 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.

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 within sea or near coast 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.

9.5.6 Impact on Social Conditions

Loss of livelihood is anticipated for few households as about 120 ha of agricultural land will be acquired for port development. During the site visit no settlement were seen at the proposed site. However, acquisition of land and loss of livelihood is anticipated on account pf port development as well as for 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.

9.6 Impacts during Operation Phase

9.6.1 Impact on Land and Shoreline

An offshore breakwater is proposed for the project at 10 and 11 m depth in the sea. This offshore breakwater will not hinder the littoral drift at this location. Thus no impact on accretion and deposition patter is anticipated at the coast line, which is designated as stable (refer **Figure 2.5**).

Mitigation Measures

- Regular monitoring of the coast line shall be carried out so as to assess any changes.

9.6.2 Impact on Water Quality

Water required during operation phase will be sourced from sea, which will be treated in a desalinisation plant for consumption.

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

- Location of sea water intake shall be planned so that it does not affect the flow and sediment pattern in the region.
- 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 stack yard 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 through authorised waste 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 coastguard personnel to take appropriate actions.
- Storm 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 and ballast water 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 at proposed Port area for prevention of marine pollution.

9.6.3 Impact on Air Quality

Vehicle traffic to service cargo at the port, emissions from port equipment, cargo handling (Coal) 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 stack yard & 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, 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.
- It will be a responsibility of labour contractors to provide for clean fuel to the labourers.

9.6.4 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, and 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 shall 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.

9.6.5 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.

Due to maintenance dredging, some 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.

9.6.6 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.

9.7 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 9.3**).

Table 9.3 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

9.8 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.

10.0 COST ESTIMATES AND IMPLEMENTATION SCHEDULE

10.1 Capital Cost Estimates

10.1.1 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 preliminary 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 first quarter of 2016.
- 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 $ = INR 65/-
- Provision towards contingencies, engineering and establishment has been included separately.

The 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.

10.1.2 Capital Cost Estimates for Phased Development

The capital cost of phased development of port, as per the proposed phasing as per **Table 7.8** has been worked out. The same is furnished below in **Table 10.1**. The capital costs given for each phase are for the facilities created during that particular phase only.

Table 10.1 Block Capital Cost Estimates (INR in Crores)

A. Port Development Cost Only

S. No.	Item	2020	2035	Total
1.	Project Preliminaries and Site Development	60	40	100
2.	Dredging	344	297	641
3.	Reclamation	75	670	745
4.	Breakwater	459	252	711
5.	Berths	298	578	876
6.	Buildings	29	159	188
7.	Stackyard and Other Backup Area	47	92	139
8.	Internal Roads and Railway	43	40	83
9.	Equipment	584	884	1,467
10.	Utilities and Others	181	146	326
11.	Navigational Aids	7	0	7
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**2,127**	**3,157**	**5,284**
13.	Contingencies @ 10%	213	316	528
14.	Engineering and Project Management @ 5%	106	158	264
Incremental Capital Cost (Rs. In Crores)		**2,446**	**3,631**	**6,076**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	2020	2035	Total
1.	**Port Development Cost**	**2,446**	**3,631**	**6,076**
2.	**Cost of land acquisition for backup area of port**	**80**	-	**80**
3.	**External connectivity including land acquisition**			
	Rail	**175**	-	**175**
	Road	**168**	-	**168**
Total Cost (INR in Crores)		**2,869**	**3,631**	**6,499**

These capital cost estimates does not include the following:

- Port crafts, as these are proposed to be leased out
- Financing and Interest Costs

10.2 Operation and Maintenance Costs

10.2.1 General

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

10.2.2 Repair and Maintenance Costs

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

- 5% of 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.

10.2.3 Manpower Costs

The estimated manpower for the initial phase of development is about 230 increasing to about 770 in the ultimate stage of development. The manpower costs have accordingly been calculated considering the number and types of personnel deployed.

10.2.4 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. 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 Firefighting & Pollution Control - 3% per annum

10.2.5 Annual Operation and Maintenance Costs

Based on the various criteria discussed above, the annual operation and maintenance cost for various phases of development of Port at Sirkazhi are summarised below in **Table 10.2**:

Table 10.2 Annual Operation and Maintenance Costs (INR in Crores)

S. No.	Item	2020	2035	Total
1.	REPAIR AND MAINTENANCE COSTS	50.2	67.0	**117**
2.	OPERATION COSTS	57.4	124.0	**181**
3.	**TOTAL**	**108**	**191**	**299**
4.	Contingencies (Rites, @ 10%-Aecom)	10.8	19.1	**30**
5.	Administrative Expenses @ 5%	5.4	9.6	**15**
Incremental O & M Costs (Rs. In Crores) per annum		**124**	**220**	**343**

The above O&M cost does not include the repair and maintenance of external rail and road connectivity.

10.3 Implementation Schedule for Phase 1 Port Development

10.3.1 General

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

10.3.2 Construction of Breakwaters

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, dredging have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 2.3 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 150 km from site.

Being offshore the breakwater shall be built 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 can be used for dumping of filter and core upto a certain level, below high water only. The balance section would need to be built up deployment of floating cranes using dumb barges which is a slow process and likely to involve higher weather downtime. It is envisaged that about 5,000 T stones can be placed per day. This would mean that the construction of breakwaters could be completed in a period of about 30 months duly accounting for weather downtime.

10.3.3 Dredging and Reclamation

The overall dredging quantity is estimated to be about 17.2 Mcum. Once the offshore breakwater construction is half way through, the dredging activity of the harbour basin and channel can commence and reclamation bunds shall be built to receive the suitable material from the dredging operations. The overall duration of the dredging and reclamation is expected to be 18 months.

10.3.4 Berths

As berths are not proposed to be contiguous to the land, construction of berths would be independent of the dredging. The construction of berths could be started by launching the gantries from the shore along the trestle. However, adequate breakwater shelter would be needed to avoid any downtime in construction.

The construction of berths 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. As the berths and approach trestle are continuous, it is possible to construct the piles using travelling gantries from the shore. 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 24 months.

10.3.5 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.

10.3.6 Implementation Schedule

The construction time of Phase 1 development of port at Sirkazhi 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 Port at Sirkazhi is shown in **Table 10.3**.

Table 10.3 Implementation Schedule

11.0 FINANCIAL ANALYSIS FOR ALTERNATIVE MEANS OF PROJECT DEVELOPMENT

11.1 Assumptions for Financial Assessment

As the coal is the assured cargo which shall kick start the project it is proposed that the financial analysis be carried out for a scenario where the port is developed only to handle coal, projected for the initial phase i.e. only for proposed phase 1 development until it reaches it capacity. With basic infrastructure in place for phase 1 development, any expansion for additional cargo could be carried out at much lower investment and thus would improve the project viability further.

The following assumptions are made while carrying out the financial assessment:

- Based on the profiling of competing ports tariff for handling coal has been assumed as Rs. 225 per tonne
- For NLC, as there is no requirement for coal storage and evacuation from port by rail, the tariff considered is Rs. 175 per tonne.
- The cost of Debt is assumed as 11% for PPP operator.
- The cost of Debt for the SPV, in case of Landlord model, is assumed at 4%.

11.2 Option 1 – By Project Proponents

In this option a Special Purpose Vehicle (SPV) shall be formed comprising of public sector entities i.e. (Chennai Port Trust, NLC and/or State Government/TNMB, SDC), who shall execute this project. They shall also be responsible to arrange funds for the project financing, manage and operate the port.

The financial analysis has been carried out considering the overall capital investment of Rs. 2,869 crores for Phase 1 port development. The project IRR in this scenario works out to about **12.5 %**.

11.3 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.

In this case the costs towards External Rail and Road Connectivity to port and land acquisition for connectivity and port facilities shall be borne by the government entities like NHAI, IPRCL and state government.

The financial analysis has been carried out considering the capital investment of Rs. 2,446 crores for Phase 1 port development. The project IRR for developer in this scenario works out to about **14.5 %**.

11.4 Option 3 – Landlord Model

In this option an SPV shall be formed in the similar fashion as in case of Option 1. The exact composition of SPV and the % share of the entities could be decided once the decision to go ahead with the project is taken. The following shall be modalities for development under this option:

1. The basic infrastructure in terms of Breakwaters, capital dredging, reclamation, access rail and road, water and power connection, harbour crafts etc. shall be arranged by SPV. Apart from that the SPV shall also be responsible providing external rail and road connectivity to port including any land acquisition for connectivity and port development. In addition SPV shall also be 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 authorities and administering subleases for the various marine terminals leased to users, terminal operators as applicable.

2. The cargo handling terminals and associated facilities comprising of berths, stackyard development, equipment, utilities etc. will be developed with private participation on PPP mode. PPP Concessionaire would be responsible for terminal operations and maintenance and sharing of its revenue with SPV as per the concession agreement.

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

A. Port Development Cost Only

S.No.	Item	SPV	Concessionaire	Total
1.	Project Preliminaries and Site Development	40	20	60
2.	Dredging	344	-	344
3.	Reclamation	69	6	75
4.	Breakwater	459	-	459
5.	Berths	-	298	298
6.	Buildings	20	9	29
7.	Stackyard and Other Backup Area	-	47	47
8.	Internal Roads and Railway	18	25	43
9.	Equipment	-	584	584
10.	Utilities and Others	100	81	181
11.	Navigational Aids	7	-	7
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**1,058**	**1,069**	**2,127**
13.	Contingencies @ 10%	106	107	213
14.	Engineering and Project Management @ 5%	53	53	106
Capital Cost of Phase 1 Port Development (Rs. In Crores)		**1,216**	**1,229**	**2,446**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	SPV	Concessionaire	Total
1.	**Port Development Cost**	**1,216**	**1,229**	**2,446**
2.	**Cost of land acquisition for backup area of port**	**80**	-	**80**
3.	**External connectivity including land acquisition**			
	Rail	**175**	-	**175.00**
	Road	**168**	-	**168.00**
Total Cost (INR in Crores)		**1,639**	**1,229**	**2,869**

To achieve the project IRR of 15% the PPP operator can even share 50% of revenue with the SPV. Based on the revenue earned the project IRR for the SPV works out to about 11.5%, which being much higher than the cost of capital to SPV makes the investment attractive. The project IRR to SPV can improve if SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall further reduce.

11.5 Conclusions and Recommendations

The proposed port development project at Sirkazhi is technically and financially suitable to be taken up for development. In terms of its ability to provide modern handling facilities and capacity to handle fully loaded capesize ships, it has a potential to attract customers.

Considering the significant traffic potential for this port to cater to the nearby power plants the project needs to be taken up on priority so as not to lose the market share to its competitors. The Landlord model as per option 3 appears to be most suitable for development.

12.0 WAY FORWARD

The following action plan is recommended for implementation of the project:

1. Formation of SPV for development of the project

2. Appointment of consultant for preparation of detailed project report, which shall use the present TEFR as a base document and detail it further by:

   a. Carrying out detailed site specific studies and investigations to provide a database for detailed design of port facilities
   b. Real Time Ship Navigational Studies to confirm the dimensions of channel and navigational areas
   c. Engineering of the Marine Structures, material handling system and onshore infrastructure to further refine the cost estimates
   d. Two and three dimensional model studies for design of breakwaters.
   e. Mathematical model studies on the final layout for further optimisation. Apart from that model studies for dispersal of dredged plume at the proposed disposal site would be needed as per the requirement of MoEF.
   f. Updated financial analysis

3. Appoint a transaction advisor for project structuring and preparation of tender documents

4. Coordination with the NHAI and Indian railways for providing road and rail connectivity to site.

5. Coordination with state government for land acquisition

6. Approvals from SFC/ EFC/ PIB/ PPPAC/ CCEA

7. Appointment of consultant for Preparation of EIA report and approval of MoEF

8. Coordination with various agencies for getting project approvals as mentioned in **Figure 12.1.**

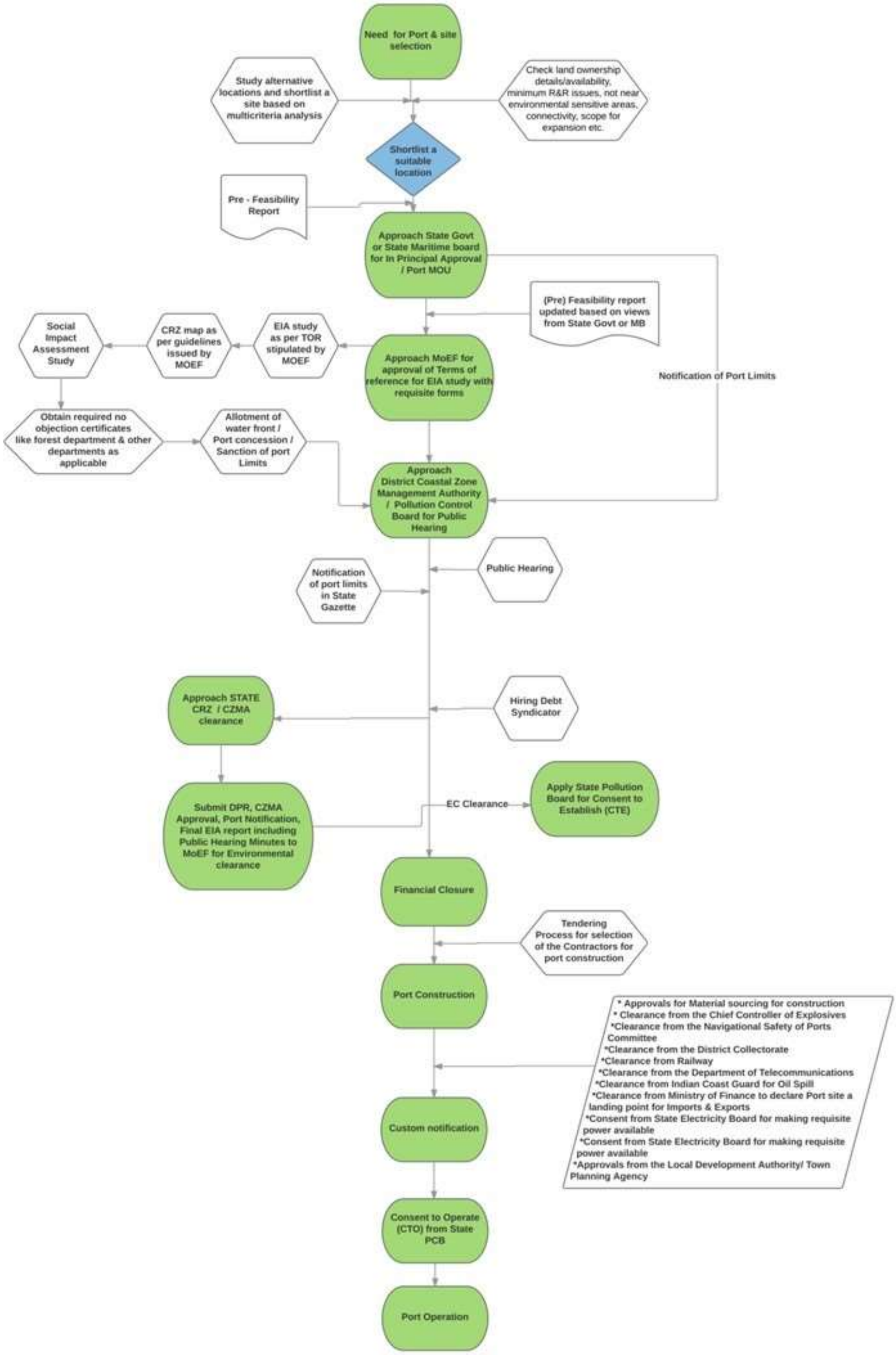


Figure 12.1 Process for the Greenfield Port Development

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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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 4^{th} 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.

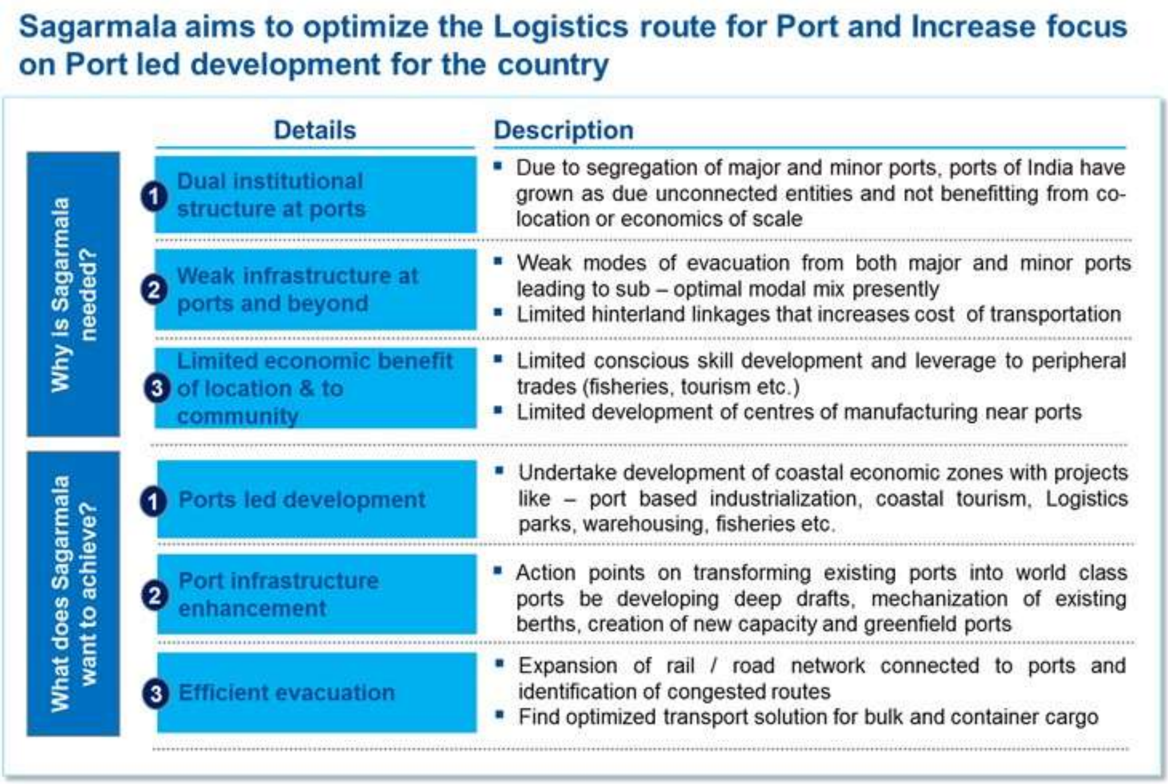


Figure 1.1 Aim of Sagarmala Development

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.

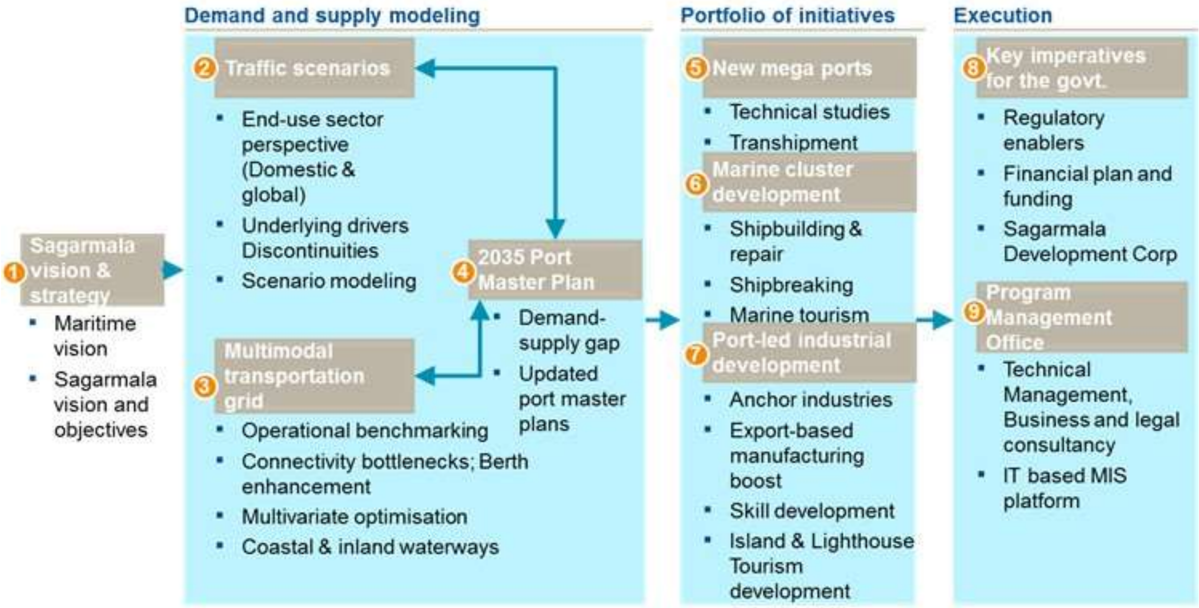


Figure 1.2 Governing Principles of our Approach

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:

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.

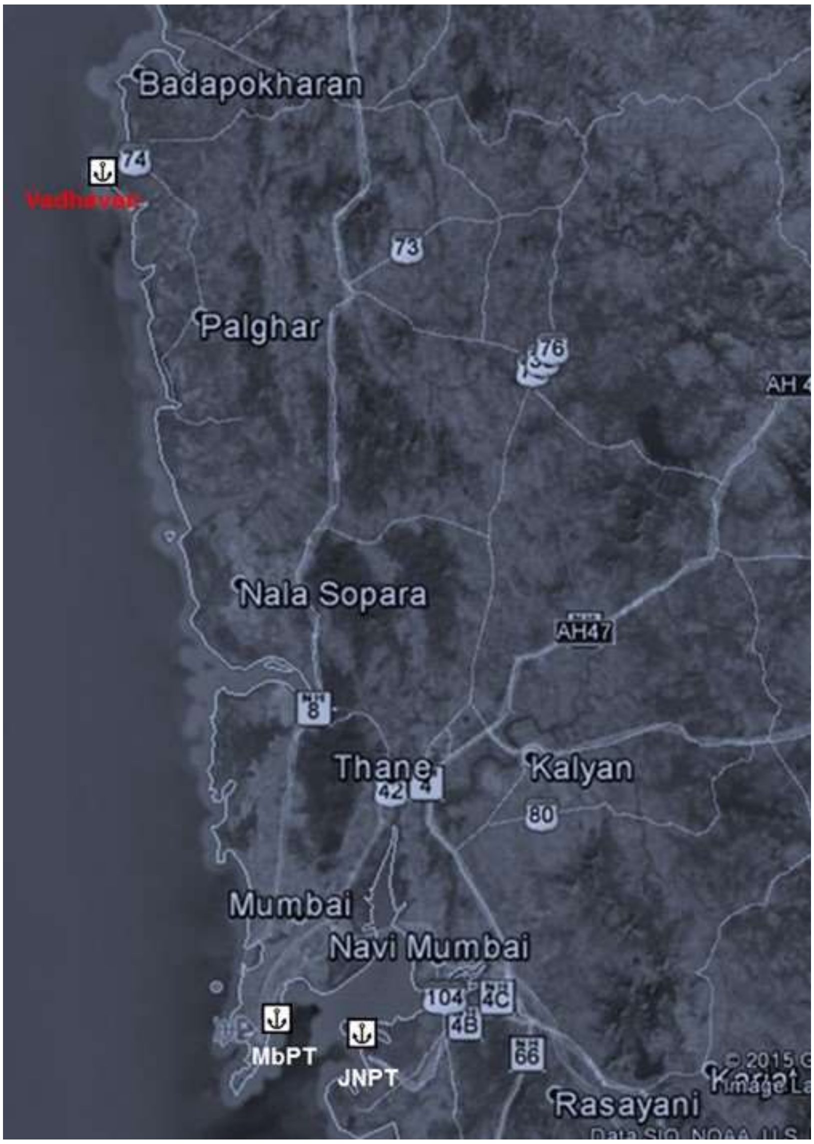


Figure 2.1 Vadhavan Location with reference to JNPT & Mumbai Port

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**.

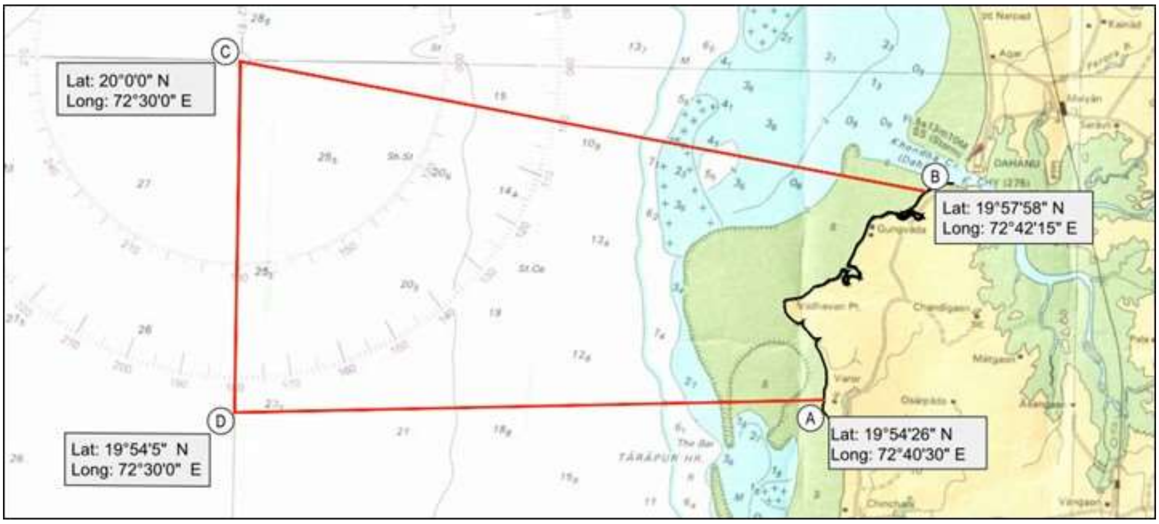


Figure 2.3 Vadhavan Port Limits

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.

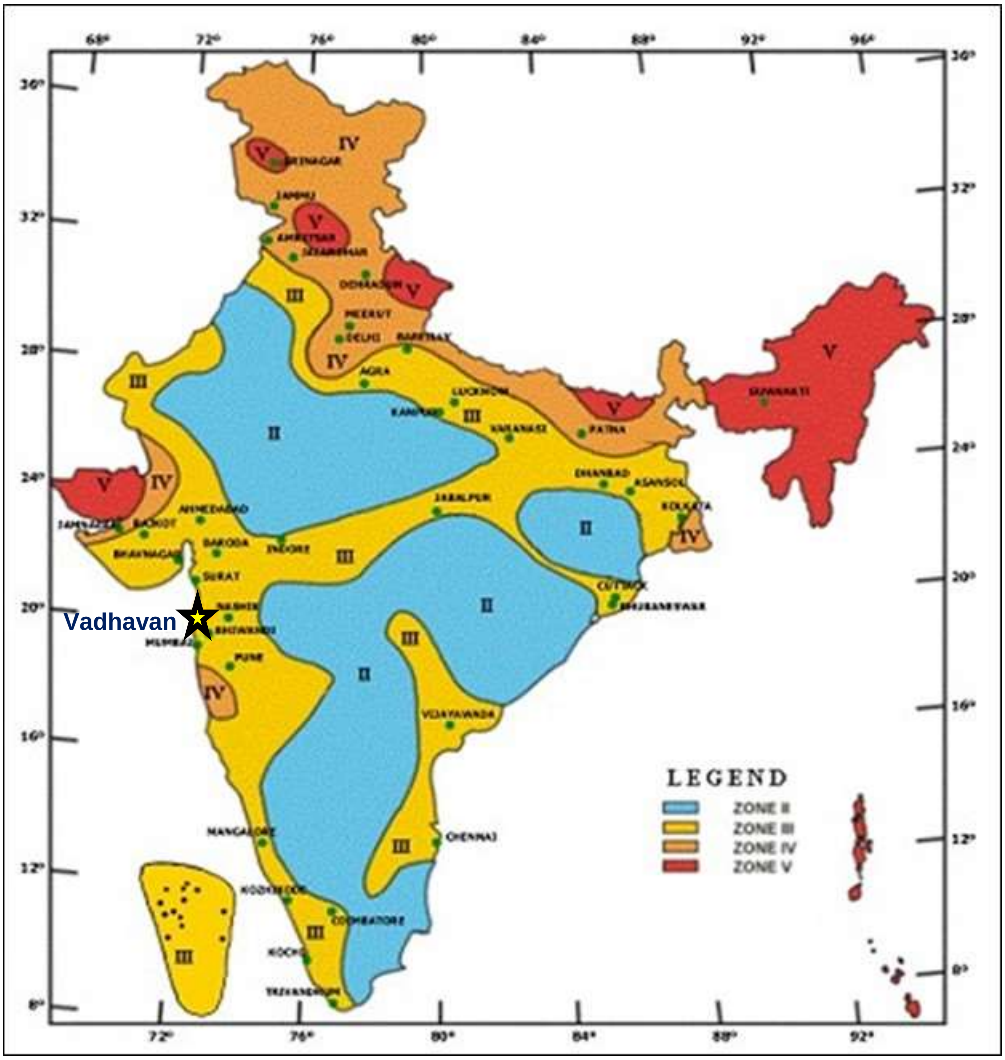


Figure 2.7 Seismic Zoning Map of India as per IS-1893 Part 1-2002

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.

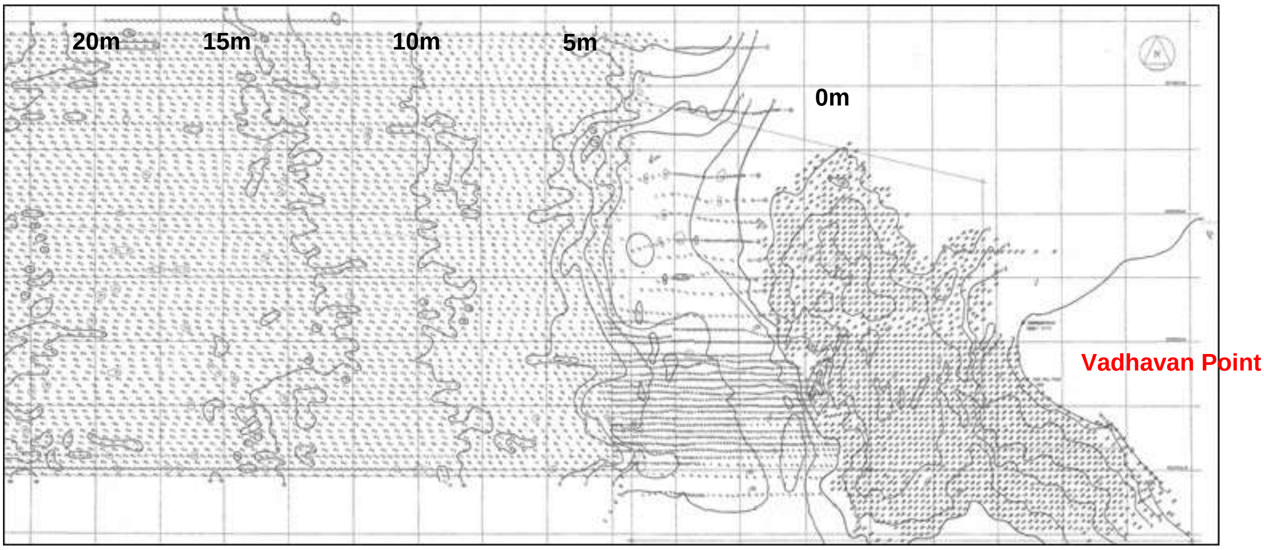


Figure 2.8 Bathymertic Survey Details at Proposed Vadhavan Port site

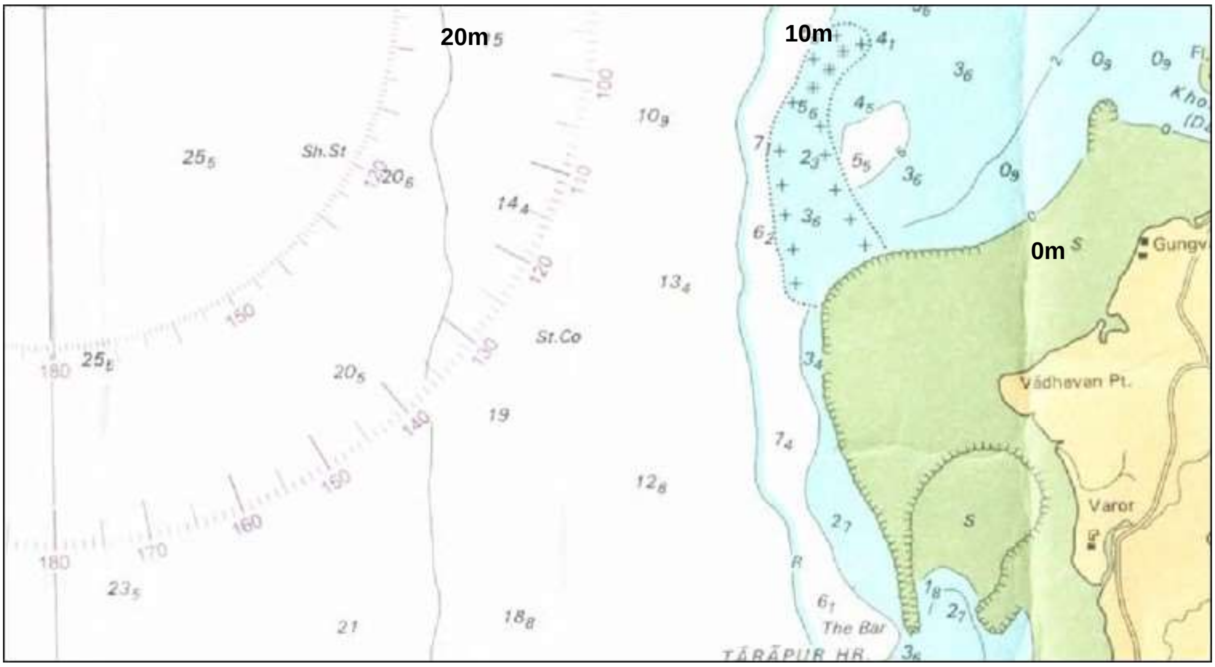


Figure 2.9 Hydrographic Chart of Vadhavan Port location
[Source: NHO Chart 210]

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.

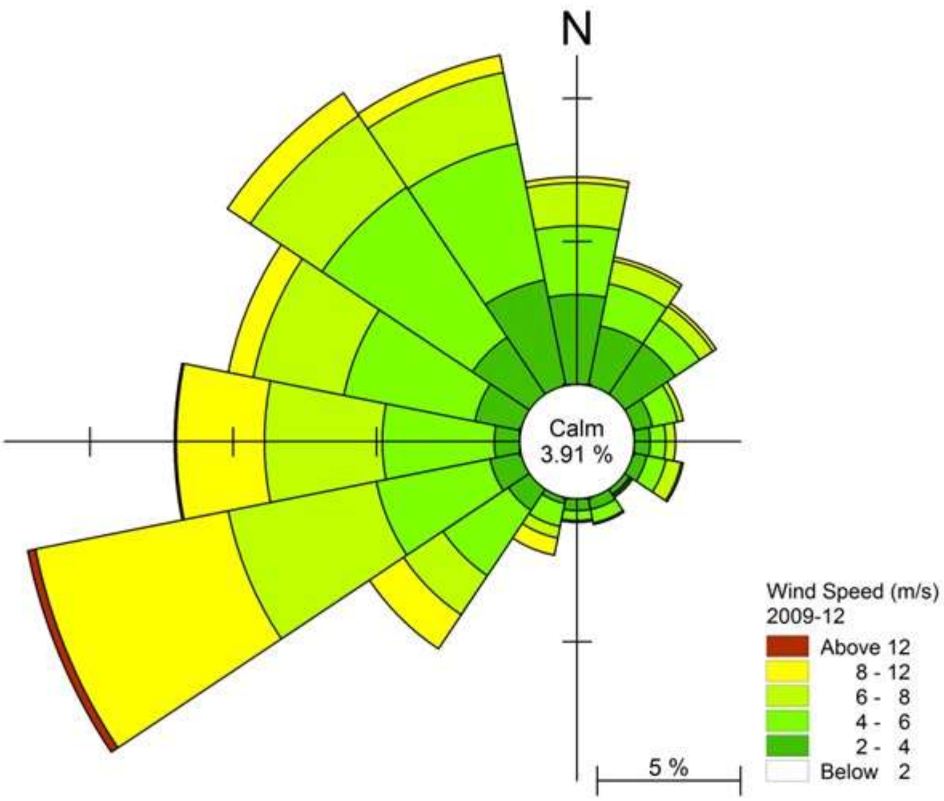


Figure 2.10 Wind Rose (UKMO: 1999-2012)

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.

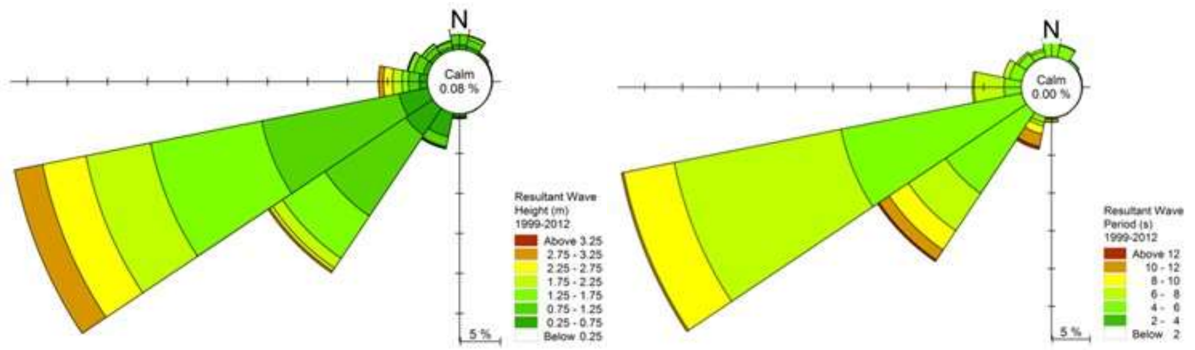


Figure 2.11 Wave rose for Resultant Wave Height and period
[Source: UKMO, 1999 – 2012]

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**).

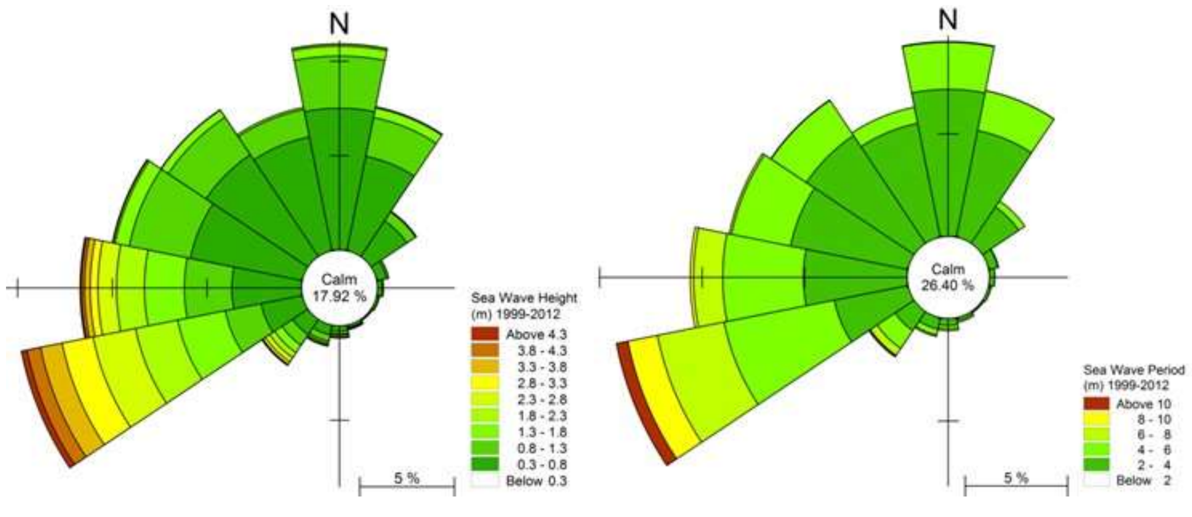


Figure 2.12 Wave rose for Sea Wave Height and Period
[Source: UKMO, 1999 – 2012]

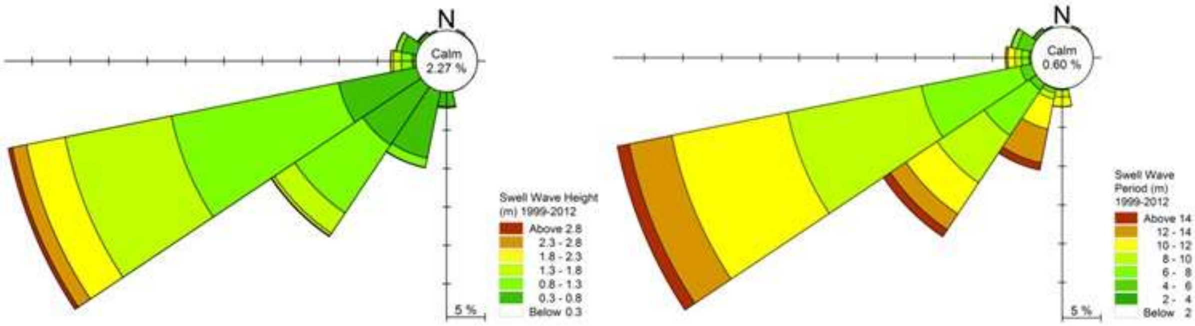


Figure 2.13 Wave rose for Swell Wave Height and Period
[Source: UKMO, 1999 – 2012]

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**).

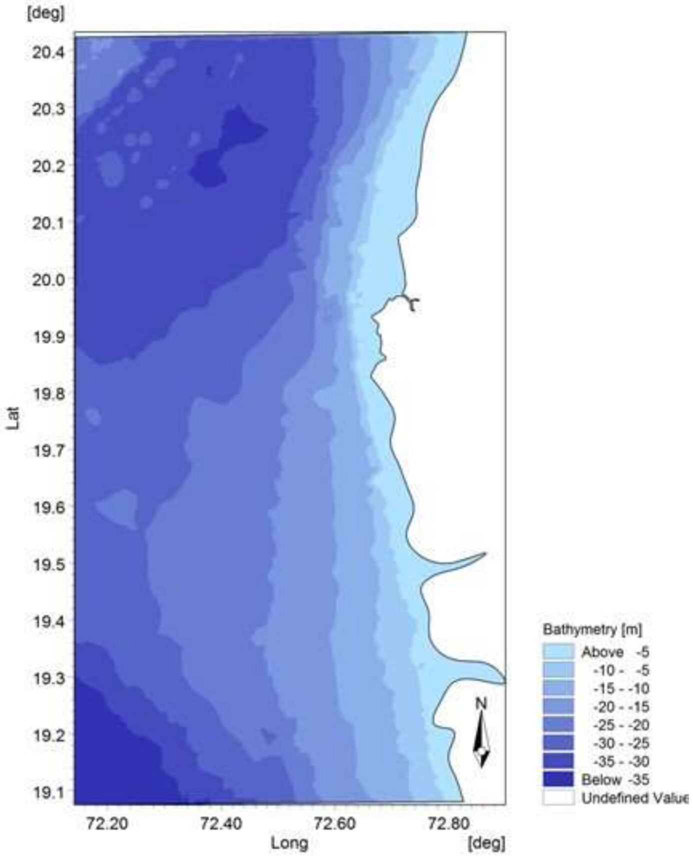


Figure 2.14 Model Domain used for Nearshore Wave Transformation Study

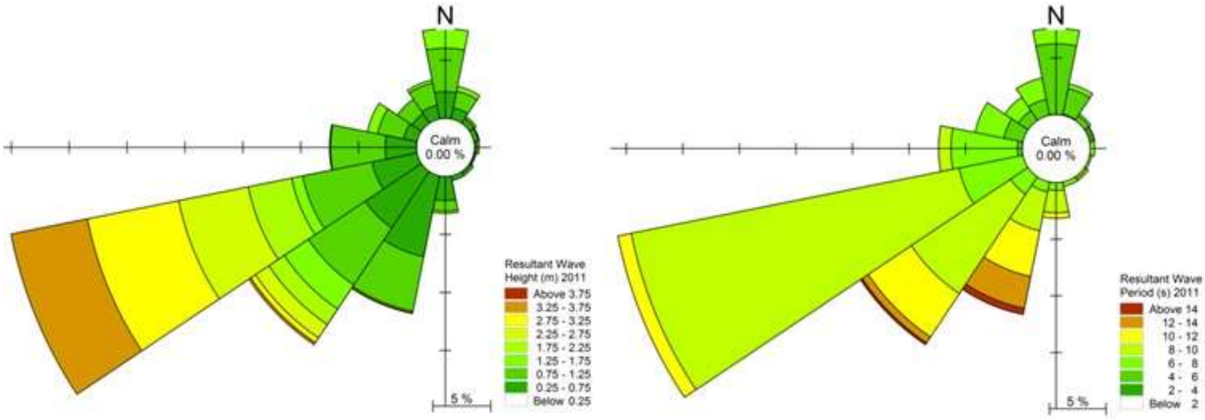


Figure 2.15 Resultant Wave height and period used as input to the model (UKMO: 2011)

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**).

