Detailed Project Report May 2013

DEVELOPMENT OF VIZHINJAM PORT

Detailed Project Report - Final

Prepared for

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Glossary

ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
APFC	Automatic Power Factor Correction
AtoN	Aids to Navigation
BMO	British Meteorological Office
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantities
BS	British Standards
CAPEX	Capital Expenditure
CBM	Cement Bound Material
CBP	Concrete Block Paving
CBR	California Bearing Ratio
CCTV	Closed Circuit Television
CD	Chart Datum
CESS	Centre for Earth Science Studies
CFO	Chief Financial Officer
CFS	Container Freight Station
CIRIA	Construction Industry Research and Information Association
CLC	Construction Logistic Centre
CLI	Concrete Layer Innovation
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
CSD	Cutter Suction Dredger
CSL	Cochin Shipyard Limited
CSR	Corporate Social Responsibility
CSS	Compact Substation
CY	Container Yard
DP	Dubai Ports
DPR	Detail Project Report
EAC	Environmental Appraisal Committee
EC	Environmental Clearance
ECH	Empty Containers Handlers
ECT	Europe Container Terminal
EDI	Electronic Data Interchange
EIA	Environmental Impact Assessment
EMC	Environmental Monitoring Cell
EMP	Environmental Management Plan
EOL	Engine on Load
EPC	Engineering Procurement Construction
eRMG	Electric Rail Mounted Gantry
eRTG	Electric Rubber Tired Gantry
FB	Fairway buoy
FLC	Fish Landing Center
FRM	Fertilizer Raw Material
FY	Fiscal Year

GDP	Gross Domestic Product
GIS	Gas Insulated Substation
GMB	Gujarat Maritime Board
GoK	Government of Kerala
GOS	Gate Operating System
GSB	Granular Sub Base
GSI	Geological Survey of India
GTA	General Terminal Area
HED	Harbour Engineering Department
HFO	Heavy Fuel Oil
HHWS	Highest High Water Spring
Hs	Wave Height Significant
HV	High Voltage
HWL	High Water Line
HYSD	High Yield Strength Deformed
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IAPH	International Association for Ports and Harbours
IBC	Inter Box Connector
ICD	Inland Container Depot
ICTT	International Container Trans-shipment Terminal
IFC	International Finance Corporation
IMD	Indian Meteorological Department
IMZ	Inter Modal Zone
INR	Indian National Rupees
IOCL	Indian Oil Corporation Limited
IRC	Indian Road Congress
ISC	Indian Sub Continent
ISPS	International Ship and Port Facility Security
IT	Informational Technologies
ITV	Internal Transfer Vehicles
IVT	Intra Terminal Vehicle
JTWC	Joint Typhoon Warning Centre
KLD	Kilo Liters per Day
KSEB	Kerala State Electricity Board
kW	Kilo Watts
LCL	Less than Container Load
LLWS	Lowest Low Water Spring
LNG	Liquefied Natural Gas
LOA	Length Overall
LTR	L&T Ramboll Consulting Engineers Limited
LV	Low Voltage
MARPOL	Marine Pollution, the International Convention for the Prevention of Pollution from Ships
MHHW	Mean Highest High Water
MHLW	Mean Highest Low Water
MLD	Million Liters per Day
MLHW	Mean Lowest High Water
MLLW	Mean Lowest Low Water

MoEF	Ministry of Environment & Forests
MSL	Mean Sea Level
MTPA	Million Tons per Annum
MVA	Mega Volt Ampere
NCEP	National Center of Environmental Prediction
NE	North East
NH	National Highway
NHO	National Hydrographic Office
NIOT	National Institute of Ocean Technology
NOx	Nitrogen Oxide
O&C	Opportunities and Constraints
PBX	Private Branch Exchange
PCC	Portland Cement Concrete
PIANC	Permanent International Association for Navigation and Congress
PM	Particulate Matter
POV	Personally Owned Vehicles
PPP	Public Private Partnership
PRECAP	Preliminary Capacity
PWD	Public Works Department
QC	Quay Crane
R&D	Receipt & Dispatch
R&R	Relocation & Rehabilitation
RCC	Reinforced Cement Concrete
RDT	Radio Data Transfer
REFCON	Reefer Control System
RFID	Radio Frequency IDentification
RH	Royal Haskoning
RMG	Rail Mounted Gantry
RMQC	Rail Mounted Quay Cranes
RPM	Radiation Portal Monitor
RS	Reach Stacker
RTC	Rail Transport Clearance
RTG	Rubber Tired Gantry
RVNL	Rail Vikas Nigam Limited
SAGT	South Asia Gateway Terminal
SEZ	Special Economic Zone
SF	Safety Factor
SOx	Sulfur Oxide
SPT	Standard Penetration Test
SPV	Special Purpose Vehicle
SSW	South-South West
STP	Sewage Treatment Plant
SW	South West
SWAN	Simulating Wave Near Shore
TEU	Twenty-foot Equivalent Unit
TGS	Twenty foot Ground Slot
TOS	Terminal Operating System

TSHD	Trailing Suction Hopper Dredge
UHF	Ultra High Frequency
UPS	Uninterruptible Power Supply
USA	United States of America
USACE	United States Army Corps Engineers
USD	United States Dollar
UTM	Universal Transverse Mercator
VAT	Value Added Tax
VDU	Video Display Unit
VISL	Vizhinjam International Seaport Limited
VTMIS	Vessel Traffic Management Information System
VTMS	Vessel Traffic Management System
WCIP	West Coast India Pilot
WGS	World Geodetic System
XLPE	Cross-Linked Polyethylene

1 Introduction

1.1 Project Background

Ports are one of the most crucial links in the development of a country's trade and its economy. This is self evident in the case of insular economies such as Hong Kong and Singapore or the United Kingdom. Even for continental economies like India, globalisation of trade is key to development of the economy. Since this trade is carried primarily by sea-borne vessels, port development gains strategic importance as the key to economic development.

India has an approximately 5,423 km long peninsular coastline and is located close to major shipping routes linking East Asia, Europe and the Middle East. India therefore has the potential to significantly grow it's maritime trade with other countries and as its economy grows, necessity of developing ports for international trade will also grow. Presently there are 12 Major Ports and 187 Non-Major ports in India. The Major Ports are all Government owned and handle around 64% of India's maritime trade.

The country's ports sector has witnessed strong growth over the past decade with total traffic handled by it increasing from nearly 300 million tonnes in FY01 to 883 million tonnes in FY11. The traffic-handling capacity of major ports increased at a CAGR of 7.3% during 2006–2011 to reach 645 million tonnes. During the same year, traffic handled at non-major ports grew at 8.6% year on year, largely due to the 12.4% year on year growth of Gujarat Maritime Board (GMB) ports.

The 12 major ports carry about 64% of the total maritime transport of the country. The share of non-major ports in cargo traffic has increased from less than 10 per cent in 1990 to the current levels of 36% due to congestion and inefficiencies at major ports and with development of minor ports by the respective states. There has been an impressive growth of about 11.6% per annum in container traffic during the five years ending 2010-11. The container trade went up to 10 million twenty-foot equivalent units (TEU) by 2012 from 2.47 million TEU in 2000.

Along its coastline of nearly 585 km, Kerala has one major port at Cochin and 17 non major ports. The non major ports are under the administration of Government of Kerala. Government of Kerala intends to provide a boost to coastal shipping with further development of ports, which will ease the burden on the heavily congested highways in the State apart from savings in transportation and social-emissions cost. Government, besides acting as a catalyst for establishment of new ship repair and ship building industries, also encourages other port based industries contributing to the development of ports. Currently, Kerala government is in the process of modernizing ports at Vizhinjam, Azhikkal, Beypore and Alappuzha.

The Government of Kerala (GoK) through its special purpose government company (SPV)-Vizhinjam International Seaport Ltd (VISL), is developing deep water Multipurpose Greenfield Port at Vizhinjam in Thiruvananthapuram, capital city of Kerala. The SPV is fully owned by the Government of Kerala.