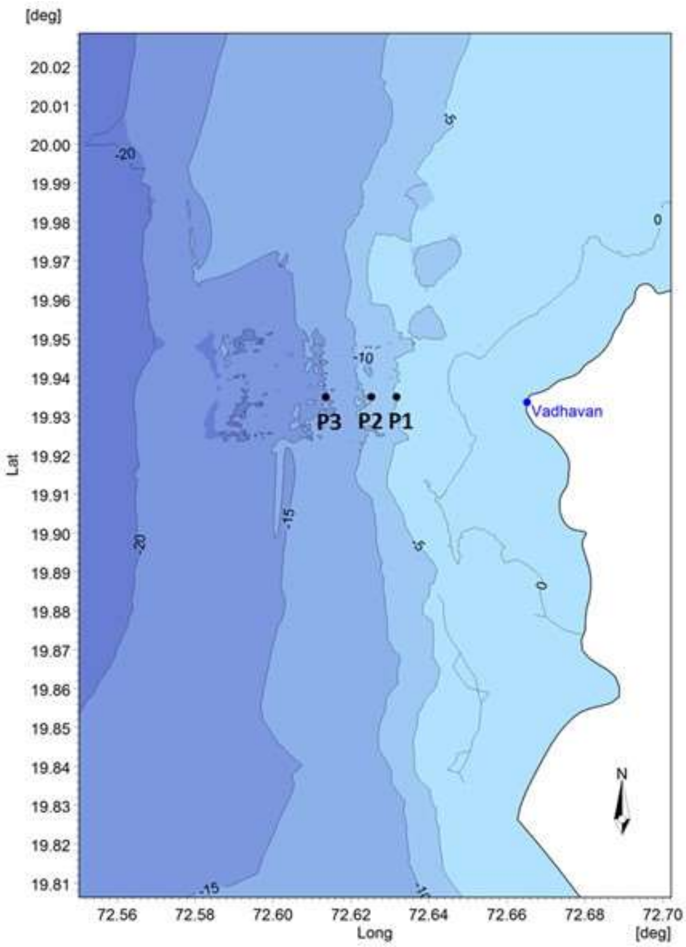


Figure 2.16 Extraction Points for near shore wave modelling at 5m (P1), 10m (P2) and 15m (P3) water depth at Vadhavan Point

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.

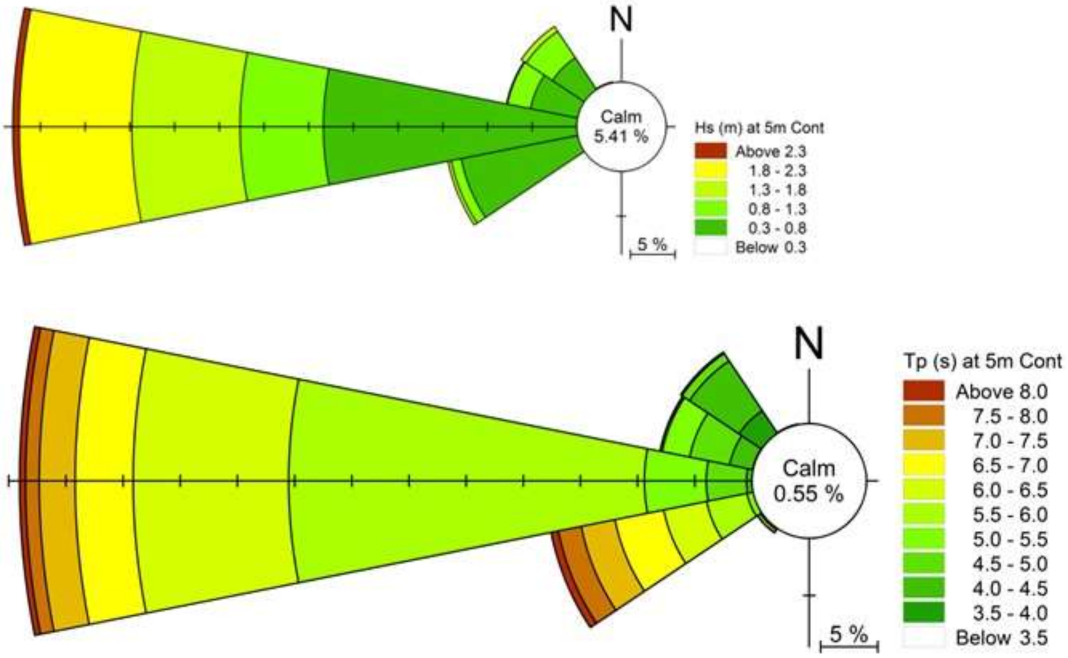


Figure 2.17 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 5m depth (P1)

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**

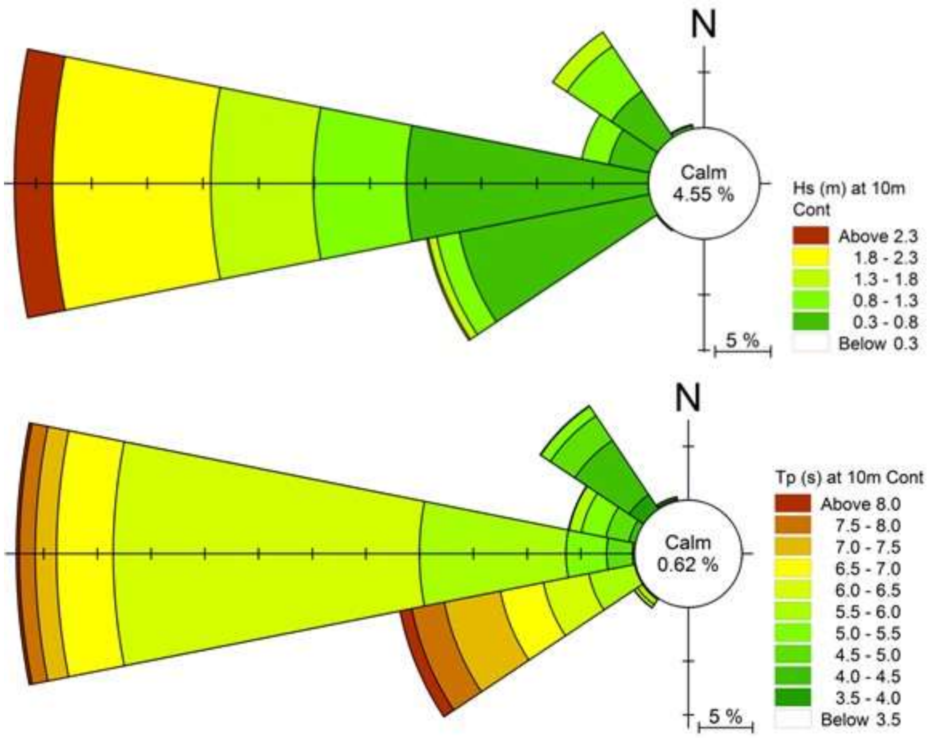
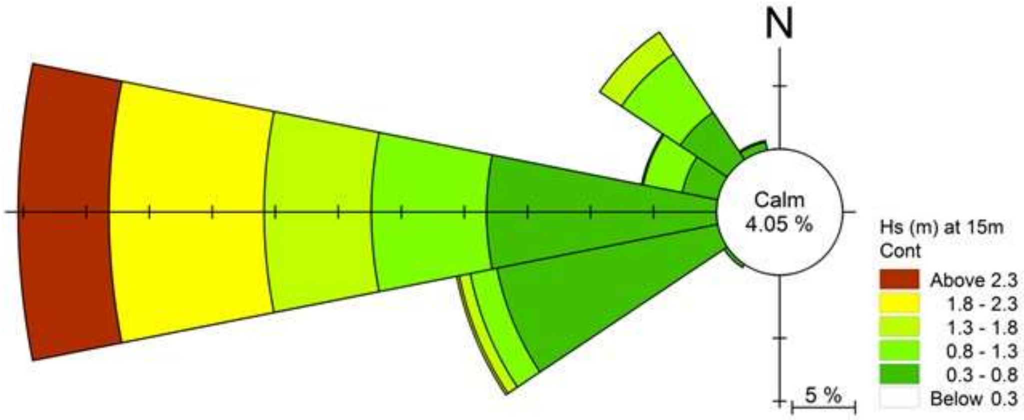


Figure 2.18 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 10 m depth (P2)

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**



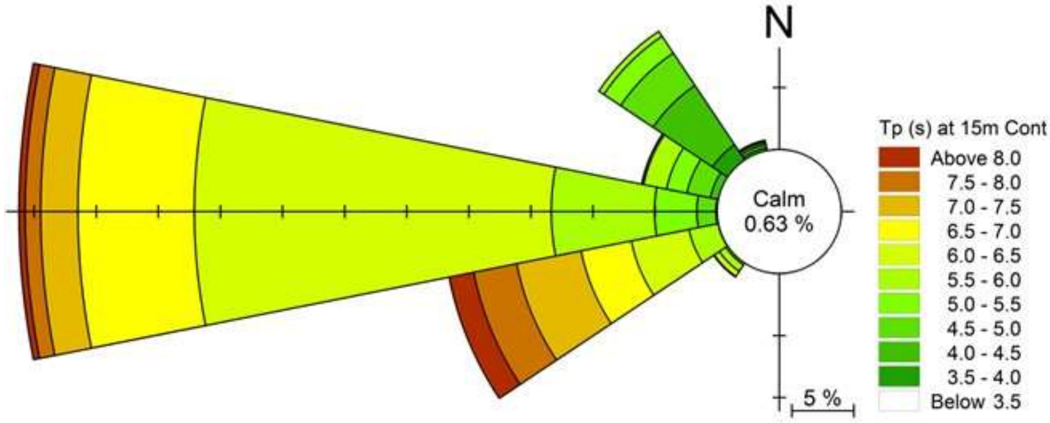


Figure 2.19 Significant Wave Height (SWH) and Peak Wave Period (PWP) at 15 m depth (P3)

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.

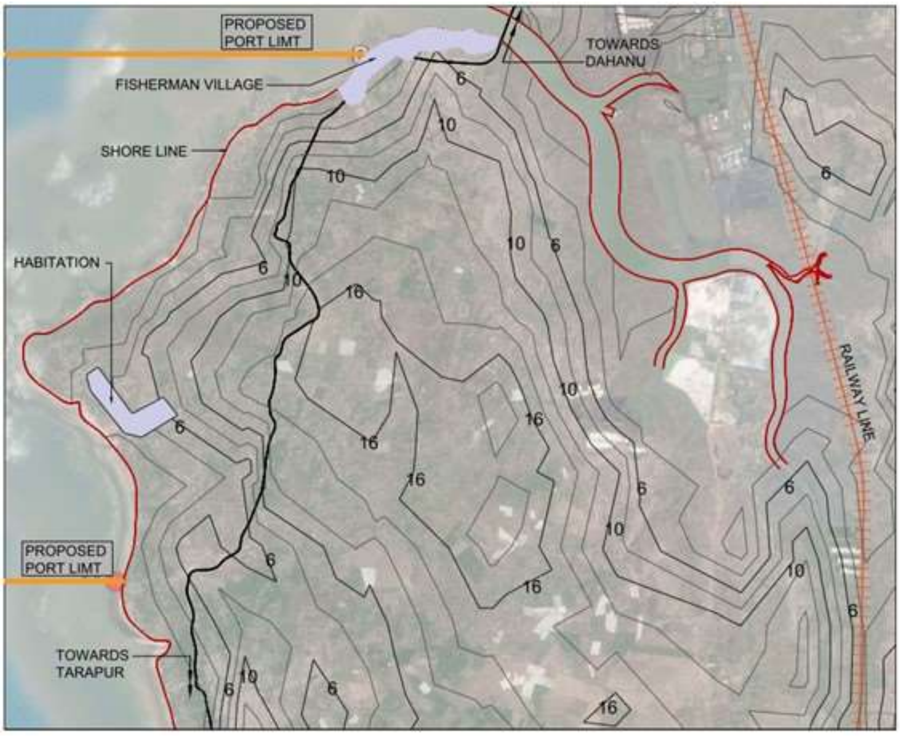


Figure 2.21 Topographic Details of the Study Area

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

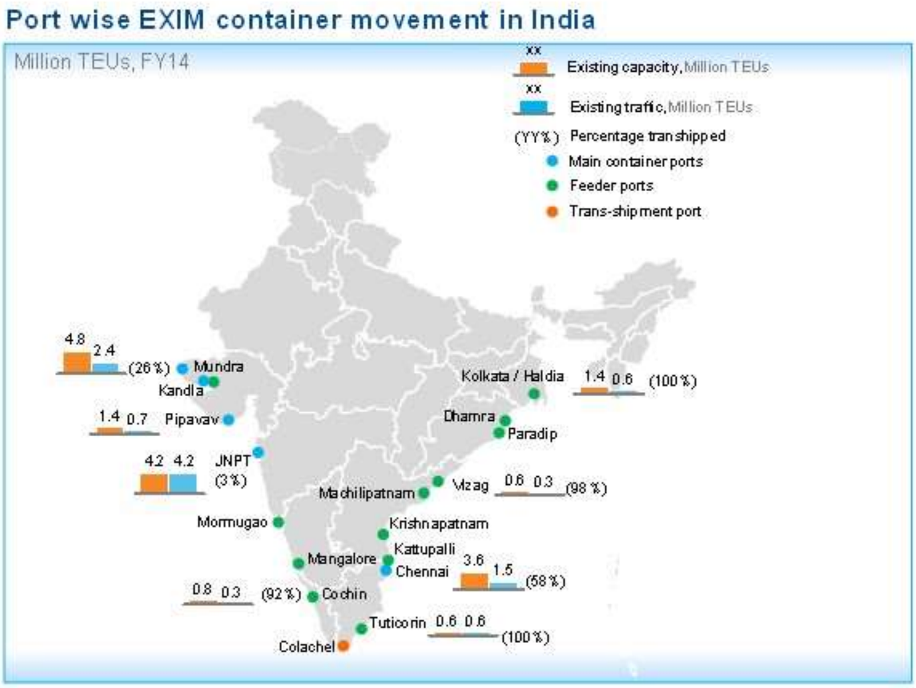
3.1 General

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.

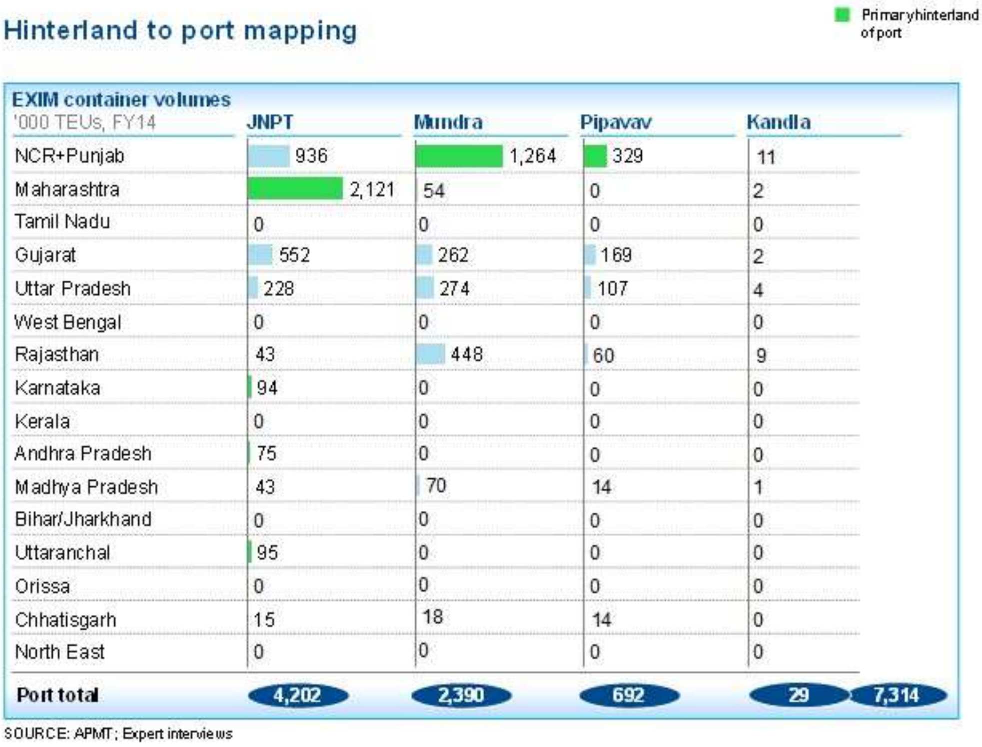
West coast container ports handled ~7.6 MTEUs out of the 10.7 M TEUs handled in India in FY14. In the same year, JNPT operated at ~100% capacity utilization handling 4.2 MTEUs (**Figure 3.1**).



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**).

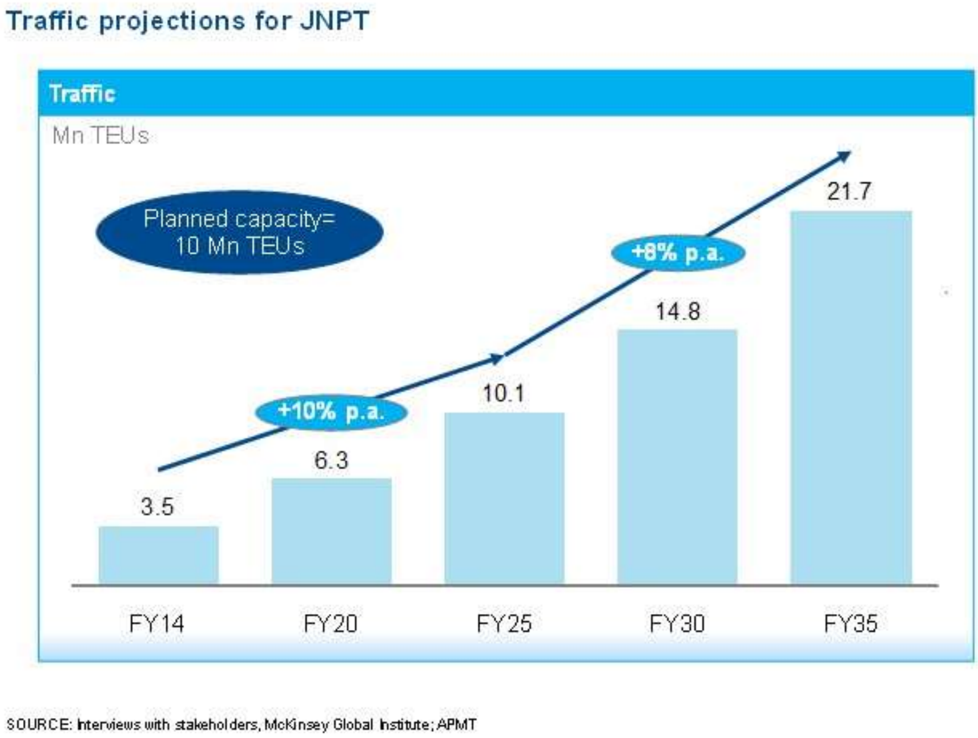


Figure 3.3 Container Traffic Projections for JNPT

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 lane 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

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**).

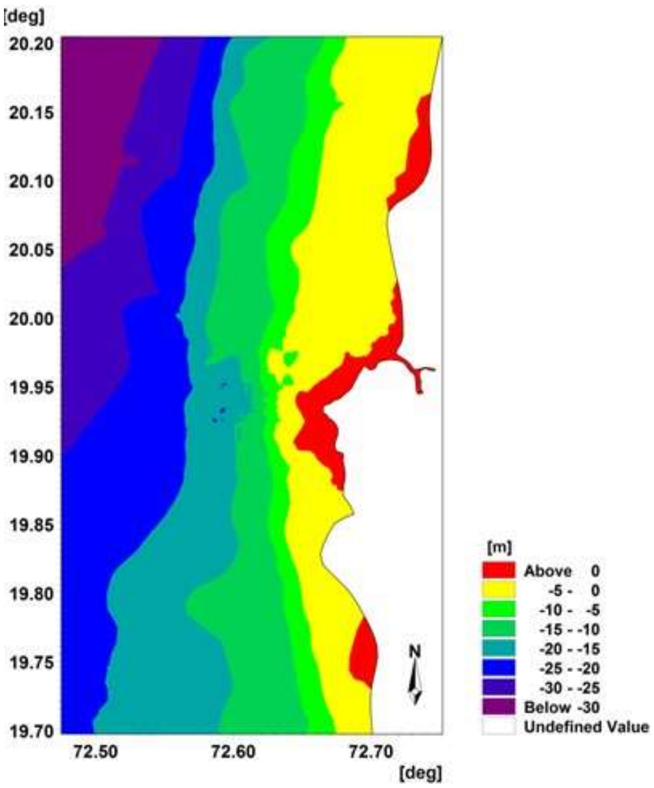


Figure 7.1 Bathymetry of the study area w.r.t. chart datum

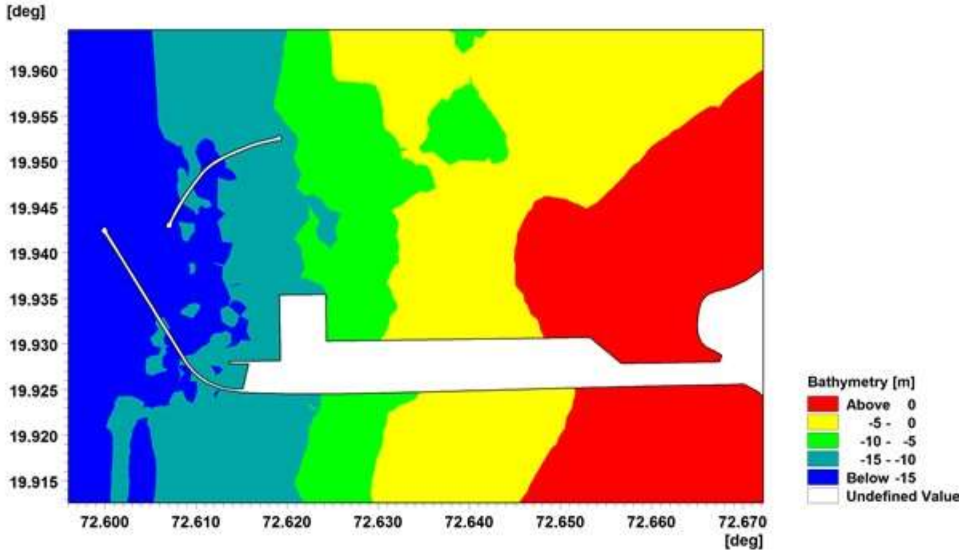


Figure 7.2 Bathymetry including Proposed Layout w.r.t. Chart Datum

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.

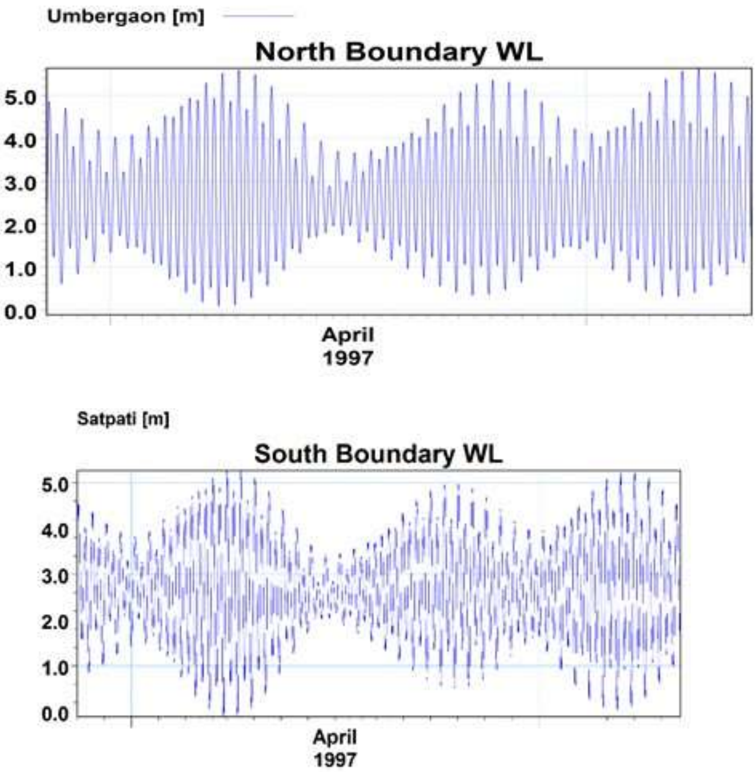


Figure 7.3 Water levels used as Northern Boundary and Southern Boundary

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).**

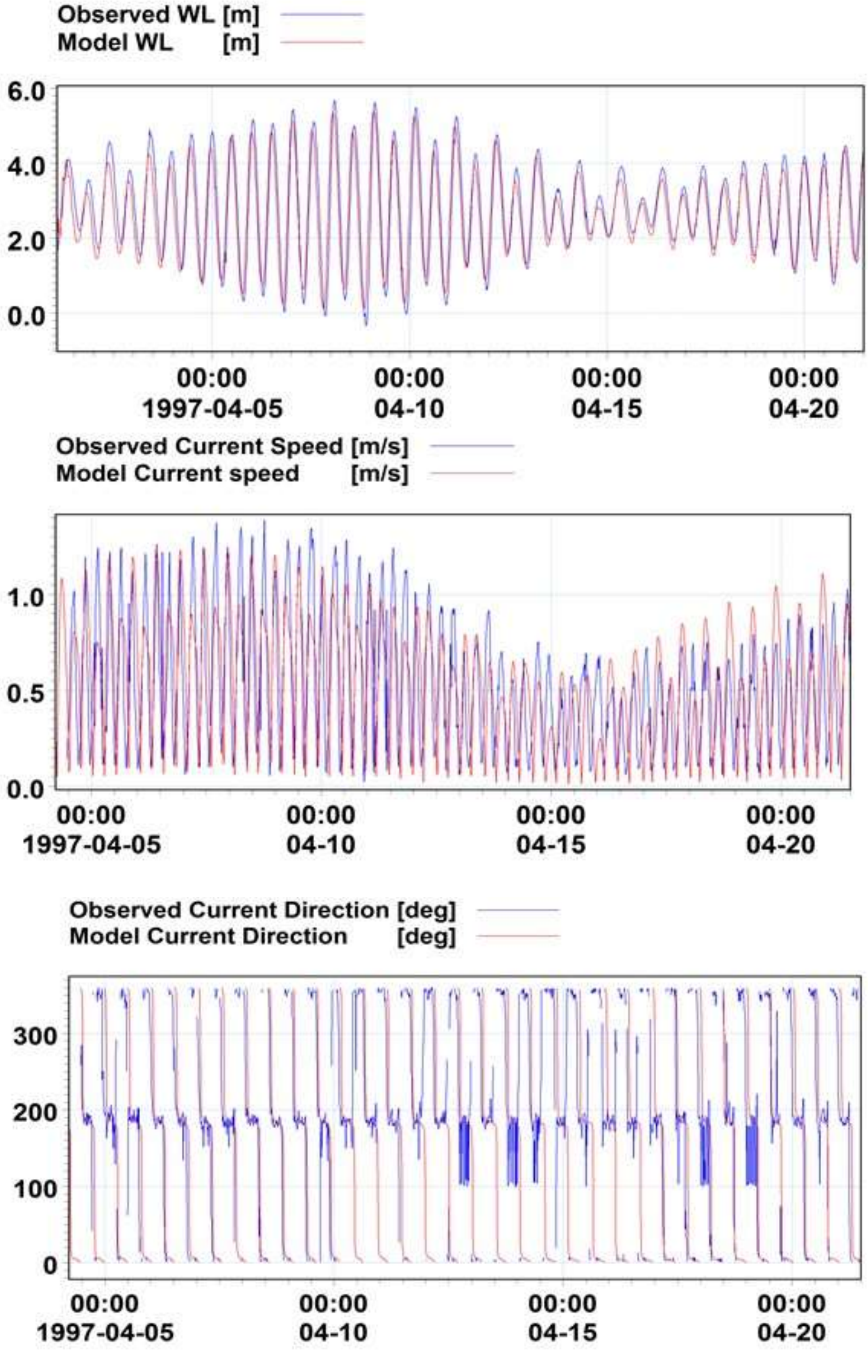


Figure 7.4 Model Calibration: Comparison of Measured (Red) and Modelled Tidal Levels (Blue) at Vadhavan

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**

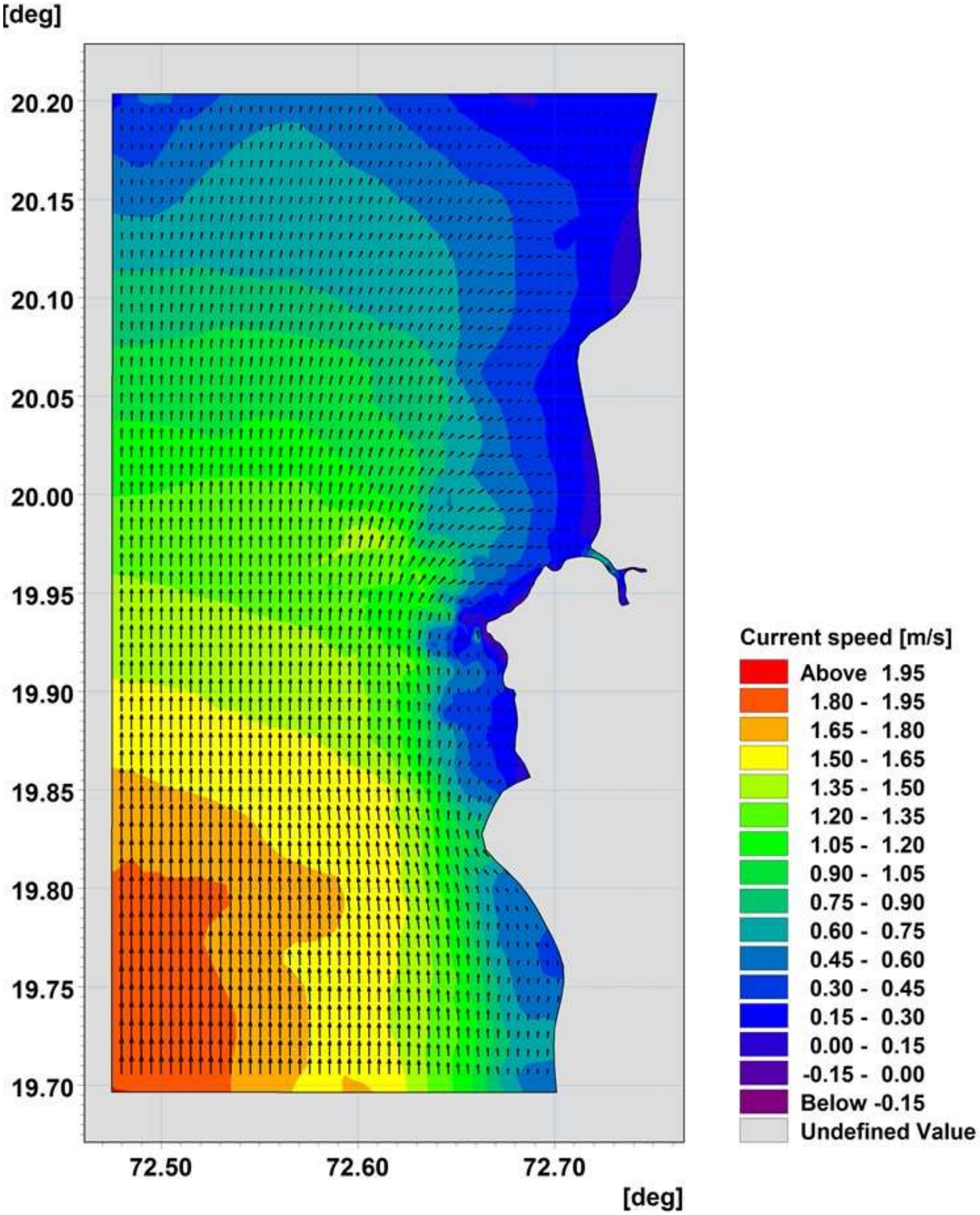


Figure 7.5 Surface Elevation in the entire region during Flood Tide

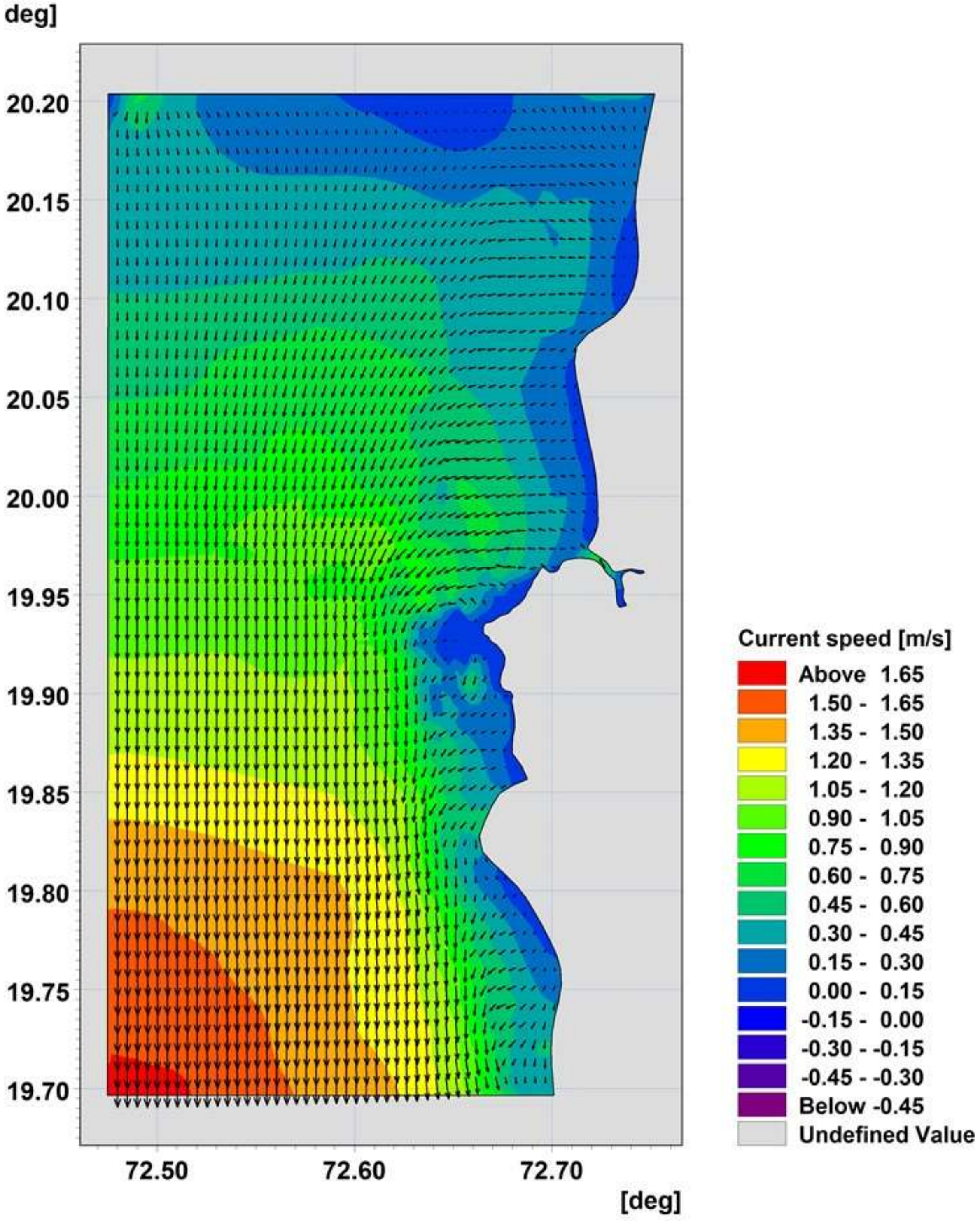


Figure 7.6 Surface elevation in the entire region during Ebb Tide

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.

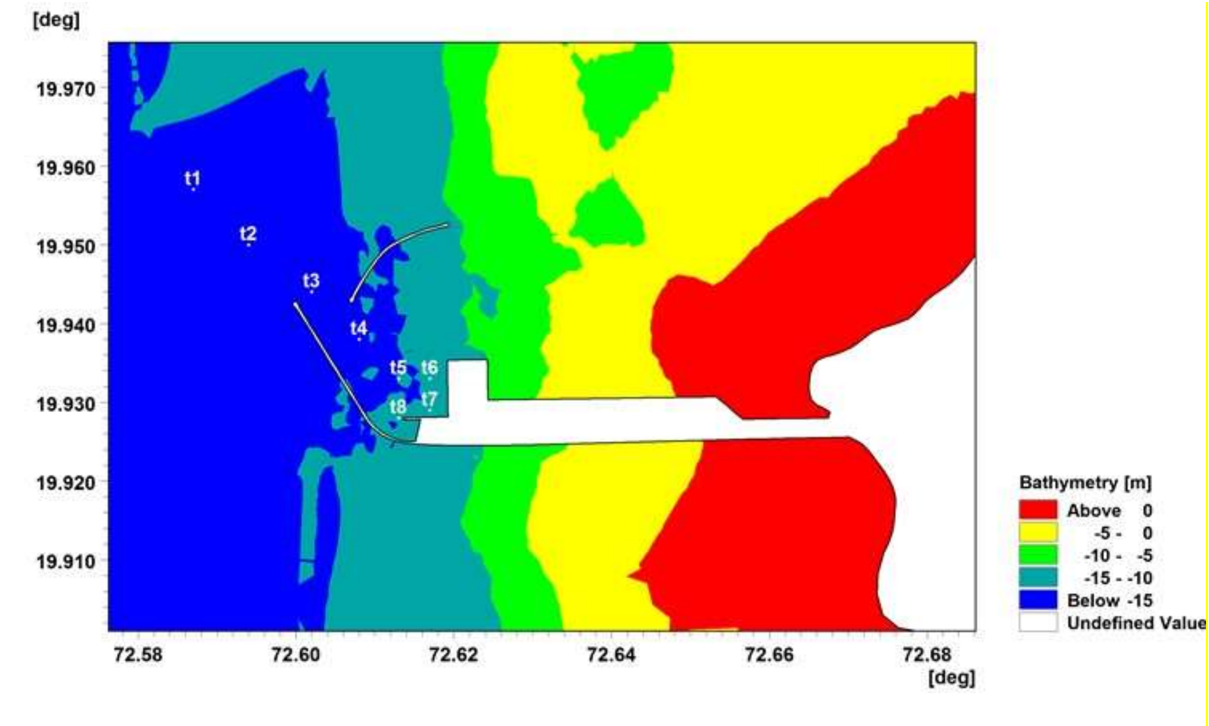


Figure 7.7 Location of Current Time-Series – Existing Conditions

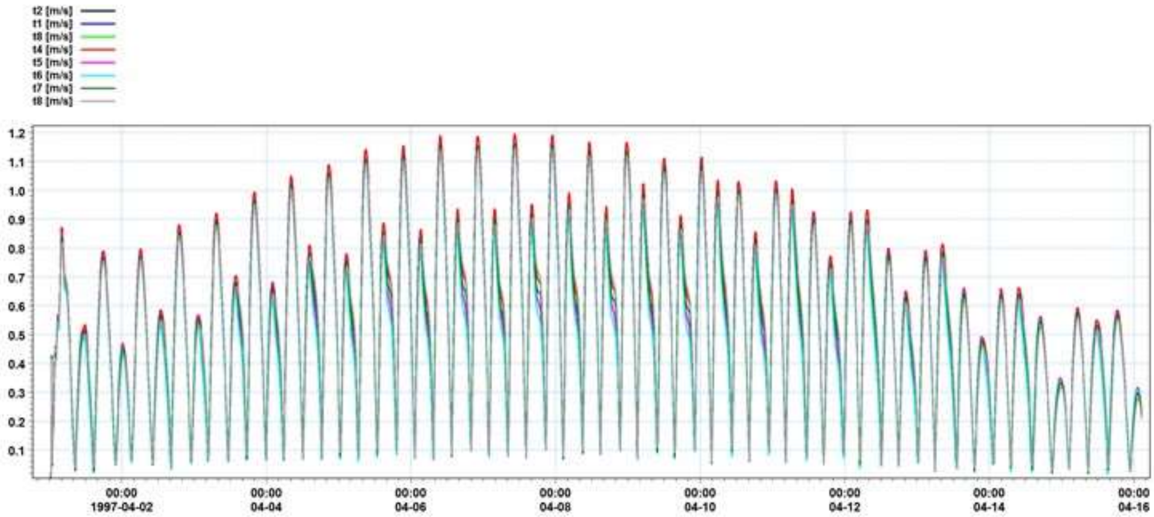


Figure 7.8 Current Time-Series at various location in the Port and Channel for Existing Conditions

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.

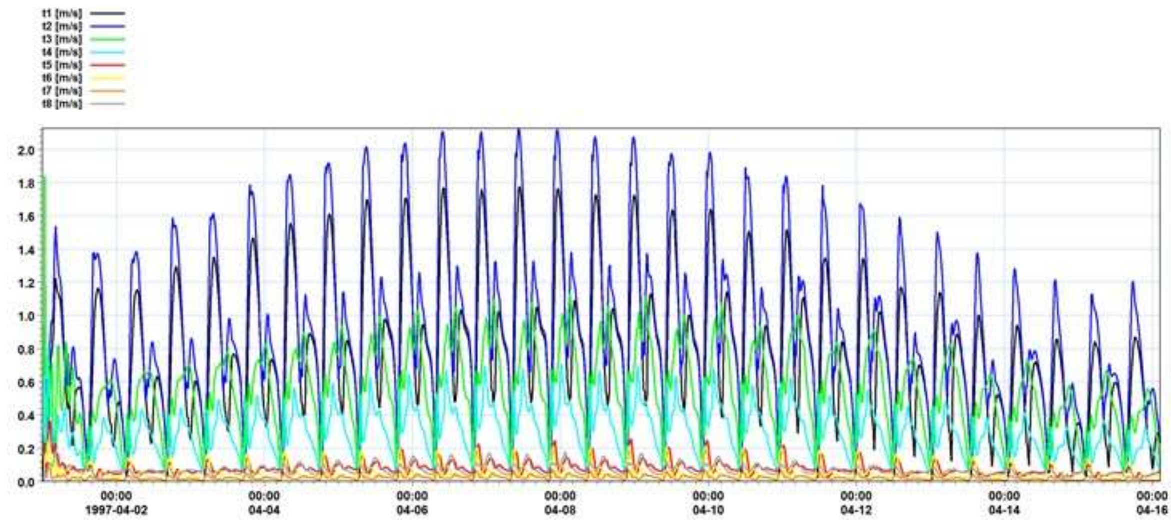


Figure 7.9 **Current time-series at various location in the Port and Channel with Proposed Layout**

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.

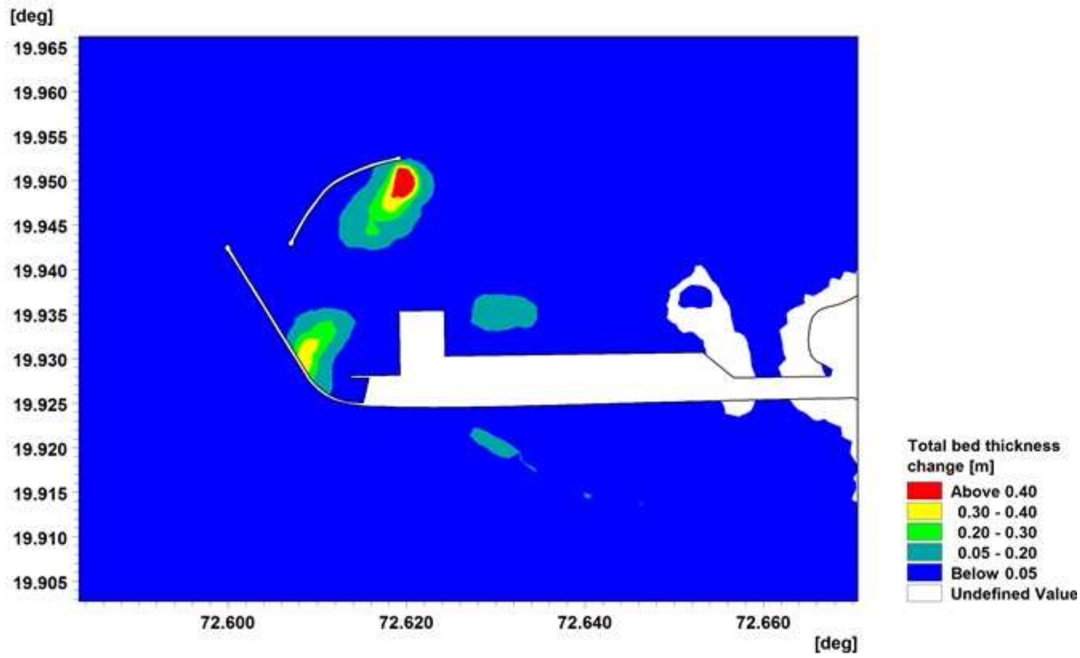


Figure 7.10 **Annual Bed level Change – with Proposed Layout**

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).

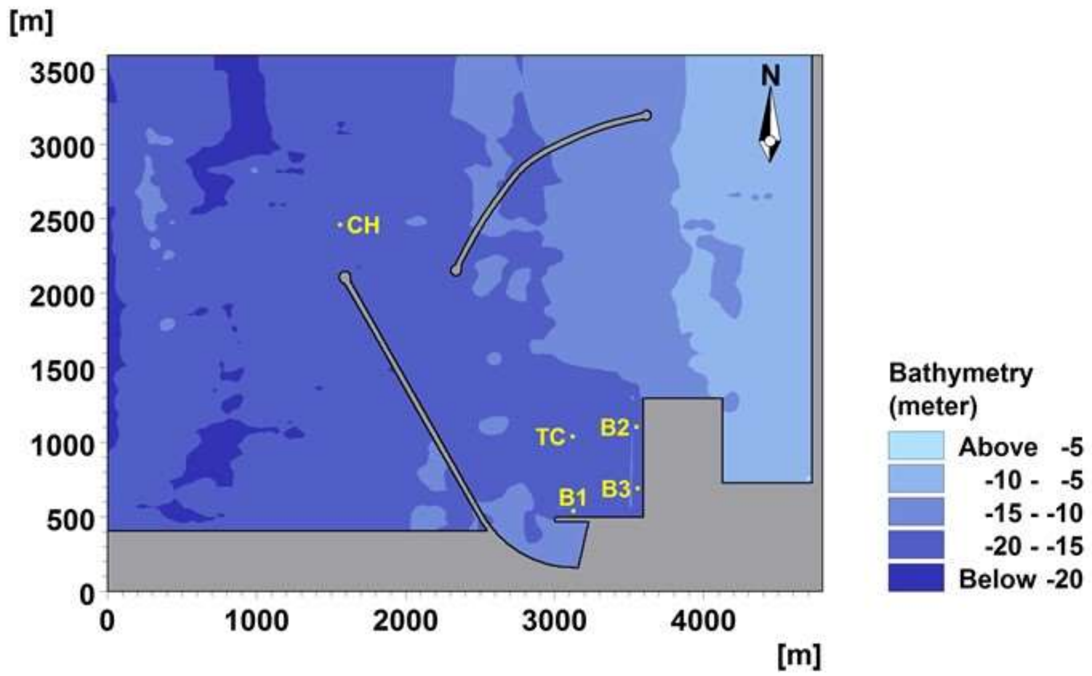


Figure 7.11 Bathymetry used for the BW

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**).

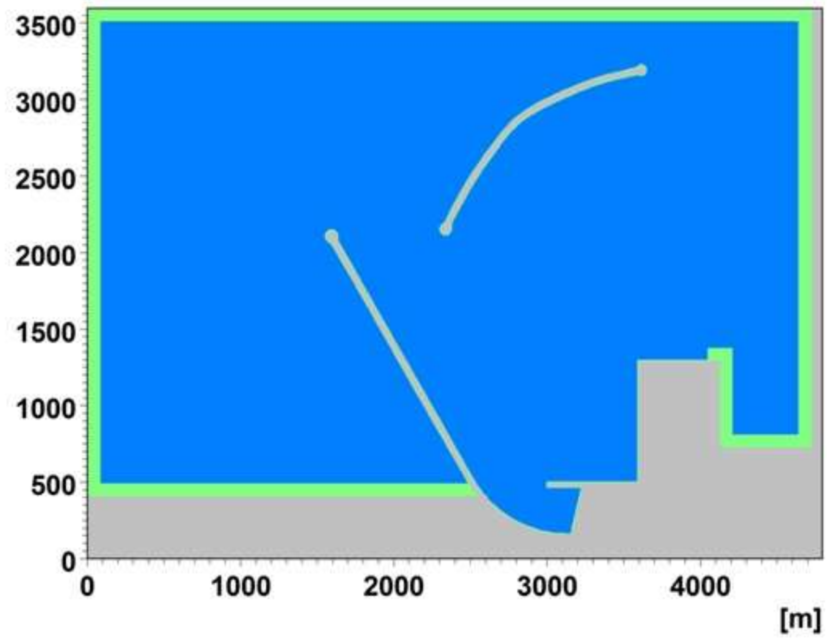


Figure 7.12 Sponge layers (in Green) along the non-reflecting boundaries

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.

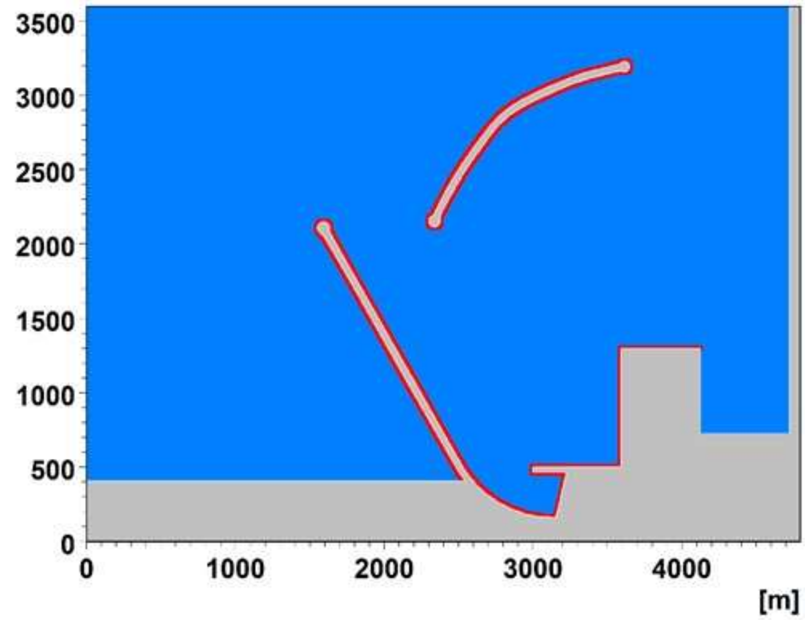


Figure 7.13 Porosity layers (in Red) along the port structures

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.

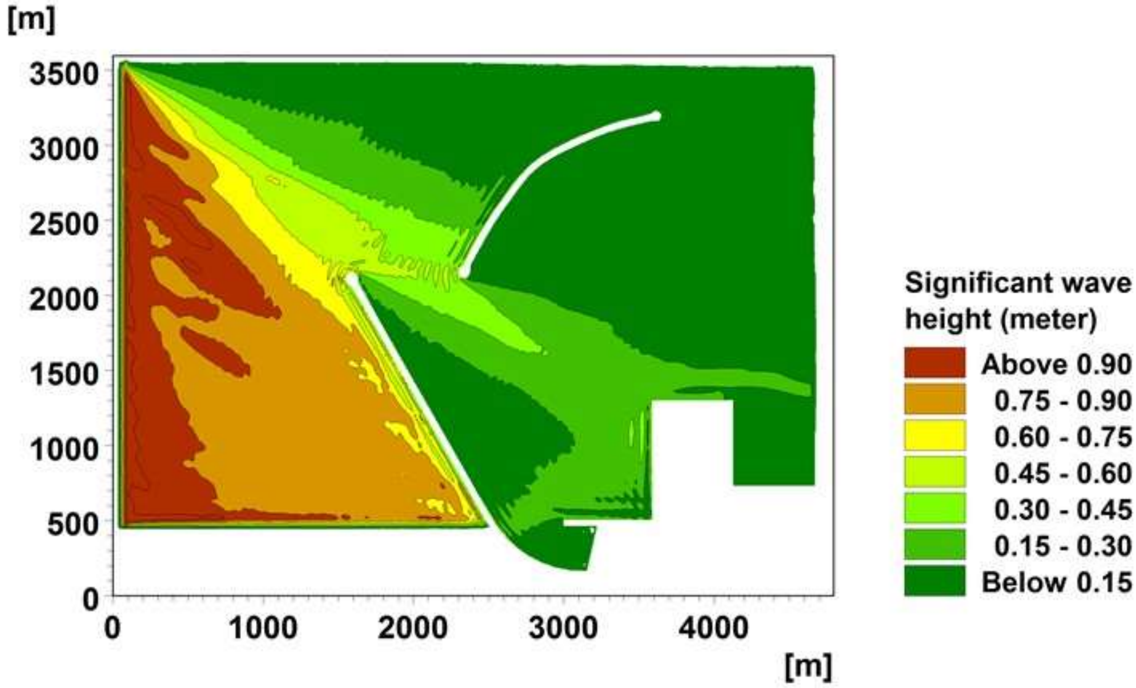


Figure 7.14 Wave Tranquililty Assessment for Waves from WNW Direction

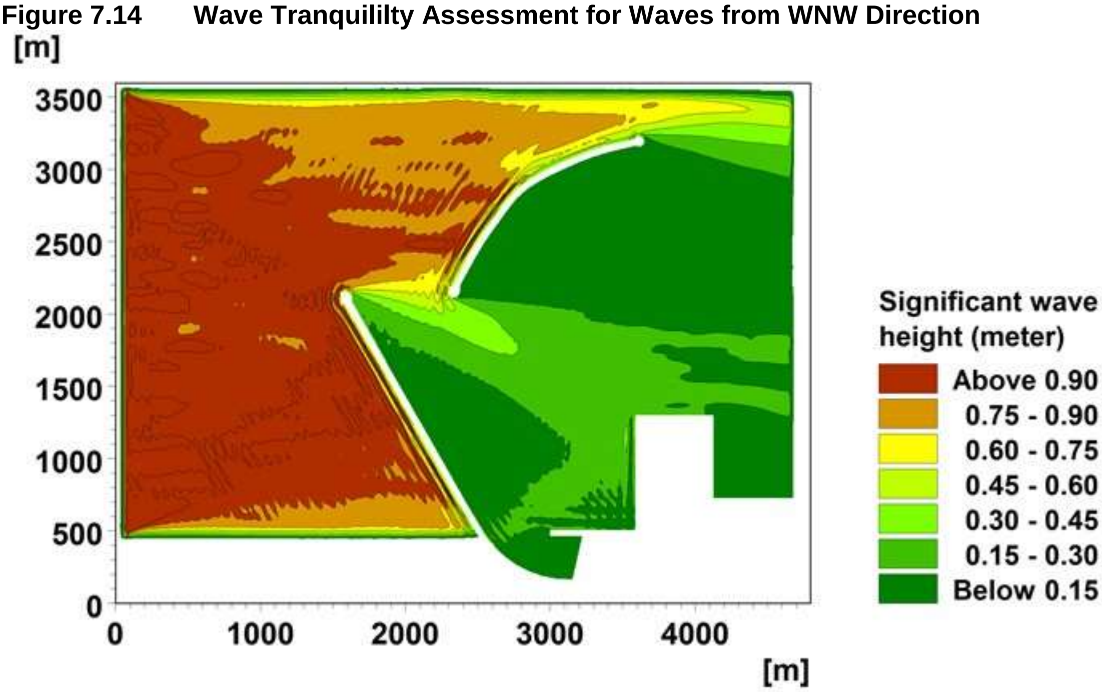


Figure 7.15 Wave Tranquililty Assessment for Waves from W Direction

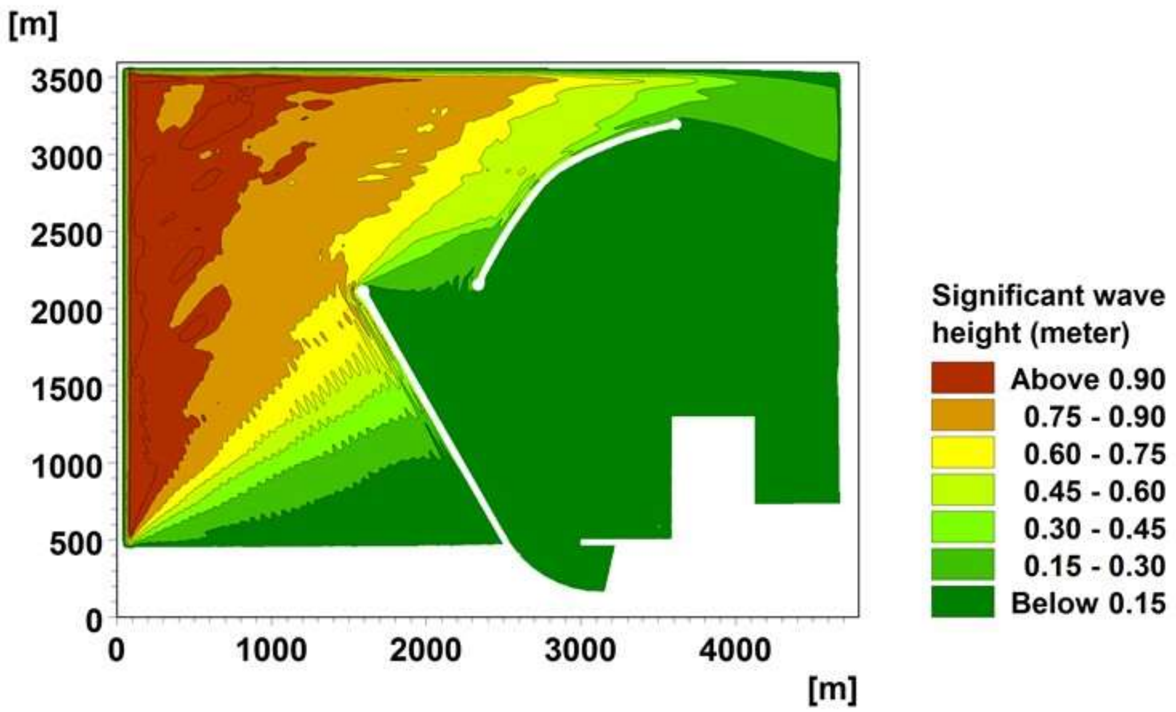


Figure 7.16 Wave Tranquililty Assessment for Waves from WSW Direction

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.

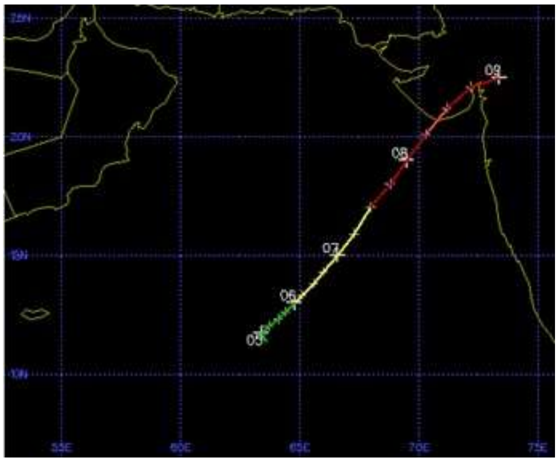
7.3 Breakwaters

7.3.1 Basic data for breakwaters design

<u>7.3.1.1 Cyclonic Storms and Extreme Wave Conditions</u>

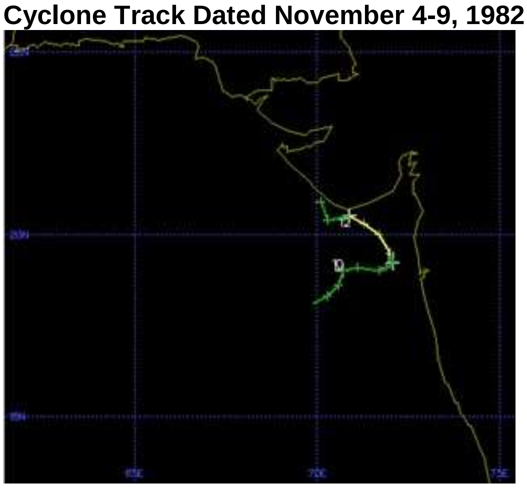
Cyclonic data from the IMD was collected in the form of storm tracks, and synoptic charts (pressure charts) along the tracks of the cyclones. Data for almost 33 years starting from 1978 to 2011 was analysed and 10 cyclones that passed near the proposed port location.

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

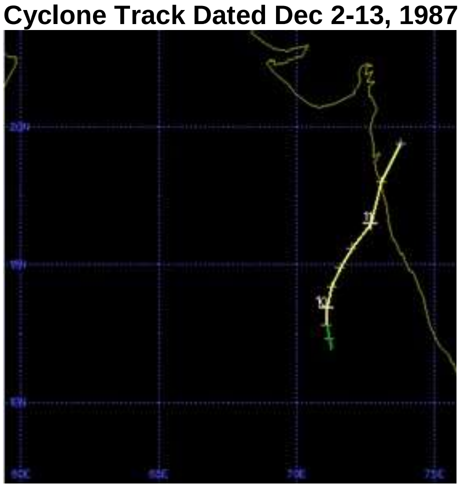


Cyclone Track Dated November 4-9, 1982

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.

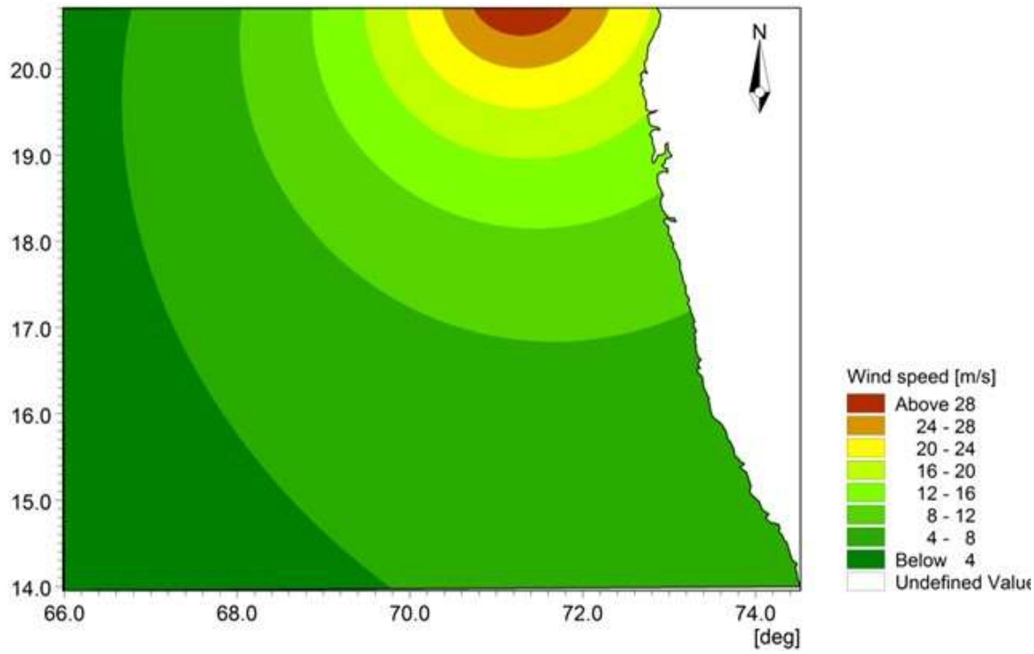


Figure 7.18 Wind Speed for cyclone of 1982

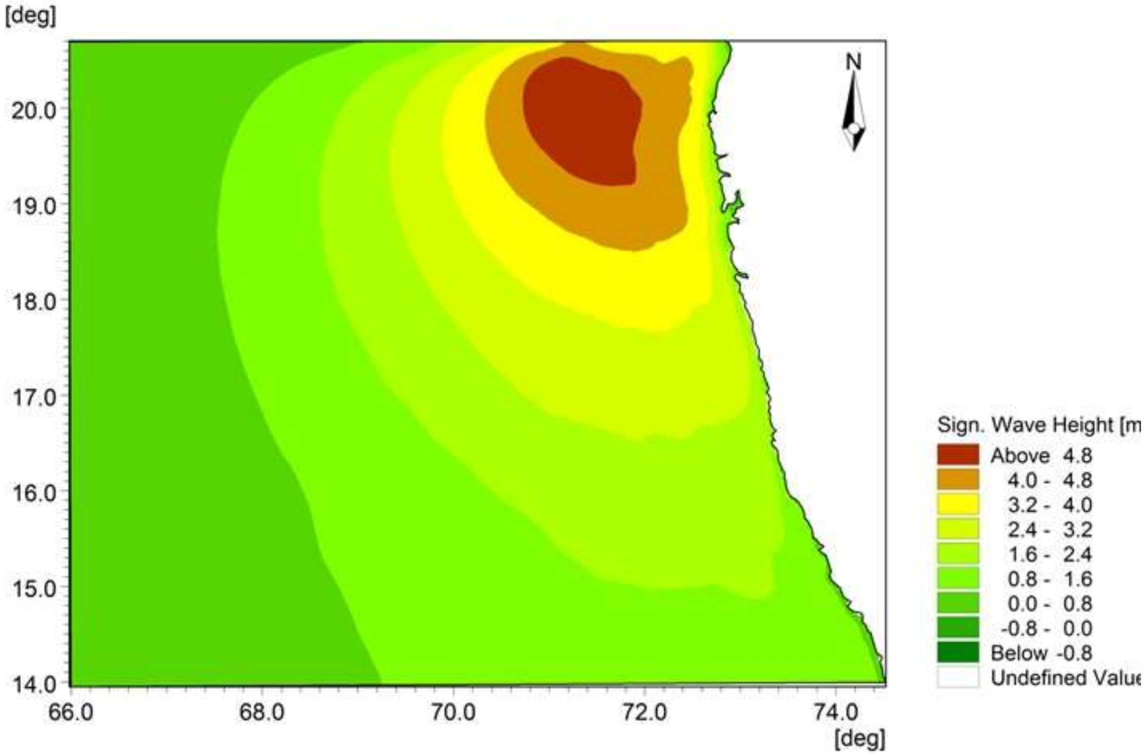


Figure 7.19 Maximum Wave height for cyclone of 1982

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

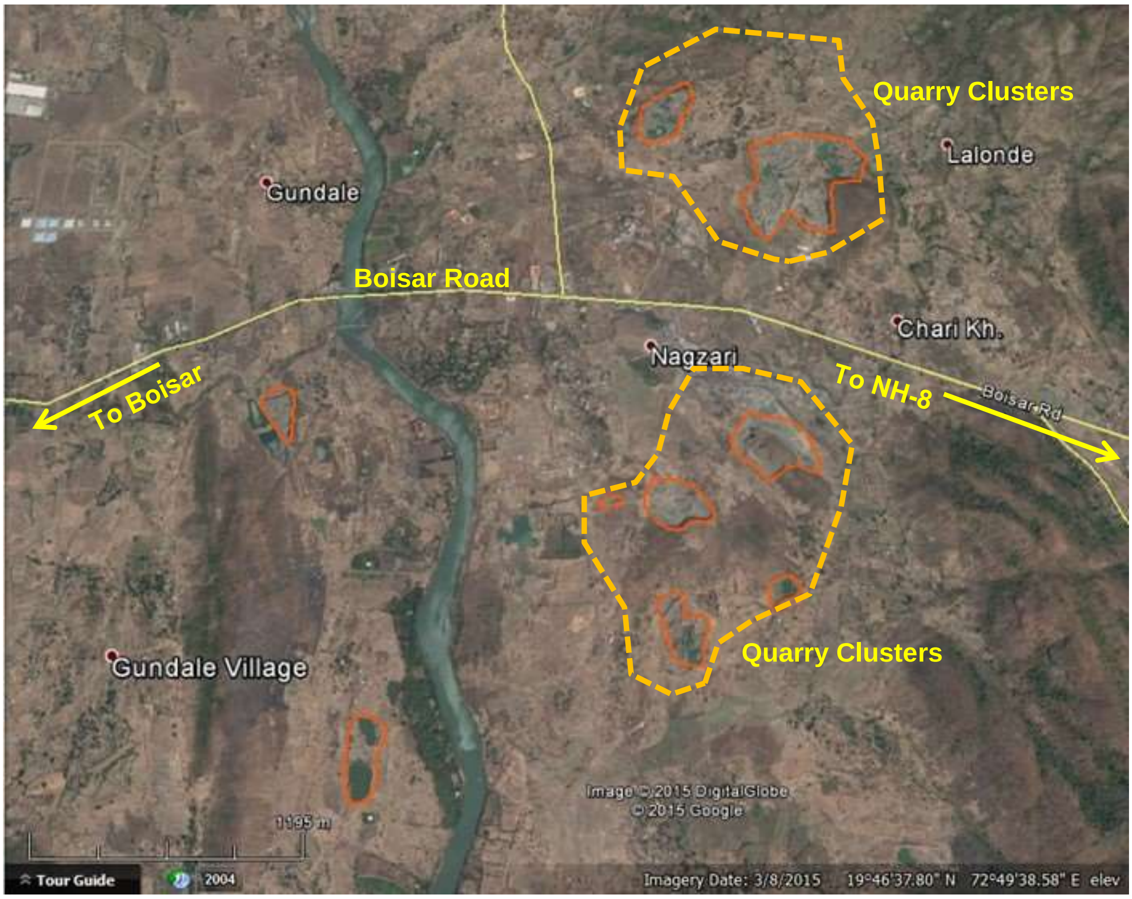


Figure 7.21 Quarry Sites in Nagzari Village

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

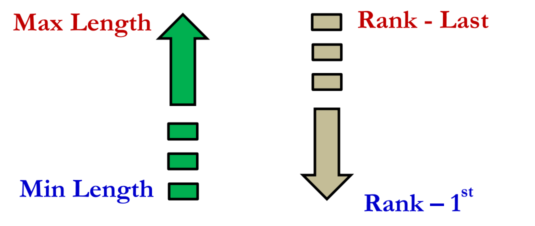
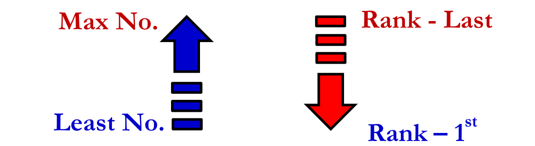
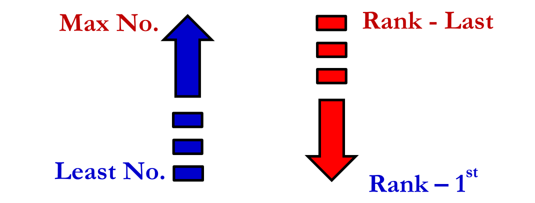
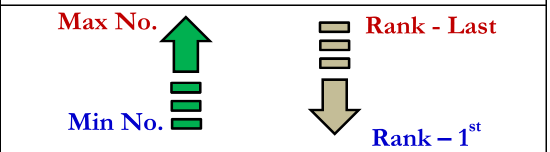
After the options are prepared, following salient techno-economic parameters were evaluated and the Options were compared against each individual parameter:

- 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-1^{st} 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-1^{st} 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

Junction with the road towards Port

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.

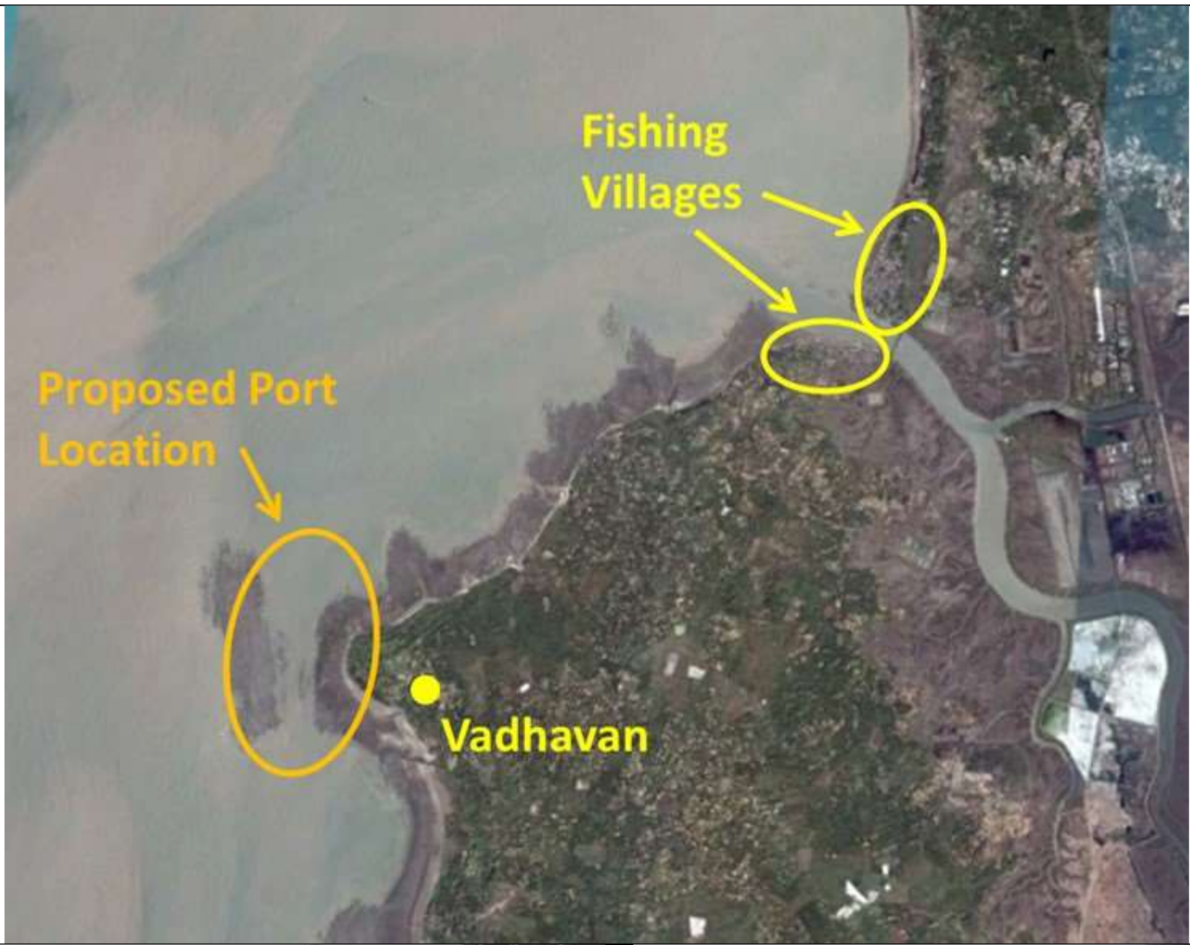
Dahanu Taluka has been designated as an ecologically fragile area and restriction had been imposed on setting up any polluting industries. Thus this region has never witnessed any industrial development and agriculture, animal husbandry, fishing, small scale units and farming are the only industries 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	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **Positive Impacts** • 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.

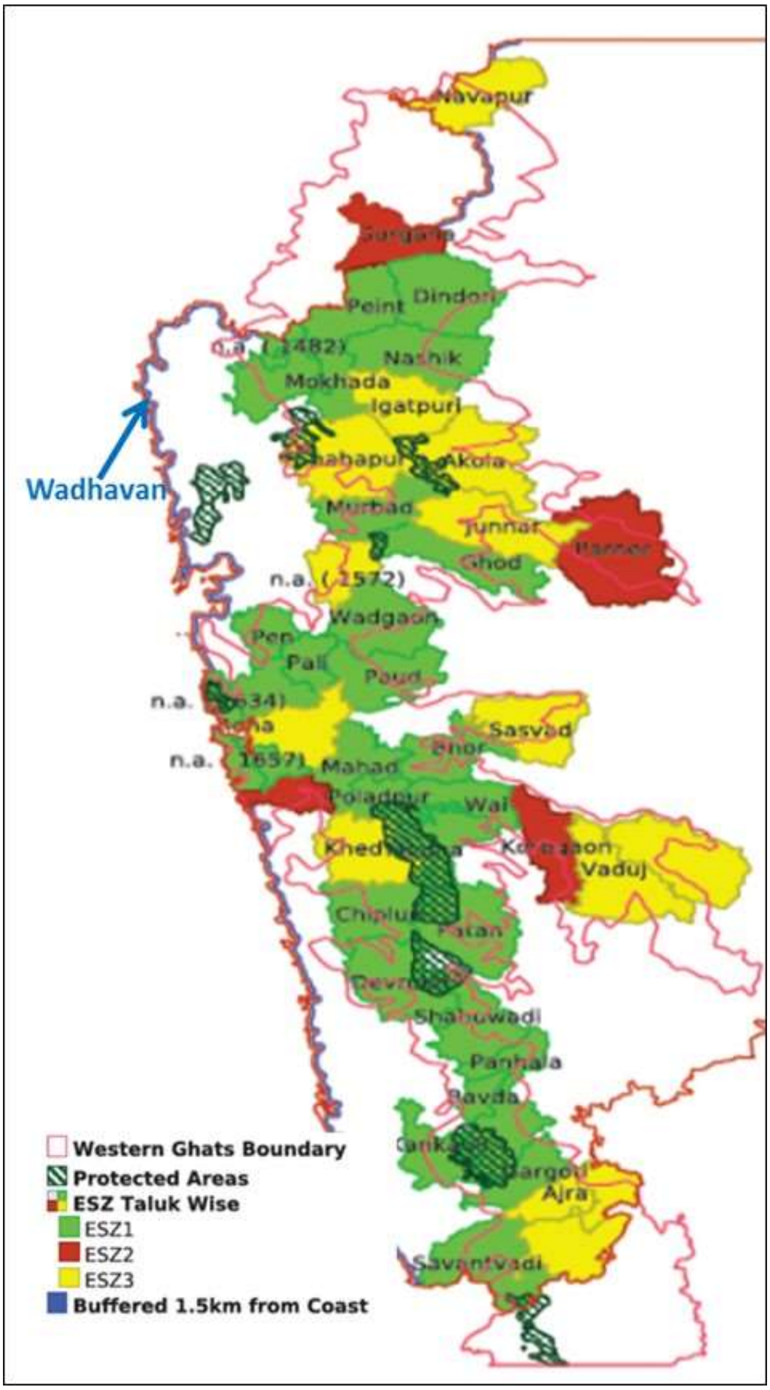


Figure 8.1 Location of Western Ghat and Vadhavan

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

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

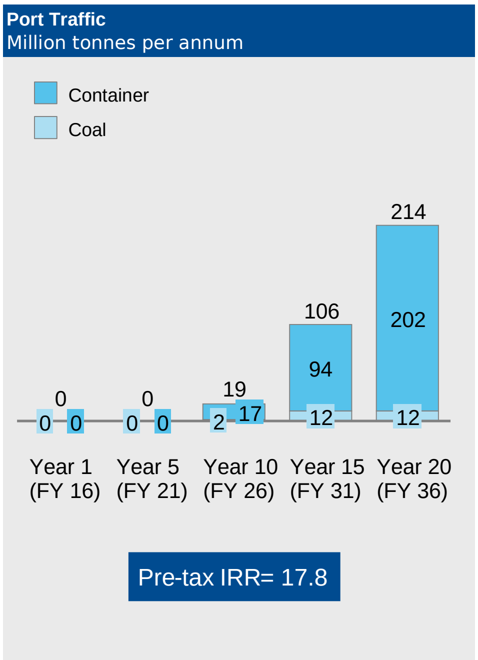


Figure 10.1 Financial Analysis

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**.

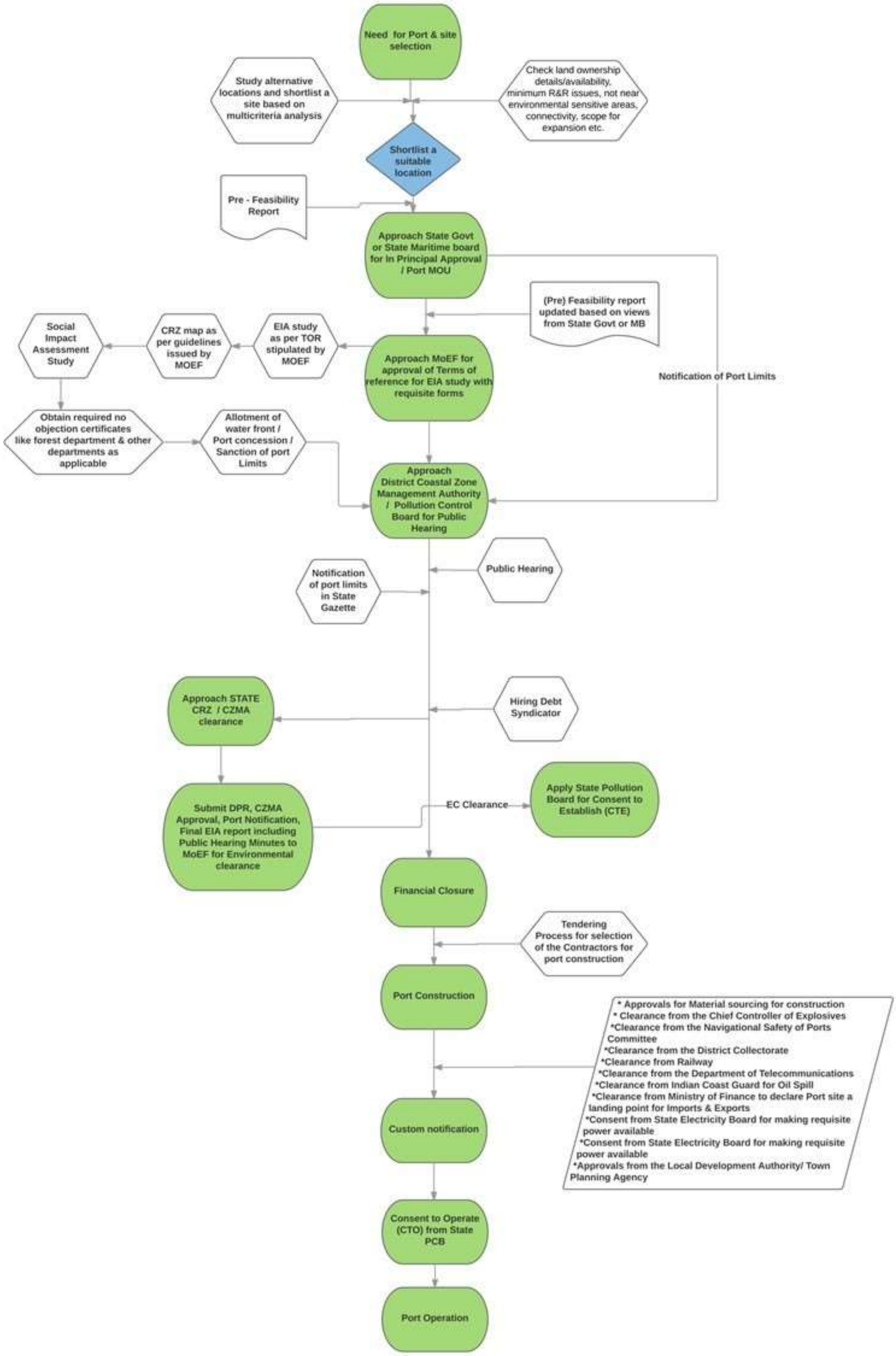


Figure 11.1 Process for the Greenfield Port Development

Techno-Economic Feasibility Report for Development of Outer Harbour of Paradip Port

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Executive Summary

Introduction

As part of its vision Coal India Limited (CIL) is planning of producing 1 billion tonnes of coal by year 2020. Out of this 250 MTPA coal will be produced from Mahanadi Coal Fields (MCL), which is currently producing only 140 MTPA. The current railway system does have adequate capacity to evacuate additional 110 MTPA to the Power Gencos situated in Andhra Pradesh, Tamil Nadu and Gujarat. An assessment has been made for the movement of coal through various combinations of rail, road and coastal shipping and it is observed that the Rail and Coastal shipping offers the cheapest mode of transfer.

The Paradip port has a locational advantage of it being in close proximity to Mahanadi coal fields and therefore is a port of choice for the coastal movement of coal to the power plants located in the southern and western states of India. The port does not have adequate capacity through existing and planned projects to handle the projected volumes of coal export and therefore there is a need to create additional capacity. Also the existing port cannot be further deepened to handle the cape size carriers which can lead to reduction in coal logistics cost particularly for the import of coking coal used by the steel plants.

As part of the master plan prepared for Paradip Port as part of Sagarmala assignment, it is suggested that expansion of Paradip Port would be needed to be able to handle the projected traffic throughout and also fully loaded cape size vessels. In pursuant to that a site for the proposed development of a deep water port has been selected which is adjacent to the south of the existing harbour.

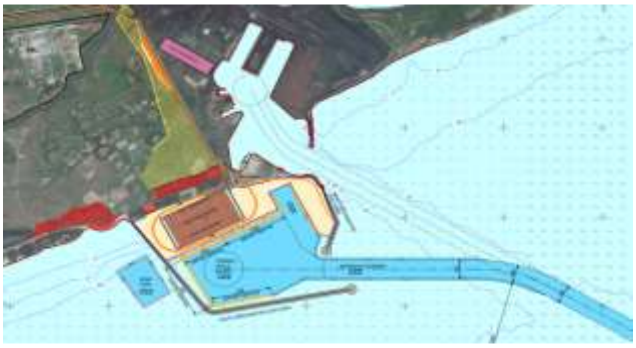
It is assessed that the proposed port shall cater to the coal export volumes 30 MTPA in Phase 1 increasing to 120 MTPA in the master plan phase (year 2036). Similarly the bulk import volumes at the proposed port are expected to be 10 MTPA increasing to 20 MTPA in the ultimate stage.

Port Development Plan

It is proposed that that the port facilities shall be developed in the phased manner commensurate with traffic growth. Considering that the coal would be the key commodity for the port, it is proposed that Phase 1 port facilities will be able to handle 200,000 DWT the cape size carriers, which shall be able to navigate in and out of the port without any tidal advantage. Further to optimise the capital costs it is proposed to use part of the approach channel to the existing port.