The GoK through VISL, appointed the International Finance Corporation (IFC) as its Transaction Advisor to assist in the structuring and implementation of the Vizhinjam Port project and also to help organize a well structured and transparent bid transaction as the port was initially proposed to be developed based on PPP model. IFC with the help of Drewry Shipping's International, UK, carried out the market assessment and Royal Haskoning as their technical consultant to prepare preliminary project plan for the proposed development. Drewry in their studies indicated that because of a small immediate hinterland, the biggest potential for Vizhinjam project was to attract container transshipment traffic. However, because of the intense competition from the ports of Colombo and Vallarpadam terminal in Cochin and other ports, it was projected that Vizhinjam would need to aggressively price its container handling services to be able to attract traffic away from the competing ports.

The bidding for the project development took place for two rounds as part of the PPP process. In the first round in 2004, consortium of Kaidi Electric Power Private Ltd (lead), Zoom Developers Pvt. Ltd and China Harbour Engg was selected but could not get security clearance from the Government of India. In the second round in 2007, consortium of Lanco Kondapally Pvt Ltd (lead), Lanco Infratech Ltd and Pembinan Rezdai, Malaysia was selected. Prolonged litigation by one of the unsuccessful bidders against the evaluation of the bids eventually resulted in the winning bidder to withdraw after the letter of award was issued. In the latest round in 2010 based on "Landlord Port Model", out of the two bidders, only one consortium (Welspun Infratech Limited (India) (lead); Welspun Corp. Limited (India) and Leighton Contractors (India) Private Limited with no operator in the consortium) got security clearance. Later the Govt. cancelled the bid and decided to go for fresh bid after obtaining environmental clearance.

The proposed project is based on a Landlord Port Model[1], where all the civil work facilities viz., construction of basic infrastructure like breakwater, quay wall, dredging, reclamation, rail and road access to the Port will be developed by VISL. Port Operation will be through the PPP model for an agreed concession time period. Terminal operator(s) may be required to develop the container yard, terminal buildings, and purchase & operate the cargo handling equipments, depending on the final project structuring plan adopted by VISL. It is envisioned to develop this port incorporating the proven and cost effective Green Port initiatives in all aspects of construction and operation.

VISL have appointed AECOM to prepare the “Detailed Project Report” (DPR) for the Development of Vizhinjam Port as part of the EIA compliance and consolidate findings from various studies conducted in past and present.

1.2 Salient Features of Phase-1 Port Development

The port will be developed in three phases. Once fully developed, the Phase-1 of the port is envisioned to have,

- Breakwater of total length 3,180 (main breakwater 3,040m with 140m extension for fish landing harbour) to be developed in Phase-1.
- Container berth length of 800m capable of handling upto current largest 18,000 TEU container vessels.
- Container yard behind the quay length with depth of up to 500m.
- Port craft berth of 100m and Coast Guard berth of 120m length.
- Cruise cum Multipurpose cargo Berth of 300m length.
- Berthing and Storage/ operation facilities for Indian Navy with berth length 500m.
- Fish landing center with a total berth length of 500m.

The port is designed primarily to cater to the container transshipment business. Fish Landing berths and Cruise berth are being developed as part of CSR activities as an outcome of the ESIA study to improve the fisheries and tourism sector in the project vicinity.

The Navy and Coast guard berths are as per the requirements of the security of the country as desired by the Ministry of Defence, Government of India, considering the strategic location of Vizhinjam Port in the Indian Peninsula for combined operations of the Army & Air force stations located in Thiruvananthapuram, Kerala.

1.3 Setting of Port Location

The proposed port at Vizhinjam (Lat 8° 22’ N, Long 76° 57’ E) is located in India in the state of Kerala, at 16 km south of the State Capital, Thiruvananthapuram which falls in close proximity to the international East-West shipping route. The location of the port is as shown in Figure 1.1.

Vizhinjam port would be competing with Cochin and Tuticorin for its gateway containerized cargo; however, the port would primarily be competing with international ports like Colombo in Sri Lanka, Salalah in Oman and Singapore for container transshipment traffic. The natural water depth available at proposed Vizhinjam port is more than any competing Indian port and more or equal than competing international ports. It will be able to capture the increasing trend of larger container vessels which none of the existing Indian ports can service, due to which majority of containers destined or generated from India are being transshipped or double-handled from competing international ports, resulting in higher import/export cost for Indian citizens. Vizhinjam port will further enhance India’s ability to handle gateway and transshipment cargo while establishing a strong supply chain network in Kerala.

[1] Definition of Landlord Port Model as per VISL: The landlord port is characterized by its mixed public-private orientation. Under this model, the port authority acts as regulatory body and as landlord, while port operations (especially cargo handling) are carried out by private companies. Examples of landlord ports are Rotterdam, Antwerp, New York, and since 1997, Singapore. Today, the landlord port is the dominant port model in larger and medium sized ports.

Apart from catering to the needs of hinterland cargo, Vizhinjam Port will facilitate entire country's maritime trade and boost the development of a Special Economic Zones (SEZ) in the region due to opening up of new supply-chain networks and opening of an international cruise terminal.

Figure 1.1 Vizhinjam Port Location Map

The port location is selected to tap the potential of development of a deep water international container transshipment port that can handle the largest container vessels serving the East-West shipping route as shown in Figure 1.2. The proposed port location is just south to the existing fishery harbour of Vizhinjam. The main competition of the port is with Colombo Port, Sri Lanka.

Table 1.1 summarizes number of container vessels traveling East-West or West-East that are stopping at Colombo vs. not stopping at Colombo. More than 70% of container vessels that are larger than 10,000 TEU in size do not stop at Colombo. On average only 50% of vessels of size 6000 to 10000 TEU make a stop at Colombo in their East-West or West-East voyage. This shows that there is a an opportunity to service these bigger vessels at Vizhinjam.

Table 1.2 lists out competitive position of proposed Vizhinjam port vis-à-vis major competing ports in terms of existing infrastructure available to handle container cargo and key performance parameters of the terminal. The information summarized in here was collected from internet searches, and latest information may have changed after submission of this report.

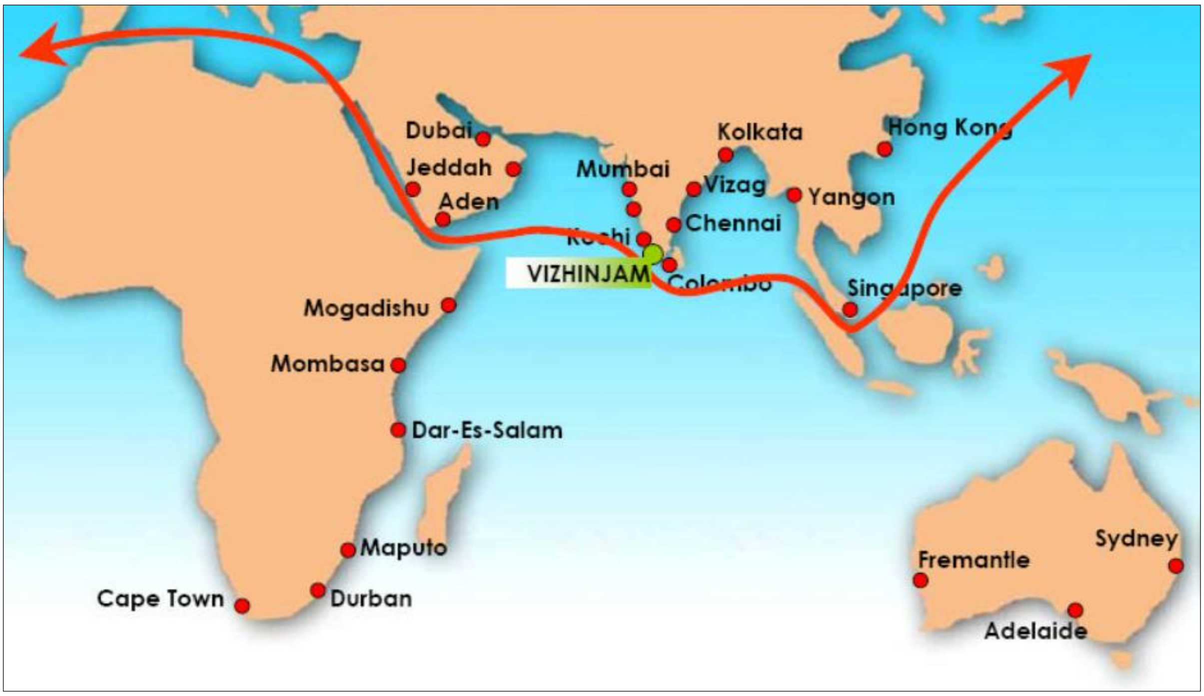


Figure 1.2 Vizhinjam Port Location with respect to International East-West Shipping Route