The proposed port layout comprised of two breakwaters; the north breakwater of 4150 m length and south breakwater of 1140 m length. In phase 1 development of the port it is proposed to provide 2 export berths and 1 import berth and the estimated capital dredging for phase 1 development is about 21 Mcum and the reclamation quantity is 10 Mcum. The stacking area for the bulk export cargo has been proposed in the reclaimed area while that for the bulk import cargo is proposed to be located at the area initially allocated for the western dock development.

State of the art material handling system shall be provided to ensure faster turnaround of ships. Bulk handling system on each export berth, shall have the design capacity of 5,000 TPH and it shall comprise of two track hoppers, two Conveyor streams, four stacker cum reclaimer units, two ship loaders & Balloon loop type railway system. The bulk import system shall comprise of two ship unloaders, one conveyor stream, two stacker cum reclaimer units and one in motion wagon loaders.



The ultimate stage layout shall be able to accommodate total 15 berths comprising of 8 bulk export berths (2,500 m), 3 bulk import berths (1000 m), and 4 multipurpose berths (1250 m).

The estimated total capital cost of overall port development up to the master plan phase is INR 8,767 crores while that for the Phase 1 development is INR 4,179 crores. Phase 1 of port development would have an implementation time of about 4 years.

Assessment and Recommendations

The viability analysis for the project has been carried out assuming the all-inclusive tariff of INR 200 per tonne and the IRR for this base case works out to **21.5%.** As sensitivity analysis was carried out for the scenario where Only Phase 1 port facilities are developed and there is no development in the subsequent stages and FIRR in this scenario works out to **13.9%.** Another scenario considered was where only bulk export terminals are built and no facilities are provided for bulk import in Phase 1 and further there is no subsequent development beyond Phase 1 and the Project IRR for this scenario works out to **14.5%.**

It is recommended that this project is taken up as landlord model, where in 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 project proponent. The cargo terminal facilities would be leased out to the various operators who shall be responsible for its construction, operations and maintenance.

Considering the significant potential for the coastal coal export in the near terms the project needs to be taken up on priority so as not to lose the market share to its competitors.

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.

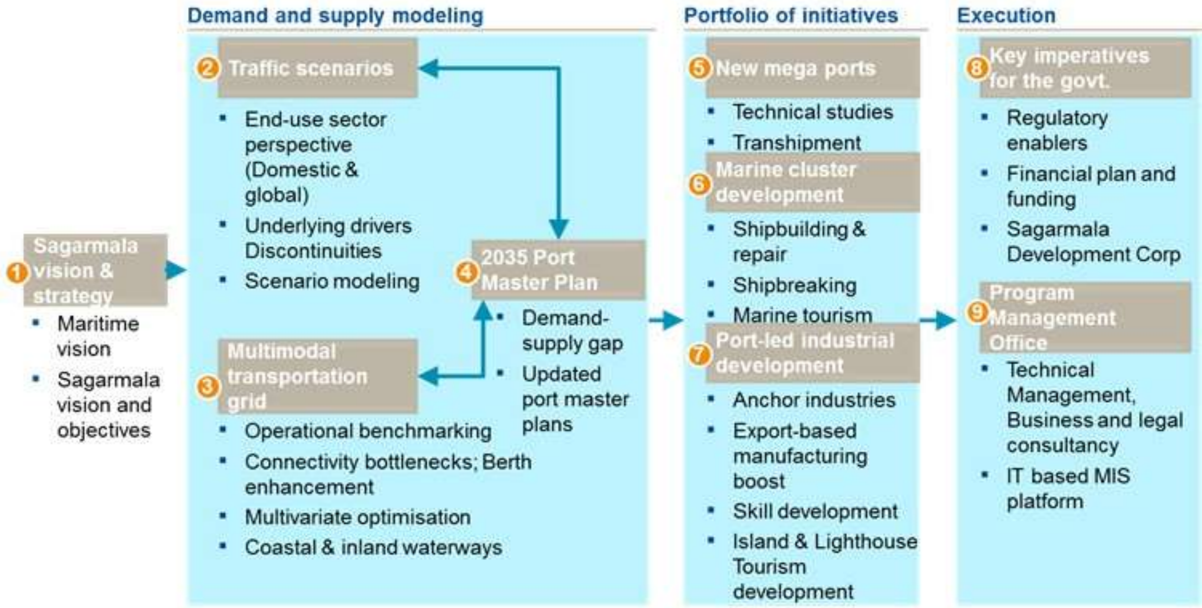


Figure 1.2 Governing Principles of our Approach

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 Development of Proposed Port

As part of its vision Coal India Limited (CIL) is planning of producing 1 billion tonnes of coal by year 2020. Out of this 250 MTPA coal will be produced from Mahanadi Coal Fields (MCL), which is currently producing only 140 MTPA. The current railway system does have adequate capacity to evacuate additional 110 MTPA to the Power Gencos situated in Andhra Pradesh, Tamil Nadu and Gujarat.

An assessment has been made for the movement of coal through various combinations of rail, road and coastal shipping and it is observed that the Rail and Coastal shipping offers the cheapest mode of transfer.

The Paradip port has a locational advantage of it being in close proximity to Mahanadi coal fields and therefore is a port of choice for the coastal movement of coal to the power plants located in the southern and western states of India. The port does not have adequate capacity through existing and planned projects to handle the projected volumes and therefore there is a need to create additional capacity.

Further the use of larger size vessels (Panamax and above) carrying larger parcel sizes would lead to reduction in coal logistics cost. This is particularly more relevant for the import of coking coal used by the steel plants, which is preferred to be brought in cape size ships and the nearby ports such that Dhamra, Visakhapatnam and Gangavaram have facilities to handle fully loaded cape size ships of size 200,000 DWT.

As part of the master plan being prepared for Paradip Port as part of Sagarmala assignment, it is suggested that expansion of Paradip Port would be needed for handling the projected traffic throughout and also fully loaded cape size vessels. In pursuant to that a site just adjacent to the south of the existing harbour has been selected for the proposed deep water port.

1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for development of Outer Harbour for Paradip Port, Odisha. This report is organised in the following sections:

Section 1 : Introduction
Section 2 : Site Information
Section 3 : Traffic Projections for Outer Harbour Development
Section 4 : Design Ship Sizes
Section 5 : Port Facility Requirements
Section 6 : Preparation of Paradip Outer Harbour 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 : Conclusions and Recommendations

2.0 Site Information

2.1 Paradip Port as at Present

2.1.1 General

Paradip Port (20°15‘55.44” N and 86°40‘27.34” E) is one of the 12 major ports in India. It is an artificial, deep-water port on the East coast of India in Jagatsinghpur district of Odisha. It is situated at confluence of the Mahanadi River and the Bay of Bengal. It is about 210 nautical miles south of Kolkata and 260 nautical miles north of Visakhapatnam. The location plan of Paradip Port is shown in the **Figure 2.1**.

Figure 2.1 Location Plan of Paradip Port

Paradip Port presently handles commodities such as iron ore, thermal coal, coking coal, fertilizers and other break bulk cargo. The port also handles substantial quantities of POL through SBMs and pipelines. The total area available with the port is 6,521 acres and is located south of Atharabanki Creek. The dock area, surrounded by a boundary wall, is about 1,500 acres.

The Port of Paradip is an artificial lagoon type harbour protected by two rubble mound breakwaters and is connected to deep water by a dredged channel. The details are as mentioned in **Table 2.1** below. The locations of various berths are shown in the following **Figure 2.2.**

Figure 2.2 Existing Facilities at Paradip Port

2.1.2 Details of Harbour

The features of the existing harbour are as follows:

Table 2.1 Details of Breakwater, Channel & Turning Basin

Breakwaters	
• North breakwater	538 m long on the north- eastern side of the port
• South breakwater	1217m long on the south-eastern side of the port
Approach channel	
• Length	2,020 m
• Width	190 m
• Depth	18.7 m below CD
Entrance Channel	
• Length	500
• Width	160
• Depth	17.1 m below CD
Turning Basin	
• Diameter	520 m
• Depths	17.1 m below CD

2.1.3 Existing Docks and Quays

Paradip port is having two docks namely Eastern and Central dock with 14 Berths (**Figure 2.2**). These docks are located at the lee of the Northern Breakwater. The Central Dock has three multipurpose berths, 1 multipurpose berth and 2 fertiliser berths, while the Eastern dock has 3 general cargo berths, 2 coal berths, 1 iron ore berth and 1 oil berth on the lee of north breakwater. In addition to 14 berths, the port has three Single Point Moorings which are dedicated to Indian Oil Company Ltd (IOCL). **Figure 2.2** provides details of all the berths at Paradip Port.

2.1.3.1 Eastern Quay (EQ)

It has a quay length of 686 m and contains three berths viz. EQ 1, EQ 2 and EQ 3. EQ 1 and 2 can handle 45,000 DWT vessels with a draft of 11 m and East Quay III can handle 60,000 DWT vessels with a draft of 12.0 m. All quays are multi-purpose berths handling thermal coal, coke, fertilizers, and other bulk cargos.

2.1.3.2 Central Quay (CQ)

Central Quay has three berths (CQ 1, CQ 2, CQ 3) with length of 755 m and a draft of 14.5 m and it can accommodate vessel sizes of 60,000 – 65,000 DWT. Out of these CQ1 and CQ2 berths are multipurpose berths whereas CQ 3 berth is mechanised berth with one ship loader and connected conveyor system for handling ore pallets.

2.1.3.3 South Quay (SQ)

South Quay is a single berth having 12.0 m draft and 265 m of quay length. It is also a multi-purpose berth and handles iron ore, POL and coking coal.

2.1.3.4 Fertilizer Berth (FB)

There are two fertilizer berths (FB I and FB II), with a quay length of 250 m and draft of 14.5 m. These berths are captive facilities and handle fertilizer and fertilizer raw material (FRM) for Paradip Phosphate Ltd (PPL) and Indian Farmers Fertilizers Cooperative Ltd (IIFCO). These berths together handle nearly 7.5 million tonnes of cargo and can accommodate vessels up to 65,000 DWT.

2.1.3.5 Iron Ore Berths (IOB)

The iron ore berth is one of the oldest berths of Paradip Port and is located in the eastern dock. It has a draft of 13.2 m and the length of 210 m. It is a fixed jetty having a R.C.C. deck supported on steel tubular piles and connecting shore arms. There are four mooring dolphins two on either side having dimensions 7.5m × 9.5m and 9.5m × 10.5m.

The berth is equipped with a mechanised ore loading system with twin wagon tipplers, conveyor system, stackers, reclaimers and one ship loader.

2.1.3.6 Coal Handling Berths (CB)

The Port has two mechanized coal jetties at the northern end of Eastern Quay with state of the art equipment. Each jetty has a draft of 14.5 m and 260 m length. It can accommodate vessel sizes up to 60,000 to 75,000 DWT. These berths are also equipped with a mechanical coal handling facilities for unloading of coal from the trains, stacking, reclaiming and loading coal into the bulk carriers. This terminal has a Merry-Go-Round (MGR) system for unloading of BOBRN wagons (2×4000 TPH capacity).

2.1.3.7 POL Jetty

The port has an oil jetty of 350 m length with dolphin to dolphin facility, located in the lee of the north breakwater. This berth handles petroleum, oil and lubes (POL). The draft at this berth is 13.5 m and handles tankers up to 65,000 DWT with Length Overall (LOA) up to 260 m.

2.1.3.8 New Oil Jetty

The port has commissioned new oil jetty with 350 m length with dolphin to dolphin facility, located in the south dock of the harbour. This is a captive jetty commissioned by IOCL to handle crude.

2.1.3.9 General Cargo/ Multi-Purpose Berths

Eight General Cargo/ Multi-Purpose Berths have been constructed along the western face of Eastern Dock, eastern face of Central Dock and on the Southern face of the pier.

2.1.3.10 Single Point Mooring Terminals

Total 3 Single point moorings (SPM) with capacity 37 MTPA are provided at the Paradip port to handle the captive crude oil for IOCL. All the SPMs are located towards the southern side of the existing port in about 30 m water depth, about 20 km away from shore, and connected to shore by means of submarine pipelines. The location plan of the SPMs and the pipelines is presented in **Figure 2.3**.

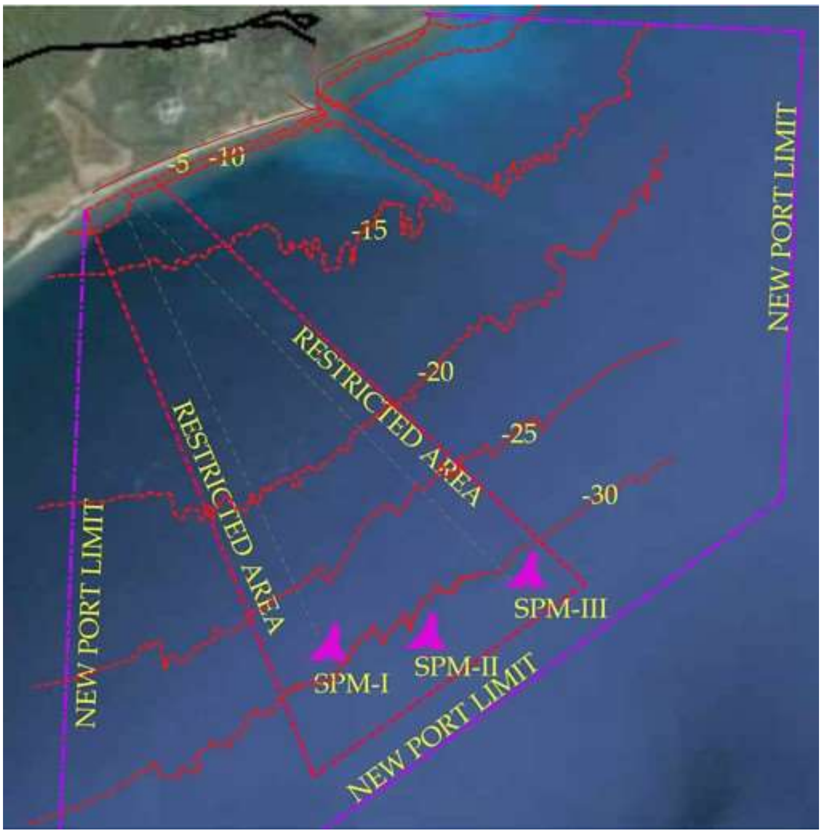


Figure 2.3 Location of SPMs

2.1.4 Pilotage and Towage Facilities

The pilotage is compulsory for all vessels having capacity of more than 200 T Gross Tonnage. The ports has 3 tugs having BP more than 35 tons and 2 port tugs having BP more than 50 tons. Mooring boats are also available for passing the mooring lines to berth or jetty.

2.2 Location for Proposed Outer Harbour

As part of the initial assessment various alternative locations for the port development were examined (**Figure 2.4**). The initial consideration for the development of new port was to select a location on the seafront within the Paradip port limit in order to utilise some of the common facilities. These locations were found to be suitable considering that area available with the Paradip Port shall be utilised for providing connectivity to the port and also locating onshore facilities for port operations and cargo storage, therefore evading the need of land acquisition.

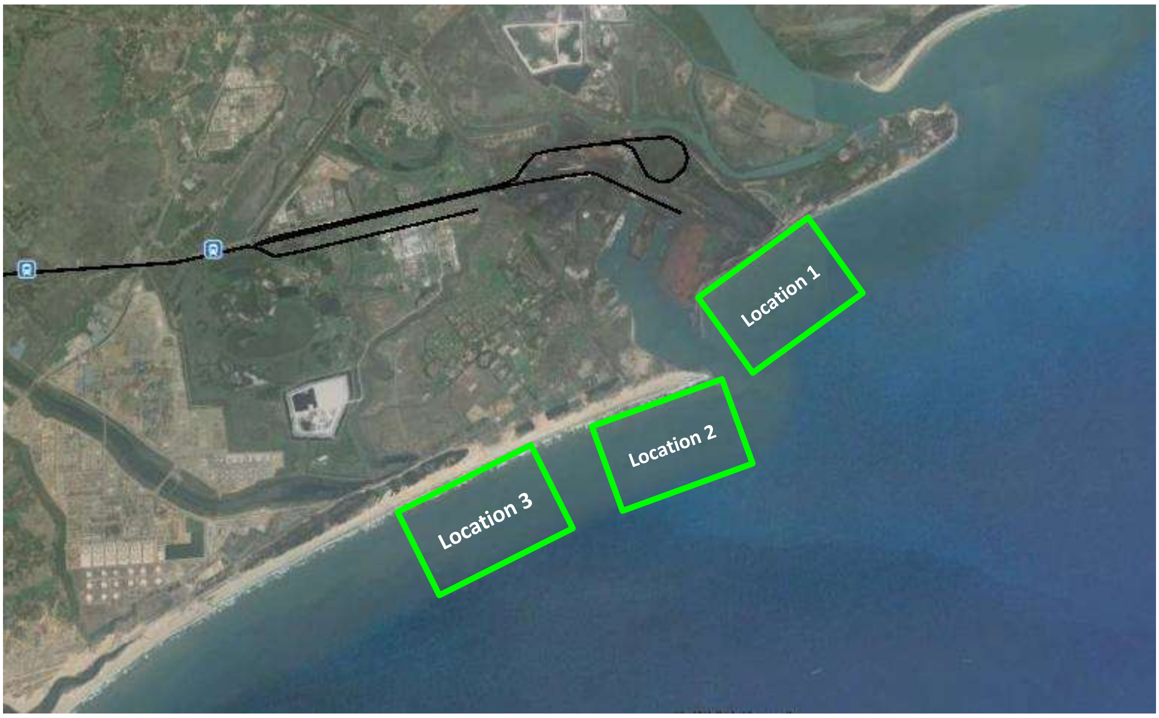


Figure 2.4 Alternative Layouts considered for the Proposed Outer Harbour

All the three locations were carefully examined, based on information collected during site visits and discussions with the port personnel. Technically, all the three locations could be developed as an outer harbour but Location 1 and 3 were found to have constraints on account of access and land availability.

Any development at Location 1 would require connectivity or access through the existing port facilities, which is likely to impact current port operations and also limit any future expansion of the proposed port. On the other hand, a fishermen village called Sandkut village exists at the waterfront of the Location 3. It was reported that land belongs to PPT but more than 10,000 people reside in that colony. This location requires augmenting a new connectivity corridor for rail and road through Paradip Phosphates Limited (PPL) establishments. Thus, Location 3 not only has Rehabilitation and Relocation (R&R) issue but also has access and environment constraints.

Therefore, the location 2 has been selected for the development of the proposed Outer harbour of Paradip Port. The site does not involve any R&R issue. Part of the onshore area for the port shall be developed in the intertidal zone while Port area available close to the shoreline will also be utilised for the development. The existing road corridor may be further strengthened to provide connectivity. A detailed assessment has been made for this site for the development of most suited port layout to meet the objectives of the port development, which shall be detailed in subsequent chapters.

2.3 Meteorological Data

The climate at Paradip is governed by the monsoons. In the months of June to September, the south-west monsoon occurs, followed by the north-east monsoon in October- December. The latter period is often indicated as the post-monsoon period. January-February is the winter period and March-May is usually the hot weather period.

2.3.1 Winds

Monthly Wind Rose diagrams for Paradip Port are presented in **Figure 2.5**. The predominant wind direction during the months of March to September is South – Southwest and the highest wind speed during this period was recorded to be 18 m/s. During the period November to January the predominant wind direction changes to North-Northeast. The months of October and February are observed to be transition months, where a marked variation in the wind direction was observed.

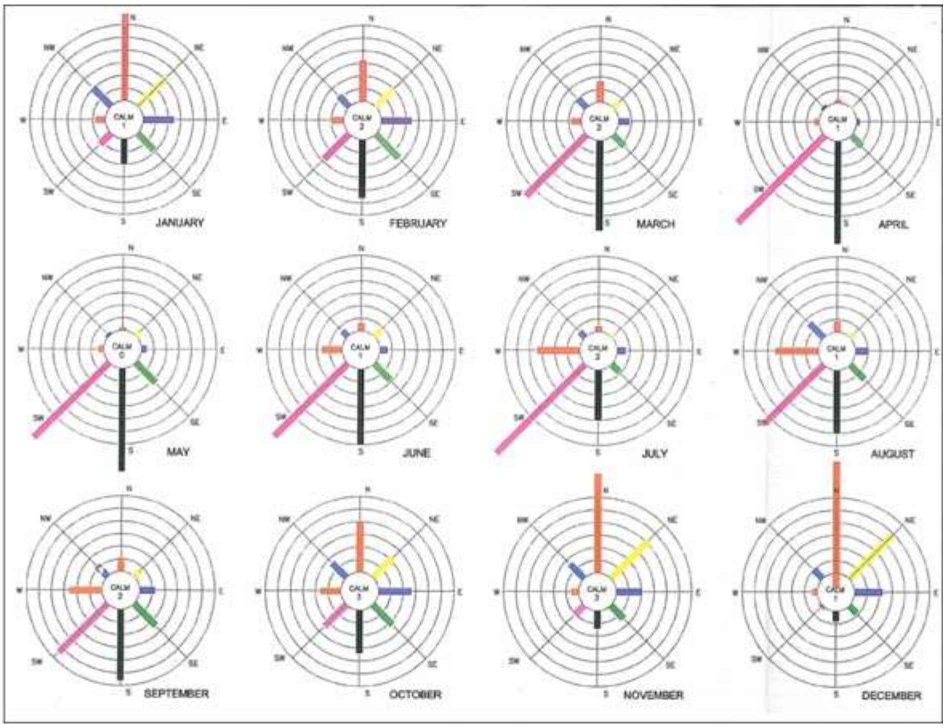


Figure 2.5 Wind Rose Diagram

2.3.2 Rainfall

Annual average rainfall at Paradip is about 1400 mm per annum, about 75% of which is received during the South-Western Monsoon season, i.e., between June and September. October contributes to about 8% of the annual rainfall as presented in **Table 2.2**.

Table 2.2 Average Monthly Distribution of Rainfall

Month	Average Rainfall (mm)	Maximum Rainfall (mm)	Minimum Rainfall (mm)
January	10.0 - 12.0	27.7	0.0
February	36.0 - 40.0	76.7	6.1
March	48.0 - 50.0	177.4	15.0
April	38.0 - 42.0	67.2	16.0
May	42.0 - 44.0	139.9	4.2
June	235.0 - 245.0	451.6	81.6
July	268.0 - 276.0	577.9	135.3
August	308.0-316.0	362.4	235.8
September	245.0-255.0	331.4	15.3
October	116.0-120.0	331.4	15.3
November	12.0-14.0	41.1	0.0
December	36.0-40.0	134.2	0.0

2.3.3 Air Temperature

The mean maximum and minimum temperature were observed to be 35.96° C and 13.30° C respectively. The maximum temperature at Paradip ranges between 28.6° C and 35.8° C, while minimum temperature varies between 13.3° C to 22.5° C. Month wise Maximum and Minimum Temperature at the port vicinity is presented in **Table 2.3**.

Table 2.3 Maximum and Minimum Tempresture - Monthwise

Month	Mean of Maximum Temperature (°C)	Mean of Minimum Temperature (°C)
January	29.52	13.30
February	30.44	15.54
March	31.38	19.12
April	33.94	20.96
May	35.82	22.54
June	34.52	22.44
July	35.96	22.50
August	33.20	21.26
September	34.14	24.88
October	33.94	22.00
November	33.42	17.66
December	28.68	13.62

2.3.4 Visibility

Generally, the visibility is very good except monsoon when it deteriorates during rains and occasional squalls. Visibility is recorded at Paradip daily at 08:30 hrs and at 17:30 hrs and records are available since 1975. Normally lowest range of visibility occurs at sunrise or at sunset and as the times of recording at Paradip observatory are fixed, lowest values are not available. Records are maintained in coded form (WMO code 4377) as approved by world Meteorological Organization. On analysis, the records maintained by I.M.D. for a particular year (1985) 87% of the readings were in scale 96.6% in scale 95 and 7% in scale 97. For other years it was comparable. Only one reading over the years was in scale 92. From these records it may be stated that during day light hours between 08:30 hrs and 17:30 hrs visibility at Paradip does not present any problem for navigation.

2.3.5 Relative Humidity

The average humidity ranges from nearly 84% in August to about 71% in December.

2.4 Oceanography

2.4.1 Bathymetry

Port has recently carried out the bathymetric survey of area within port limits and that very well covers the site for the proposed Paradip Outer Harbour Port. The bathymetry charts indicate that the depth contours prevail almost parallel to the coastline. The seabed falls steep till 10 m water depth at a distance of 900 m from the coast. Consequently, the reverse trend is conspicuous in the deeper water i.e., along the seabed between 10 m and 15 m depth contours. The slopes are gentle 1: 1000 beyond 10m with 15 m water depth occurring at a distance of 6000 m. Thereafter the 20 m water depth occurs at a distance of 6000 m.

M/s Indomer Coastal Hydraulics (P) Ltd, Chennai carried out bathymetric survey at proposed outer harbour location in January, 2016. The details are presented in Figure 2.6. Bathymetry survey was carried out covering a distance of 2,400 m along the coast and 11,000 m distance into the sea.

ODOM Echotrac CVM Digital Dual Frequency Echo sounder manufactured by ODOM Hydrographic Systems, USA was used for the survey. This Echosounder has incorporated the cutting edge technology, features and reliability of the Echotrac MKIII, plus the ease and flexibility of operation of a networked Windows interface.

Figure 2.6 Bathymetric Details of Paradip Outer Harbour

The bathymetric investigations show that the seabed in the study area is gently sloping seaward resulting in shore parallel and smooth contours. The nearshore area up to 10 m depth is comparatively steeper with 1:50 gradient and 10 m water depth to 15 m depth the seabed is relatively gentle with 1:280 slope. Beyond 15 m depth to the end of survey the seabed is gently sloping with 1:540 slope. The occurrence of water depth with distance from shoreline in the study area is depicted below in Table 2.4.

Table 2.4 Water depth with distance

Depth w.r.t. CD (m)	Distance from shoreline (m)
3	170
4	240
5	290
6	340
7	390
8	430
9	480
10	540
11	640
12	860
13	1,330
14	2,330
15	4,240
16	6,860
17	9,430
18	9,680
19	9,840
20	10,080
21	10,670
22	11,720
23	12,580

2.4.2 Tides

The tides at Paradip are semi-diurnal characterized by two High and two Low Waters each day with a tidal range, relative to the Chart Datum (CD), as follows:

Highest High Water Level (HHWL)	+ 3.50 m
Lowest Low Water Level (LLWL)	+ 0.40 m
Mean High Water Springs (MHWS)	+ 2.58 m
Mean High Water Neaps (MHWN)	+ 2.02 m
Mean Sea Level (MSL)	+1.70 m
Mean Low Water Springs (MLWS)	+ 0.71 m
Mean Low Water Neaps (MLWN)	+ 1.32 m

The above levels are with respect to chart datum, which is approximately the level of Lowest Astronomical Tide.

2.4.3 Currents

The flood and ebb currents during spring tides were reported to be of the order of 0.6 knots (0.3 m/s) and during the neap tides 0.45 knots (0.23 m/s). Maximum currents reported did not exceed 1.2 knots (0.6 m/s).

2.4.4 Waves

2.4.4.1 Offshore Waves

The offshore wave data from the Wave atlas for south of Paradip (NIOT) were analysed and the significant wave heights (Hm_0) and mean wave period (T_{01}) for the waves are given in **Figure 2.7**. It could be seen that, the maximum Hm_0 is about 4.2m. This data is extracted at ~30m water depth and its coordinates are 20.0° N 86° 38.0’ E.

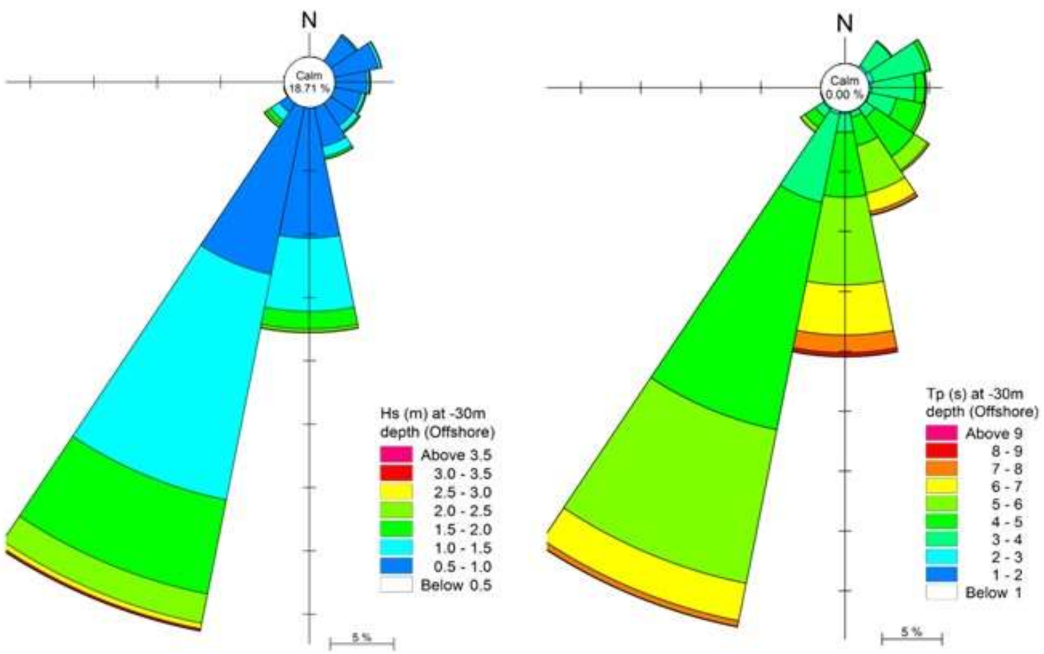


Figure 2.7 Wave Rose for Significant Wave Height and Mean Wave Period

[Source: NIOT Wave Atlas, Data 1998 – 2012]

Similarly, as far as the wave periods are concerned, the maximum waves conform to the 2 to 6 seconds band. Longer period waves up to 9.8 seconds are also observed. The annual distribution of wave period in the form of a rose diagram is shown as **Figure 2.7**.

2.4.4.1 Nearshore Wave Transformation

As waves propagate from deep water into 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 60 km × 20 km (**Figure 2.8**). The NIOT data for the year of 2011 is used for transformation study.

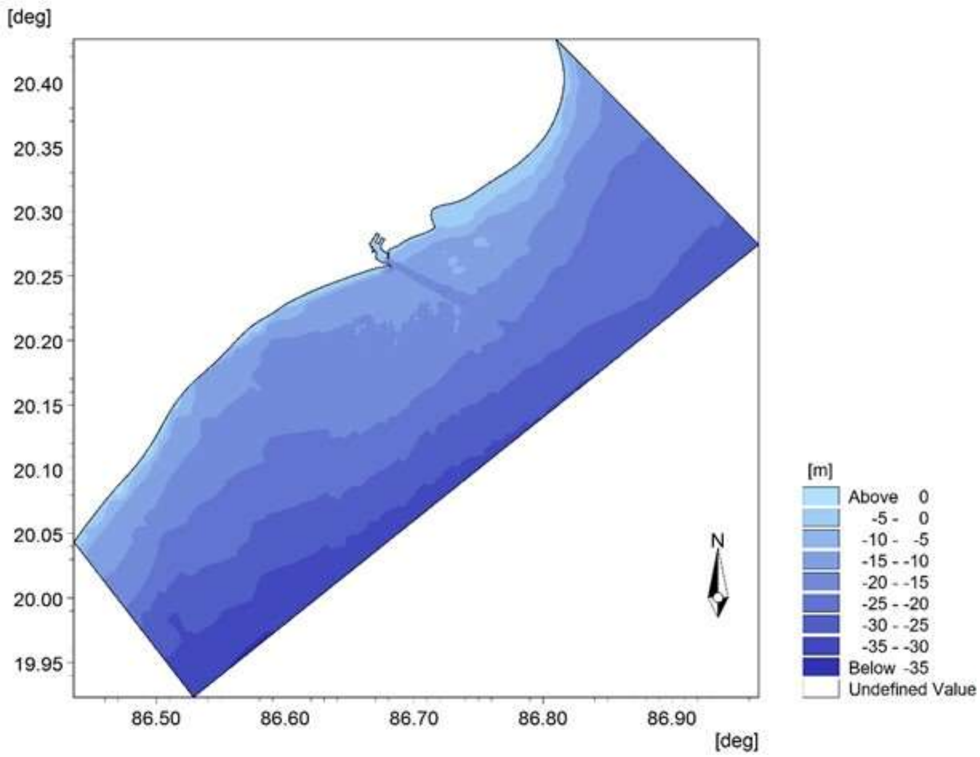


Figure 2.8 Model Domain used for Nearshore Wave Transformation Study

The likely position of breakwater for the proposed port is at 14 m contour, therefore the detailed nearshore transformations were carried out at 5, 10,15 and 20 m depth (**Figure 2.9**).

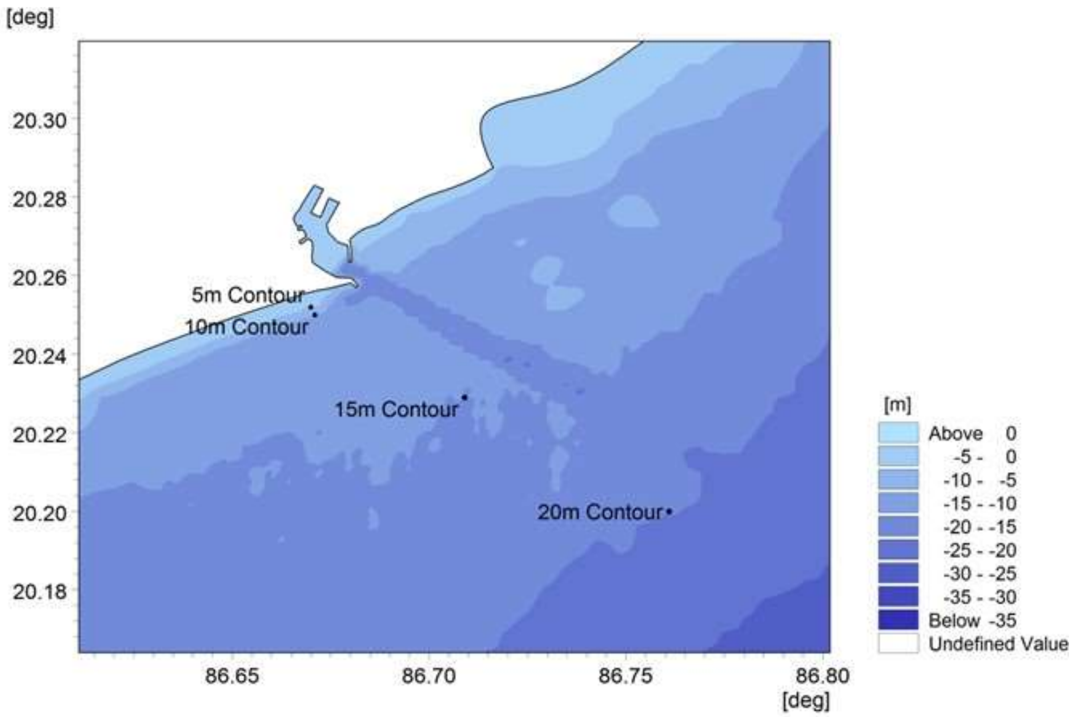


Figure 2.9 Extraction Points for near shore wave modelling at 5m, 10m, 15m and 20m water depth at Outer Harbour locations

The model results showed that predominant wave direction at near shore points is south (**Figure 2.10, Figure 2.11, Figure 2.12 and Figure 2.13**). More than 51%, 53%, 57% & 59% of the waves at are found to approach the shore from S at 5m, 10m, 15m and 20m contours respectively (**Table 2.5**, **Table 2.6, Table 2.7** and **Table 2.8**).

The wave height of the incoming waves at 5m water depth is less than 1m for about 75% of the time in a year. Similarly, less than 1 m waves are encountered for about 71%, 66%, and 64% at 5m, 10m, 15m and 20m contours respectively. The time periods for the waves at the mentioned points are less than 6s.

It is important to note that Waves from SSE and SE are also observed for more than 25% of the time at the mentioned locations. However, the wave height is less than 2m at 5m, 10m, 15m and 20m contours respectively.

Table 2.5 Annual Occurrence Probabilities (in %) of Nearshore wave heights at 5m depth

Hs	E	ESE	SE	SSE	S	All
0 - 0.5	4	5	4	15	3	**31**
0.5 - 1	0	1	3	13	26	**44**
1 - 1.5	-	-	1	3	19	**23**
1.5 - 2	-	-	0	0	2	**2**
Total	**4**	**6**	**7**	**32**	**51**	**100**

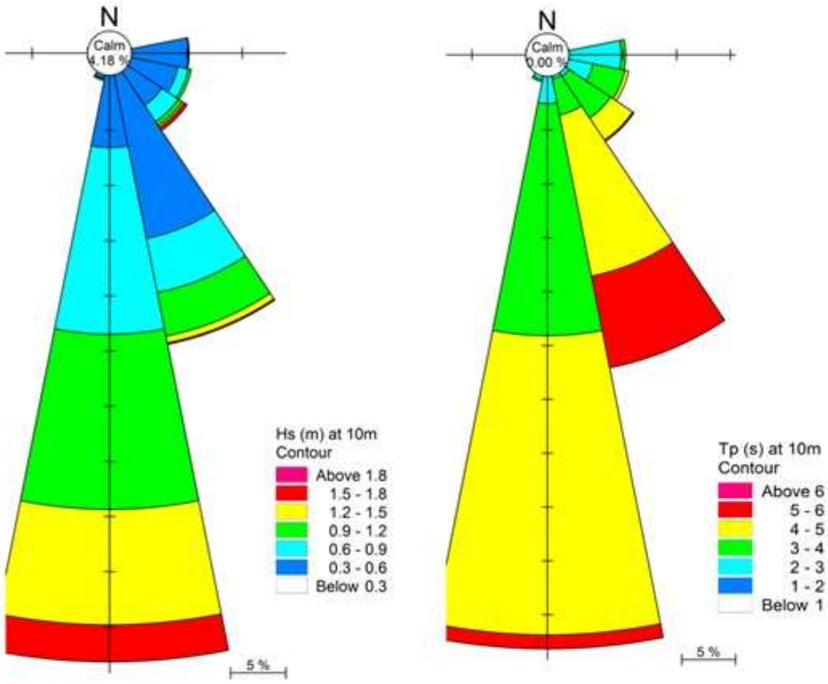


Figure 2.10 Significant Wave Height (SWH) and Mean Wave Period (MWP) at 5m depth

Table 2.6 Annual Occurrence Probabilities (in %) of Nearshore wave heights at 10m depth

Hs	E	ESE	SE	SSE	S	SSW	All
0 - 0.5	5	3	4	13	3	0	**28**
0.5 - 1	0	2	3	11	26	0	**43**
1 - 1.5	-	0	1	3	22	0	**25**
1.5 - 2	-	-	0	0	3	-	**4**
Total	**5**	**6**	**8**	**28**	**53**	**1**	**100**

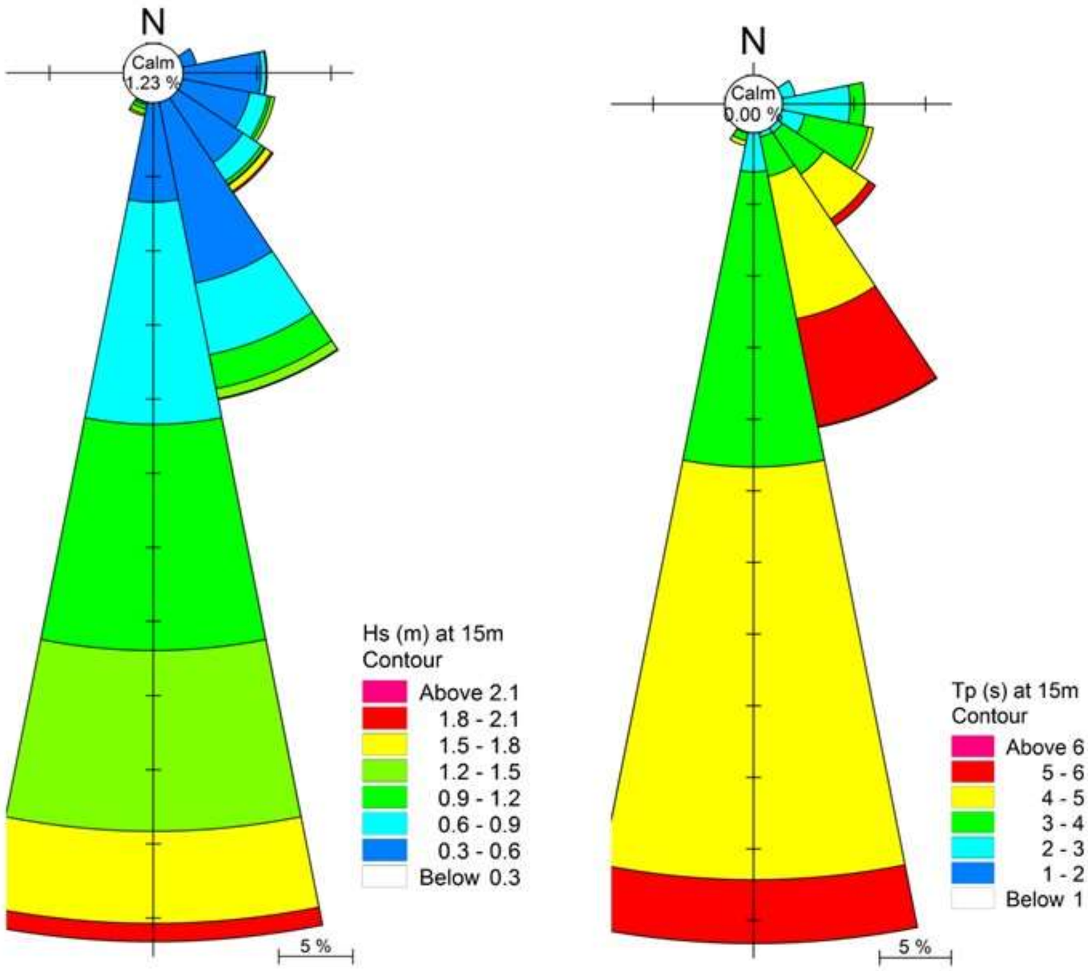


Figure 2.11 Significant Wave Height (SWH) and Mean Wave Period (MWP) at 10m depth

Table 2.7 Annual Occurrence Probabilities (in %) of Nearshore wave heights at 15m depth

Hs	ENE	E	ESE	SE	SSE	S	SSW	All
0 - 0.5	1	3	4	4	10	2	-	**24**
0.5 - 1	-	2	2	3	9	25	0	**42**
1 - 1.5	-	-	0	0	2	22	1	**26**
1.5 - 2	-	-	-	1	0	7	0	**8**
Total	**1**	**6**	**7**	**8**	**21**	**57**	**1**	**100**

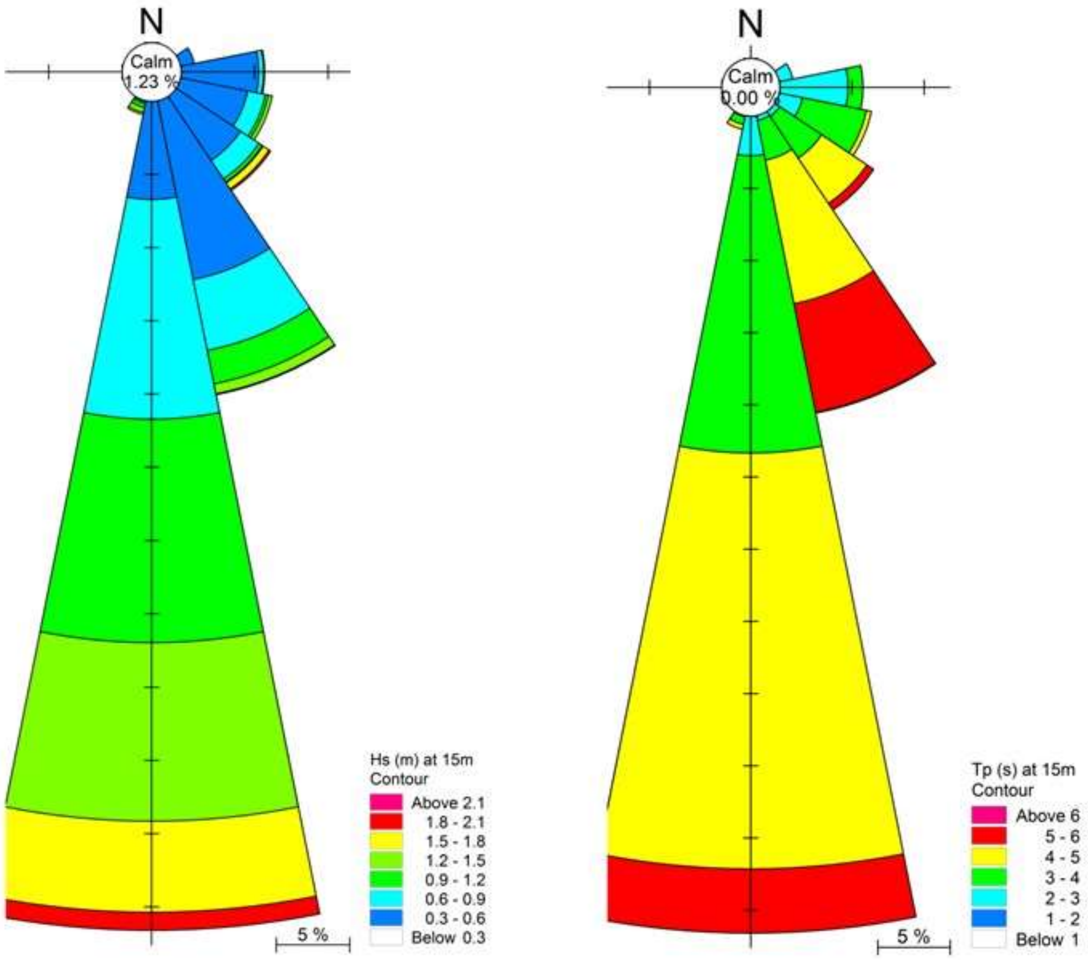


Figure 2.12 Significant Wave Height (SWH) and Mean Wave Period (MWP) at 15m depth

Table 2.8 Annual Occurrence Probabilities (in %) of Nearshore wave heights at 20m depth

Hs	ENE	E	ESE	SE	SSE	S	SSW	All
0 - 0.5	0	4	3	5	8	2	0	**23**
0.5 - 1	0	2	2	3	8	25	0	**41**
1 - 1.5	-	-	0	0	2	24	1	**26**
1.5 - 2	-	-	-	0	0	7	1	**9**
2 - 2.5	-	-	-	0	-	1	-	**1**
Total	**1**	**7**	**5**	**9**	**18**	**59**	**2**	**100**

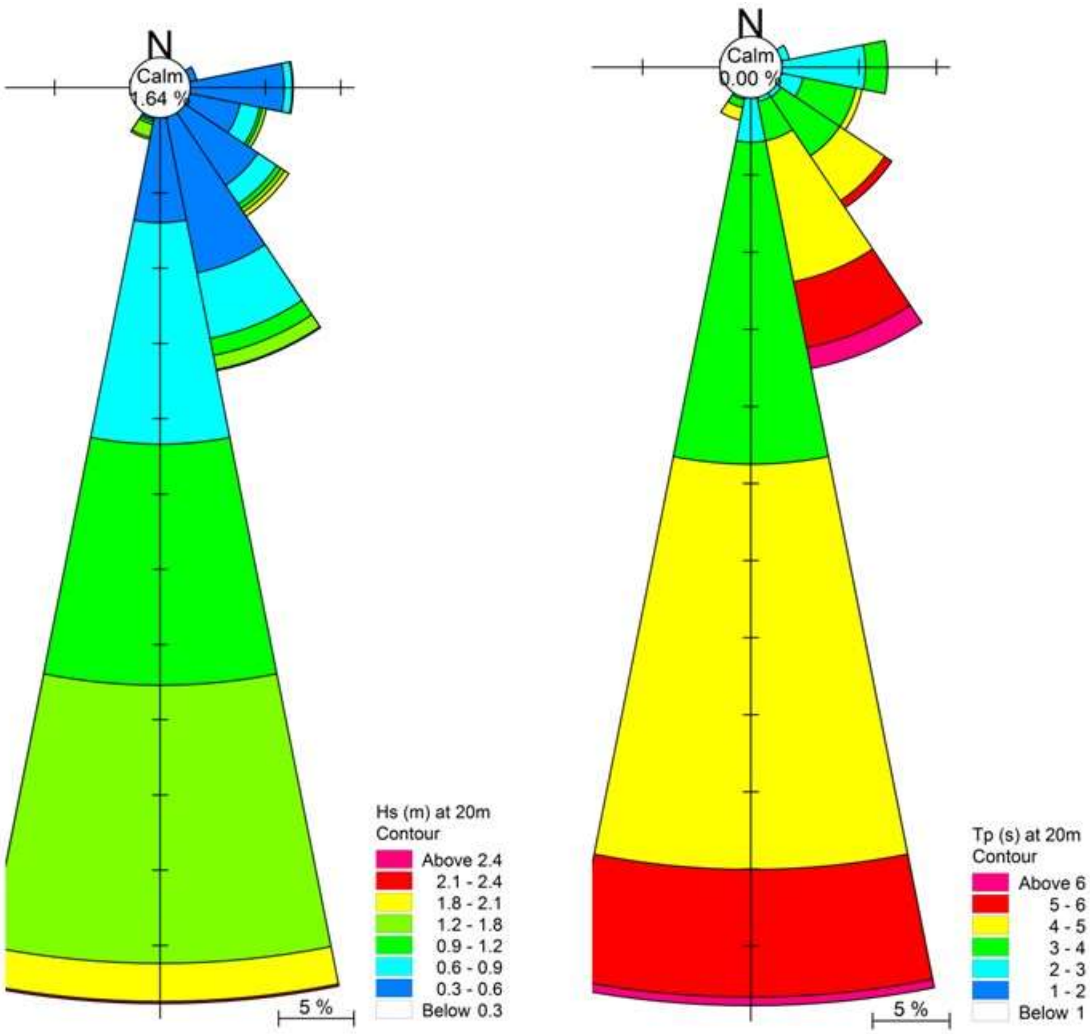


Figure 2.13 Significant Wave Height (SWH) and Mean Wave Period (MWP) at 20m depth

2.4.5 Littoral drift

The east coast is subject to the phenomenon of littoral transport of sediments, which is predominantly from south to north and comparatively smaller volumes in the reverse direction. The desk calculations based on collected wave data for various wave heights and directions were carried out and basis that the annual northerly and southerly transport volumes was worked out to be about 1.0 million cum and 0.20 million cum respectively. This matches well with the drift volumes observed at the port.

2.4.6 Cyclones

East Coast is prone to cyclonic storms round the year but mostly these occur prior to south west monsoon i.e. in May and after south-west monsoon i.e. in October and November. Around 18 depressions are formed annually in the Bay of Bengal out of which 6 turn out to be cyclonic storms on an average. Paradip Port is a cyclone prone area and affected by the cyclones developing in the Bay of Bengal. During cyclonic conditions wind speeds may exceed 248 kmph as recorded during the 1999 super cyclone.

2.4.7 Geotechnical Data

Borehole data collected by Paradip Port Trust within the areas of existing port indicates that the seabed sub-strata generally comprises of silty clay with average N value of 10 up to 7m depth below seabed. Soil below 7m to 14m consists of silty sand with average N value of 15. Below 14m soil consist of clayey silt and sand up to a depth of 30m with average N varies in the range of 20 to 30.

In addition, site specific Geotechnical Investigations at project site were conducted by M/S Fargo Consultants Private Limited, Kolkata during the month of February, 2016. The sub-soil formation in this area was investigated by carrying out four boreholes drilled upto maximum depth of 30 m below the existing ground level. The field investigation data and the results of laboratory test conducted on samples collected from the borehole indicate the presence of three soil layers as below:

- Brownish Yellow medium dense silty sand
- Brownish Yellow dense silty sand
- Brownish Yellow very dense silty sand

The subsoil profile along BH-01, BH-02, BH-03 & BH-04 is presented in **Figure 2.14**.

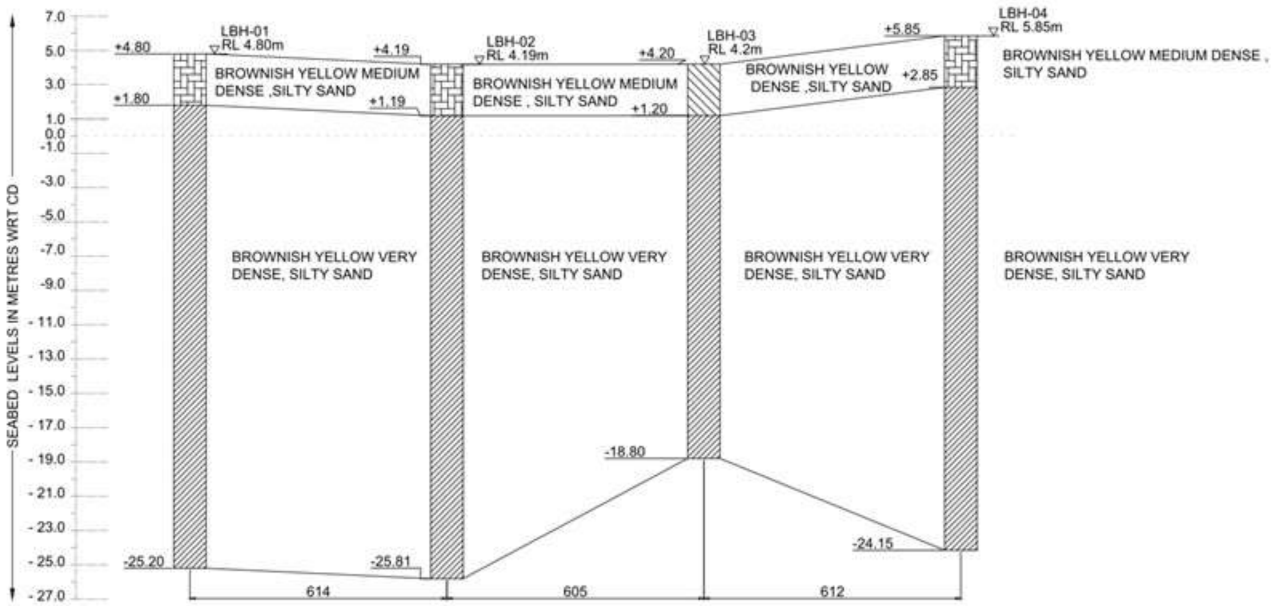


Figure 2.14 Subsoil Profile along BH-01, BH-02, BH-03 & BH-04

Table 2.9 Details of Boreholes

Borehole No.	Location (co-ordinate)		RL at borehole top (m CD)	Depth of Borehole (m)
	Northing	Easting		
BH-1	2240117.988	466278.271	4.80	30
BH-2	2240023.467	465675.134	4.19	30
BH-3	2239767.485	465130.601	4.20	23
BH-4	2239672.964	464527.463	5.85	30

To supplement the borehole data site specific seismic survey was carried out by M/s Indomer Coastal Hydraulics (P) Ltd, Chennai in January, 2016.

Benthos CAP 6600 Chirp III dual frequency acoustic Sub-Bottom Profiler manufactured by TELEDYNE BENTHOS, Inc., USA was used for carrying out the shallow seismic survey. Shallow seismic survey was carried out covering an area of 2800 m along the coast and 5500 m into the sea at 100 m line spacing.

The seismic records show the existence of a silty clay layer occurs to an average thickness of 1.0 m to 1.5 m in the survey area. This silty clay layer starts abruptly at about 800 m from the shore and ends at around 3 km offshore. At the middle portion of the survey area, i.e. at 2500 m offshore, the formation of sediment thickness is found upto 18 m depth below the seabed. At few places the traces of signal attenuation due to gas seepage is noticed in the water column. The sediments with more than 20 m thickness were found to be existing as three linear patches oriented perpendicular to the shoreline starting from 14.5 m water depth. The sediment thickness in rest of the area is mostly about 18 m. A patch of very thick bottom sediment (>20 m) is observed south of south breakwater which is appear to be due to dredging activity.

Overall, the seismic data indicates that the seabed of the survey area is composed of sediment deposits like silty sand, silt and clay. The seismic penetration indicates that the sediment thickness is varying from 4 m to 22 m below the seabed till the acoustic bottom.

The shallow seismic data does not show any presence of hard strata like rocks within the penetration limit in the survey region. The sediment stratum below the seabed is primarily composed of one dominant layer. The details are presented in **Figure 2.15**.

Figure 2.15 Shallow Seismic Survey details for Outer Harbour of Paradip Port

2.5 Site Seismicity

Paradip is in **Zone III** of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone (**Figure 2.16)**.

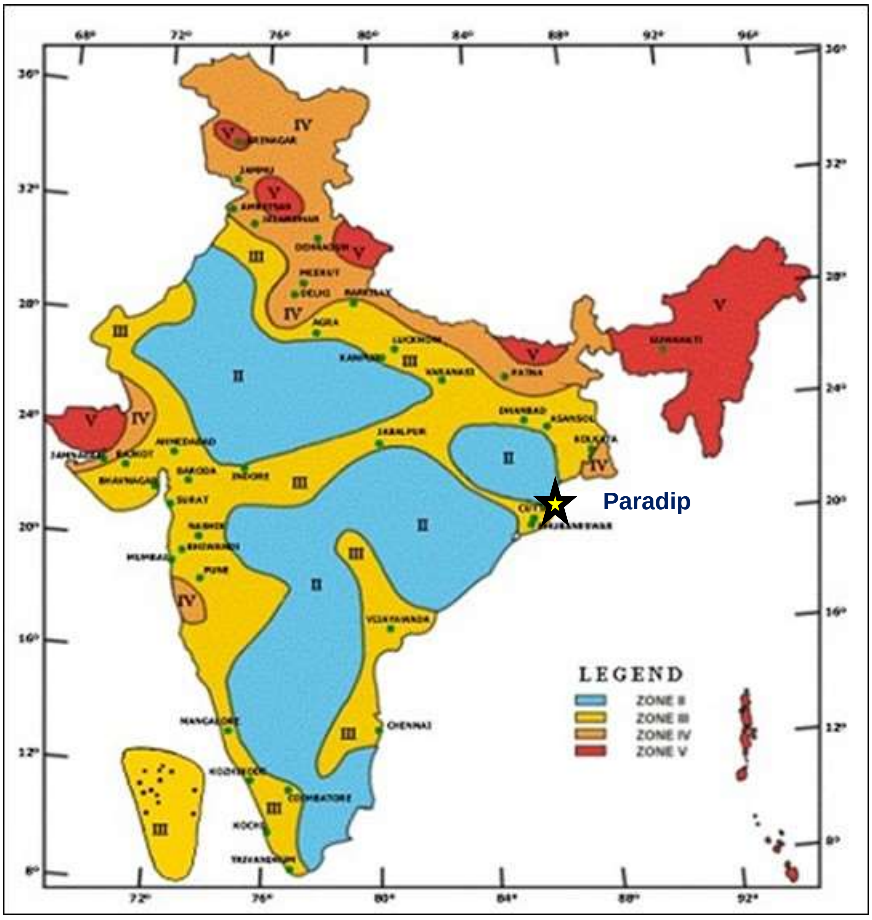


Figure 2.16 Seismic Zoning Map of India as per IS-1893 Part 1-2002

2.6 Topographic Information

The topographical survey of the proposed outer harbour at Paradip was carried out by M/s Indomer Coastal Hydraulics (P) Ltd., in January, 2016. The topographic details are shown in **Figure 2.17**.

The topography of the shore area is fairly uniform and the ground levels are ranging from 3.6 to 5.7 m w.r.t. CD. The backup area opposite the waterfront of the proposed port is lightly built up.

Figure 2.17 Topographic Survey Details

2.7 Connectivity to Port Site

2.7.1 Existing Rail Connectivity

Paradip Port's rail network is a part of the East coast railway system and is connected to the Hinterland via Cuttack by a broad gauge rail link. Cuttack is around 90 km from Paradip and connects Port to Howrah-Chennai main line. Beyond Cuttack the line connects Paradip to Kolkata (route length of about 500 km) on the North and Chennai on the South (route length of about 1340 km). The current rail connectivity to Paradip Port is shown in **Figure 2.18**.

Figure 2.18 Rail Connectivity to Paradip

2.7.2 Existing Road Connectivity

Paradip Port is connected with all major National Highways through Cuttack and Chandikhol, which are two of the major cities in Odisha.

- Cuttack and Paradip are connected by NH-5A (4 lanes).
- Cuttack and Chandikhol are connected by SH-12 (2 lanes).

All-important destinations in India whether on the North, West or East could be accessed through any one of the above mentioned Highways as shown in **Figure 2.19**.

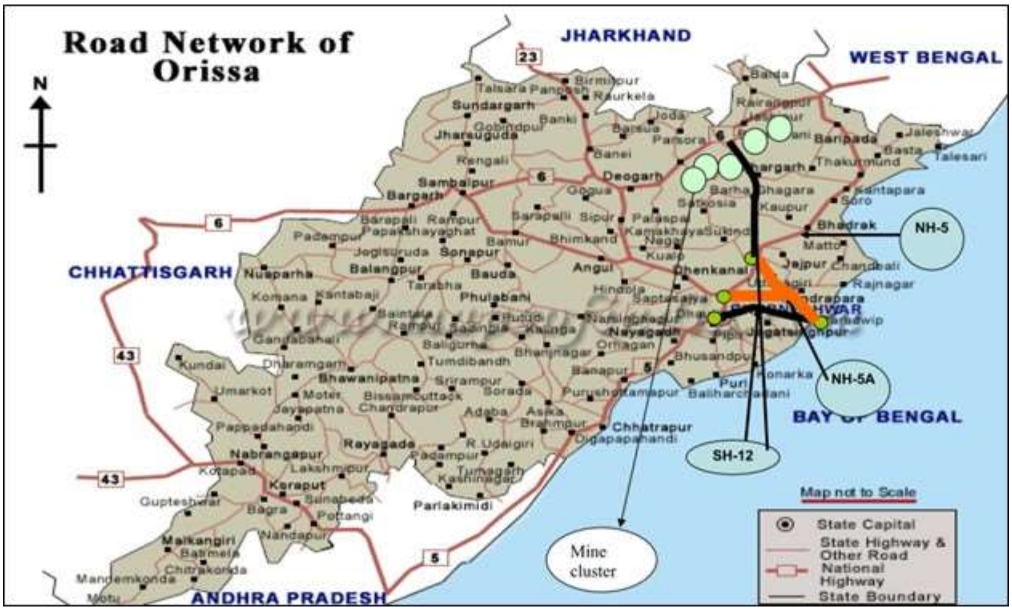


Figure 2.19 Road Connectivity to Paradip

2.8 Water Supply

At present PPT draws water from the Taldanda irrigation canal, passing very close to the port. The water from the canal is stored in 3 reservoirs in the area of approximately 175 hectares having capacity of 220 million Gallon as shown in **Figure 2.20** below. Prior to supply, the water is treated in an existing 6 MGD Water Treatment Plant within PPT.

Taldanda Canal (90 Km in length) which is the main source of water supply for Paradip derives water from barrage at Cuttack over river Mahanadi.


.

Figure 2.20 Reservoir at Paradip

2.9 Power Supply

Paradip Port is availing single-point power supply from Orissa Power Transmission Corporation Limited (OPTCL) for Port operations and as well as for its domestic and commercial demand.

The power is received from OSEB at the main receiving substation at Atharbanki (132 kV/33kV), as shown in **Figure 2.21** below.

Figure 2.21 Electrical Substation at Paradip

3.0 Traffic Projections for Outer Harbour Development

3.1 General

In terms of volumes, Paradip is one of the largest major ports in the country handling more than 70 MTPA of cargo. Paradip is strategically located in the mineral rich state of Odisha.

Currently, the major commodities handled in the port are coal and POL. Approximately 23 MTPA of coal is exported from the port and is coastally shipped to the South and the Western hinterlands of the country. Additionally, the port imports around 18 MTPA of POL primarily to serve the IOCL refineries at Paradip and Haldia.

As per the TOR, the consultants are expected to map out the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports and develop traffic scenarios for a period of 20 years. Accordingly, based on a macro-level analysis the future traffic for Paradip Port has been assessed.

3.2 Major Commodities and their Projections

3.2.1 Thermal Coal

Coal deposits are mainly confined to eastern and south central parts of the country. The states of Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra account for nearly all of the total coal reserves in the country. The State of Jharkhand is the largest producer of coal in the country as of March 2014 followed by Odisha and Chhattisgarh. Since one of the key objectives of Sagarmala is optimizing logistics efficiency for mega-commodities, the main focus area is thermal coal. The states of Chhattisgarh and Odisha are the leading producers of thermal coal in India.

Presently, the power plants located in Maharashtra consume the highest quantity of coal- about 77 MTPA, followed by power plants in Chhattisgarh and Uttar Pradesh, at 62 MTPA and 60 MTPA respectively. Overall, ten states account for more than 80% of current thermal coal requirement for power generation in India as shown in **Figure 3.1**.

Therefore, while coal production is concentrated mostly in Eastern and Central parts of India, it is transported for power generation to nearly all corners of the country as shown in **Figure 3.2**. For example, 26 MTPA is sent from Odisha to Tamil Nadu. Similarly, volumes of coal also move from Chhattisgarh to Maharashtra (19 MTPA) and Gujarat (14 MTPA). Coal imported from Indonesia and South Africa arrives at various ports and then moves inland.

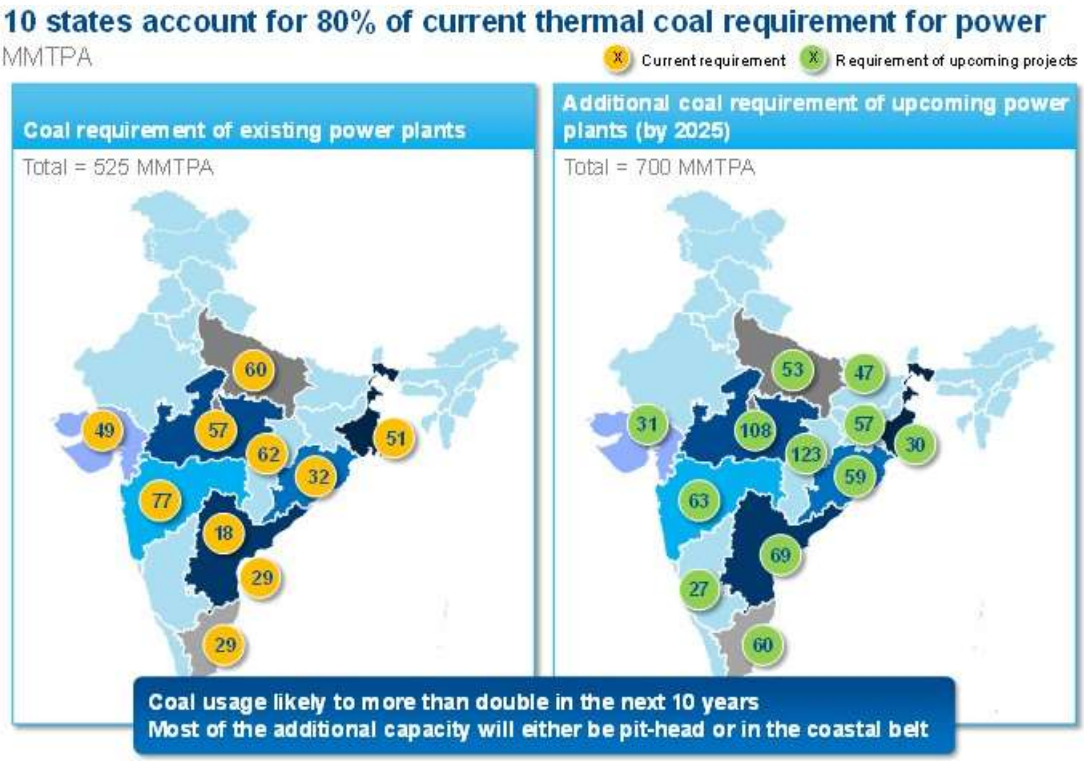


Figure 3.1 Thermal Coal Requiremnt of Existing and Upcoming Power Plants

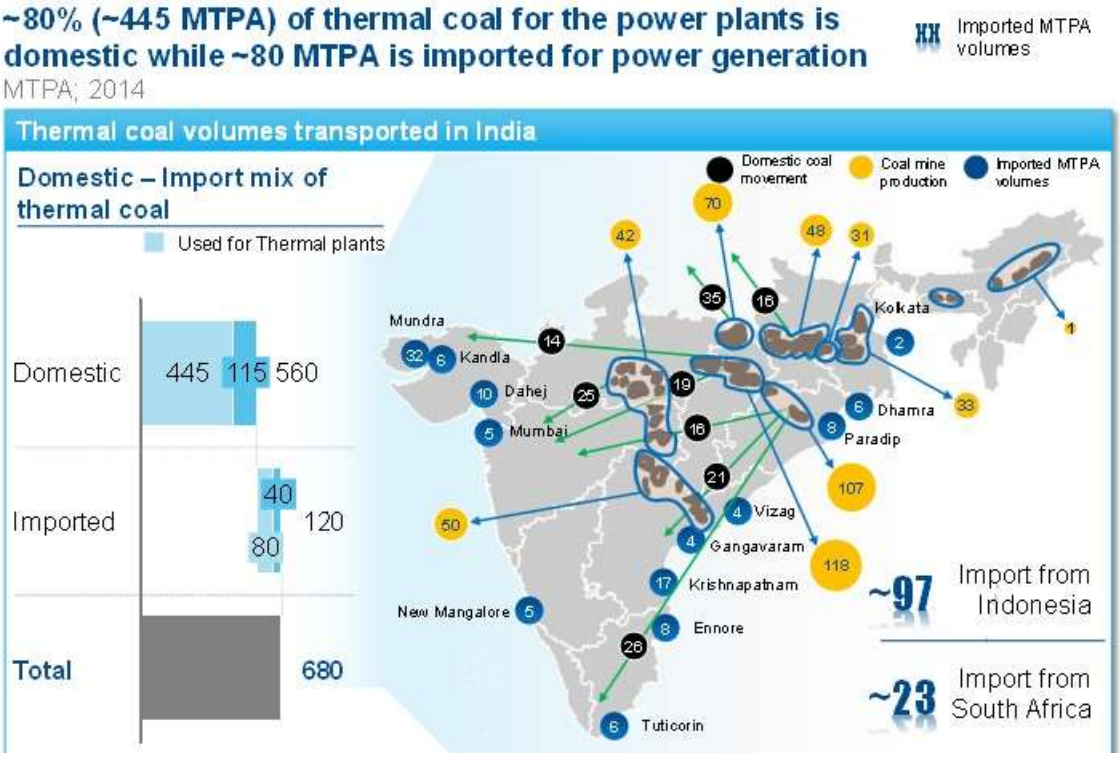


Figure 3.2 Current Coal Movement

Rail is currently the preferred mode with 61% share in overall domestic volume movement, while coastal shipping has a negligible share. While rail freight is INR 1.2-1.5 per T KM for coal movement; the same for coastal shipping is nearly one-sixth as shown in **Figure 3.3**.

Figure 3.3 Coal Movement by Road Rail and Caostal Shiping

Further, the current rail network is already congested and industry experts believe that it cannot suffice for the future freight load projected due to growth in power generation facilities and industrial corridors. Congested rail lines cause high dwell time, resulting in an average freight speed of only 25kmph. More than 90 per cent of rail routes relevant for coal movement have more than 100% utilisation (defined as maximum efficient capacity) as shown in **Figure 3.4**.

Ports are facing severe shortage of rolling stock, which causes overstocking of coal the ports and using of sub-optimal methods of conventional handling and road transportation. The expansion of rail network is slow to keep up with coal capacity needed. In the past few years rail network has only grown at 0.7 per cent year on year.

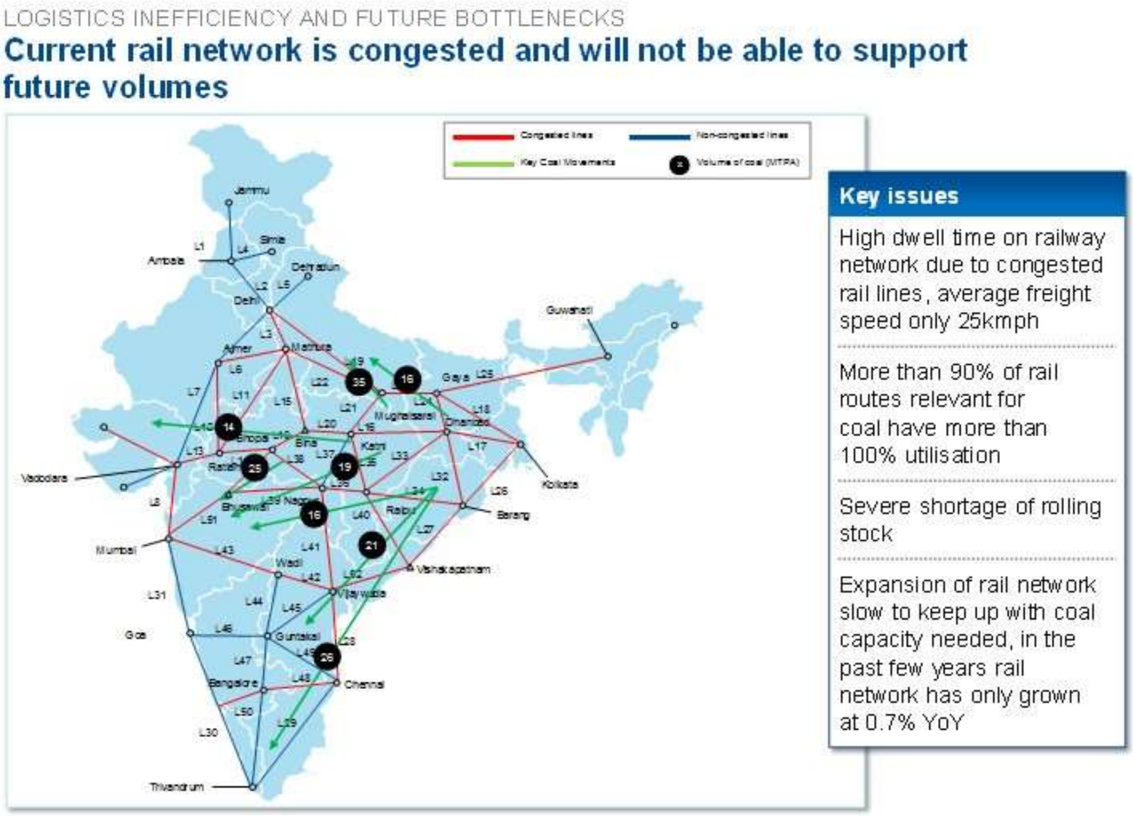


Figure 3.4 Current Rail Network

While rail is the primary mode of transport used for long distance coal movement currently, analysis based on research data and industry expert opinions indicate that there is a significant cost reduction potential in causing a modal mix shift towards coastal shipping. Therefore, the ***"Urjamala"*** initiative - which focuses on coastal shipment of thermal coal - has been identified as a key component of the overall Sagarmala vision.

An in-depth study was conducted across 400 operational thermal power plants in the country to examine the origination, destination and mode of coal movement used presently as shown in **Figure 3.5**. At the same time, a cost comparison of all possible combinations of modal mix under different scenarios of vessel capacity was also done as shown in **Figure 3.6**. For example, for movement between Talcher in Orissa to a power plant at Mundra port in Gujarat, the cost for movement via rail is INR 2,980 per ton while the same via rail supported coastal shipping could be much lower at INR 1,320 per ton (i.e. a potential cost saving of as high as 56 per cent).

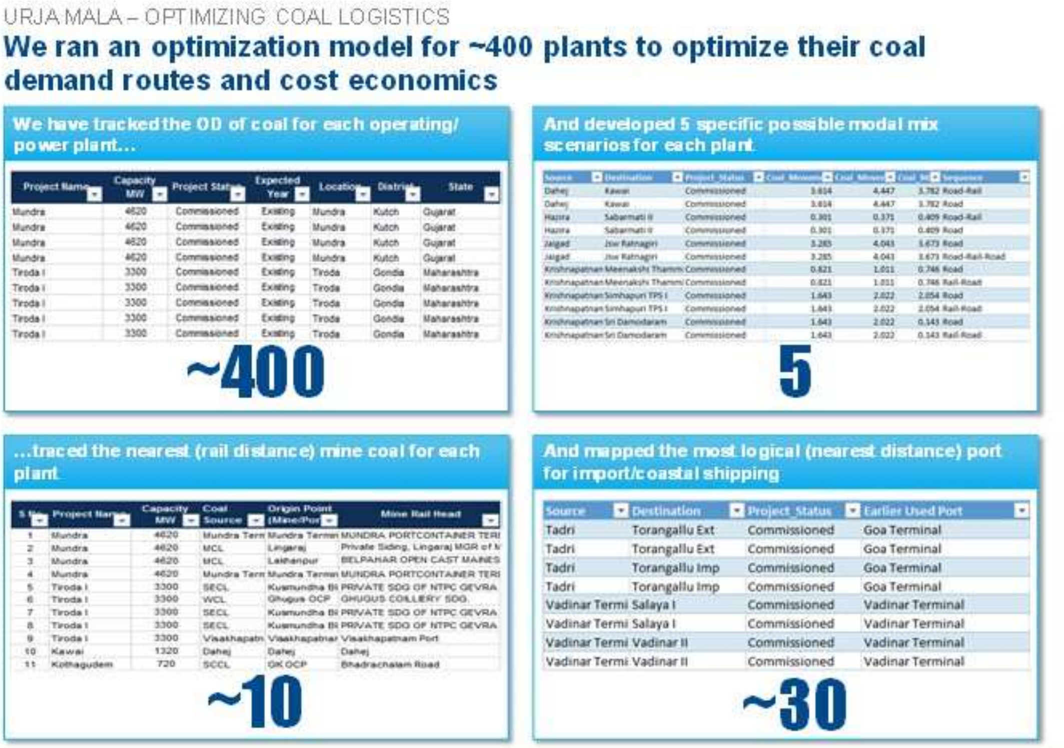


Figure 3.5 Optimization Model for Coal Logistics

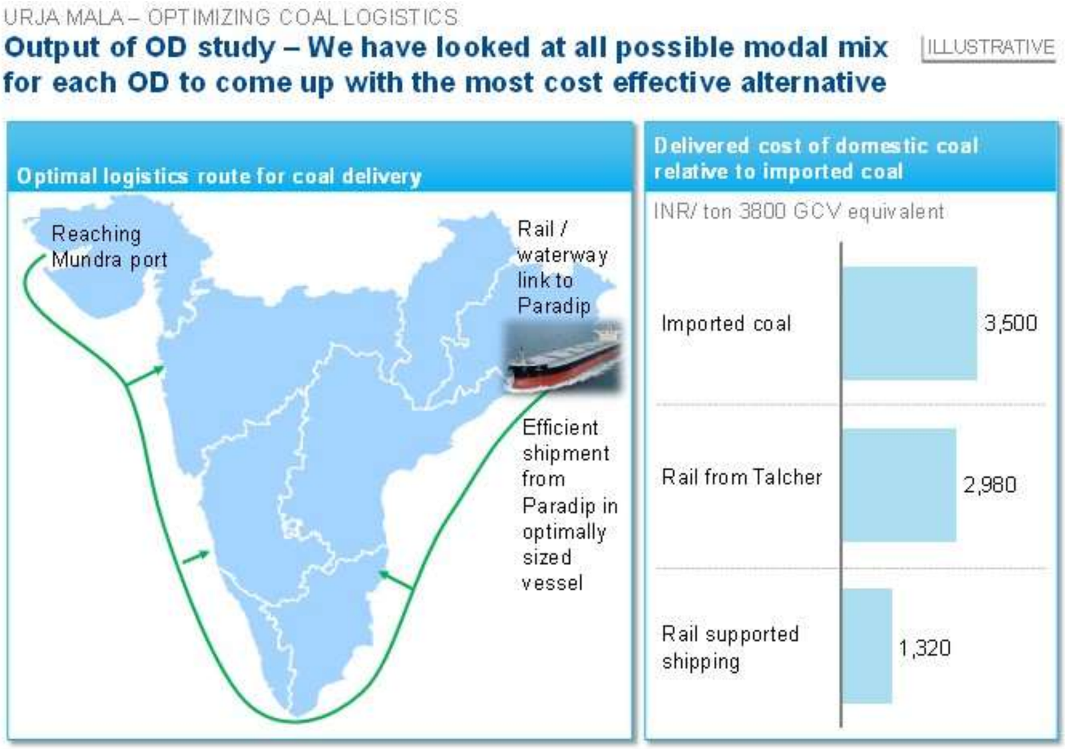


Figure 3.6 Output of O-D Study

Eventually, 12 coal fields and 37 power plant linkages (including both existing and under construction plants) were identified as having considerable cost saving potential through increased movement via coastal shipping as shown in **Table 3.1**. In some cases, the cost economics give a very marginal advantage to coastal shipment, but overall railway congestion implies that there still may be a case for coastal shipment to be undertaken in such plants.

Table 3.1 Power Plants identified as having considerable cost saving potential through increased movement via Coastal Shipping

Power Plant	State	Source	Coal Movement at 80% PLF (MMTPA)	Status
Andhra Pradesh Power Generation Corporation Limited, Dr. N. Tata Rao - Krishna	Andhra Pradesh	MCL - Lingaraj	8.1	Existing
Andhra Pradesh Power Generation Corporation Limited, Rayalseema - Cuddapah	Andhra Pradesh	MCL - Lingaraj	2.9	Existing
Andhra Pradesh Power Generation Corporation Limited, Rayalseema IV - Kadapa	Andhra Pradesh	MCL - Lakhanpur	2.8	Under construction
Andhra Pradesh Power Generation Corporation Limited, Sri Damodaram - Nellore	Andhra Pradesh	MCL - Lingaraj	4.6	Existing
Gayatri Projects Limited/Sembcorp Utilities, Thermal Powertech I - Krishnapatnam	Andhra Pradesh	MCL - Lakhanpur	3.0	Existing
Gayatri Projects Limited/Sembcorp Utilities, Thermal Powertech I (Partly Commissioned) - Krishnapatnam	Andhra Pradesh	MCL - Lakhanpur	3.0	Under construction
Hinduja National Power Corporation Limited, Vishakhapattnam - Vishakhapatnam	Andhra Pradesh	MCL - Samaleswari	4.8	Under construction
Meenakshi Energy Private Limited, Meenakshi Thamminapatnam II - Nellore	Andhra Pradesh	MCL - Lingaraj	3.2	Under construction
Nagarjuna Construction Company/Gayatri Projects Limited, Muthukur Mandal I - Nellore	Andhra Pradesh	MCL - Lingaraj	3.0	Under construction
National Thermal Power Corporation Limited, Simhadri - Krishna	Andhra Pradesh	MCL - Hingula-II	7.8	Existing
National Thermal Power Corporation Limited, Simhadri - Krishna	Andhra Pradesh	ECL - Khottadih OC	1.4	Existing
Adani Power Limited, Mundra - Kutch	Gujarat	MCL - Lakhanpur	4.6	Existing
Adani Power Limited, Mundra - Kutch	Gujarat	MCL - Lingaraj	4.6	Existing
Gujarat State Electricity Corporation Limited, Gandhi Nagar - Gandhinagar	Gujarat	SECL - Dipka	4.0	Existing
Gujarat State Electricity Corporation Limited, Sikka Rep. - Jamnagar	Gujarat	SECL - MANIKPUR OC	2.3	Existing
OPG Power Gen Limited, Mundra OPG - Kutch	Gujarat	SECL - MANIKPUR OC	1.4	Under construction
Haryana Power Generation Corporation Limited, Rajiv Gandhi - Hisar	Haryana	MCL - Ananta	1.8	Existing
Karnataka Power Corporation Limited, Bellary Tps - Bellary	Karnataka	MCL - Bharatpur	2.3	Existing
Karnataka Power Corporation Limited, Raichur - Raichur	Karnataka	MCL - Ananta	2.8	Existing
Karnataka Power Corporation Limited, Raichur - Raichur	Karnataka	MCL - Bharatpur	1.2	Existing
National Thermal Power Corporation Limited, Kudgi I - Bijapur	Karnataka	Pakri Barwadih - Pakri Barwadi	11.1	Under construction
Indiabulls Power Limited, Nasik I - Nasik	Maharashtra	MCL - Lakhanpur	1.2	Existing
Reliance Power, Dhanu - Thane	Maharashtra	SECL - Dipka	2.3	Existing
Ind Barath Power Infra Limited, Ind Barath Madras I - Tuticorin	Tamil Nadu	MCL - Samaleswari	3.0	Under construction
KVK Energy and Infrastructure Private Limited, Nagai - Nagapattinam	Tamil Nadu	MCL - Lingaraj	1.4	Under construction
National Thermal Power Corporation Limited/Tamilnadu Electricity Board, Vallur I - Thiruvallur	Tamil Nadu	MCL - Hingula-II	6.9	Existing
Neyveli Lignite Corporation Limited/Tamilnadu Electricity Board, Tuticorin NLC - Tuticorin	Tamil Nadu	MCL - Hingula-II	2.3	Existing
Neyveli Lignite Corporation Limited/Tamilnadu Electricity Board, Tuticorin NLC (Partly Commissioned) - Tuti	Tamil Nadu	MCL - Samaleswari	2.3	Under construction
OPG Power Gen Limited, Chennai I - Thiruvallur	Tamil Nadu	MCL - Lakhanpur	0.4	Existing
OPG Power Gen Limited, Chennai II - Thiruvallur	Tamil Nadu	MCL - Lakhanpur	0.4	Existing
OPG Power Gen Limited, Chennai III - Thiruvallur	Tamil Nadu	MCL - Lakhanpur	0.4	Existing
Tamilnadu Electricity Board, Ennore - Thiruvallur	Tamil Nadu	MCL - Jagannath/Jagannath Ex	2.1	Existing
Tamilnadu Electricity Board, Ennore II - Thiruvallur	Tamil Nadu	Mandakini B - Mandakini B	3.0	Under construction
Tamilnadu Electricity Board, Mettur - Salem	Tamil Nadu	MCL - Jagannath/Jagannath Ex	6.6	Existing
Tamilnadu Electricity Board, North Chennai - Thiruvallur	Tamil Nadu	MCL - Jagannath/Jagannath Ex	8.4	Existing
Tamilnadu Electricity Board, Tuticorin - Tuticorin	Tamil Nadu	MCL - Jagannath/Jagannath Ex	4.8	Existing
Telangana State Power Generation Corporation Limited, Kothagudem II - Khammam	Telangana	MCL - Lingaraj	2.3	Existing
TOTAL			128.6	

Note:
Power Plant Name — *Cases where cost advantge from coastal shipping may be marginal*

Based on these projections it was concluded that given Paradip is the nearest port to the cluster of coal mines which are suitable for coastal shipping of coal, Paradip will have a step jump in terms of coastally shipped coal. From the current traffic of 23 MTPA, there is a potential traffic of nearly 95 MTPA by 2020, 140 MTPA by 2025 and 200 MTPA by 2035. In order to realize this potential many connectivity projects need to be undertaken in order to feed the requisite amount of coal to the port. These projects are discussed in National Perspective Plan submitted separately under the Sagarmala Assignment.