Table 1.1 Container Vessels Voyage Analysis (East to/from West movement)

Vessel Size (TEU)	Vessels Stopping at Colombo	Vessels Not Stopping at Colombo	Total		% Vessels Stopping at Colombo	% Vessels Not Stopping at Colombo
>=10000	20	50	70		28.6%	71.4%
8001 - 9999	41	54	95		43.2%	56.8%
6001 - 8000	40	38	78		51.3%	48.7%
4001 - 6000	189	64	253		74.7%	25.3%
2001 - 4000	112	20	132		84.8%	15.2%
1000 - 2000	62	57	119		52.1%	47.9%
< 1000	40	39	79		50.6%	49.4%
All	504	322	826		61.0%	39.0%

[Source: AECOM research using JOC Sailings Website and other secondary data]

Table 1.2 Container Transhipment Port Benchmarking Parameters

Port Study Parameters	SAGT - Colombo	JCT - Colombo	Colombo Port - Total	Jebel Ali (Dubai)	PSA Singapore Combined	Salalah Port - Oman	Kwai Tsing Container Terminals - Hongkong	VISL Phase-1	VISL Phase-2	VISL Phase-3
Quay Crane Type and Numbers	10 QC	20 QC	30 QC	79 QC	192 QC	25 QC	104 QC	8 QC	12 QC	20 QC
Maximum Vessel Size in TEU, Draft (m), LOA(m)	10,000 TEU	10,000 TEU	10,000 TEU	12,500 TEU*	12,500 TEU*	12,500 TEU*	12,500 TEU*	18,000 TEU	18,000 TEU	18,000 TEU
Total Berths	3	6	9	22	52	7	37	2	3	5
Berth Datails	3	4 Main + 2 Feeder	7 Main + 2 Feeder	22	52	7	25 main + 12 Barge	2 Container Berths	3 Container Berths	5 Container Berths
Dredged Depth (m)	15	12 to 15	12 to 15	11 to 17	up to 16.7	16 to 18	up to 15.5	18.4	18.4	18.4
Total Terminal Area (acre)	68	104	176	815	1482	276	722	80	119	197
Estimated Throughput ('000 TEU)	1,950	2,000	3,950	13,000	29,370	3,500	17,416	900	1,800	3,350
Berth Length (m)	940	1,642	2,582	7,475	16,000	2,428	11,056	800	1,200	2,000
Average Berth Length (m/berth)	313	274	287	340	308	347	299	400	400	400
Berth Length (m) per QC	94	82	86	95	87	97	106	100	100	100
Annual throughput per quay crane ('000 TEU/QC)	195	100	132	165	153	140	167	113	150	168
Annual throughput per gross acre ('000 TEU/QC)	29	19	22	16	20	13	24	**8**	11	14
Annual throughput per berth length (TEU/meter)	2,074	1,218	1,530	1,739	1,836	1,442	1,575	1,130	1,500	1,680

* Maximum vessel size as per Emma Mersk **E** Class container ship calls

1.4 Preliminary Project Report by Royal Haskoning

1.4.1 General

VISL through IFC appointed Drewry to study the traffic potential at the proposed Vizhinjam port. Drewry submitted their final report in November 2010. Royal Haskoning (RH) prepared the report on project preliminary plan for developing the conceptual layout in parallel with the market assessment for the proposed Greenfield port in October 2010. The Vizhinjam Port is to be developed as a deep draft all weather multipurpose port with state-of-art facilities to ensure least turnaround time to the vessels. The port is planned to be developed in phases as and when the traffic builds up. The conceptual layout for Phase-1 development plan prepared by RH is shown in Figure 1.3 envisaging 650m container berth to handle the capacity up to 820,000 TEUs.

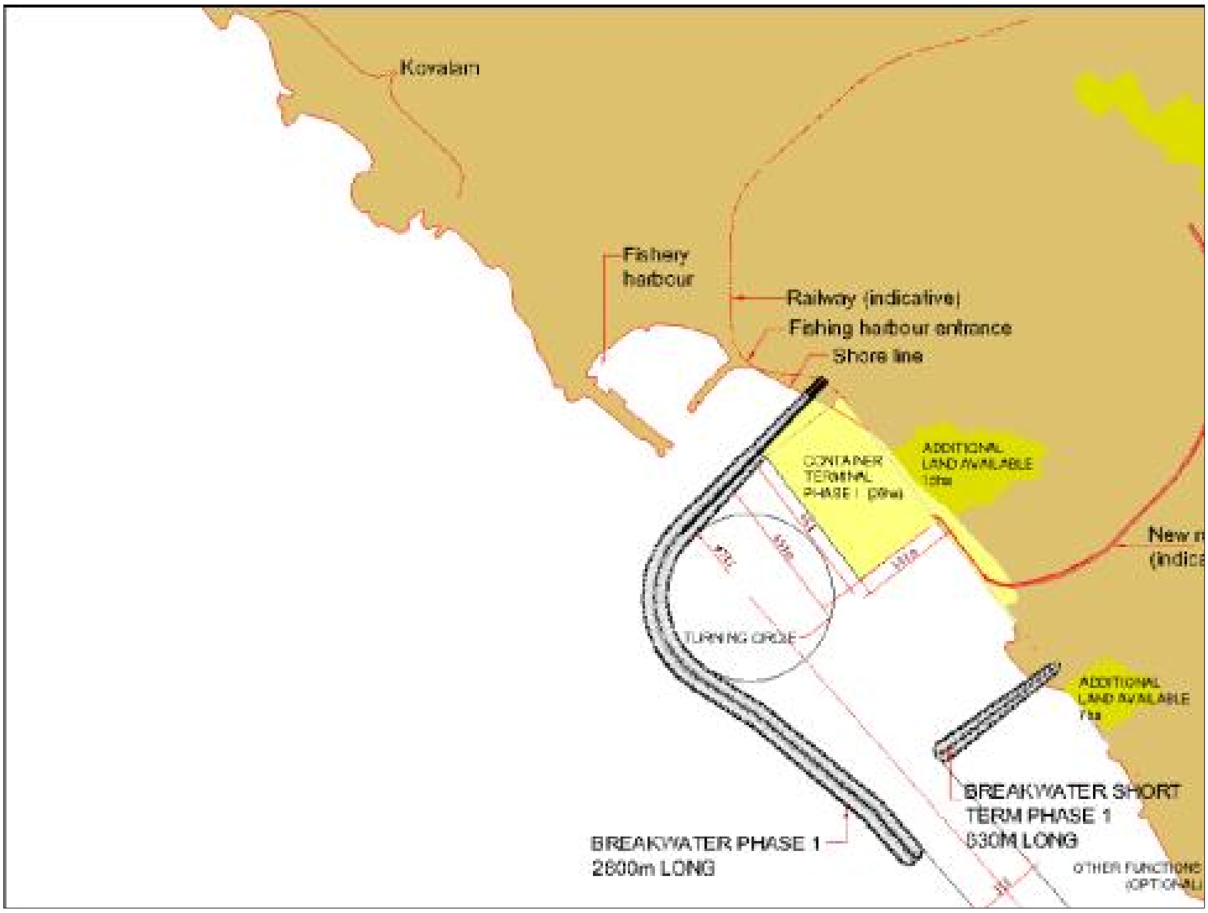


Figure 1.3 Port Concept Layout for Phase-1 Development

[Source: RH Project Preliminary Plan Report, 2010]

Subsequently, VISL approached the Ministry of Environment & Forests (MoEF), Government of India for the Phase-1 environmental clearance (ie. approval of Terms of Reference (ToR) for the EIA study) for the project. MoEF issued the approval for the ToR in June/July 2011 and insisted for an all season EIA study. The EIA study for the Port part was arranged by IFC through RH and Asian Consulting Engineers (Pvt) Ltd. and the EIA study of the external infrastructure was arranged by VISL through L&T Ramboll Consulting Engineers Ltd (LTR). Both of them are MoEF accredited EIA consultants. The task of integrating the two EIA reports for submission to the MoEF was also entrusted by VISL to LTR.