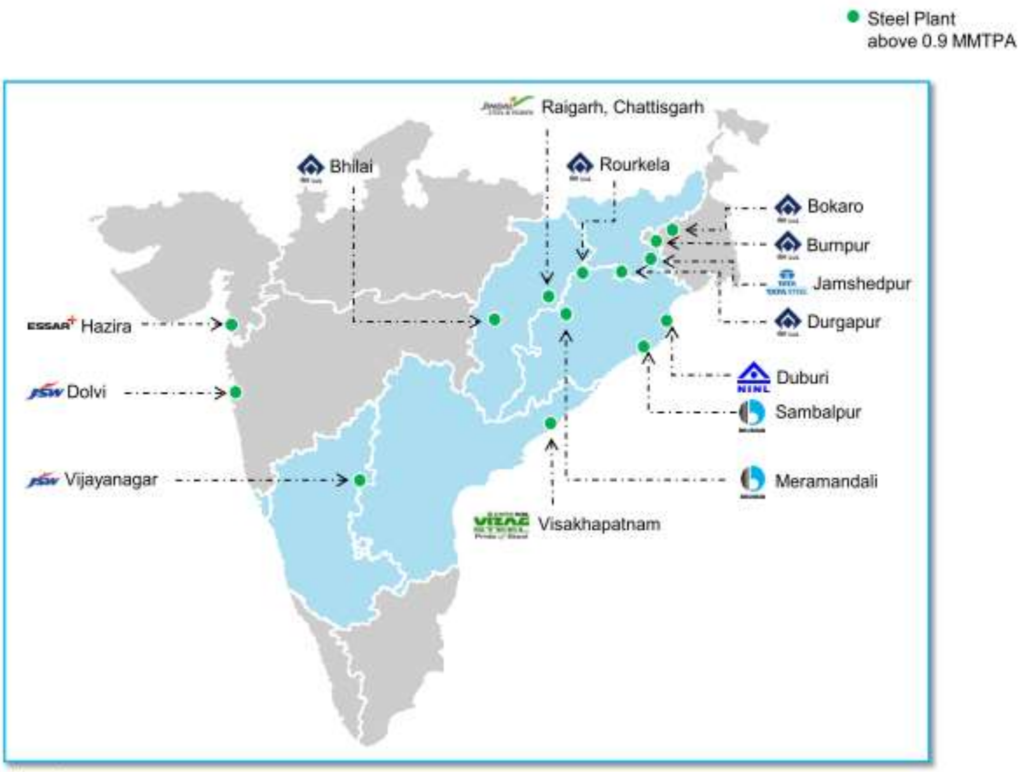
3.2.2 Coking coal

Another major commodity imported in Paradip is coking coal. To service the demand of blast furnace-based steel production, around 60 to 65 MTPA of coking coal is transported in the country, and around 54 MTPA is consumed for the production of steel. Around 80 percent of the coking coal consumed is imported due to insufficient coking coal reserves in India.

Eastern India (West Bengal, Jharkhand, Odisha and Chhattisgarh) is the biggest cluster of steel production in the country with 45 MTPA (around 40 percent) of total installed steel capacity.

For an OD analysis, 14 steel plants are most relevant since they are the major producers of steel (around 60 percent of the total) and consume around 80 percent of the total imported coking coal **Figure 3.7**.

These 14 plants need around 45 MTPA of coking coal; imported coking coal fulfils 37 MTPA of this demand.



1 Blast furnace based

SOURCE: World steel association; Steel authority of India Limited; Expert interviews

Figure 3.7 Steel Plants[1] Relevant for Coking Coal

While the current coking coal evacuation is facing challenges due to limited availability of rakes at unloading ports and rail line capacity at key train routes around 21 MTPA of new steel capacity at key steel plants (1 MTPA and above blast furnace based) is under construction and would need around 18-20 MTPA of coking coal to be evacuated on the same rail routes which are currently running at above 100 percent utilization.

According to estimates, the coking coal demand for steel would reach around 130-140 MTPA in 2035 based on increased steel demand in the country for programs like Make in India and construction impetus. Also, historically the steel growth has been growing faster than GDP with the multiplier being GDP: 1.14.

Thus, the evacuation capability at the relevant unloading ports and the railway routes will need to be improved for optimal evacuation of coking coal.

Figure 3.8 **Future Coking Coal Volumes**

Based on these projections we expect the traffic at Paradip to increase to 16 MTPA in the next 5 years, 23 MTPA by 2025 and 40-46 MTPA by 2035. This will primarily be driven by the new Tata Kalinganagar plant and the expansion of the Bhushan Steel plant in Meramandali.

3.2.3 Other commodities

In addition to coal and coking coal, POL is pegged to grow to roughly 33 MTPA by 2020, 45 MTPA by 2025 and roughly 75-80 MTPA by 2035.

In the base case scenario we expect the exports of Iron Ore from the port to be depressed due to the crashing of the global prices and the non-competitiveness of the Indian ore in the export markets.

Fertilizer traffic is also projected to grow to roughly 10-11 MTPA by 2035 due to the presence of IFFCO and good connectivity to agricultural areas in Bihar and UP. Overall projections for the port of Paradip are shown in **Figure 3.9**

Commodity	Current	2020	2025	2035	Remarks
Liquid Cargo					
POL	18.0	33.1	44.1	73.0	• Mainly Crude oil imports by IOCL Paradip, IOCL Haldia (including 2-3 MMTPA of ad-hoc coastal volume)
Dry and Break Bulk Cargo					
Thermal Coal (Loading)	23	95	135	200	• Driven by coastal shipping from MCL mines
Thermal Coal (Unloading)	7.0	5.0	4.8	7.9	• Imported Coal for power likely to be reduced as CIL production increases
Coking Coal	7.9	16.3	22.6	40.1	• TATA Kalinganagar and Bhushan Steel Meramandli expansion
Iron Ore	2.2	2.8	3.8	6.7	• Mostly exports; likely to remain low. Optimistic case is related to the volumes handled before ban. Pellets are part of others
Limestone	2.2	3.1	4.3	7.6	
Dolomite	0.7	1.0	1.35	2.4	
Gypsum	0.8	1.1	1.5	2.7	
Fertilizers	4.4	5.6	7.0	10.5	
Containers and other Cargo					
Containers (MnTEU)	0.004	0.02	0.10	0.15	
Others	4.6	6.1	8.2	13.6	• Highly fragmented
Total (MMTPA)	**71.0**	**169.5**	**234.4**	**367.1**	

Figure 3.9 Overall Traffic Projection for Paradip Port

3.2.4 Coastal Shipping Potential

Paradip is strategically positioned to serve large areas in the hinterland of the country through coastal shipping; Steel can be major commodities from Paradip in case coastal shipping revolution takes place in the country shown in **Figure 3.10.**

The key plants which will lead to the advent of coastal shipping of steel from Paradip are TISCO Jamshedpur, SAIL Rourkela, Bokaro, BSL Meramandali, BSPL Sambalpur and Tata Kalinganagar.

Paradip Port – New Opportunities Possible via Coastal Shipping

Units: MMTPA (except Containers)

Commodity	2020	2025	2035	
Steel (Loading)	3.91	5.23	9.37	
Steel (Unloading)	0.50	0.67	1.19	
Cement (Loading)	0.01	0.01	0.02	
Cement (Unloading)	1.27	6.7	8	• 5 MMTPA can be shipped if from Central AP cement cluster(If Central AP port comes up)
Fertilizer (Loading)	0.87	1.06	1.57	
Fertilizer (Unloading)	0.39	0.47	0.70	
Food Grains (Loading)	0.40	0.49	0.72	
Food Grains (Unloading)	-	-	-	

Figure 3.10 New Opportunities possile via Coastal Shiping for Paradip Port

While comparing the existing and planned capacities for the Paradip port with the traffic projections as shown in the **Table 3.2**, it could be observed that there is likely to be significant capacity gap for the thermal coal export traffic. In case of coking coal import assuming that the planned projects of Essar and CQ1-2 are commissioned within the stipulated time frame, the capacity would be adequate but the limitation in terms of design vessel size would still remain.

Table 3.2 Additional Need for Capacity by 2020 and 2035

Cargo Handled	I/E	Current Capacity including planned	Projected Traffic	Capacity Augmentation Required	Projected Traffic	Capacity Augmentation Required (over current)
			2020		2035	
Coal - Export	E	53.52	95.00	**41.48**	200.00	**146.48**
Coal – Import	I	30.05	21.30	**0.00**	48.00	**17.95**
Breakbulk	I/E	15.30	11.70	**0.00**	29.30	**14.00**
Iron Ore	E	10.00	2.80	**0.00**	6.70	**0.00**
Fertiliser	I	8.82	5.60	**0.00**	10.50	**1.68**
Crude/ POL	I	54.50	33.10	**0.00**	73.00	**18.50**
Total		**172.19**	169.50	**41.48**	367.50	**198.61**

It is therefore necessary that action be initiated immediately for the capacity augmentation of handling bulk cargo, so that the projected could be completed by year 2020. In addition to that there is likely to be significant demand for berths for Breakbulk cargo in the later phases of development.

3.2.5 Cargo Planned for Proposed Outer Harbour

For planning of the outer harbour, the phase wise traffic as shown in **Table 3.3** has been considered.

Table 3.3 Projected Cargo for Outer Harbour

Cargo Handled	I/E	Projected Traffic (MTPA)			
		2021	2026	2031	2036
Coal - Export	E	30.00	60.00	90.00	120.00
Coal – Import	I	10.00	10.00	10.00	20.00
Breakbulk	I/E	0.00	0.00	2.00	4.00
Total		**40.00**	**70.00**	**102.00**	**144.00**

It may be noted that while the traffic figures for the Phase 1 development could be more or less taken as firm, the same for the later phases of development would depend on the competitive positioning of the proposed outer harbour facilities. The variability of traffic has been duly captured while carrying out the financial appraisal of the outer harbour project.

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 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 Outer Harbour have been identified as:

- Thermal Coal Export
- Coking Coal Import
- Limestone, Gypsum

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 Coking Coal

The coking coal is imported mainly from Australia, Indonesia and South Africa. In view of the long shipping routes, the savings in voyage cost are substantial if this commodity is handled in large parcel sizes. At neighbouring ports of Paradip like Dhamra, Visakhapatnam and Gangavaram the facilities for handling 200,000 DWT cape size ships exist. Therefore in order to be competitive, Outer Harbour should also be able to handle 200,000 DWT cape size ships.

4.2.2 Thermal Coal

Presently the coastal shipping of thermal coal to southern states is carried out using ship sizes limited to Panamax size. However more and more facilities are being built in the southern states to receive vessels up to cape size. The costal shipping in cape size carried offer additional cost advantage for many of the users and it would be prudent the proposed port should also have loading facilities for cape size ships.

4.2.3 Limestone

Limestone is an essential raw material for the iron and steel industries. These industries have stringent quality requirements, for which the limestone needs to be imported. Presently the import is through UAE and Thailand. In view of the projected annual throughput it is expected that the maximum ship size for the import of limestone will be limited to 65,000 DWT, although most ships deployed are likely to be of handymax sizes.

4.3 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed Outer Harbour are presented in **Table 4.1**.

Table 4.1 Parameters of Ship Sizes

Commodity	Design Ship Sizes (DWT)	Maximum Parcel Size (T)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Dry Bulk	80,000	72,000	240	32	14.5
	120,000	110,000	260	40	16.5
	200,000	**200,000**	**300**	**50**	**18.3**

5.0 Port Facility Requirements

5.1 General

The layout of the master plan of any port should be based on the facility requirements in terms of number and length of berths, navigational requirements, material handling equipment, storage area required for each type of cargo, road and rail access for the receipt and evacuation of cargo, and other utilities and service facilities.

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

5.2.2.1 Dry Bulk Import

To enable the calling of the Panamax and Cape size ships, fast turnaround time has to be ensured. Ideally these ships should be unloaded within a period of 2 to 3 days depending on the parcel size without having to attract the demurrage payment. Therefore, it is proposed to provide a fully mechanised coal handling system comprising of gantry type coal unloaders, conveyor system, stacker, reclaimers and in motion wagon loading system etc. It is expected that with the proposed handling arrangement about 50,000 T coal can be unloaded per day at one berth.

5.2.2.2 Dry Bulk Export

Thermal coal export facility would comprise of the track hoppers for unloading the rakes, connected conveyor system for transfer to stackyard, stackers and reclaimers at stackyard and connected conveyor system to berth to feed the ship loader for loading to ships. It is expected that with the proposed handling arrangement about 75,000 T coal can be loaded per day at one berth.

5.2.3 Operational Time

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.

5.2.4 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.

5.2.5 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.

5.2.6 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 5.1** below:

Table 5.1 Estimated Berths for Outer Harbour Development

S. No.	Berth Type	Commodities Handled at Berths	Import (I) / Export (E)	Total Berth Provided			
				2021	2026	2031	2036
1.	**Bulk Export**	Thermal Coal	**E**	2	4	6	8
2.	**Bulk Import**	Coking Coal, Limestone, Gypsum	**I**	1	1	1	2
3.	**Multipurpose Terminal**	Break Bulk	**I/E**	0	0	1	2

5.2.7 Port Crafts Berth

For the initial stage development, the port would require 4 tugs (3 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.

5.2.8 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.

The proposed length of isolated berth for the different design ships are presented in **Table 5.2** below.

Table 5.2 Total Berth Length

Berth Type	Design Ship Size	Design Ship's LOA	Minimum Berth Length
Bulk Berths	80,000 DWT	240 m	290 m
	120,000 DWT	260 m	310 m
	200,000 DWT	300 m	350 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,
- 10 days for export bulk cargo

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 31 Ha increasing to 96 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

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 Paradip Outer harbour, as shown in **Table 5.3**:

Table 5.3 Evacuation Pattern for Various Cargo

S. No.	Commodity	2021		2026		2031		2036	
		Road Share %	Rail Share %	Road Share %	Rail Share %	Road Share %	Rail Share %	Road Share %	Rail Share %
1.	Thermal Coal Export	0%	100%	0%	100%	0%	100%	0%	100%
2.	Bulk Import	5%	95%	5%	95%	5%	95%	5%	95%
3.	Break Bulk	80%	20%	80%	20%	80%	20%	80%	20%

5.5.2 Port Access Road

The port would need to be connected to national highway NH5A for evacuation which is approximately 1km from the port site. There is already an existing access road to the port which connects to NH5A and it would need to be widened once the throughput picks up in later phases of development.

5.5.3 Rail Connectivity

The port shall be connected to the nearest rail link for effective evacuation of cargo. The provision to handle heavy haul rakes, being planned for movement of coal from mines to the port, shall be duly considered while planning the bulk import 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 1.7 MLD increasing to about 5.8 MLD in the master plan phase.

5.7 Power Requirements

HT and LT power supply at the port would be required for Handling Equipment, 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 14 MVA increasing to about 41 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at various berths.

5.8 Land Area Requirement for Paradip Outer Harbour

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 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 5.4** below:

Table 5.4 Land Area Requirement for Paradip Outer Harbour

S. No.	Commodity	Land Allocation over Master Plan Horizon (sqm)			
		2021	2026	2031	2036
1.	Storage Space for various Cargoes	309,673	445,758	614,121	955,129
2.	Internal Roads and Circulation Space in Storage areas @ 25%	77,418	111,440	153,530	238,782
3.	Rail and Road Corridor	141,000	162,150	186,473	214,443
4.	Port Building Complexes including parking	5,000	7,368	12,229	18,212
5.	Landscaping, Green belt and other for Expansion	200,000	333,333	533,333	800,000
	Total Land Area Required (Sqm)	**733,091**	**1,060,049**	**1,499,687**	**2,226,566**
	Total Land Area Required (Hectares)	**73**	**106**	**150**	**223**

The master plan details have been worked out based on traffic studies only up to 2036. However, ports are normally planned for 50 to 70 years of growth and hence there is need to provide at least double the area over the area requirement assessed for the year 2036.

6.0 Preparation of Paradip Outer Harbour Layout

6.1 Layout Development

The key considerations that are relevant for the establishment of layout for the proposed Paradip Outer harbour 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
  - Ability to cater for Littoral Drift
  - 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 and R&R 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 for Paradip Outer Harbour.

6.2.1 Potential Traffic

The potential traffic that the proposed 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 Paradip Outer harbour development.

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. The basic premise for developing the proposed port is to cater to the 200,000 DWT design ships and suitable water depths would need to be provided in the initial stages or subsequent years itself.

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. Based on the information available at the existing port the soil mainly comprise of silty sand and hence suitable for dredging as well as most of the dredged material is likely to be suitable for reclamation. The presence of very stiff clay layer beyond 30 m levels indicates good founding strata and therefore the geotechnical conditions at the proposed site are considered favourable.

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 data on the existing wave conditions at the outer harbour site of Paradip Port, it is assessed that that mainly waves from SSE and SE directions would approach the harbour. The orientation of the breakwaters would need to be decided accordingly.

6.2.2.4 Ability to Cater for Littoral Drift

The phenomenon of littoral drift of sediments along the east coast of India is well known. The drift of sediments along the coast is caused by the action of waves impinging on the coastline at an angle, and this slowly drives the material in the direction of the waves. This is predominantly from south to north along the east coast of India, but there is some reverse drift in the NE monsoon season.

At existing Paradip port the net drift northwards is expected to be about 1.0 million cubic metres per year. The new port being south of the existing one, it should be prepared for the capital and annual costs of dealing with it, and should also be prepared to satisfy the environmental requirements for preventing erosion along the coast north of the port. The selected port development plan should also clearly address this issue.

6.2.2.5 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 and breakwater. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. At Paradip, 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 at Chandikhol which is approximately 90 km from port site, as was being done while extension of existing south breakwater.

6.2.2.6 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.

6.2.2.7 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.

6.2.2.8 Flexibility for Development in Stages

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

6.2.2.9 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. Same is the case for reducing the area required to be reclaimed in the initial phase.

6.2.2.10 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 2036 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing in 2036. 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.

Some of the land areas which have already been allocated to government agencies and hence may not be available for locating the port infrastructure are shown in **Figure 6.1**.

Figure 6.1 Demarcation of Land Availability

Further it has been informed by port that the area initially allocated for western dock development would be available for cargo storage. While arriving at the port layout these aspects shall be duly considered

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. 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 2.5m. As in the present case the pilots shall be boarding seawards of the navigational channel then take the ship to the harbour.

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=1.0 m to Hs=1.5 m depending on 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 ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for 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

6.3.2 Breakwaters

The purpose of breakwater is to provide tranquil conditions inside the port in operating conditions. The predominant wave attack is from S and SSE directions, though some waves from E and SE are also expected. This would require two breakwaters to provide round the year wave tranquillity within the harbour. Final layout and alignment of the breakwaters shall be decided based on the wave tranquillity studies and the length shall be kept minimum to limit the overall capital expenditure.

6.3.3 Berths

The estimated number of berths for the various phases of development has been worked out and is presented in the **Table 6.2** below:

Table 6.2 Berth Requirement Estimation

S. No.	Berth Type	Commodities Handled at Berths	Import (I) / Export (E)	Total Berth Provided			
				2021	2026	2031	2036
1.	**Bulk Export**	Thermal Coal	**E**	2	4	6	8
2.	**Bulk Import**	Coking Coal	**I**	1	1	1	2
3.	**Multipurpose Terminal**	Break Bulk	**I/E**	0	0	1	2

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.

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 advantage, 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

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 (DWT)	Beam (m)	Channel Width (m)				Loaded Draft (m)
		Straight Channel		Curved Channel		
		One Way	Two Way	One Way	Two Way	
200,000	50	270	570	280	590	18.3
80,000	32	175	365	180	376	14.5

The channel length for handling 200,000 DWT ships works out to approximately 11 Km and therefore the transit time of the ships in the channel will be about 1.0 hours at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1 hour, maximum of 12 ship movements per day (6 in and 6 out) could be accommodated with one set of tugs. Taking an average of about 10 ship movements per day in the channel, a one way channel can handle about 1750 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 for the proposed outer harbour. However if the option of shared channel with the existing port is to be used, the common channel portion may need to be doubled in due course of time. 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.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship as calculated in **Table 6.5** below:

Table 6.5 Dredged Levels at Port for the Design Ships

Ship Size	Draft (m)	Approach channel outside breakwater (m CD)	Inner channel and manoeuvring area (m CD)	At Berths (m CD)
80,000 DWT	14.5	16.7	16.0	16.0
200,000 DWT	18.3	21.0	20.1	20.1

It may however be noted that above values are arrived at considering the design ship navigates the channel and harbour basin during low water levels and therefore without the advantage of tide. However in case the port is designed for cape size ships, the number of calls of such ships would be limited in the initial years and therefore a tidal advantage of atleast mid tide level of +1.7 m above CD could be considered. This would enable phasing of the capital expenses on the dredging. This aspect can however be dealt during execution stage.

6.3.5 Elevations of Backup Area and Berths

Considering the mean high water springs as +2.58 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 +6.0 m CD. The finished levels of onshore areas immediately adjacent to the berths will be kept at around +5.7 m CD.

6.3.6 Scheme for Littoral Drift Management

When a breakwater is constructed protruding out from the coastline it creates a barrier to the natural drift. Therefore the drift material will accumulate against the breakwater as shown in **Figure 6.2** below:

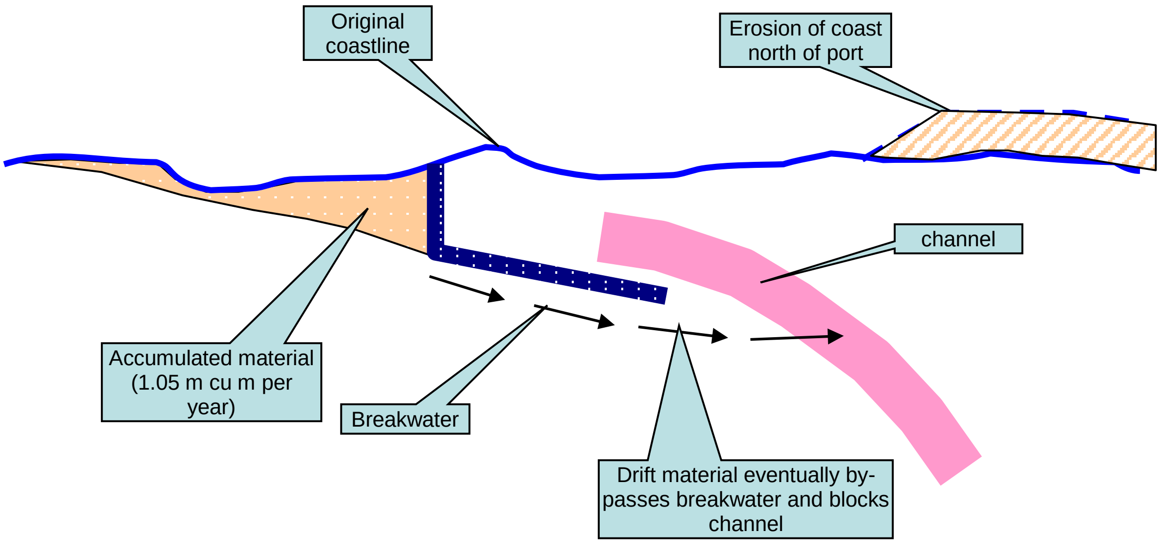


Figure 6.2 Diagramatic Illustration of Littoral Drift

Figure 6.2 shows what can be expected to happen if no action is taken to deal with the drift. The coastline north of the port is starved of the material which has occurred naturally in the past. The consequent erosion of the coastline north of the port would certainly be environmentally unacceptable.

Therefore it is necessary to collect the material and deposit it north of the port as part of an essential environmental management plan. Three possible methods of dealing with this problem for the proposed port are illustrated diagrammatically in **Figure 6.3** to **Figure 6.5**.

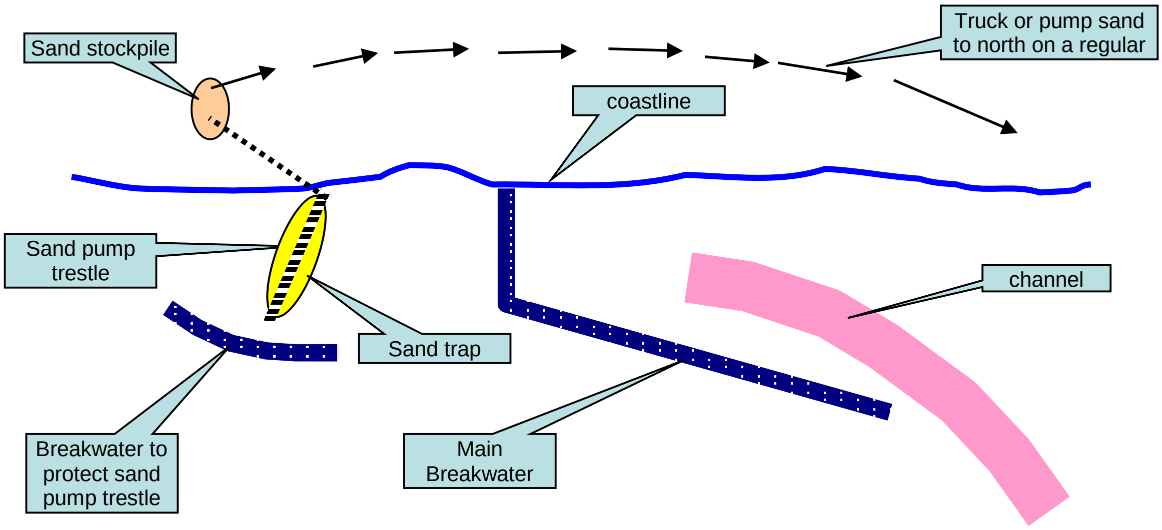


Figure 6.3 Littoral Drift Management Scheme 1

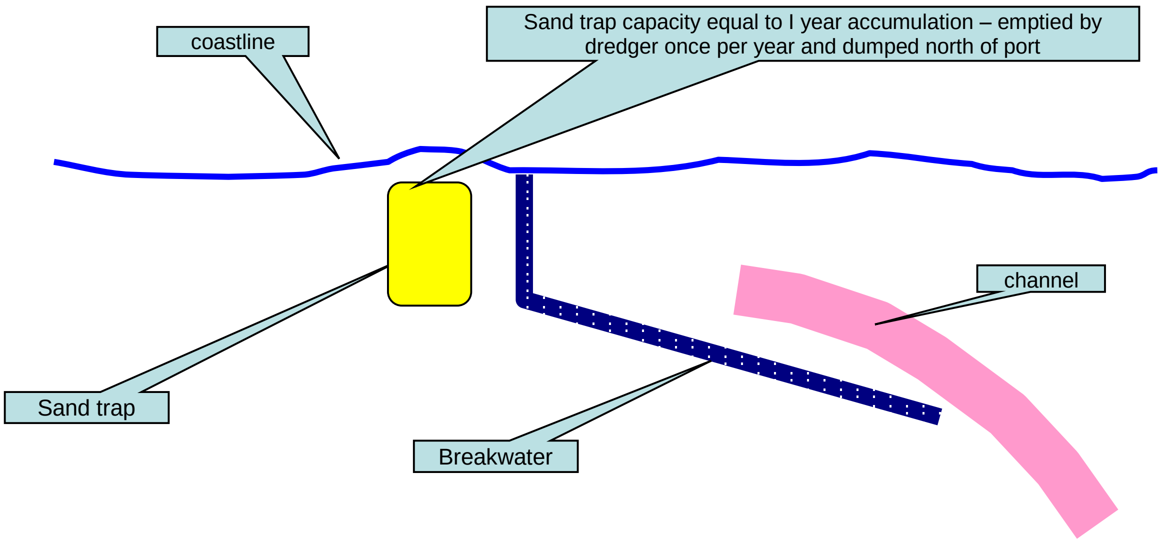


Figure 6.4 Littoral Drift Management Scheme 2

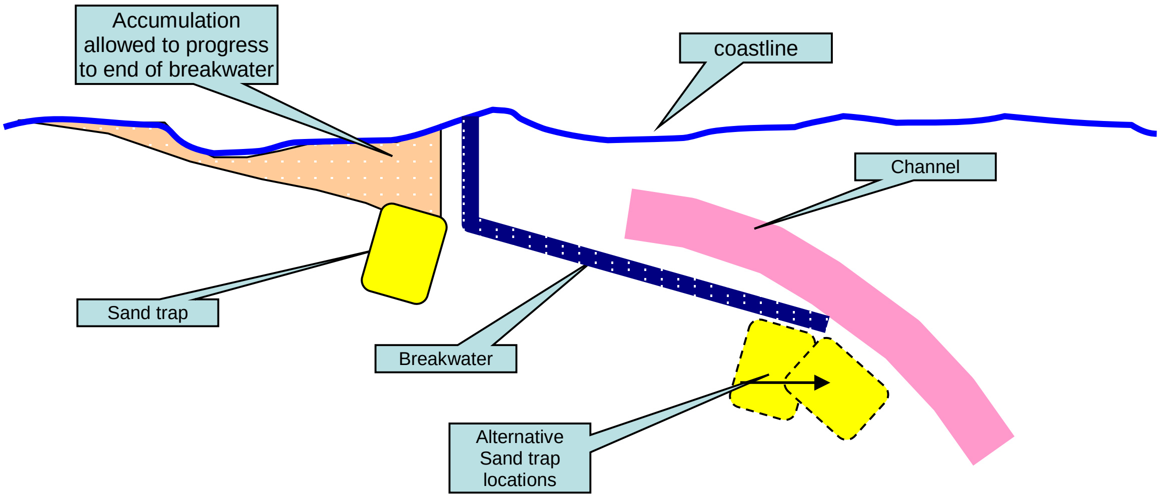


Figure 6.5 Littoral Drift Management Scheme 3

The drift occurs mainly between the high water line and -6.0 m contour. In all three schemes, therefore, the aim is to interrupt the accumulation of material in this zone.

In scheme 1, a sand trap is provided south of the port in the location of the existing 0-6 m contours i.e. before any accumulation of material has occurred. A sand pump mounted on a trestle removes the material monthly and pumps it round to the north, or alternatively to a stockpile ready for trucking to the north. The trestle and sand pump need to be protected by an island breakwater, and for this reason the scheme incurs a high capital cost. Its only advantage is that it can replenish the northern side on a regular monthly basis.

In scheme 2 a sand trap is provided in the same location as in scheme 1. This sand trap would have enough capacity to hold an entire 1 year's accumulation of drift material, and it would be emptied by a dredger annually. The annual dredged material would be deposited by the dredger on the northern side by rain-bowing technique or any other suitable method. The capital cost is much less than scheme 1, being merely an extension of the capital dredging contract by 1-1.5 million cubic metres.

In scheme 3 the coastline is allowed to advance to the end of the breakwater before any measures are taken to collect the drift material. Thereafter the scheme is the same as scheme 2, with a sand trap provided between the new high water mark and the new -6.0 m contour. This scheme creates valuable additional land and would be considered acceptable provided that during the few years taken for the southern beach to advance, suitable measures can be taken to protect the northern beaches, which could be by way of constructing groynes or dumping any surplus material.

It may be noted that the total quantity of littoral transport handled would remain same as currently being handled at the Paradip port only the location of accretion shifts further south. The similar measures that are being considered for prevention of erosion of north side would need to be continued.

6.4 Alternative Marine Layouts

Several alternative layouts for the development of Paradip Outer Harbour were prepared, to cater 200,000 DWT capesize vessels, keeping in view various considerations discussed above. The following three layouts have been shortlisted for further evaluation:

Alternative Layout 1

The harbour area shall be protected by two breakwaters with south breakwater of 3700 m length and that north breakwater of 2200 m length. The approach channel for the proposed harbour shall be independent of the existing channel. Initially berths for handling bulk cargo shall be provided and provision shall be kept for handling breakbulk or liquid bulk in future. The rail and road access to this port will also be free from constraints posed currently at port. However, the port being located to the south of existing port littoral drift management would be necessary.

It is proposed to locate the bulk export berths in the lee of north breakwater whereas the bulk import berth is located perpendicular to export berths. The stackyard shall be located in the lee of north breakwater in a reclaimed land and shall be adequately sized to enable forming a rail loop for faster movement of rakes. The bulk as well as import stackyards are located within the rail loop. The master plan layout and phase 1 layout for this alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-POH1001** and **POH1002** respectively.

Alternative Layout 2

The planning parameters for this alternative are similar to the alternative 1 with south breakwater of 3350 m length and that north breakwater of 1900 m length. However, the initial bulk export as well import berths are located parallel to shore. Provision for breakbulk handling shall be kept in the dock provided in the lee of north breakwater. The railway loop is partly located on the reclaimed land and partly on the existing shore. The master plan layout and Phase 1 layout for this alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-POH1003** and **POH1004** respectively.

Alternative Layout 3

This layout is similar to Alternative 2 but developed with an objective to utilise the existing approach channel to the port so as to minimise the capital dredging in the channel. In this alternative the length of south breakwater is increased to 4150 m so as to provide higher shelter to the harbour basin. The north breakwater is shorter at 1140 m length. Further it is proposed that the entire bulk export cargo shall be located in the reclamation area whereas the stackyard for the bulk import cargo would be located in the area previously allocated for Western dock. The master plan layout and Phase 1 layout for this alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-POH1005** and **POH1006** respectively.

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 Key Items for Alternative Layouts

Item	Phase 1 Development			Master Plan Development		
	Layout 1	Layout 2	Layout 3	Layout 1	Layout 2	Layout 3
Breakwaters	1318	1211	1192	1318	1211	1192
Dredging	537	602	575	434	395	423
Reclamation	554	425	290	388	246	200
Total	**2408**	**2239**	**2057**	**2140**	**1852**	**1816**

It is observed that cost of development is lower in case of layout 3, as the berths in this case are near the shore and therefore area for reclamation is minimised.

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

Alternate	Estimated Rock Quantity (million tonnes)	Estimated Construction Time (months)
Alternative 1	9.45	49
Alternative 2	8.72	46
Alternative 3	8.58	45

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. Considering a patch of state government land right opposite the waterfront, it is required that adequate land be reclaimed for the required cargo storage and operational areas.

In all the alternative layouts, the cargo storage is proposed in the reclaimed land as well as the areas available with port.

6.5.4 Expansion Potential

It is observed that alternative layouts 2 and 3 offer development of maximum number of 15 berths within harbour. This is higher than alternative 1 where 13 berths can be built.

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.	**Soil Profile**	The soil characteristic would dictate the cost of dredging and marine structures.	The soil comprises of stiff clay and thus forms reasonable founding strata for breakwaters and piled foundation.	Same as Alternative 1.	Same as Alternative 1.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	As only part of dredged material is suitable some borrowed fill would be needed for reclamation.	Optimal use of dredging and reclamation material.	Same as Alternative 2.
3.	**Protection to the berths from waves and swell**	The predominant wave direction is from S and SE	The berths are generally protected but might result in some downtime on account of penetrated waves	Same as Alternative 1.	The breakwaters provide excellent shelter from waves resulting in minimal downtime.
3.	**Ability to cater to Littoral drift**	The scheme should be able manage littoral transport so as to minimize the shoreline changes	A sand trap would need to be provided outside the south breakwater	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 so as to provide faster receipt / evacuation of cargo and also provide separation between dirty and clean cargo	Effective utilization of backup area. Clear separation of clean and dirty cargo possible.	Same as Alternative 1.	Same as Alternative 1.
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	Suitable rail and road connectivity is provided	Same as Alternative 1.	Same as Alternative 1.
6.	**Environmental issues related to development**	Blockage of sediment movement should not result in choking of the river mouth.	The sand trap shall be provided and maintained to mitigate accretion of land.	Same as Alternative 1.	Same as Alternative 1.
7.	**Potential Reclamation Area**	The higher reclamation area could be used to meet the storage and operation requirements of master plan stage	279 Ha	193 Ha	193 Ha

S. No.	Factor Description	General	Alternative 1	Alternative 2	Alternative 3
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 13 berths possible	Total 15 berths possible	Total 15 berths possible

6.7 Recommended Master Plan Layout

It could be observed from above that alternative layout 3 appears to be the best in terms of minimal investment for Phase 1 development and it also meets the long term expansion requirements of the port. The detailed master plan layout of the Paradip outer harbour is shown in **Drawing DELD15005-DRG-10-0000-CP-POH1005**.

6.8 Phasing of the Port Development

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 2021	Phase 2 - Year 2026	Phase 3 - Year 2031	Master Plan -Year 2036
Maximum Ship Size				
• *Dry Bulk (DWT)*	*200,000*	*200,000*	*200,000*	*200,000*
• *Breakbulk (DWT)*	*80,000*	*80,000*	*80,000*	*80,000*
Number of berths (Total length of berths in meters)				
• *Bulk Export Berths*	*2(700)*	*4(1350)*	*6(2050)*	*8(2850)*
• *Bulk Import Berths*	*1(350m)*	*1(350m)*	*1(350m)*	*2(750)*
• *Multipurpose berths*	*0*	*0*	*1(300m)*	*2(600m)*
Navigational Areas				
• *Length of Approach Channel (m)*	*9,000*	*9,000*	*9,000*	*9,000*
• *Width of Approach Channel (m)*	*300*	*300*	*300*	*300*
• *Diameter of Turning Circle (m)*	*600*	*600*	*600*	*600*
Breakwaters				
• *South Breakwater (m)*	*4150*	*4150*	*4150*	*4150*
• *North Breakwater (m)*	*1140*	*1140*	*1140*	*1140*
Design Draft of the Ship (m)	18.3	18.3	18.3	18.3
Dredged Depths at Port (m below CD)				
• *Approach Channel*	*21*	*21*	*21*	*21*
• *Manoeuvring Areas*	*20.1*	*20.1*	*20.1*	*20.1*
• *Berths*				
○ *Breakbulk*	*16*	*16*	*16*	*16*
○ *Bulk*	*20.1*	*20.1*	*20.1*	*20.1*
Incremental Dredging Quantity (million cum)	*21.14*	*2.58*	*2.26*	*2.76*
Incremental Reclamation Quantity (million cum)	*10.02*	*0.00*	*0.00*	*4.48*
Total Reclamation Area (Ha)	*170*	*170*	*170*	*193*

The phase wise development plan of Outer Harbour of Paradip Port is indicated in **Drawings DELD15005-DRG-10-0000-CP-POH1008** to **POH1010**.

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

Figure 7.19 shows 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 538.

To represent the existing conditions, the bathymetry inside port has been modified to deepen dock area to 17.1 m and channel to 18.7m below CD (**Figure 7.1**). While, modified mesh is prepared to include the layout of the proposed port and the channel (**Figure 7.2**).

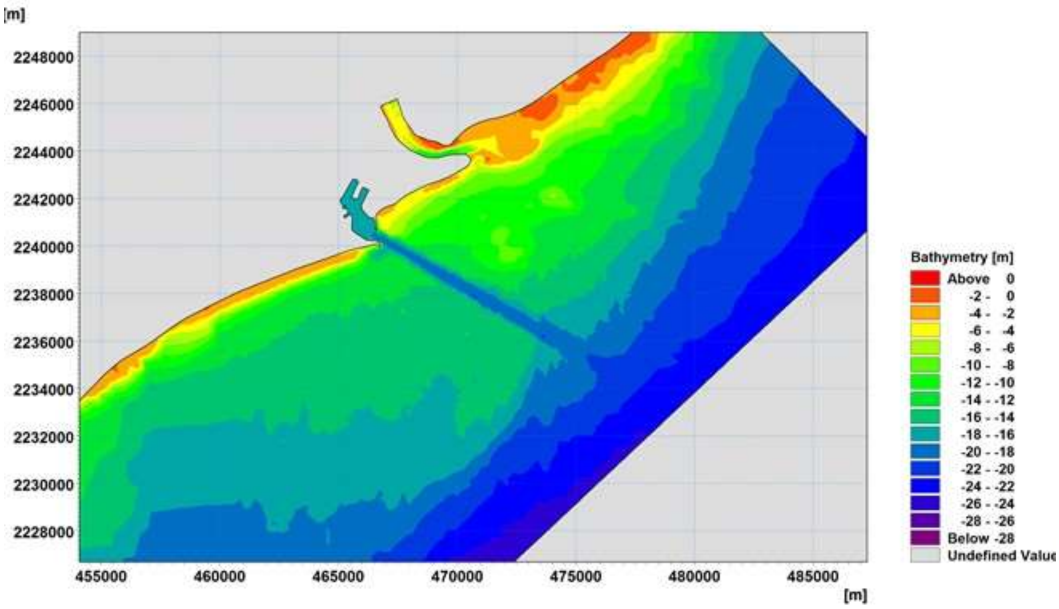


Figure 7.1 Bathymetry of the study area w.r.t. chart datum

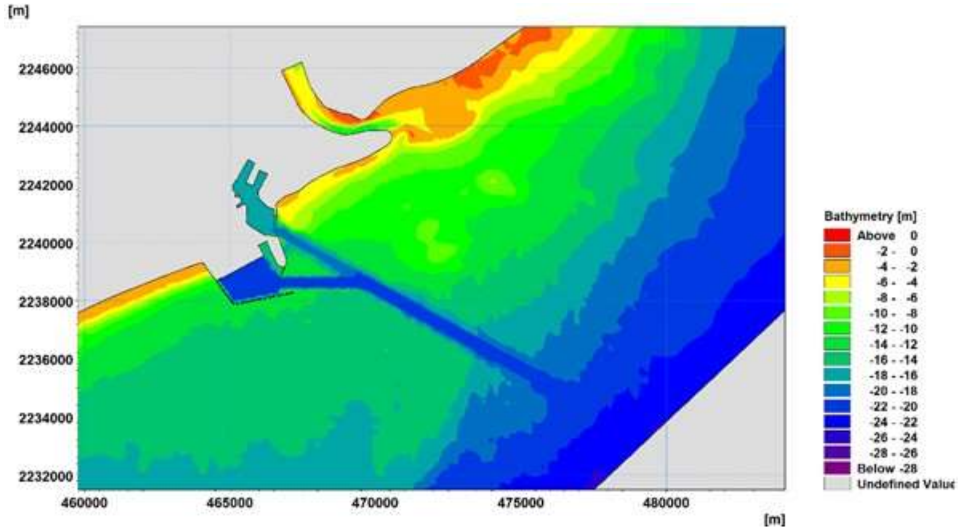


Figure 7.2 Bathymetry including Proposed Layout w.r.t. Chart Datum

7.1.2.2 Boundary Conditions

The tidal information for location called false point has been taken from International Hydrographic Organisation (www.iho.int) to be used as Northern Boundary. In absence of information, false point tide has been used at Southern boundary also with appropriate phase lag and water level adjustments. The tide was found to vary between 0.4 to 2.6 m (**Figure 7.3)**. Discharge of 100 m^3/s has been considered for the Mahanadi River.

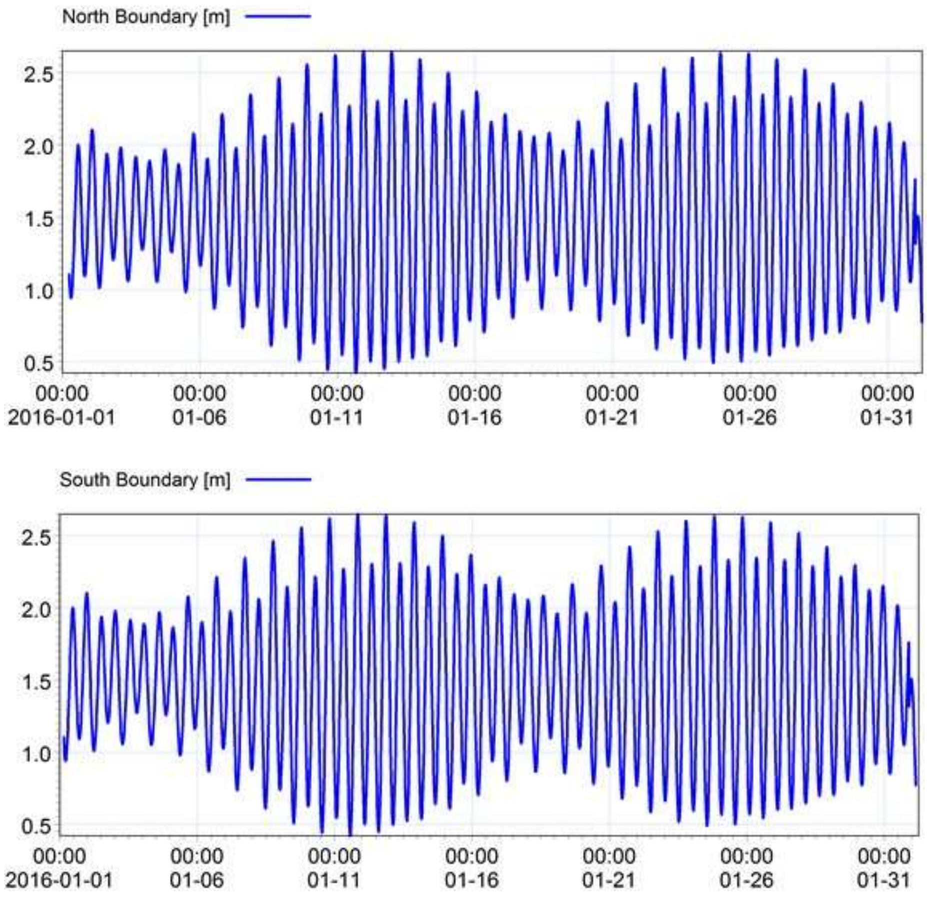


Figure 7.3 Water levels used as Northern Boundary and Southern Boundary

7.1.2.3 Model Calibration

The model was first calibrated in order to compare the model results with the observed tidal levels at Paradip port. The tidal range and phase were found to be comparable at Paradip Port (**Figure 7.4**).

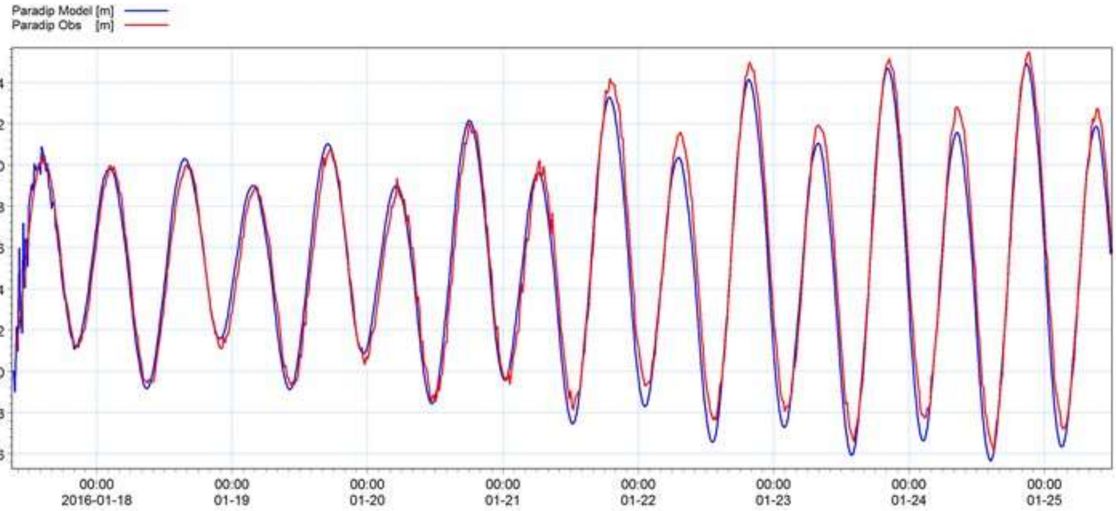


Figure 7.4 Model Calibration: Comparison of Measured (Red) and Modeled Tidal Levels (Blue) at Paradip Port

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**

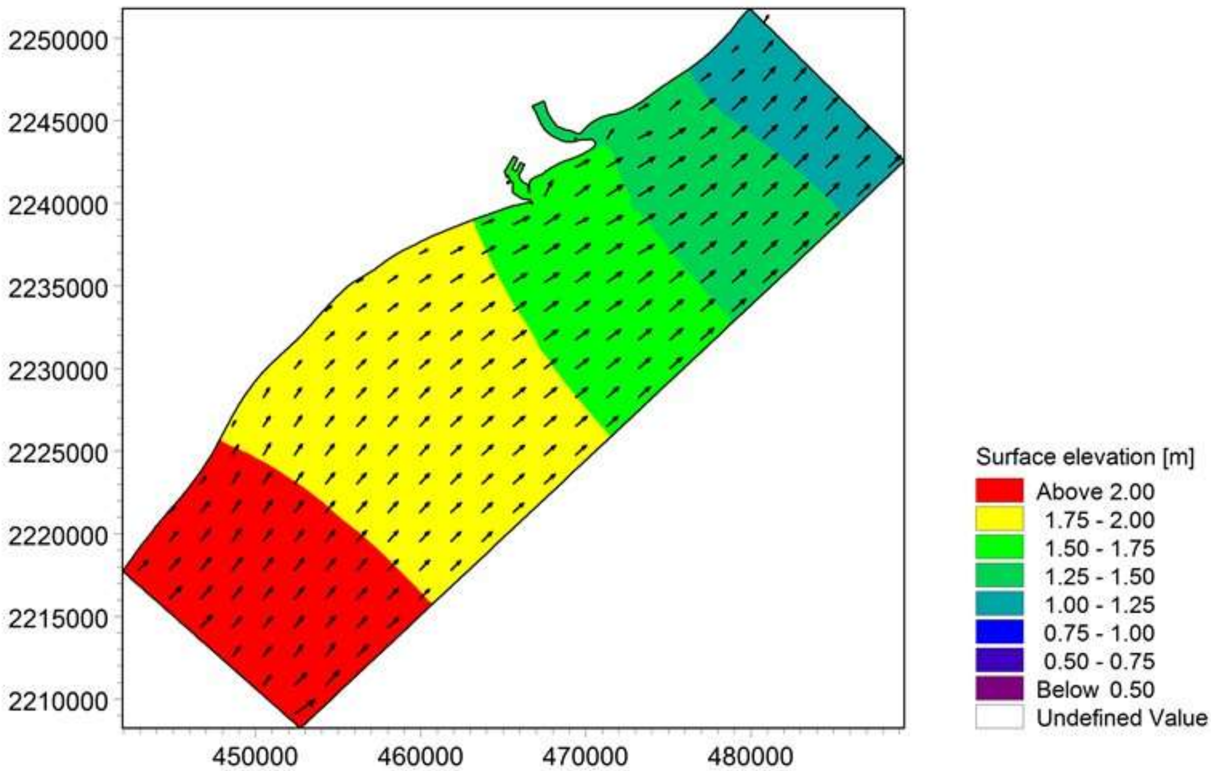


Figure 7.5 Surface Elevation in the entire region during Flood Tide

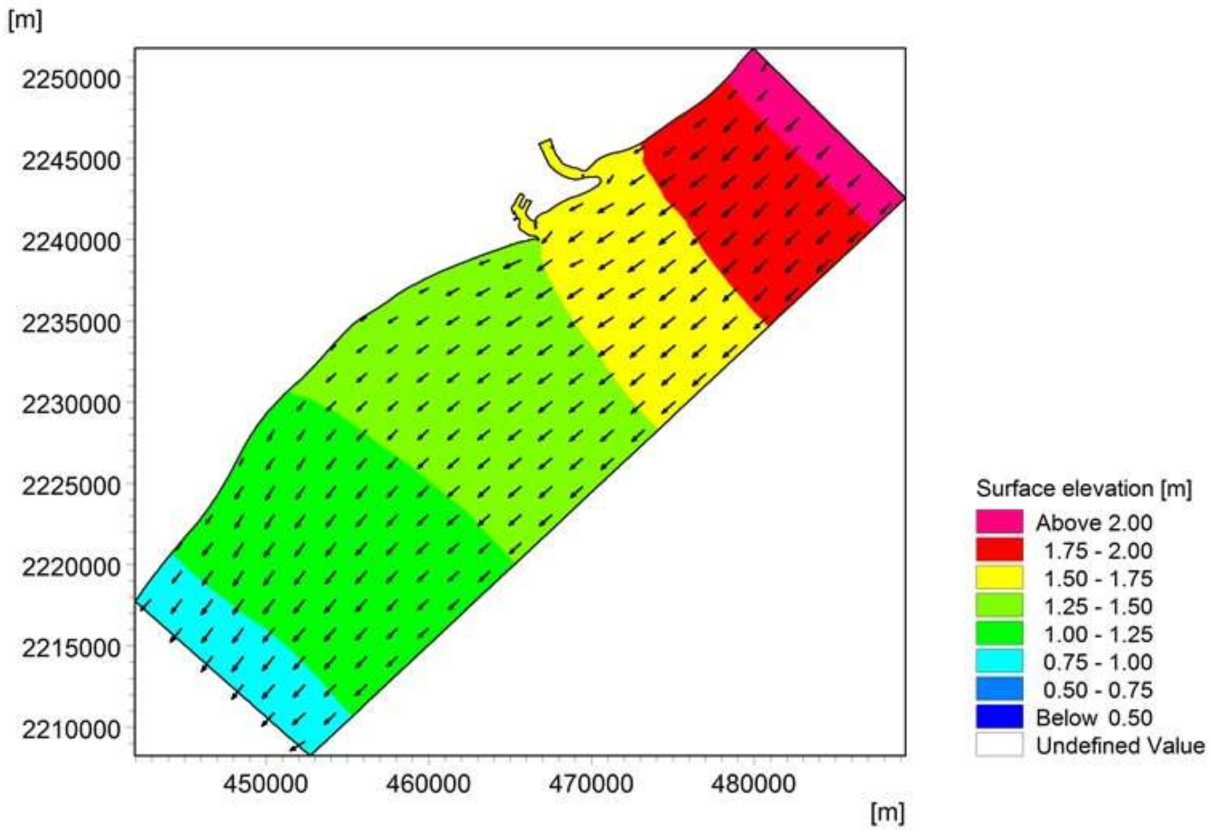


Figure 7.6 Surface elevation in the entire region during Ebb Tide

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** and are presented in **Figure 7.8**. It may be observed that velocities inside the port are relatively lower than other locations. The presence of breakwaters and deep channel were observed to be the reason for lower velocities in that region. The maximum currents at these locations near Paradip port were about 0.1 m/s, while at offshore locations was upto 1.2 m/s

Similarly velocities were extracted in the proposed port area and the new channel (**Figure 7.9** and **Figure 7.10**). It is important to note that location of velocities t5, t6, and t7 in the exiting condition are same as t3, t4 and t5 with the proposed layout and it may be seen that further deepening in the outer channel is not found to change the velocities in the channel.

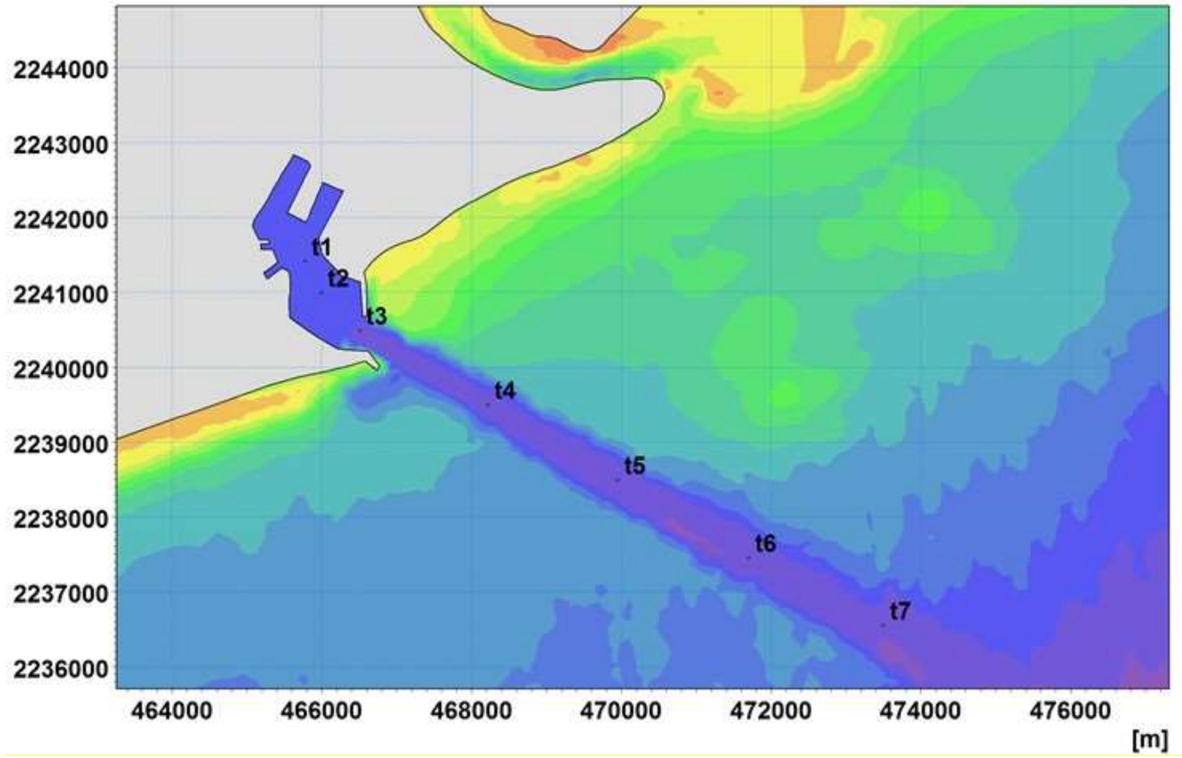


Figure 7.7 **Location of Current Time-Series – Existing Conditions**

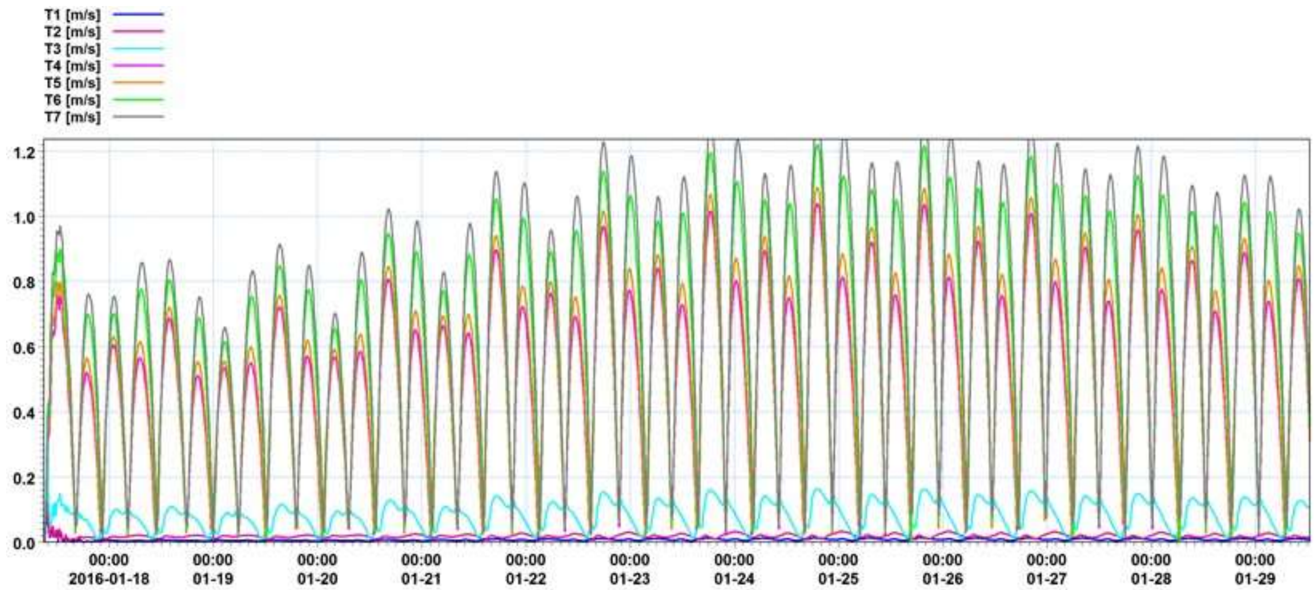


Figure 7.8 **Current Time-Series at various location in the Port and Channel for Existing Conditions**

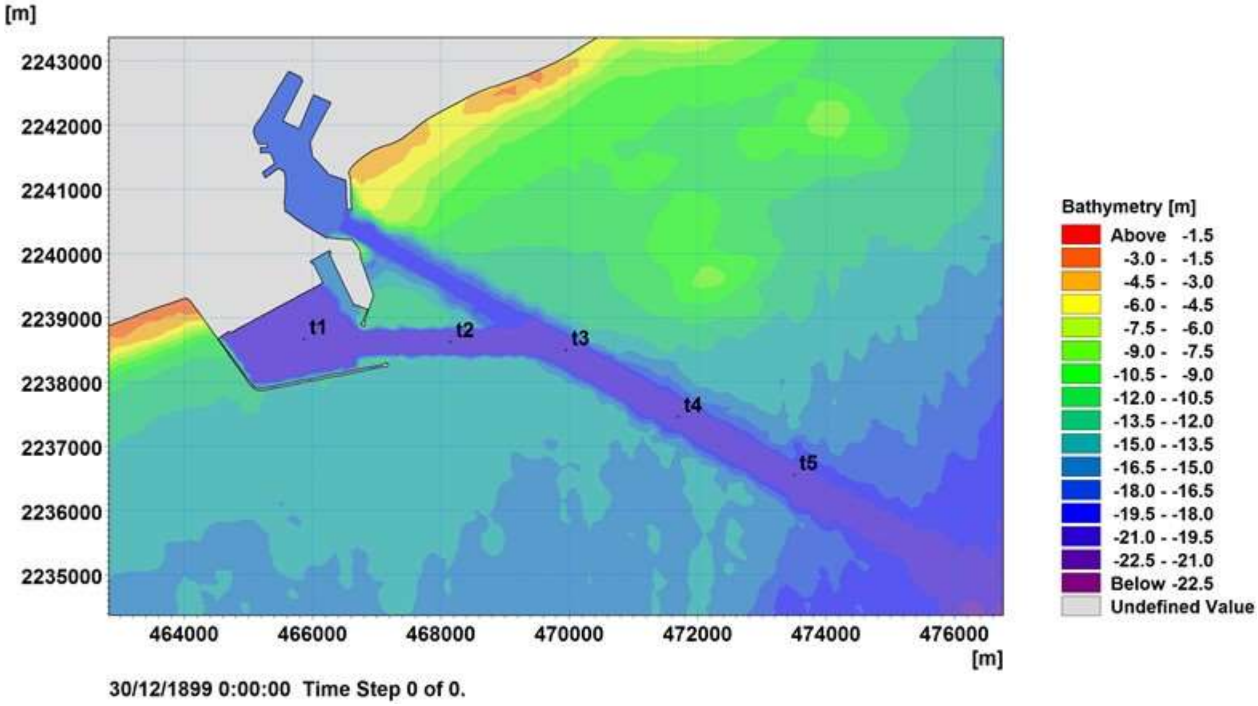


Figure 7.9 Location of Current Time-Series – with Proposed Layout

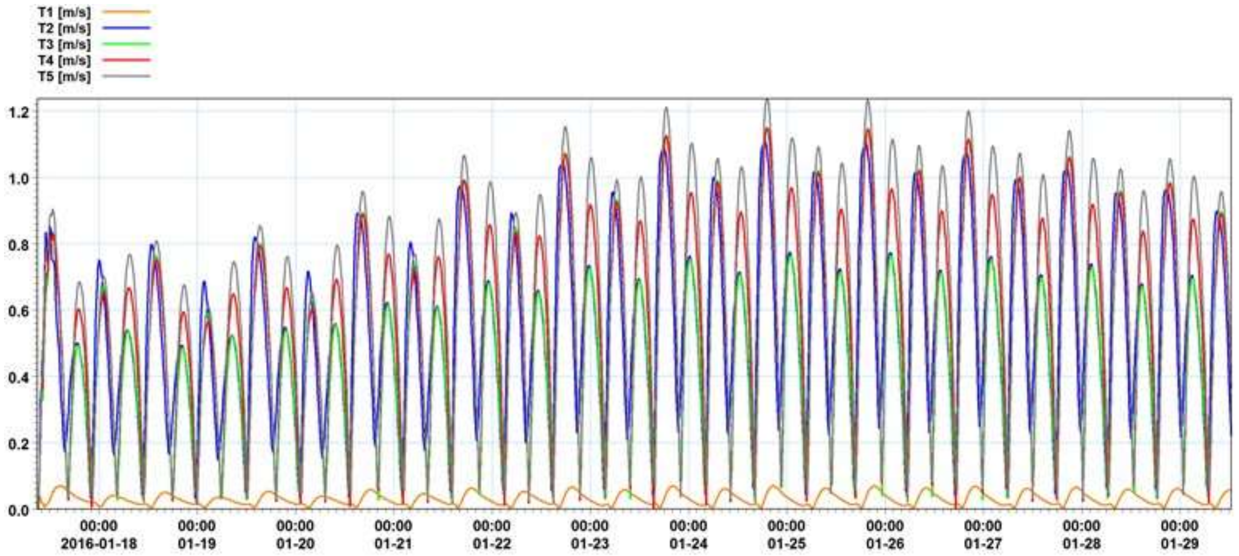


Figure 7.10 Current time-series at various location in the Port and Channel with Proposed Layout

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 to represent existing condition and also proposed port. For exiting condition most of the sedimentation occurs near the breakwaters at the entrance of the port (**Figure 7.11**). Figure 7.12 presents sedimentation for the region with construction of outer harbour.

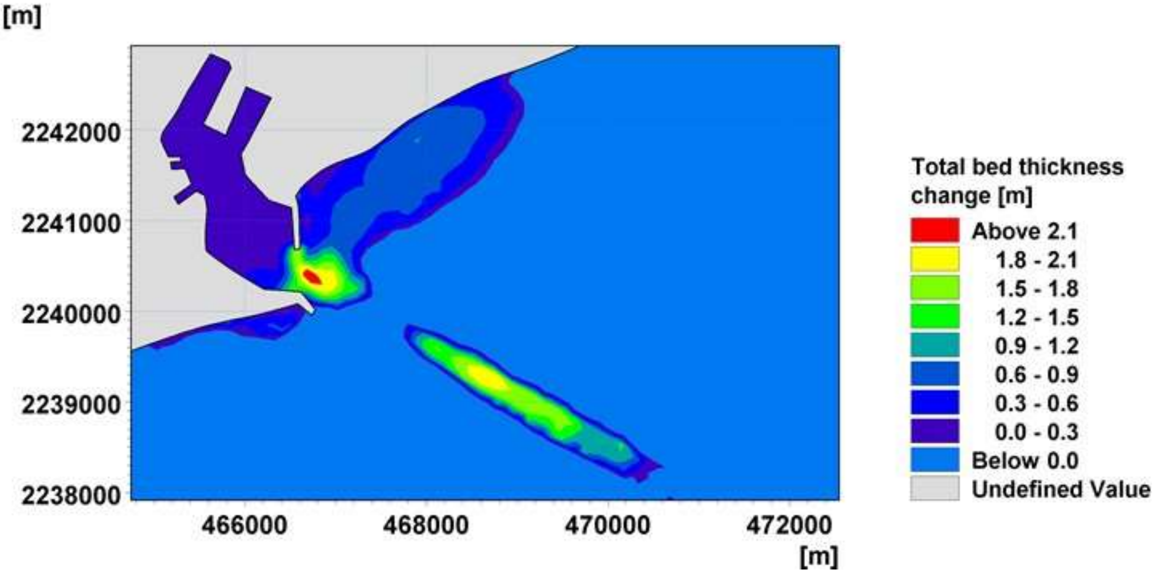


Figure 7.11 Annual Bed level Change – Existing Condition

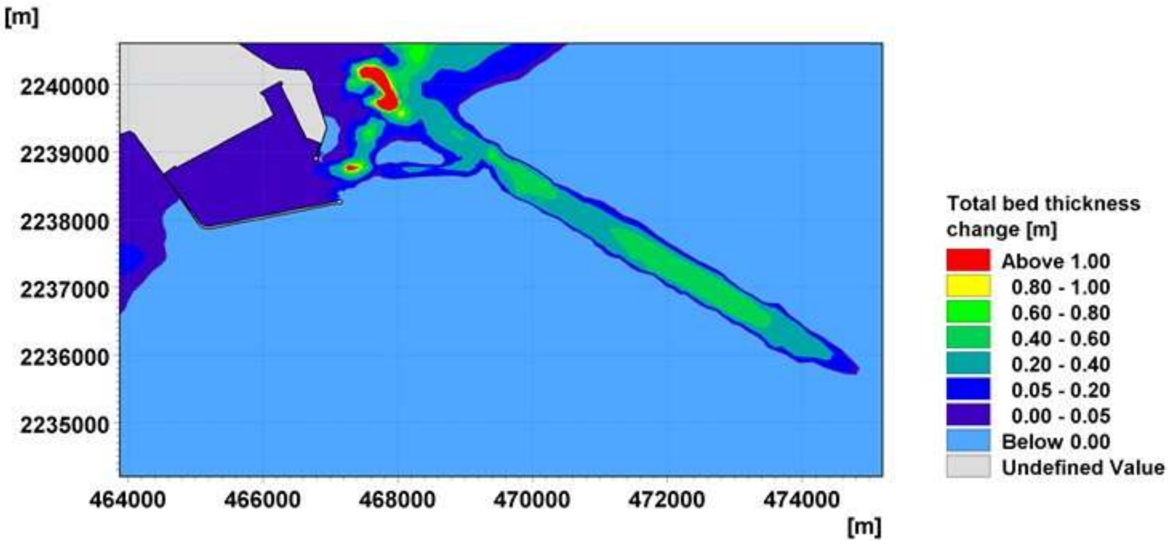


Figure 7.12 Annual Bed level Change – with Proposed Layout

Based on the model results, annual maintenance dredging for the new port is assessed as about 3.58 Mcum (**Table 7.1**).

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

S. No.	Description	Estimated Dredge Volume (Mcum)
1.	Harbour Basin	*0.46*
2.	Entrance Channel	*1.87*
3.	Approach Channel	*2.09*
	Total	**3.58**

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 shown in **Figure 7.13**. All the numerical simulations of the wave agitation were carried out with a water level corresponding to the Chart Datum (CD).

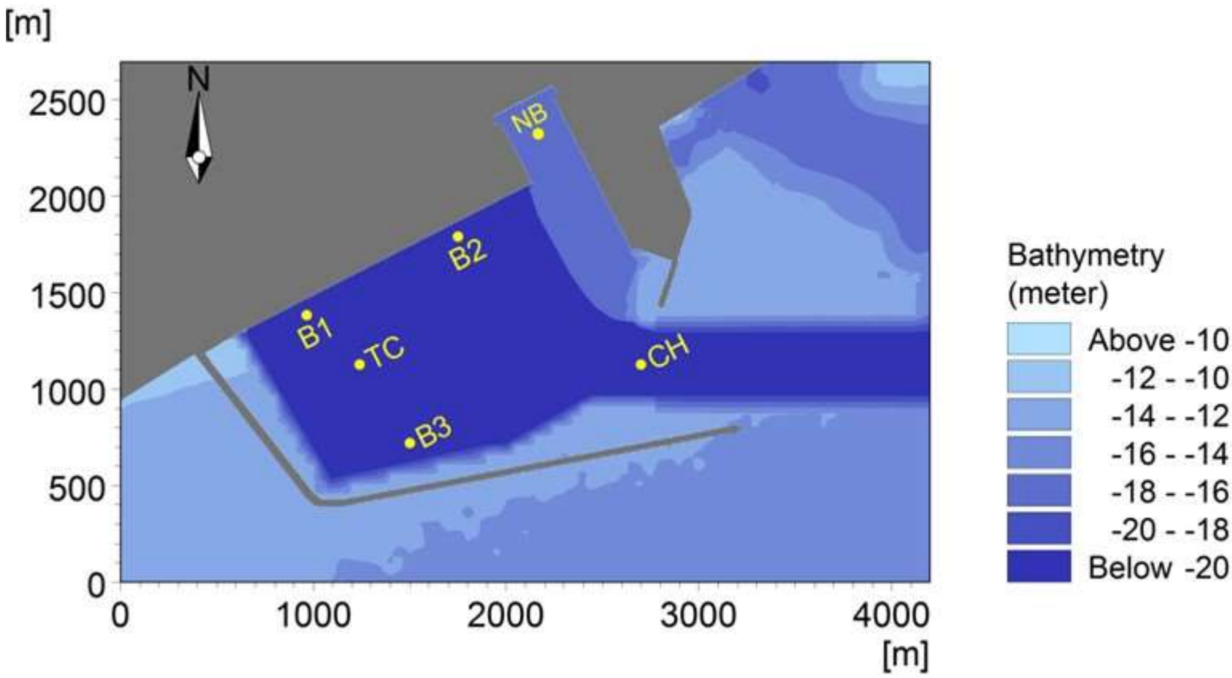


Figure 7.13 Bathymetry used for the BW

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 closed boundaries (**Figure 7.14)**.

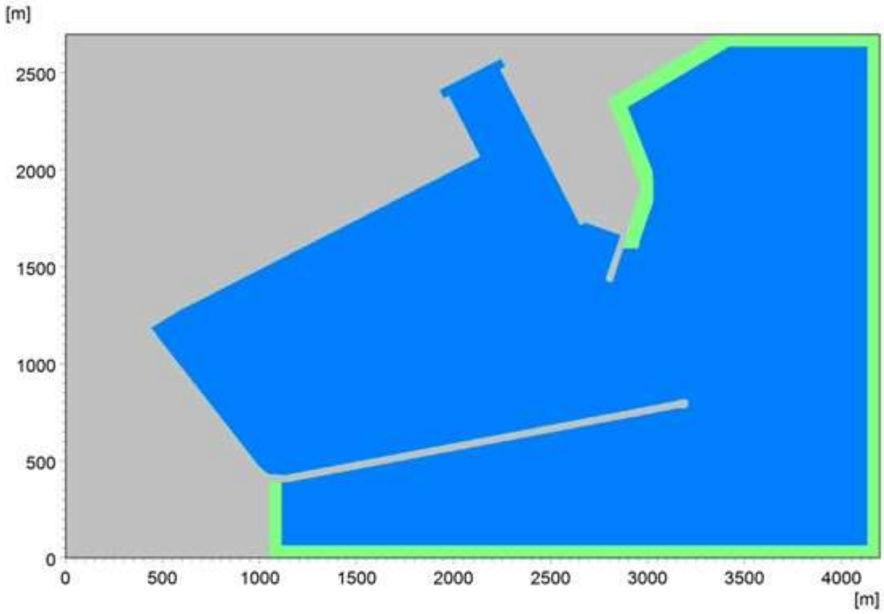


Figure 7.14 Sponge layers (in Green) along the non-reflecting boundaries

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 7.15**). 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.

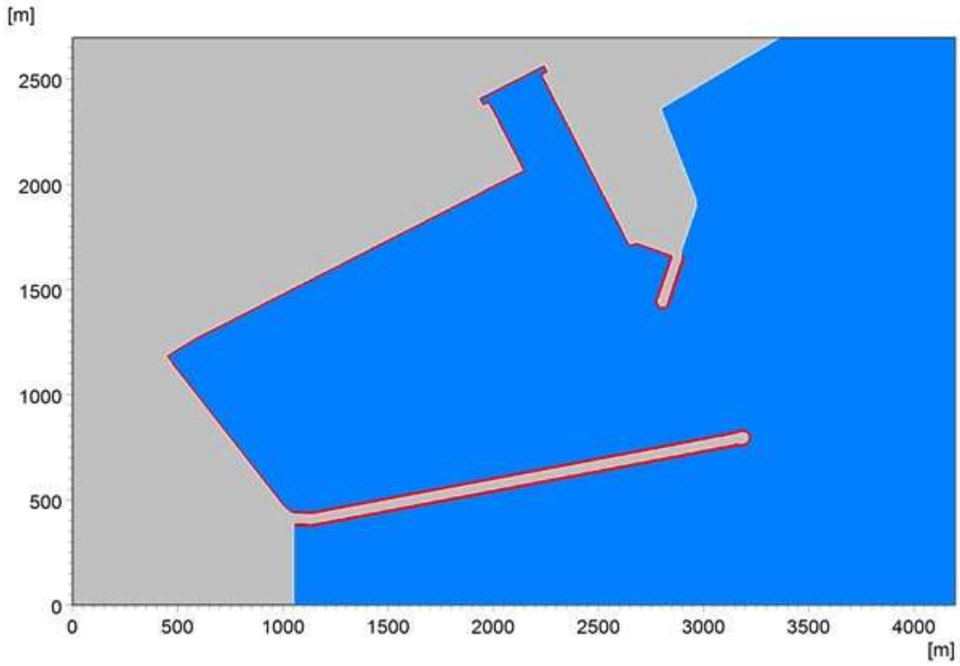


Figure 7.15 Porosity layers (in Red) along the port structures

The proposed layout provides effective protection from N, S, SW and partially from the SE, E and NE. 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 6.5 s.

7.1.4.2 Model Results

Figure 7.16 to **Figure 7.18** provides wave height that may be encountered within the harbor under the impact of 1 m waves from NE, E and SE directions respectively. It may be observed that the wave entering the harbour have maximum impact at the berth locations and turning circle, while NE and SE waves are attenuated at the breakwater.

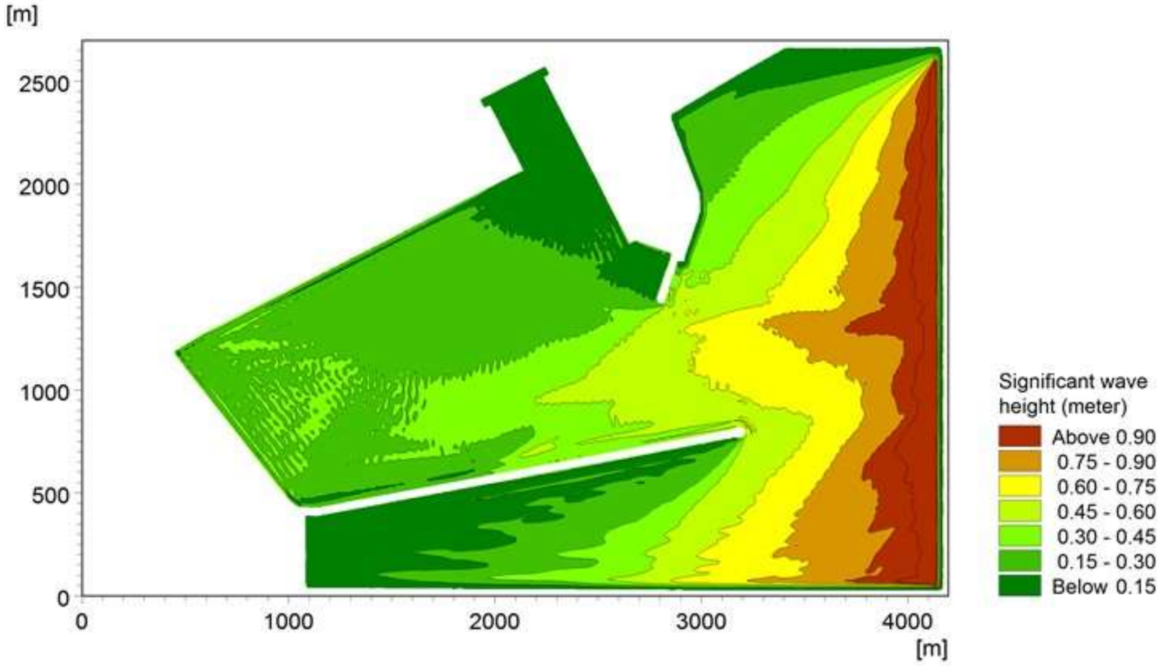


Figure 7.16 Wave Tranquililty Assessment for Waves from NE Direction

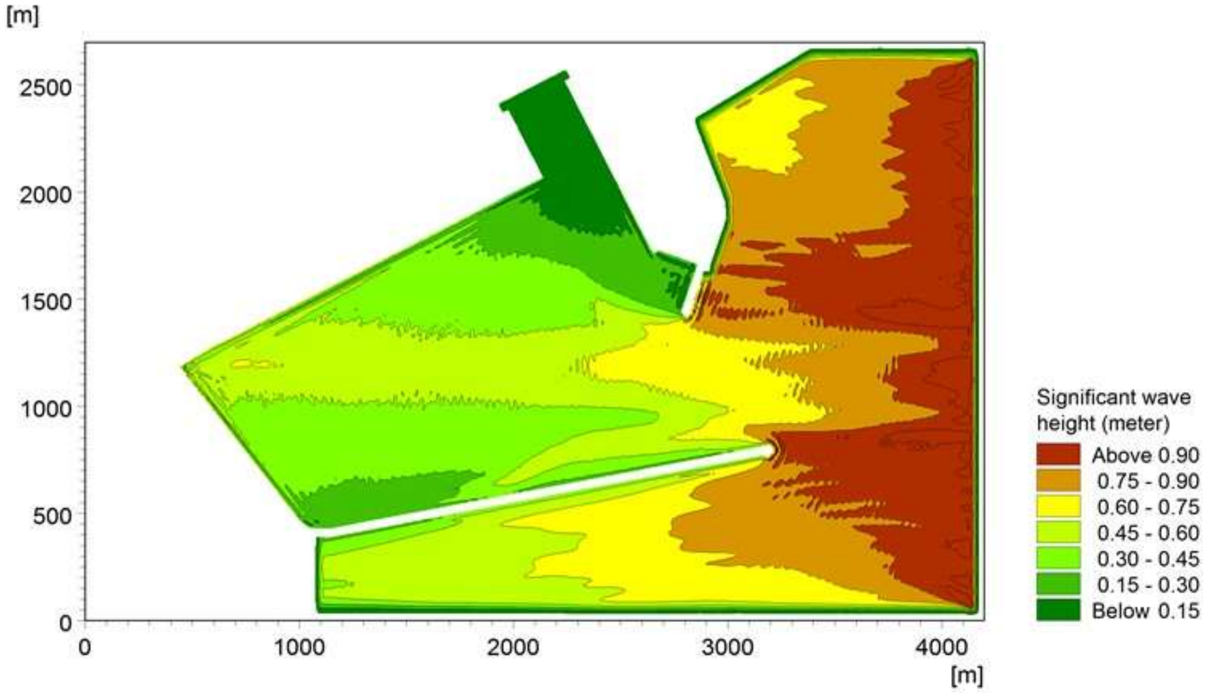


Figure 7.17 Wave Tranquililty Assessment for Waves from E Direction

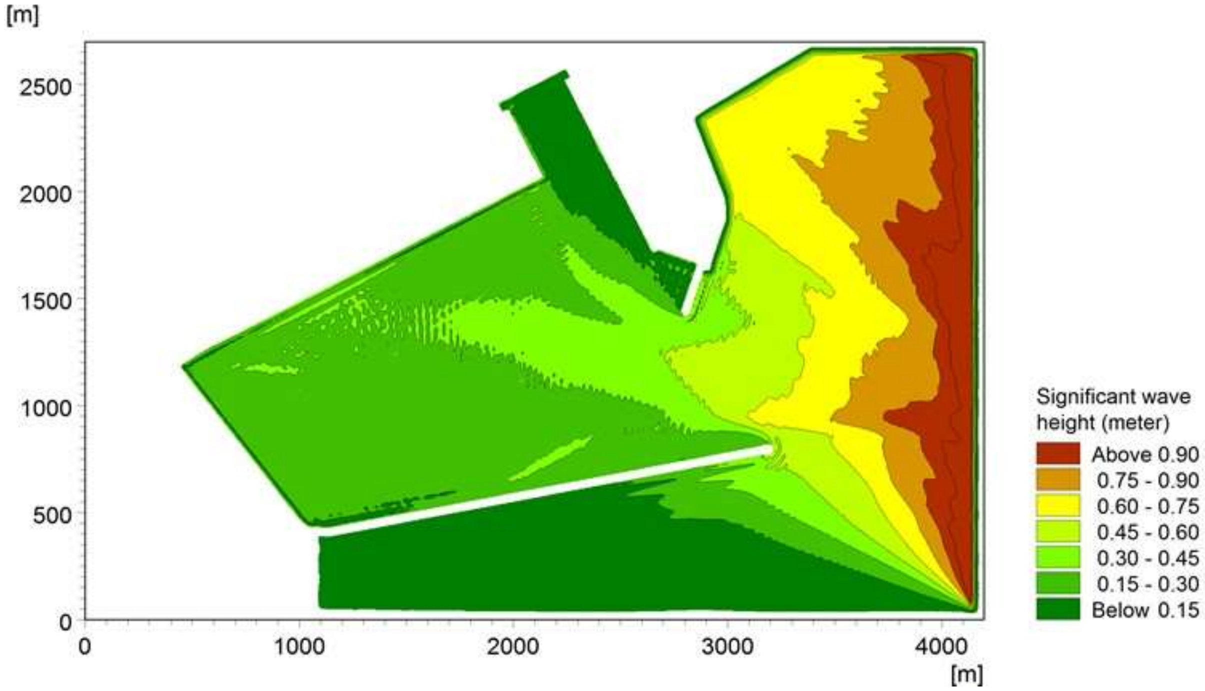


Figure 7.18 Wave Tranquililty Assessment for Waves from SE Direction

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

Table 7.2 Wave Disturbance Coefficients

Location	NE	E	SE
Channel (CH)	0.556	0.668	0.474
Turning Circle (TC)	0.307	0.491	0.229
Berth 1 (B1)	0.247	0.436	0.272
Berth 2 (B2)	0.203	0.283	0.204
Berth 3 (B3)	0.277	0.317	0.183
Northern Basin (NB)	0.068	0.081	0.117

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 0.44 m reaches location B1 if incident wave of 1 m approach the port from E direction.

Considering that the berths under consideration are for handling bulk cargo, cargo handling operations can be effectively undertaken for a significant wave height of 1.0 m, which corresponds to an offshore incident wave height of more than 2.5 m.

Based on the percentage exceedance of waves at 15 m contour (**Table 2.7**), it is assessed that waves exceeding even 2m are negligible and hence it may be safely concluded that downtime at the port with proposed layout is practically nil under the normal wave conditions.

7.2 Marine Layout of the Port

The mathematical model studies undertaken on the recommended layout confirms that the proposed layout provide adequate tranquillity within the harbour for round the year operations. The following observations are made with reference to the impact of the proposed port:

- The existing south breakwater already diverts the finer sediment offshore and therefore any additional impact on the shoreline immediately to the north due to the proposed new harbour is not expected.
- Coarser sediment fractions (say 0.3-0.5mm) are likely to continue accreting to the south of the new South Breakwater which is the same as the present day situation. The proposed sand trap is sized 300m x 700 m and it is expected to intercept significant quantity of the littoral movement. The proposed dredged level of sand trap is about -15 m CD so that it can hold about 1.0 million of material and thus requiring only annual maintenance.
- Finer sand fractions can be carried in suspension and will therefore be diverted further offshore by the new South Breakwater. Some of this material will settle on the sea bed and some is likely to settle in the new approach channel.
- Though some of the berths of future phases are aligned perpendicular to the predominant wind direction, it is unlikely to have any impact on the operability as the wave conditions at those berths are absolutely tranquil.

7.3 Layout of Onshore Facilities

The main consideration, in locating the facilities has been to have segregation of operation/ handling areas. The buildings catering to port operations, 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 bulk stackyards of export due consideration has been given to the geometric requirement of providing the rail loop. The bulk import yard has been planned in the area allocated previously to western dock.

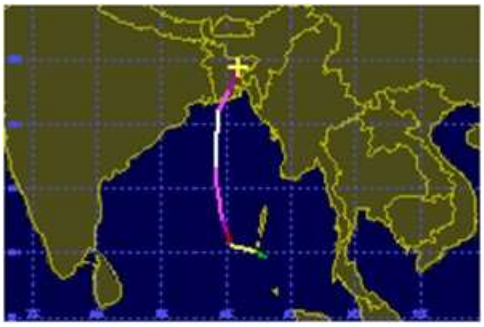
7.4 Breakwaters

7.4.1 Basic Data for Breakwaters Design

7.4.1.1 Cyclonic Storms and Extreme Wave Conditions

Cyclonic data from the IMD was screened for almost 33 years starting from 1978 to 2011 and 12 most sever cyclones that passed near the proposed port location have been selected for hindcasting. Storm tracks and synoptic charts (pressure charts) were collected for these cyclones.