VISL has appointed AECOM for completion of Detailed Project Report (DPR) for the project after its need was identified in August 2012 for EIA completion. The model studies for Ship Simulation were undertaken by BMT, Mumbai on a Fast time ship simulator in December 2012 for validating the alignment and dimensions of the approach channel of the planned port. The model studies for validating the wave transformation and wave tranquility modeling studies have been undertaken by LTR, Chennai. The modeling study was validated with site specific data on wind, wave, tide and current monitored through M/s EGS Survey Pvt. Ltd, Navi Mumbai.

1.5 Objective and Outline of the DPR

AECOM was entrusted in September 2012 to prepare a Detailed Project Report for Phase-1 Development of Greenfield port at Vizhinjam to cater to the forecasted traffic which would be met by providing the harbour, berthing, storage and evacuation facilities at the port – a step forward based on the previous studies.

To realize this objective, the data and various studies already carried out for the proposed project were compiled and reviewed. This study was a step forward in terms of reassessing the port layout based on the prevailing site condition and model studies to cater to sixth generation container vessels forecasted to call at the port.

The outcome of the studies is presented in the current report to assist VISL in EIA clearance process for the proposed Greenfield port.

1.6 Field Investigations and Studies Organized by VISL

VISL have carried out the all the required technical studies, which have become the base of this report.

Table 1.3 mentions reports related to Vizhinjam port project and work carried out by previous consultants that have been sourced and referenced in preparation of the DPR:

Table 1.3 Past Studies carried out for Vizhinjam Port

S. No.	Description of the Study/Investigations	Agency	Time (Month – Year)
OCEANOGRAPHIC/GEOTECHNICAL INVESTIGATIONS			
1.	Field Surveys and Investigation Report, May 2004	L&T-RAMBØLL Consulting Engineers Limited, Chennai, Rogge Marine Consulting GMBH, Germany (RMC), RAMBØLL, Hannenmann & Højlund A/S, Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC).	May 2004
2.	Geotechnical and Geophysical Survey Works	Fugro Geotech Pvt. Limited	May 2011
3.	Oceanographic Investigations for Tides Currents and Wave observations	EGS Survey Pvt. Ltd.	March 2013
MODEL STUDIES			
1.	Mathematical model studies by Royal Haskoning	Royal Haskoning	October 2010
2.	Updated Mathematical Model Study	L&T-RAMBØLL Consulting Engineers Limited, Chennai	May 2013
3.	Ship Simulation Study for Vizhinjam Port	BMT Consultants India	May 2013
TECHNICAL STUDIES			
1.	Rapid Environmental Impact Assessment Report	L&T-RAMBØLL Consulting Engineers Limited, Chennai	February 2004
2.	Detailed Techno-Economic Feasibility Study	L&T-RAMBØLL Consulting Engineers Limited, Chennai in association with Rogge Marine Consulting GMBH, Germany (RMC), RAMBØLL, Hannenmann & Højlund A/S,	May 2004, Revision June 2007

S. No.	Description of the Study/Investigations	Agency	Time (Month – Year)
		Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC).	
3.	Preliminary Project Plan Report	Royal Haskoning	October 2010
4.	DPR for Rail Connectivity from Neyyattinkara to Vizhinjam International Seaport	Rail Vikas Nigam Limited, Chennai	July 2011 May 2012
5.	Integrated Master Plan Report	AECOM India Private Limited	November 2012
6.	CRZ Status Report	Centre for Earth Science Studies Thiruvananthapuram	April 2013
TRAFFIC STUDIES			
1.	Kerala Port PPP – Market Study	Drewry Shipping Consultants Ltd.	November 2010
ECONOMIC AND SOCIAL IMPACT ASSESSMENT STUDIES			
1.	Integrated ESIA Report	L&T-RAMBØLL Consulting Engineers Limited	May 2013
2.	Estimation of Economic Internal Rate of Return of the Vizhinjam Port project-Draft Report	Deloitte Touche Tohmatsu India Private Limited	May 2013

1.7 Organization of Detailed Project Report

The Detailed Project Report has been finalized after including the results of additional mathematical model studies and taking into considerations the comments/views of VISL and the entrusted technical committee appointed by VISL on the draft DPR.

The Detailed Project Report presented is organized in the following sections:

Section 2 : Site Conditions

Section 3 : Traffic Potential and Forecast

Section 4 : Design Ship Sizes

Section 5 : Port Facility Requirements – Phase-1

Section 6 : Port Facility Requirements – Master Plan

Section 7 : Model Studies for Phase-1 Development

Section 8 : Phase-1 Development Recommendations

Section 9 : Environmental Compliance

Section 10 : Engineering of Major Civil Works

Section 11 : Terminal Equipments

Section 12 : Infrastructure and Port Facilities

Section 13 : Cost Estimates

Section 14 : Implementation Schedule

Section 15 : Economic IRR of the Project

Annexure 1 : DPR Drawings

Annexure 2 : Detailed CAPEX Breakdown

2 Site Conditions

2.1 General

The data on site conditions for Vizhinjam Port site has been compiled from the various site specific studies / investigations undertaken by various agencies with a view to ascertain the suitability of the site for development of a deep water port and arrive at the design parameters.

The brief outcome of these studies / investigations is referenced appropriately in this report.

2.2 Location of Vizhinjam Port

Vizhinjam benefits from its geographic location – it is almost located at the tip of the southern peninsula on the west coast of India. It is strategically located approximately 10 nautical miles from the international shipping route which could attract large share of the container transshipment traffic destined or originated to/from India. Vizhinjam Port is located at the proximity of southern railway which connects to Mumbai through Konkan railway in the north and southern part of Tamil Nadu through Nagercoil and Tiruchirapalli. Vizhinjam Port is located approximately 8km from NH 47 which connects Kanyakumari in the south to Mumbai in the north.

Kovalam beach is an important tourist centre located about 2km towards the North of Vizhinjam village. Near the Vizhinjam village is the Vizhinjam harbour which is developed in a natural bay protected by breakwaters and is one of the busiest fishing harbour in Thiruvananthapuram (Trivandrum) area.

Vizhinjam fishery harbour is located to the north and communities related to fishing and resort resides to the south of the proposed harbour. A 2.5km long waterfront has been identified at Vizhinjam near Thiruvananthapuram, in Kerala for the proposed port development. The coastline is mainly oriented towards Northwest-Southeast direction (bearing of the shore line is about 155° - 304°N. The terrain along the coastline in the area of interest is hilly and steep.

2.3 Meteorological and Oceanographic Data

2.3.1 Meteorological Data

2.3.1.1 General

This information has been extracted from previous studies for the project as well as from the West Coast of India Pilot (WCIP) climatological table applicable for the Trivandrum area and the project site.

2.3.1.2 Climate

Vizhinjam has a tropical humid climate with hot summers and the region is characterised by two seasonal monsoons:

- The North-East monsoon occurs between October to December and is characterised by predominant north-easterly winds.
- The South-West monsoon extends from June to September and is characterised by occurrence of rain, with predominantly south westerly winds.

2.3.1.3 Temperature

The mean maximum daily temperature varies from 29°C and 32°C. March, April and May are considered to be the hottest months of the year with temperature rising up to 33° Celsius. Mean minimum daily temperature varies between 24°C to 30°C, with the lowest occurring in December.

2.3.1.4 Relative Humidity

Humidity is high and rises to about 89% during the southwest monsoon in the month of June. The mean monthly average relative humidity varies between 73% and 84%.

2.3.1.5 Precipitation

The average rainfall is around 1835mm per annum. The region gets most of the rainfall from the south west monsoon which lasts till September, while the northeast monsoon commences in October. May to November is the wettest months of the year with an average rainfall in excess of 220mm per month, with a maximum of 356mm in June. Rainfall is at its peak in the month of June and July.

Dry weather sets in by the end of December lasting up to May with average rainfall of approximately 27mm per month.

2.3.1.6 Cyclone

Cyclones occasionally make landfall in the west coast compared to the east coast of India. It is observed from the tracks of the cyclones in the Arabian Sea that in the last 100 years only 4 storms have passed nearby the project location of which only 2 had impact on the study region in the above said period i.e. the frequency of the cyclone occurrence is approximately once in 25 years.

2.3.1.7 Visibility

Throughout the year visibility is good as the region has zero fog days and therefore there are no constraints to the navigation in this regard.

2.3.2 Oceanographic Data

Oceanographic data has been previously compiled in two reports:

- Royal Haskoning (RH), October 2010.
- L&T-RAMBØLL Consulting Engineers Limited (LTR), September 2012.

2.3.2.1 Wind

The hydrodynamics of the region is influenced by the prevailing local wind conditions. The information provided in WCIP shows the presence of three distinct climatic conditions, namely during SW monsoon, during NE monsoon and during the transition period. The three major wind patterns prevalent during these seasons are moderate to strong wind blowing from SW, moderate to strong wind blowing from NE and very low wind speeds.

LTR has analyzed offshore wind data at 8° 00’ 00” N and 76° 15’ 00” E from offshore dataset (BMT ARGOSS) for the period of 1992 to 2009. The analysis of BMT ARGOSS data revealed that the most prominent wind direction is SW during southwest monsoon period and NE corresponding to the north east monsoons which are relatively less intense than the wind from SW. During the SW monsoon, the wind blow predominantly from South to West (during August to September). The wind gradually shifts towards north with reduced intensity and gradually increasing towards east direction indicating the onset of north east monsoons. The predominant wind direction is found to be between 240° and 315° that occurs approximately for 54% of the time. The highest wind speeds are about 15m/s.

During the Non-Monsoon season, from January to April, wind direction varies strongly. The most dominant directions are West and Northeast. Over 50% of all wind speeds are lower than 4 m/s in this season. The wind rose is as shown in Figure 2.1.

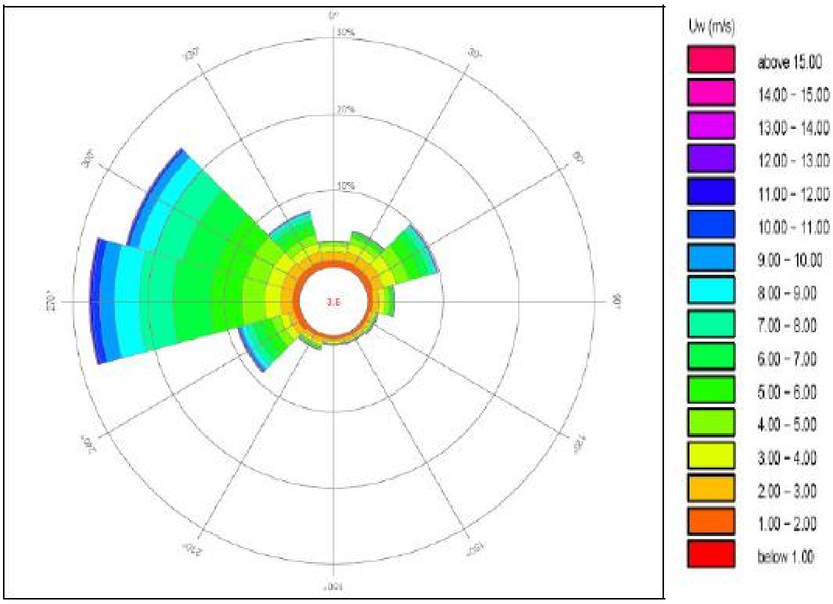


Figure 2.1 Wind Rose from BMT Data

[Source: BMT ARGOSS 1992-2009]

2.3.2.2 Waves

Four sets of offshore wave data have been obtained previously as listed below:

1. From BMT ARGOSS, for the period 18 years from 1992 to 2009

2. BMO data for the period of 8 years from 1995 to 2003 consisting time-series of wind wave parameters (significant wave height, mean wave period and mean wave direction) with records every 6 hours.

These data do not represent the cyclone winds and waves that are essential for estimating the design wind and wave conditions. Hence, the cyclone data was extracted from:

3. Cyclone eAtlas from India Meteorological Department (IMD) for the period of 1891 to 2007.

4. From the *Joint Typhoon Warning Centre (*JTWC[2]) website, which is a combined United States Air Force/Navy organization under the operational command of the Commanding Officer, JTWC, and Pearl Harbour, Hawaii.

The locations of BMO and BMT ARGOSS data points are shown in Figure 2.2.

[2] *Joint Typhoon Warning Centre - responsible for the issuing of tropical cyclone warnings in the North West Pacific Ocean, South Pacific Ocean and Indian Ocean for United States Department of Defense interests*

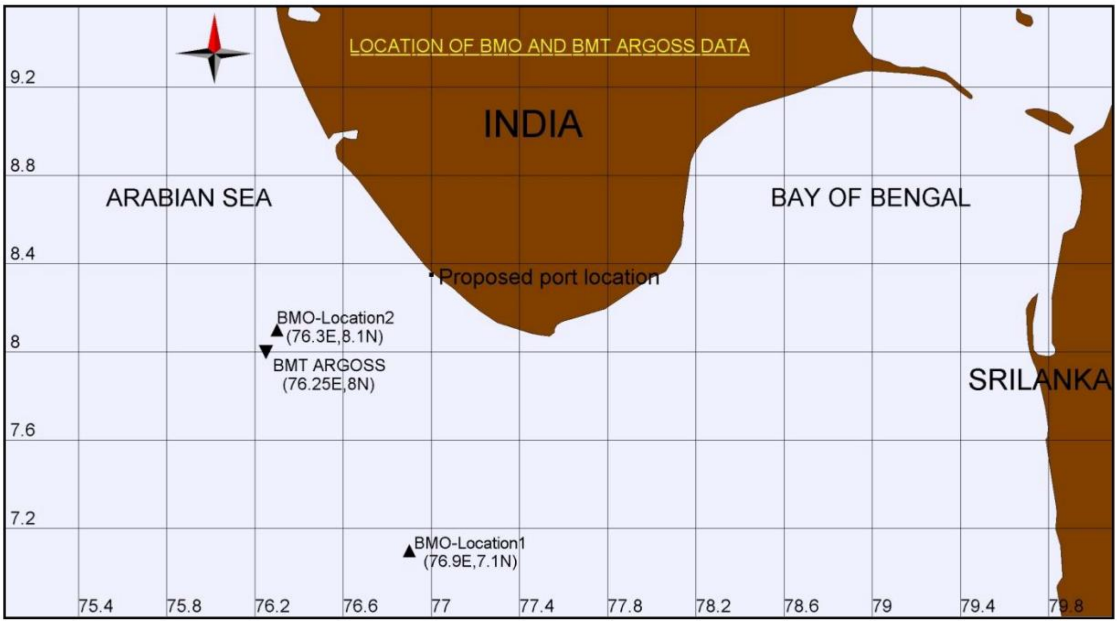


Figure 2.2 Location of BMT ARGOSS and BMO Data

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

2.3.2.2.1 BMT-ARGOSS Data Analysis

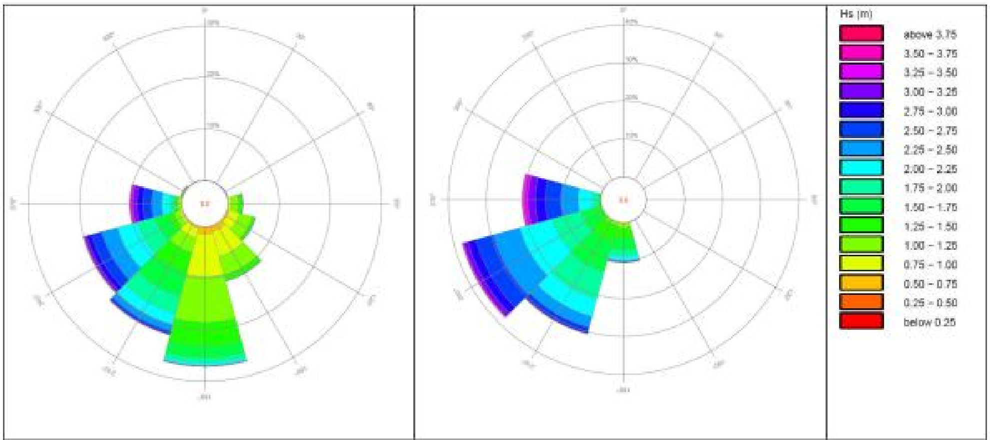
RH procured offshore data from BMT ARGOSS. ARGOSS wind and wave data are derived from the 3rd generation hindcast wave model Wave Watch III. The model uses ice- and wind-data provided by the National Center of Environmental Prediction (NCEP), the marine modeling branch. The global model provides data along the coasts of the larger oceans and is the source for boundary data for regional models around the world. The global model provides 3-hourly time series of wave spectra covering a period of seventeen years (1992-2009). Analysis of this offshore data is presented in Table 2.1. A wave rose from the BMT-ARGOSS dataset is presented in Figure 2.3