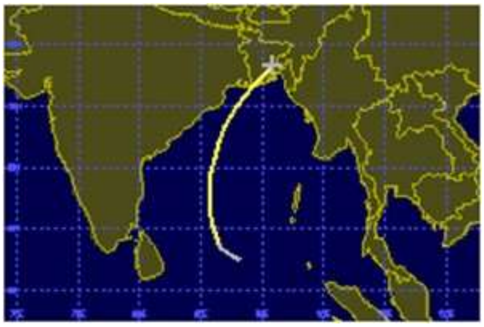
Figure 7.19 shows storm tracks used in the analysis for the some of the cyclones.



Cyclone Track Dated Nov 10-16, 2007

Cyclone Track Dated Oct 25 – Nov 3, 1999

Cyclone Track Dated Apr 22 - 30, 1991



Cyclone Track Dated Dec 5 - 9, 1973

Figure 7.19 Cyclone Tracks used for the study

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 7.20 provides the significant wave height near the port location due to the 1999 super cyclone.

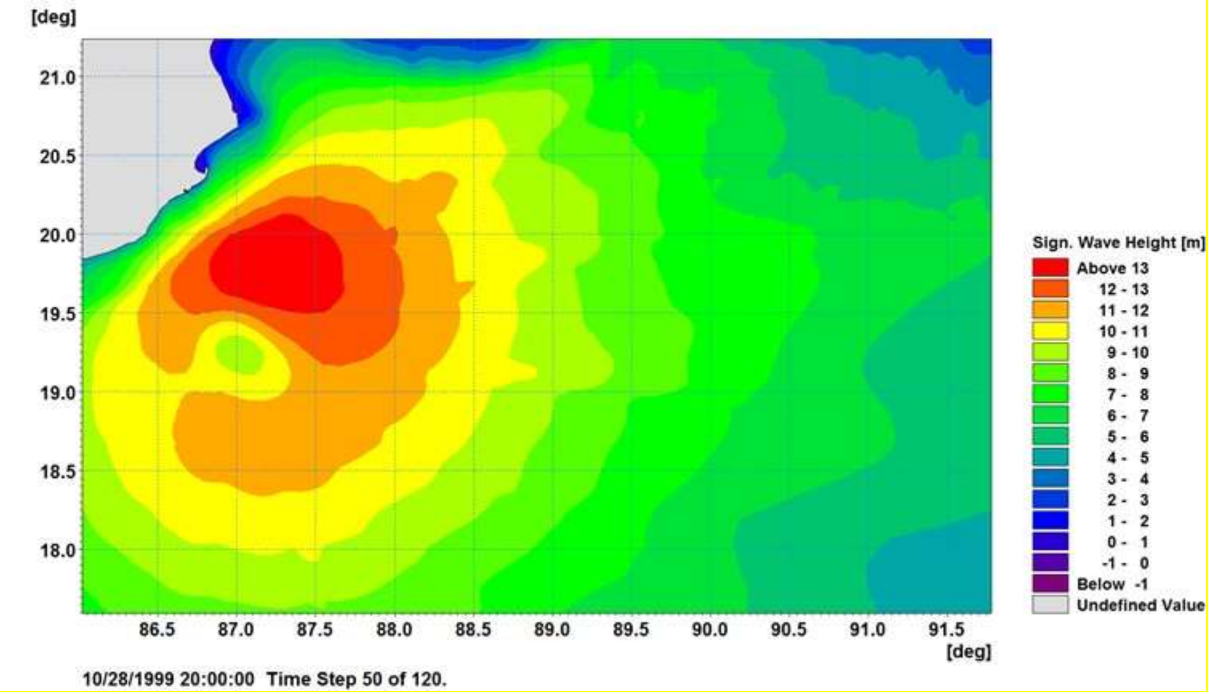


Figure 7.20 Significant Wave Height for cyclone of 1999

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, 13.5, 15 and 20 m depths.

The most server cyclone during 1999 provided maximum significant wave height of 5.4 m and 5.9 m at 13.5 and 15 m depth respectively (**Table 7.3**).

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

S. No.	Cyclone	Significant Wave Height (m)				
		5m	10m	13.5 m	15m	20 m
1.	10-16 Nov, 2007	4.0	4.4	4.6	5.1	5.9
2.	25 Oct - 3 Nov, 1999	4.5	5.0	5.4	5.9	7.7
3.	15-18 Oct, 1999	3.9	4.3	4.5	4.8	5.2
4.	16-23 Nov, 1998	2.9	2.9	3.0	3.3	3.7
5.	13-20 May, 1997	2.8	2.7	2.7	2.9	3.1
6.	18-25 Nov, 1995	3.6	3.7	3.8	4.0	4.6
7.	26 Apr- 3 May, 1994	2.9	2.8	2.8	3.2	3.3
8.	22-30 Apr, 1991	3.4	3.6	3.7	4.2	4.7
9.	21-30 Nov, 1988	3.5	3.6	3.6	4.0	4.7
10.	Dec 5-10, 1981	3.1	3.1	3.1	3.4	4.0
11.	23-28 Nov, 1974	2.7	2.6	2.6	2.8	3.0
12.	Nov 3-9, 1973	1.9	1.9	1.9	2.1	2.4

Based on the wave heights estimated at 5, 10, 13.5, 15 and 20 m contour, extreme value analyses was carried out to find out wave height for extreme conditions for various periods of return (**Table 7.4**).

As may be seen for 100 years, the estimated wave height for 100 years return period is 7.5 m at 13.5 m contour, where proposed breakwater are to be constructed.

Table 7.4 Significant Wave Height for Extreme Condition for various Return Periods

Return Period	5 m	10 m	13.5 m	15 m	20 m
10	4.80	5.47	5.98	6.51	8.02
25	5.21	6.01	6.61	7.22	8.98
50	5.51	6.41	7.07	7.73	9.67
100	5.80	5.47	7.52	8.23	10.34

7.4.1.2 Storm Surge Analysis

The term storm surge is used to indicate rise in water level over and above normal water level due to the action of storms. Reliable estimates of water level changes under storm conditions are essential for the planning and design of coastal engineering works. The surge consists of two parts, i.e., water setup due to wind stress and inverted barometric effect during cyclonic conditions.

In order to find out storm surge at the port location, MIKE 21 HD was setup with wind and pressure forcing as used in cyclonic wave generation and estimated storm surge for various events at various depths are presented in **Table 7.5**.

Table 7.5 Storm Surge/ Water Level during Extreme Conditions near the Proposed Port Location

S. No.	Cyclone	Water Level / surge (m)			
		10m	13.5 m	15m	20 m
1.	10-16 Nov, 2007	0.27	0.26	0.23	0.15
2.	25 Oct - 3 Nov, 1999	0.49	0.50	0.45	0.26
3.	15-18 Oct, 1999	0.10	0.09	0.08	0.06
4.	16-23 Nov, 1998	0.11	0.10	0.10	0.08
5.	13-20 May, 1997	0.22	0.22	0.21	0.13
6.	18-25 Nov, 1995	0.25	0.25	0.24	0.16
7.	26 Apr- 3 May, 1994	0.21	0.20	0.18	0.11
8.	22-30 Apr, 1991	0.27	0.25	0.21	0.14
9.	21-30 Nov, 1988	0.13	0.13	0.12	0.11
10.	Dec 5-10, 1981	0.13	0.12	0.13	0.16
11.	23-28 Nov, 1974	0.09	0.09	0.08	0.07
12.	Nov 3-9, 1973	0.09	0.08	0.08	0.07

The surge values estimated for various cyclones are further subjected to extreme value analyses to calculate water levels for 100 years return at various depths. The storm surge for 100 years of return period has been estimated to be 1 and 0.92 at 10 and 13.5 m depth respectively (**Table 7.6**).

Table 7.6 Significant Wave Height for Extreme Condition for various Return Periods

Return Period	10 m	13.5 m	15 m	20 m
10	0.56	0.54	0.49	0.29
25	0.72	0.69	0.62	0.37
50	0.83	0.80	0.73	0.43
100	1.01	0.92	0.83	0.50

7.4.1.3 Design Wave Height

The estimates derived from the extreme value analyses of wave height during cyclonic conditions were found to be 7.5 at the tip of breakwater, i.e., 13.5 m. Thus, the significant wave height for the breakwater design is taken as 7.5 m.

7.4.1.4 Design Water levels

As per the EVA carried out, the storm surge of 1.0 m has been calculated at the site at 13 m contour. 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 +3.58 m CD (Mean High Water Springs i.e. +2.58 m CD plus 1.0 m storm surge), as the design high water level for the breakwater design.

- Other Design Assumptions
- Stones up to 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.

7.4.1.5 Design Wave Height

The extreme wave conditions at the project site are given in **Table 7.3** 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 7.4.1.1

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

7.4.1.6 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.

7.4.1.7 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 Core-loc or Xblock.

7.4.2 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 years 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 7.7 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-POH1011**.

7.4.3 Geotechnical Assessment of Breakwaters

The seabed level at the breakwaters varies from +3.0 m CD nearshore to a maximum of -14.0 m CD. The crest level of breakwater at the maximum depth is about +9.0 m CD.

The stability of the breakwater foundation needs to be analysed for the subsoil conditions. This would be more relevant for the sections in deeper water. Based on the existing port data on soil type as silty sand up to -10 m CD with under layer of silty clay with sand up to -17 m CD and therefore likely to provide reasonably good founding strata for the breakwater. There is unlikely to be requirement for any soil replacement which would increase the cost estimates for breakwater significantly though wider toe may need to be provided at some locations to provide stability. However any shortfall in the stability found at the detailed engineering stage could be managed by increasing the toe width and/or depth.

7.4.4 Rock Quarrying and Transportation

7.4.4.1 Location of Quarries

Existing quarry sites are located at Chandikhol and Daitari which are around 90 km and 180 km away from the proposed port location respectively as shown in **Figure 7.21** and **Figure 7.22** below.

Figure 7.21 Quarry Location with respect to Paradip Port

Figure 7.22 Existing Quarry Site in Chandikhol and Daitari

7.4.4.2 Transport to Site

The proposed quarry site is located at about 90 km from port location. The quarry material will have to be transported in through dumpers. The rock material for the maintenance of exisitng breakwaters and their extension was is also sourced from these quarries.

7.5 Berthing Facilities

7.5.1 Location and Orientation

The location and orientation of the proposed berths is shown **Drawing DELD15005-DRG-10-0000-CP-POH1008**. As all the berths proposed in initial phase are only bulk berths, the contiguity to the shore is not needed. It is therefore proposed that the berths are located away from the backup area and connected by means of an approach trestle. This would have an advantage of constructing berth independent of the construction of reclamation and revetment.

The bulk export berths shall be oriented at 63° N and that import berths as nearly perpendicular to these at 150°N.

7.5.2 Deck Elevation

The deck elevation of the berths has been fixed at +6.0 CD. This deck elevation will prevent the waves slamming the deck during cyclones. This level will also ensure adequate clearance to the deck during operational wave conditions.

7.5.3 Design Criteria

7.5.3.1 Design Ships

The structural design of the berths shall be carried out 200,000 DWT ships.

7.5.3.2 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -20.5 m CD.

7.5.3.3 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
    - *Loads due to Gantry type unloaders with rail centres at 20 m c/c on import berth*
    - *Loads due to Gantry type loader with rail centres at 20 m c/c on export 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 below:

Table 7.8 Details of Berthing Energy, Fender and Berthing Force applied at Berths

Parameters	Value
Berthing Energy	2975 kNm
Fender	Trellborg Cell Type Fenders SCK 2500H E1.1 or equivalent
Rated Berthing Force	2711 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.

7.5.3.4 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.

7.5.3.5 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.

7.5.4 Proposed Structural Arrangement of Berths

7.5.4.1 Bulk Export Berths

The access from berth to the backup area is provided through a 20 m wide approach trestle. 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-POH1012** and **Drawing DELD15005-DWG-10-0000-CP-POH-1013** present the general arrangement and cross section of bulk export 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 the two bulk export berths is taken as 700m.

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 6.0 m c/c in the longitudinal direction. The piles will be founded in dense clay at levels beyond 40 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 loaders. A 300 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 conveyor supports are provided in the rear side of the berth at a spacing not exceeding 24 m.

7.5.4.2 Bulk Import Berth

The structural arrangement of the bulk import berths as well as the orientation shall be similar to the export berths. The overall length of the import berth shall be 350 m.

Drawing DELD15005-DWG-10-0000-CP-POH-1014 and **Drawing DELD15005-DWG-10-0000-CP-POH-1015** present the general arrangement and cross section of import berth.

7.6 Dredging and Disposal

7.6.1 Capital Dredging

The capital dredging for Phase 1 of the port development is estimated to be around **21.2 million cum**. The soil is likely to comprise of loose to dense fine sand. At some area silty clay is also expected. Nearly half of the dredged material shall be used for reclamation and balance shall be disposed off at a suitable location offshore at about 30 m contour.

7.6.2 Maintenance Dredging

Based on the mathematical model studies the annual siltation at the harbour and approach channel (including that of the common channel) is estimated to be about 3.6 million cum.

However, as the total littoral transport of about 1.0 million cum per annum from south to north would be obstructed by the south breakwater, this shall result in accretion on the south of the south breakwater. Most of the material shall be accumulated in the proposed sand trap from where it could be periodically dredged and transported to nourish the shoreline to the northern side of the port. Therefore the total annual maintenance dredging at the port is expected to be about 4.6 Mcum.

7.7 Reclamation

It is proposed that initially only the area behind the bulk export berths shall be reclaimed to provide the space for laying the railway loop and storage of cargo.

The required reclamation quantity of **10.0 Mcum** in Phase 1 development can be carried out using suitable material obtained out of capital dredging. 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 using 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 +3 m above CD. Between the elevations +3 to +5.7 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. The ground improvement of the reclaimed area would be carried out using band drains and placing of surcharge as per design requirements.

The typical cross section of reclamation bund is as shown in **Drawing DELD15005-DWG-10-0000-CP-POH1016**

7.8 Material Handling System

7.8.1 Bulk Import System

7.8.1.1 General System Description

A fully mechanized ship unloading system is planned at the bulk import berth. The system is designed for a rated capacity of 4,400 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 6,600 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
- Rapid Loading System
- Connected Conveyor system

7.8.1.2 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.

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.

7.8.1.3 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 4,400 TPH with capability to be upgraded to 6,600 TPH in the later stages.

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.

7.8.1.4 Stacking and Reclaiming

It is proposed to provide two stacker-cum-reclaimer units at the stackyard. One of the equipment shall be used to receive coal from the ship and stacking in the yard and simultaneously other equipment can be utilised to reclaim the coal from stackyard for transfer 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, with capability to be upgraded to 6,600 TPH in the stacking mode in the later stages.

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 and 50 m wide stockpiles.

Figure 7.24 Typical Stacker cum Reclaimer

7.8.1.5 Wagon Loading

It is proposed to provide rapid loading system for loading of the rakes. The system comprise of one concrete/steel silo with a capacity to hold 800 T of coal fed from the stackyard by a conveyor system. The cylindrical shaped silos have a conical discharge chute with gate system, load cells to automatically discharge coal/limestone into a moving rake. The silos have necessary chute level sensors, heat sensors, and raw water sprinkling system for efficient, safe and clean operations.

Figure 7.25 Typical in-motion Wagon Loading System

The diesel loco hauls the empty rake through the railway balloon loop, which passes under the silos. As the first wagon of the empty rake which is in motion comes under the silo discharge chute, the wagon loading starts through the chute with the quantity of loading automatically getting controlled by load cells and the speed of movement of the rake. The diesel locos and track side equipment with creep control devices provided for maintaining slow speeds required will ensure correct loading of each wagon.

7.8.1.6 Bulk Import Stackyard

The stackyard for the bulk import cargo has been planned at the area allocated for western dock development about 3.0 km away from the proposed berth. It is proposed to provide three rows of stockpiles, each of total length of about 800 m, for the storage of bulk import cargo. The outer rows of stockpiles shall be 50 m wide and that the inner one is proposed to be 85 m wide. To allow storage for various users and various grades each row of stockpile shall be split into about 4 nos. of smaller stockpiles. With the proposed arrangement about 1.03 MT of coking coal could be stored in the bulk import stackyard.

7.8.2 Bulk Export System

7.8.2.1 General

The bulk export system, on each berth, shall have the design capacity of 5000 TPH for loading coal to the ships. The details of the bulk export system at two berths for loading the thermal coal broadly consists of the following:

- Two track hoppers of separate rail track for unloading two rakes simultaneously of BOBRN wagons bringing thermal coal to port. Each track hopper is designed to unload coal from 6 wagons simultaneously so as to enable unloading a complete rake within a period of 1 hour.
- Two Conveyors from track hoppers complex shall carry the coal to the stackyard proposed to be located within the rail loop.
- Two Stacker cum Reclaimer units at the stackyard shall be used for stockpiling of coal unloaded from wagons and conveyed through conveyors, with the machines working in stacking mode
- Additional two Stacker cum Reclaimer units shall be used in the reclaiming mode to reclaim the coal from stackyard and transfer to conveyor for carrying it to the respective ship loader.
- Two ship loaders, one on each berth, shall be used loading of coal from the shipping conveyors into the ship’s holds.
- The system also includes a “Balloon loop type railway system” for taking the unloaded empty coal wagons directly to the rapid loading silos after passing through cleaning station in between

A summary of the details of the Track hoppers, Stacker cum Reclaimer units, Conveyors and Ship Loaders are given in paragraphs below.

7.8.2.2 Track Hoppers

The train with BOBR Wagons with engine on, move over the hopper at controlled speed and as the wagon door gets exactly positioned over the hopper, they open up discharging over the contents into the hopper.

The BOBR wagons have bottom discharge doors which are pneumatically operated. The door-opening mechanism is triggered by line side devices running on a 24V or 32V DC source. As the wagons in a rake pass by the triggering devices, their doors open and their contents are unloaded into the hopper below the tracks. There are different variants in BOBR wagons with different height, holding capacity, based on the number of doors like 12 doors or 8 doors and with different types their opening and closing. But typically the bottom discharge doors have double link mechanism operated by pneumatic system with compressed air supply from loco. The wagons have also provision for external compressed air supply with input through quick coupling & double check valve. The external system is used in case of unloading BOBR wagons by indexing system which means that the wagons are exactly positioned on the track hopper and stopped when the door opening mechanism is operated by manual connection of external pneumatic supply to the wagons. The wagons are allowed to move out only after complete unloading of wagon contents into the hopper, from where it is conveyed through a series of conveyors to the stackyard. The rake is then moved to index the next set of wagons to position themselves on the hopper. A BOBR rake with a creep control speed of 0.2 m/s will ensure unloading of full rake in one hour.

7.8.2.3 Stacker cum Reclaimer Units

The stacker cum reclaimer shall have the rated capacity of capacity of 4000 TPH in stacking mode and 5000 TPH in reclaiming mode. The machine is designed to handle a stockpile of 15 m height. The length of boom (Slew centre to bucket wheel centre) is proposed to be 45 m. The machine runs on rails with a gauge of 10 m, so as to allow two conveyors underneath, and has provision for travel for a distance of about 1100 m covering the full length of stackyard.

7.8.2.4 Ship Loader

The loading of thermal coal from shore to ship is affected by a single ship loader having a rated capacity of 5000 TPH designed for handling vessels in the range of 60,000 to 200,000 DWT. Though smaller vessels up to 10,000 DWT could also be used at lower efficiency owing to the need for adjustment to the boom of the loader to cover smaller hatches of these ships, there will also be mismatch between the design capacity of the loader as against the maximum rate at which the cargo could be received by smaller ships due to requirement of maintaining even keel. The ship loader is proposed to be travelling, luffing, shuttle boom type with a travelling tripper car. The loader through its tripper is fed by the berth conveyor located in the rear of the berth.

At the discharge end of the ship loader boom a discharge chute with a spout to load the material into the ship's hold is provided to reduce the height of free fall to enable containing of dust generated. At the discharge end of the spout a spoon capable of tilting shall be provided for deflecting the material to the extreme ends particularly during final trimming operations.

Figure 7.26 Typical Ship Loader

The transfer shuttle of the boom conveyor enables telescopic traversing of the same to handle the range of vessels with different beam sizes. The ship loader shall move on a rail gauge of 20 m to cover the length of the ship.

7.8.2.5 Bulk Export Stackyard

The stackyard for the bulk export cargo has also been planned within the rail loop, by the side of the bulk import yard. The proposed arrangement would be exactly similar to that for the bulk import yard. However considering the bulk density of thermal coal being higher than the coking coal, about 1.7 MT of Thermal coal could be stored in the bulk import stackyard.

The typical export and import stackyard is as shown in **Drawing DELD15005-DRG-10-0000-CP-POH1017**.

7.9 Road Connectivity

7.9.1 External Road Connectivity

The external road connectivity to reach the proposed outer harbour would be same as is being used for the existing port i.e. the NH5A. The stretch of existing road from the proposed outer harbour site requires to be widened to cater the seamless movement of port traffic.

7.9.2 Internal Roads

The main approach road to the proposed outer harbour of Paradip port shall be in north south direction. There is already an existing road which would be utilised. The width of the existing road is about 7m and is adequate considering the receipt and evacuation of proposed cargo for the outer harbour of Paradip port shall be mainly by rail. However, with the commissioning of clean cargo berth, traffic on this road is likely to increase necessitating widening.

7.10 Rail Connectivity

7.10.1 External Rail Connectivity

The rail connectivity for the proposed port shall be tapped off from the Paradip station. Two rail line shall be taken initially parallel to the main line and thereafter turn towards the site. It is proposed to develop a separate rail yard at the location, with 6 holding lines initially, where Golf club exists at present.

7.10.2 Internal Rail links

The internal rail lines will be developed so that after the rakes are unloaded at the track hoppers they could be taken straight to the wagon loading system without loco shifting and reversing the rakes. The main rail lines would form a loop at the port backup for nonstop movement of incoming and outgoing rakes.

7.11 Port Infrastructure

7.11.1 Electrical Distribution System

7.11.1.1 Introduction

The handling systems for bulk loading and unloading are power intensive and hence require considerable high tension electrical power for their operation. 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. The various terminals within port will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

7.11.1.2 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 40 MVA over the proposed master plan horizon.

7.11.1.3 Source of Power Supply

Power supply to the Paradip Outer Harbour can be tapped from the existing Paradip Gara substation. The substation has a capacity of 18 MVA which may be enhanced to 80 MVA to cater the outer harbour requirement. Currently, maximum power demand at the port is around 15 MVA which leaves 3 MVA of surplus spare capacity. It is proposed that the existing transmission lines be tapped off and extended up to the proposed location of the main receiving substation.

7.11.1.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the boundary of the proposed outer harbour, where the main 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.

7.11.1.5 Distribution of Power

11 KV feeders from main receiving substation will feed to two secondary substations; one for the bulk import terminal and other for bulk export 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.

7.11.1.6 Standby Power Supply

It is proposed to install one diesel generator of 2 MVA at each of the two substations. This would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

7.11.1.7 Illumination

The illumination level in various areas will be maintained as per the industry standards and shall generally be as in **Table 7.9** below:

Table 7.9 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.

7.11.1.8 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.

7.11.1.9 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.

7.11.1.10 Power Factor Improvement

Suitable rating HT capacitors with automatic power factor correction arrangement will be installed to maintain the overall power factor correction to 0.97.

7.11.2 Communication System

7.11.2.1 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.

7.11.2.2 Telephone System

To meet the total port requirements, an EPABX of 100 lines capacity will be installed. Suitable telephone instruments to suit the site requirement with adequate protection will be provided.

7.11.2.3 Radio Communication

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

7.11.2.4 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.

7.11.3 Computerized Information System

7.11.3.1 Overall Objectives

The computerised information system proposed for Paradip Outer harbour 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.

7.11.3.2 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
- Operations Equipment Control (OEC)
- Cargo Control (CC)
- Yard Planning, gate delivery and receipt control
- Landside planning processes
- Enterprise Resource Planning

7.11.3.3 Technology Infrastructure

The IT Infrastructure of Outer harbour of Paradip 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.

7.11.4 Water Supply

7.11.4.1 Water Demand

The water demand for the Outer Harbour of Paradip Port has been worked out in the **Table 7.10** below:

Table 7.10 Estimated Water Demand for Outer Harbour of Paradip Port

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	1,458	5,167
2.	Potable Water (KLD)	260	675
	Total Water Demand at Port (KLD)	**1,719**	**5,842**

7.11.4.2 Sources of Water Supply

The water requirement for the Paradip outer harbour shall be sourced from Taldanda Canal from where the supply to the existing port is also being provided.

7.11.4.3 Storage of Water

The water supply from the main header shall be fed to the underground water tank of 2000 cum located near the current shoreline which is equivalent to about 1 day 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).

The water from the main sump would be pumped to secondary sump of 600 cum capacity located near the stackyard within the rail loop. The sump shall be split into three compartments of 100 cum, 300 cum and 200 cum. The compartment of 100 cum will retain water permanently for firefighting; the compartment of 300 cum will be used for water supply to buildings, ships and greenery, where a small filtration unit shall be provided. The third compartment of 200 cum will provide water for dust suppression system in the bulk terminal.

Another water sump of total 300 cum with 3 compartments shall be provided near the bulk import stackyard in the western dock area to serve the needs for fire-fighting, dust suppression and potable water supply.

7.11.5 Drainage and Sewerage System

7.11.5.1 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 stackyard within the loop, the drainage system would comprise of open drains for taking the discharge to the settling pond, also located within the rail loop. 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.

7.11.5.2 Solid Waste Management

For the buildings complex having administration building and port user buildings, a small sewage treatment plant of 10 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 berths and hence separate treatment proposals are not contemplated.

7.11.6 Floating Crafts for Marine Operations

7.11.6.1 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, including tug for standby/ emergency.

7.11.6.2 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.

7.11.6.3 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.

7.11.6.4 Harbour Crafts

The requirements of Harbour Crafts for the first phase of the Paradip Outer harbour development are given in **Table 7.11** below.

Table 7.11 Harbour Crafts Requirements

S. No.	Harbour Craft	Number
1.	Tugs 50 T bollard pull	4
2.	Pilot cum Security Vessels	2
3.	Mooring Boats	2

7.11.7 Navigational Aids

7.11.7.1 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 at the berths. 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.

The layout of navigational aids to be provided for the proposed port is shown in **Drawing DELD15005-DRG-10-0000-CP-POH1018** and is detailed below:

7.11.7.2 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 mile. In addition some buoys are proposed in the respective harbour basins as well. IALA maritime buoyage system as per region A, in which Outer Harbour of Paradip Port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

7.11.7.3 Leading / Transit Lights

Considering the channel being 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.

7.11.7.4 Beacons / Mole Lights

One Beacon at each breakwater head would be provided.

7.11.7.5 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. 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

In case of outer harbour of Paradip Port, the service area will be the approach channel, the anchorage area, the harbour basin etc. As part of the anchorage areas and part of the approach channel are common with the existing port, it is proposed that the existing VTMS system at the Paradip port shall be utilised. Only a slave station at the control room of the proposed port shall be provided which shall be linked to the main VTMS.

7.11.8 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.

7.11.9 Fire Fighting System

7.11.9.1 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.

7.11.9.2 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
- Track Hoppers
- 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

7.11.10 Pollution Control

7.11.10.1 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

7.11.10.2 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.

The following Dust Suppression System has been planned for the bulk handling facilities:

Table 7.12 Dust Suppression System

S. No.	Facilities	Dust Suppression System
1.	Ship Unloaders and Loaders	Plain water fine spray with medium pressure standard hydraulic system using raw water.
2.	Stacker cum Reclaimers	Plain water fine spray with medium pressure standard hydraulic system using raw water.
3.	Coal Stackyard	Swiveling plain water sprinklers for abatement of coal dust generation along the length of the stockpile.
4.	Transfer Towers	Plain water fine spray nozzles for dust suppression of airborne dust at the conveyer discharge and receipt points.

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 South Paradip. 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

Paradip is a Municipal city in district of Jagatsinghapur, having a population of 68,585, out of which 37,300 are males while 31,285 are females as per Census of India, 2011. Literacy rate of Paradip city is 85.93 % where about 90.25 % males are literate as against only 81% females.

The proposed Greenfield port is planned to be developed on the south of existing Paradip Port. It is proposed that existing south breakwater of Paradip port will be extended to develop North breakwater of the new port and a water front of about 3000 m will be used for development of berths and other facilities. In order to avoid any rehabilitation issue the port will be limited just before the fishing village Sandkut on the south.

8.3 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 5 MTPA.	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, GoO

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
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, GoO; 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	Odisha 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	Odisha Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Odisha 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.	Odisha Pollution Control Board
11.	Mines and Minerals (Regulation and	• Permission of mining of aggregates and sand	Yes, mining of borrow material to	Department of Mines, GoO

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
	Development), Act, 1952, 1996		be undertaken.	
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.

8.4 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. • Construction of breakwater	• 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. • Shoreline changes	• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• Contamination of water due to spillage

Environmental aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	**Potential Impacts**	**Activities**	**Potential Impacts**
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	• 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	• 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	• Increase in noise
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	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities

Environmental aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	Potential Impacts	Activities	Potential Impacts
		and utilities for rail and road development • Increased traffic movement • Occupation health issues		• Reduction in fish catch. **Positive Impacts** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

8.5 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.

8.5.1 Impacts on Land and Soil

The proposed port is located within the existing Paradip port limit and all the land used for the provision of facilities belongs to the Paradip Port. Moreover, the proposed port is planned on reclaimed land between shoreline to 10 m depth. Moreover, present road and railway connectivity will be augmented to support new development.

The anticipated impact during construction 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.

- 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 of through municipal facility.

8.5.2 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. At present for Paradip Port water is sourced from the Taldanda Canal and the same source is planned to be used to supply for the new port also. All the required permissions from the state authorities will be sought for 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:

- 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 vans.
- 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 to avoid water stagnation/ ponding near work and camp sites to curb vector borne diseases;
- Fuel/ oil storage will be sited away from any waterbodies; 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 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.

8.5.3 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 Odisha 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.

8.5.4 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.

Mitigation Measures

- 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;
- 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.

8.5.5 Impacts on Ecology

As mentioned, no land is required for the port as reclaimed land will be used for the entire development. Thus, no tree cutting is envisaged towards land side except a tract of few Casuarina trees that have been planted by the State forest department on the coast.

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 dredging and development of 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.

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.
- 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.

8.5.6 Impact on Social conditions

Care has been taken to avoid any disturbance to the fishermen colony on the south of the proposed development. However, it is important to mention that entire fishermen colony is on the port land and is been illegally encroached by the habitants.

No land and loss of livelihood is anticipated for the provision of rail and road connectivity and current port land will be used for this purpose.

8.6 Impacts during Operation Phase

8.6.1 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 stackyard; (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

- A sewage treatment plant will be provided to treat all the waste that is expected to be generated due to port operations and living quarters.
- 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 South Paradip Port area for prevention of marine pollution.

8.6.2 Impact on Air Quality

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

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

Mitigation Measures

- As such, a system consisting of pumps, storage tank, and 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.

8.6.3 Impact on Noise Quality

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, and 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.
- 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.

8.6.4 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.

8.6.5 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.

8.7 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

8.8 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 $ = INR 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. The same is furnished below in **Table 9.1**. The capital costs given for each phase are for the facilities created during that particular phase only.

Table 9.1 Block Capital Cost Estimates

S. No.	Item	2021	2026	2031	2036
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	25	6	5	5
2.	DREDGING AND RECLAMATION	836	157	59	220
3.	BREAKWATER AND REVETMENT	1,285	-	18	92
4.	BERTHS	315	231	316	418
5.	BUILDINGS	44	11	48	30
6.	STACKYARD AND OTHER BACKUP AREA	72	43	9	24
7.	ROADS AND RAILWAY	134	41	56	117
8.	EQUIPMENTS	739	419	473	1,015
9.	UTILITIES AND OTHERS	177	52	55	71
10.	NAVIGATIONAL AIDS	8	-	0	0
11.	Total (1+2+3+4+5+6+7+8+9+10)	**3,634**	**959**	**1,039**	**1,991**
12.	Contingencies @ 10%	363	96	104	199
13.	Engineering and Project Management @ 5%	182	48	52	100
Incremental Capital Cost (Rs. In Crores)		**4,179**	**1,103**	**1,195**	**2,290**

These capital cost estimates do not include the following:

- Cost of land acquisition as it is informed that the required land for the port development including the rail and road connectivity to site is already available with the Paradip Port.
- 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.

9.2.2 Repair and Maintenance Costs

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

- 5% of 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 200 increasing to about 700 in the master plan 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

The operation costs for the equipment run by electrical power have been calculated based on the maximum throughput and utilisation of the equipment. 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 Firefighting & Pollution Control - 3% per annum

9.2.5 Annual Operation and Maintenance Costs

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

Table 9.2 Annual Operation and Maintenance Costs

S. No.	Item	2021	2026	2031	2036
1.	REPAIR AND MAINTENANCE COSTS	67.8	28.2	30.9	62.3
2.	OPERATION COSTS	157.3	28.9	47.6	65.3
3.	**TOTAL**	**225.1**	**57.1**	**78.5**	**127.6**
4.	Contingencies @ 10%	22.5	5.7	7.8	12.8
5.	Administrative Expenses @ 5%	11.3	2.9	3.9	6.4
Incremental O & M Costs (Rs. In Crores) per annum		**258.9**	**65.6**	**90.3**	**146.7**

9.3 Implementation Schedule for Phase 1 Port Development

9.3.1 General

The main components for the Development of Outer Harbour of Paradip 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 Breakwaters

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, dredging and reclamation have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 8.6 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 90 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 up to 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 breakwaters could be completed in a period of about 45 months duly accounting for weather downtime.

9.3.3 Dredging and Reclamation

The overall dredging quantity is estimated to be about 21 Mcum. Once the breakwaters construction have reached 12 m contour, the dredging activity can commence and reclamation bunds shall be built to receive the suitable material from the dredging operations. The overall duration of the dredging and reclamation is expected to be 30 months.

9.3.4 Berths

As berths are not proposed to be contiguous to the land, construction of berths would be independent of the dredging. The construction of berths could be started either by launching the gantries from the shore or partly completed reclaimed area. However adequate breakwater shelter would be needed to avoid any downtime in construction. 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 24 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 Outer Harbour of Paradip port is likely to take over 48 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 Outer Harbour of Paradip Port is shown in **Table 9.3**.

Table 9.3 Implementation Schedule

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 Cost Estimates and Phasing

For the base case scenario of having two bulk export berths and one bulk import berth, the cost estimates as provided in **Table 9.1** have been considered. The operations and maintenance cost estimates as indicated in **Table 9.2** have been considered.

In addition another scenario of the Phase 1 port development was considered i.e. with only two export berths. The capital cost and annual O&M costs for this scenario are estimated as **3,529 crores** and **214 crores** respectively.

Phase 1 of port development is spread over 4 years with the investment phasing as 20%, 20%, 25% and 35% respectively for years 1 to 4. While the other phases of development are expected to take about 24 months with investment phase of 40% in first year and 60% in second year.

10.3 Tariff

For the purpose of this preliminary analysis, it has been assumed that the terminals in the proposed outer harbour charge all-inclusive tariff of INR 200 per tonnes, which is benchmarked with the applicable charges currently at existing port.

10.4 Financial Viability

The project IRR on the basis of the above assumptions works out to **21.5%** for the base scenario.

10.5 Alternative Scenarios

The following alternative scenarios of development have been considered to assess the impact on the viability of the Paradip Outer Harbour:

Scenario 1 - **Only Phase 1 port facilities are developed and there is no development in the subsequent stages**

Scenario 2 – **Only bulk export terminals are built and no facilities are provided for bulk import in Phase 1 and further there is no subsequent development beyond Phase 1.**

The project IRR for the scenarios 1 and 2 works out to **13.9%** and **14.5%** respectively, which is reasonably good.

11.0 Conclusions and Recommendations

11.1 Project Assessment

The proposed Outer harbour of Paradip Port project is technically and financially suitable to be taken up development. In terms of its ability to provide modern handling facilities and capacity to handle fully loaded capesize ships, it has a potential to attract customers.

Considering the significant potential for the coastal coal export in the near terms the project needs to be taken up on priority so as not to lose the market share to its competitors.

11.2 Alternative Means of Project Development

11.2.1 Option 1 – By Project Proponents

In this option the project shall be executed by the public sector entity i.e. (Paradip Port Trust and/or State Government/Coal India), who shall also arrange funds for the project financing, manage and operate the port.

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 with the existing Paradip Port. 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. The government agency will be directly responsible for 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.

11.2.4 Recommended Option

1. The proposed Outer Harbour shall be set up as a Satellite port of Paradip Port, as a major port under Indian Companies act 2013 and will not be governed under Major port trust act 1963.

2. A Special Purpose Vehicle (SPV) shall be formed comprising of Paradip Port Trust and other government entities which may include Orissa State Government, Sagarmala Development Corporation, Coal India Limited etc. The exact composition of SPV and the % share of the entities could be decided once the decision to go ahead with the project is taken.

3. The proposed outer harbour is recommended be developed as per landlord model, where in the basic infrastructure in terms of Breakwaters, capital dredging, reclamation, access rail and road,

water and power connection, harbour crafts etc. shall be arranged by SPV. In addition SPV shall also be 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 Access Charges to Paradip Port Trust of the common facilities to be shared such as:
    - *Part of Approach Channel to port, which is common with the Paradip port*
    - *Utilisation of storage area for bulk import cargo, proposed at the western dock site location*
    - *Connection to water and power infrastructure.*
    - *Common rail facilities*
- Furnishing management information to the appropriate authorities and administering subleases for the various marine terminals leased to users, terminal operators as applicable.

4. The cargo handling terminals and associated facilities comprising of berths, stackyard development, equipment, utilities etc. will be developed with private participation on PPP mode. PPP Concessionaire would be responsible for terminal operations and maintenance and sharing of its revenue with SPV as per the concession agreement.

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

S. No.	Item	Port	Concessionaire
1.	PROJECT PRELIMINARIES AND SITE DEVELOPMENT	18	7
2.	DREDGING AND RECLAMATION	730	106
3.	BREAKWATER AND REVETMENT	1,285	-
4.	BERTHS	-	315
5.	BUILDINGS	22	22
6.	STACKYARD AND OTHER BACKUP AREA	24	48
7.	ROADS AND RAILWAY	114	20
8.	EQUIPMENTS	-	739
9.	UTILITIES AND OTHERS	102	75
10.	NAVIGATIONAL AIDS	8	-
11.	Total (1+2+3+4+5+6+7+8+9+10)	**2,303**	**1,331**
12.	Contingencies @ 10%	230	133
13.	Engineering and Project Management @ 5%	115	67
Incremental Capital Cost (Rs. In Crores)		**2,648**	**1,531**

The process of Development of Outer harbour of Paradip Port 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. This report shall use the present TEFR as a base document and refine it further by:

    a. Carrying out marine geotechnical investigations

    b. Real Time Ship Navigational Studies

    c. Engineering of the Marine Structures, material handling system and onshore infrastructure to further refine the cost estimates

    d. Two and three dimensional model studies for design of breakwaters.

    e. Mathematical model studies on the updated layout, if any, for further optimisation. Apart from that model studies for dispersal of dredged plume at the proposed disposal site would be needed as per the requirement of MoEF.

    f. Updated financial analysis

2. Approvals from SFC/ EFC/ PIB/ PPPAC/ CCEA

3. Preparation of EIA report and approval of MoEF

4. Preparation of tender documents for Selection of contractors for the works to be undertaken by project proponents (PPT)
5. Start the construction of Breakwaters, reclamation, dredging and basic onshore infrastructure
6. Selection of Transaction Advisor and bidding for the selection of operator(s) for the terminal development
7. Terminal development works by the BOT operators
8. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

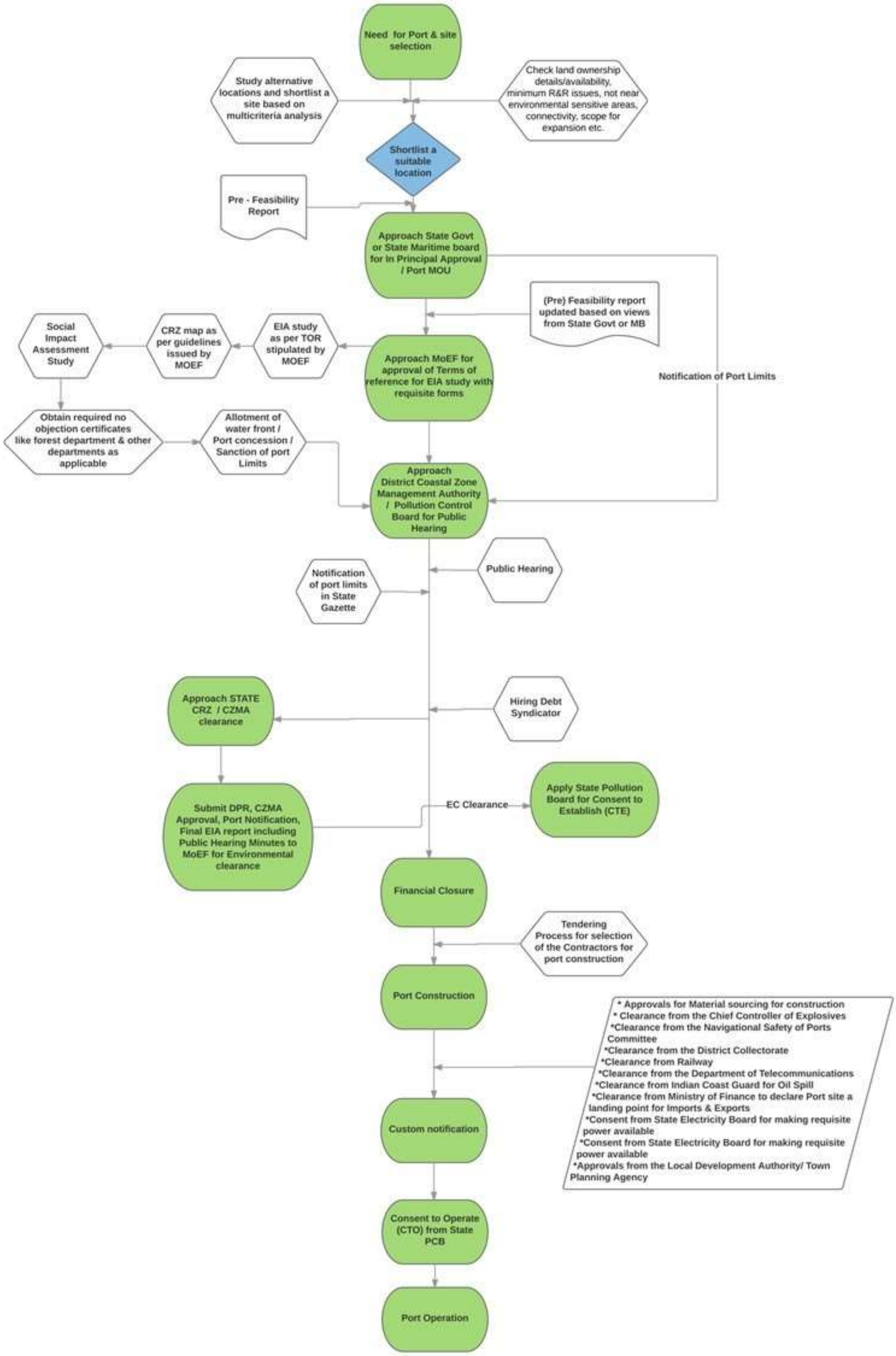


Figure 11.1 Process for the Greenfield Port Development