Table 2.1 Offshore Joint Probability of Wave Height Occurrence Overall Sea State 1992 - 2009

	(Deg)	-15	15	45	75	105	135	165	195	225	255	285	315	All classes
Hs	**(m)**	**15**	**45**	**75**	**105**	**135**	**165**	**195**	**225**	**255**	**285**	**315**	**345**	
0	**0.25**													**0**
0.25	**0.5**				0.01	0.01	0.01	0.02	0.02					**0.06**
0.5	**0.75**			0.01	0.06	0.39	1.15	1.43	0.39	0.14	0.06	0.04	0.01	**3.67**
0.75	**1**	0.02	0.03	0.04	0.6	2.13	4.97	8.24	1.98	0.55	0.3	0.16	0.04	**19.06**
1	**1.25**		0.01	0.04	1.37	2.55	3.79	8.88	2.95	1.08	0.5	0.12	0.02	**21.30**
1.25	**1.5**			0.02	0.72	0.6	1.07	4.60	3.96	1.32	0.32	0.1	0.01	**12.72**
1.5	**1.75**			0.01	0.13	0.06	0.09	2.32	4.80	2.49	0.39	0.02		**10.31**
1.75	**2**			0.01	0.03		0.01	0.97	3.54	3.60	0.73			**8.89**
2	**2.25**				0.01			0.5	2.21	4.02	1.64			**8.38**
2.25	**2.5**							0.12	1.30	3.16	1.94			**6.53**
2.5	**2.75**							0.05	0.51	2.04	1.70			**4.31**
2.75	**3**								0.19	0.97	1.15			**2.30**

	(Deg)	-15	15	45	75	105	135	165	195	225	255	285	315	All classes
Hs	**(m)**	**15**	**45**	**75**	**105**	**135**	**165**	**195**	**225**	**255**	**285**	**315**	**345**	
3	**3.25**								0.06	0.5	0.79			**1.36**
3.25	**3.5**								0.02	0.17	0.53			**0.72**
3.5	**3.75**									0.08	0.16			**0.23**
3.75	**4**									0.03	0.07			**0.1**
4	**4.25**										0.03			**0.03**
4.25	**4.5**										0.02			**0.02**
4.5	**4.75**										0.01			**0.01**
Total		**0.03**	**0.04**	**0.12**	**2.93**	**5.73**	**11.09**	**27.13**	**21.92**	**20.16**	**10.35**	**0.44**	**0.07**	**100.00%**

[Source: RH Wave Modeling Report, August 2010]



Wave data – year round (swell and sea waves)	Wave data in monsoon period (May - September)	Legend

Figure 2.3 Annual Wave Rose Diagram of BMT-ARGOSS Offshore Data

[Source: RH Wave Modeling Report, August 2010]

The dataset shows that waves up to 4 - 4.5m can be observed offshore of the site and the biggest waves are coming from around W and WSW though the pre-dominant wave direction is from South. A return period analysis of the offshore BMT-ARGOSS data is provided in Table 2.2. It is evident from the Table that a 1:100 year offshore wave of height 5.3m and a peak period of 7.8 sec can be expected near the project site.

Where

U_w = Wind Speed
H_s = Significant wave height
S_0 = Wave steepness
Dir = Wave direction in degrees

Table 2.2 Wave Parameters as Function of Return Period

Return Period	Extreme Wind Condition	Wind direction	Significant Wave Height	Wave Direction	Wave Peak Period
Qs	**U_WS (m/s)**	**U_WDir (deg)**	**H_S (m)**	**H_SDir (deg)**	**Tp (s)**
1:1	12.1	280	3.33	260	9.8
1:10	13.8	280	4.38	260	8.8

Return Period	Extreme Wind Condition	Wind direction	Significant Wave Height	Wave Direction	Wave Peak Period
Qs	U_WS (m/s)	U_WDir (deg)	H_S (m)	H_SDir (deg)	Tp (s)
1:25	14.5	280	4.76	260	8.4
1:50	15.0	280	5.05	260	8.1
1:100	15.5	280	5.32	260	7.8

[Source: RH Wave Modeling Report, August 2010]

2.3.2.2.2 BMO Data Analysis

LTR obtained the six hourly offshore wave and wind data from the global wave model operated by BMO. The location of the BMO data is as shown in Figure 2.2. The BMO data set consisted of resultant wave parameters and frequency of occurrence for the period of January 1995 to June 2003.

The wave heights were analyzed for long-term probability of occurrence of extreme wave heights spanning over hundred years. Table 2.3 and Table 2.4 present the distribution of wave heights and direction over the year respectively at the offshore location of BMO dataset.

Table 2.3 Percentage Distribution of Wave Height (Deep Water BMO Data)

Wave Height (m)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann (%)
0	**0.5**	0	1.5	0	0	0	0	0	0	0	0	0	0	**0.1**
0.5	**1**	40.0	37.1	29.6	18.5	3.0	0	0	0	0.1	5.5	30.2	35.4	**16.1**
1	**1.5**	44.5	48.6	53.9	53.2	28.0	3.1	0.1	1.4	14.3	37.9	57.4	51.9	**32.1**
1.5	**2**	13.9	11.8	15.7	26.8	36.6	32.0	23.2	44.0	62.7	43.4	12.3	12.3	**28.1**
2	**2.5**	1.4	0.8	0.8	1.4	22.6	39.1	36.7	33.5	20.4	11.5	0	0.5	**14.6**
2.5	**3**	0.1	0.2	0	0.1	8.3	23.3	36.1	19.1	2.5	1.3	0	0	**8.0**
3	**3.5**	0	0	0	0	0.7	2.1	3.5	1.5	0.1	0.4	0	0	**0.7**
3.5	**4**	0	0	0	0	0.7	0.3	0.3	0.5	0	0	0	0	**0.2**
4	**4.5**	0	0	0	0	0	0.1	0	0	0	0	0	0	**0**
4.5	**>**	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

Table 2.4 Percentage Distribution of Wave Direction (Deep Water BMO Data)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Jan	0.3	1.2	16.7	21.1	3.1	0.3	4.4	7.5	33.9	10.7	0.3	0	0	0	0	0.4
Feb	0.2	1.3	10.0	8.6	2.0	0.1	6.6	16.9	38.4	13.2	1.0	0	0.3	0.3	0.9	0.1
Mar	0	0	3.1	3.5	0.6	0.1	7.8	17.4	41.6	19.5	0.5	0.1	0.6	1.7	2.4	0.5
Apr	0	0	0	0	0	0.1	7.5	21.7	40.0	18.3	2.6	0.4	2.3	5.0	1.8	0.3
May	0	0	0	0	0	0	0.9	8.4	31.5	7.6	3.4	12.5	23.4	11.4	0.9	0
Jun	0	0	0	0	0	0	0.2	3.1	12.0	11.9	5.2	17.8	36.1	12.7	1.0	0
Jul	0	0	0	0	0	0	0	0.8	12.3	12.4	7.6	8.2	29.8	26.9	1.9	0
Aug	0	0	0	0	0	0	0	3.5	21.3	9.9	5.2	5.4	30.7	21.4	2.5	0
Sep	0	0	0	0	0	0	0.4	7.4	32.5	6.6	1.6	9.3	28.3	13.4	0.3	0
Oct	0	0	0	0	0	0	2.4	12.4	38.3	9.9	3.6	13.3	13.1	6.3	0.7	0

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Nov	0	0	0.6	0.4	1.0	0.2	3.4	11.5	51.0	20.1	1.1	1.5	3.7	4.9	0.7	0
Dec	0	0.9	12.1	14.7	2.2	0.6	3.4	6.3	43.9	11.7	3.5	0.1	0	0	0.6	0.1
Ann	**0**	**0.3**	**3.5**	**4.0**	**0.7**	**0.1**	**3.1**	**9.7**	**32.5**	**12.6**	**3.0**	**5.9**	**14.5**	**8.9**	**1.2**	**0.1**

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

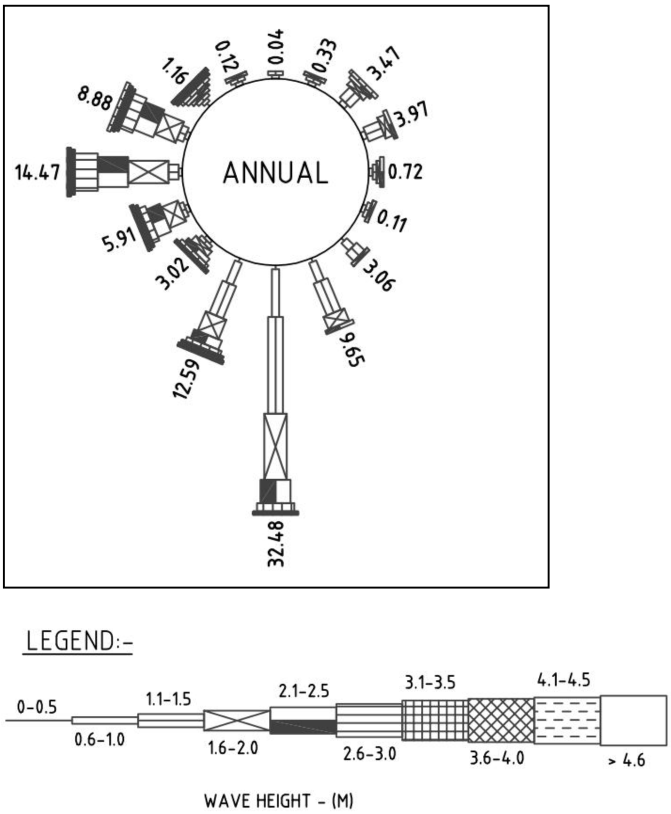


Figure 2.4 Annual Wave Rose Diagram of BMO Offshore Data

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

As seen in the Figure 2.4, the dominant wave direction in the offshore region is from the south with 33% of the waves coming from south direction. From Table 2.3, it can be concluded that majority of the offshore wave heights are in the range of 0.5m to 2.5m. It is observed that the significant wave heights (Hs) are below 1.5-2.0m during the calm season from January to April, whereas it reaches up to 4.5m in May to September during SW monsoon. Table 2.5 shows the results of return period analysis performed on the BMO data.

Table 2.5 Long-term Distribution of Wave Height at BMO Offshore Location

Return Period	Yr	1	5	10	25	50	100
Wave Heights	m	3.64	4.17	4.4	4.71	4.94	5.17

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

Based on the initial analyses of the datasets by LTR, the BMT ARGOSS data mainly displayed the waves from WNW to E directions and the waves predominantly are higher for W, WSW directions. The BMO data ranged from NNE to NNW with two sectors, S and W, predominantly showing the higher waves which are realistic for such locations. Hence, wave events from the BMO data were used by LTR for further studies.

2.3.2.2.3 Offshore Waves Transformation to Nearshore for Normal Conditions

As the wave travels from deep waters to the shallow zones, the waves get modified due to various factors, such as shoaling, refraction, diffraction. This process of transforming the deep water waves to near shore has been carried out by using SWAN model by RH and LTR using BMT-ARGOSS and BMO offshore data respectively. The model predicts wave activity at near shore site by representing the effects of refraction and shoaling on all components of a given offshore spectrum. RH analysis is site-specific and is described in Section 7. Summary of LTR analysis is presented in this section.

Table 2.6 and Table 2.7 summarize the results of wave parameters obtained from near shore wave modeling study performed by LTR.

Table 2.6 Percentage Distribution of Resultant Wave Height at 20m Contour

Wave Height Range (m)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
0	0.5	47.9	32.6	13.1	4.2	0	0	0	0	0	0.9	6.7	33.3	**11.3**
0.5	1.0	38.9	50.3	55.0	50.5	21.6	2.2	1.7	4.1	14.6	28.6	56.7	48.1	**30.2**
1.0	1.5	13.2	16.4	30.8	43.7	53.7	46.3	40.7	59.4	65.6	59.8	36.6	18.6	**40.6**
1.5	2.0	0	0.7	1.0	1.6	21.6	46.6	46.3	32.5	19.7	10.0	0	0	**15.7**
2.0	2.5	0	0	0	0	2.8	4.9	10.8	4.1	0.1	0.6	0	0	**2.0**
2.5	3.0	0	0	0	0	0.3	0	0.4	0	0	0	0	0	**0.1**
3.0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	**0**
3.5	4.0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
4.0	>	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

Table 2.7 Percentage Distribution of Resultant Wave Direction at 20m Contour

Wave Direction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
SE	0	0	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0	0	0	0
S	11.9	23.6	25.2	29.2	9.3	3.3	0.8	3.5	7.9	14.9	14.9	9.6	12.7
SSW	44.6	51.5	61.1	58.2	39.1	23.9	24.8	31.2	39.1	48.2	71.1	55.6	45.1
SW	0.3	1.0	0.5	2.6	3.4	5.2	7.6	5.2	1.6	3.6	1.1	3.5	3.0
WSW	0	0	0.7	2.3	35.4	53.7	38.2	36.0	37.6	25.9	4.8	0.1	20.2
W	0	1.5	4.1	7.2	12.8	13.9	28.6	24.0	13.8	7.4	6.0	0.6	10.2
WNW	0	0	0	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	0	0	0	0

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

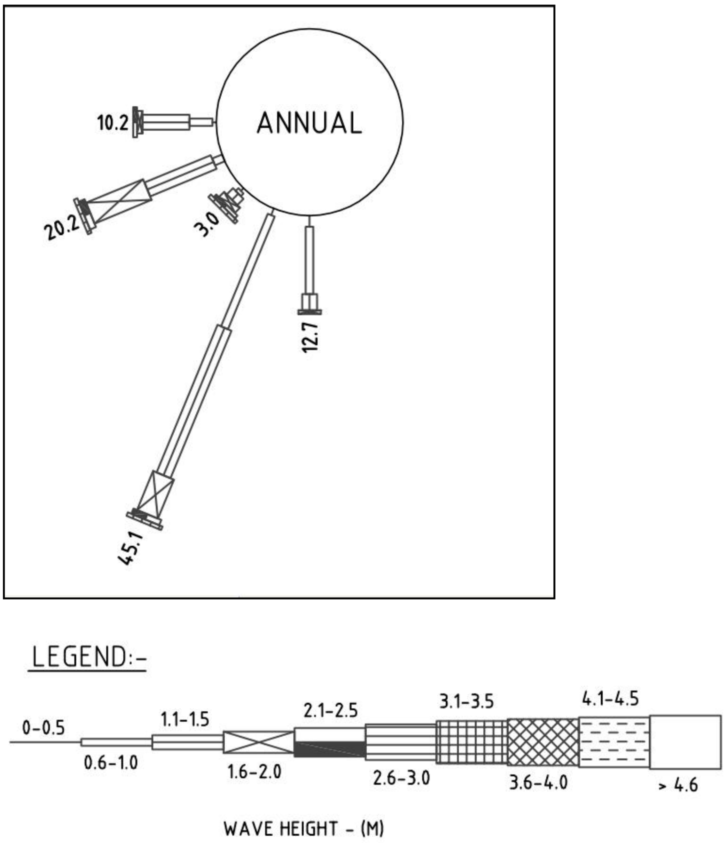


Figure 2.5 Annual Nearshore Wave Rose Diagram at 20m Depth Contour

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

As per the nearshore wave modeling done by LTR using the BMO offshore wave data set, the dominant nearshore wave direction at 20m depth contour is from the South-South West direction (45%), the other dominant wave direction being South-South West (SSW) with 20% of total waves. An extreme analysis was also performed for the site and various return period waves obtained at the 20m contour are listed in Table 2.8. It is estimated that a 1:100 year significant wave height of 4.5m can be expected at the 20m contour.

Table 2.8 Long-term Distribution of Wave Height for Various Return Periods at 20m Depth

Return Period	Wave heights
(Yrs)	(m)
1	2.60
5	3.40
10	3.60
25	4.10
50	4.20
100	4.50
200	4.70

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

2.3.2.2.4 Nearshore Wave Measurements

Apart from the above, VISL appointed EGS Survey to carry out the nearshore wave observation for the operating conditions for 1 year covering all seasonal variations. The results available till date are from 22nd January to 4th April 2013.

ADCP has been used to measure currents at three locations and one of the ADCPs was also programmed to measure waves. These were set to measure wave at every synoptic interval of 3 hours. The data was then processed using WavesMON®.

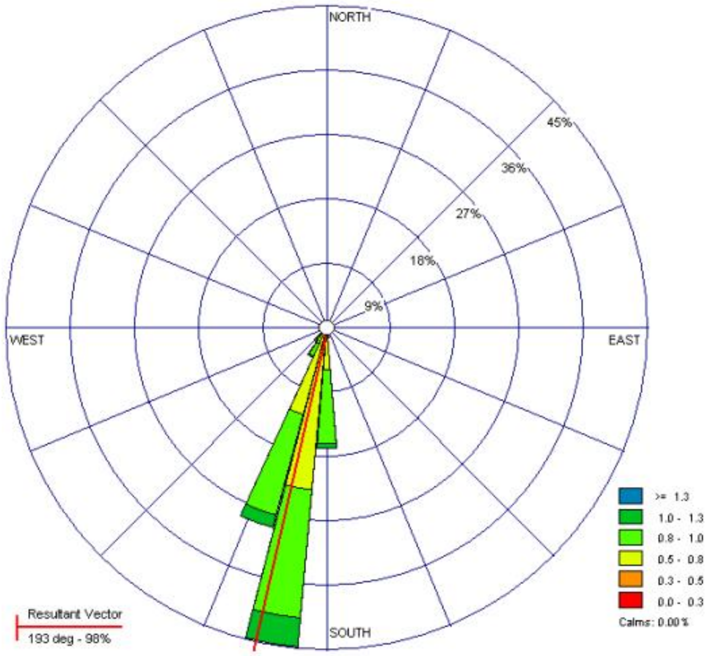


Figure 2.6 Observed Nearshore Wave Rose Diagram

[Source: EGS Investigation Report 2013]

As expected, the direction of waves is from south - southwest, with the resultant vector showing the wave hitting from 193°. The sea was calm during the first two weeks of the data collection campaign. The maximum wave, 1.13m with a period of 11.6 seconds, was recorded on 24th February at 14:00 hrs. The histogram of significant wave heights is given in the figure below.

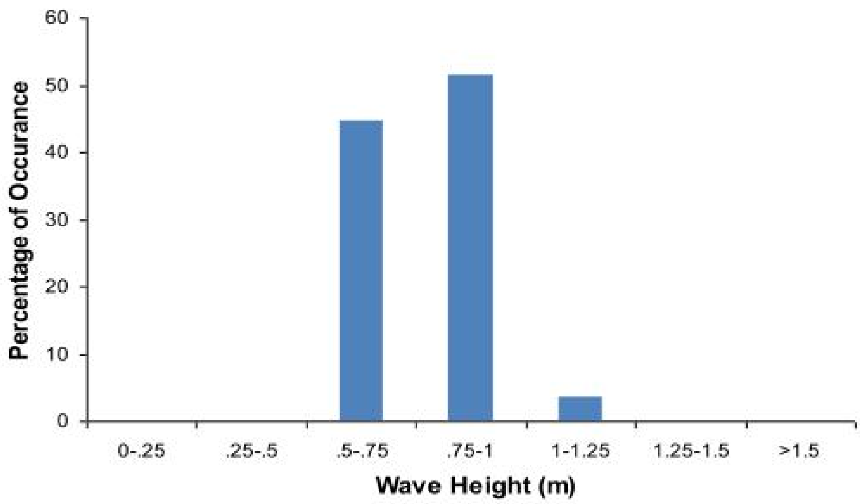


Figure 2.7 Percentage Occurrence of Wave Height

[Source: EGS Investigation Report 2013]

2.3.2.3 Extreme Cyclonic Wave Conditions

Cyclones produce higher wind speeds which in turn produce extreme waves at the location of the disturbances. These propagate to the coast and can affect the tranquility within the harbour in addition to causing damage to the ships. Hindcasting analysis for storm waves was carried out only for the severe storms relevant to the site.

2.3.2.3.1 RH Analysis

As the site specific cyclone data was not available for the study in the past, the reference was taken by RH from previous study done by Delft Hydraulics / Oceanweather Inc. (Cyclone Hindcast Study, part I and II, Karwar India, October 1989) which contains the detailed study of cyclones along the Indian West Coast. Cyclone wave and wind parameters taken from Delft Hydraulic/ Oceanweather Cyclone Hindcast which were used by RH for offshore design conditions are as shown in Table 2.9.

Table 2.9 Extreme Cyclonic Offshore Wind and Wave Conditions

Return Period	Extreme Wind Condition	Wind direction	Significant Wave Height	Wave Direction	Wave Peak Period
Qs	UWS (m/s)	UWDir (deg)	HS (m)	HSDir (deg)	Tp (s)
1:100	> 20	180	3.8	180	14
1:100	> 20	210	6.3	210	12
1:100	> 20	240	5.5	240	10
1:100	> 20	270	4.6	270	9
1:100	> 20	300	5.9	300	8

[Source: RH Wave Modeling Report, August 2010]

The extreme cyclonic analysis estimated that 1:100 year wave height will be around 5.9m with a peak wave period of 8 seconds.

2.3.2.3.2 LTR Analysis

Cyclonic data in the form of storm tracks were collected from IMD by LTR. Data for almost 117 years covering the period 1891 – 2007 were analyzed and 4 selected cyclones of various years namely 1961, 1987, 1993 and 2005 were considered for further analysis, as these were most severe with regard to intensity that hit in the vicinity/ nearby of the proposed port location. LTR concluded that all these cyclones passed through the land mass before emerging into the sea near to the project site thus dissipating energy. Peak wind velocity is occurring far from the project site (as seen in Figure 2.8). Due to these factors LTR concluded that the effect of cyclone is expected to be insignificant at the project site of Vizhinjam port and hence extreme analysis presented in Table 2.8 is applicable for the project site.

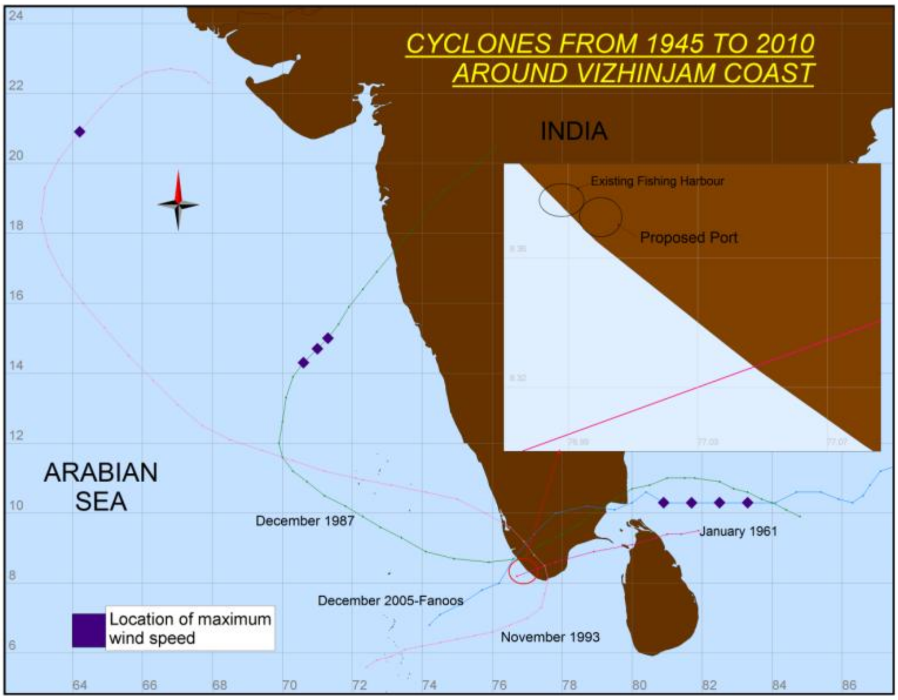


Figure 2.8 Cyclone Tracks of Major Cyclones around Vizhinjam Coast

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

2.3.2.4 **Water Levels**

2.3.2.4.1 Tides

The tides in the region are of the semi-diurnal type i.e. characterized by occurrence of two High and two Low Waters every day. Tidal levels for Vizhinjam are extracted from National Hydrographic Chart 222 as presented below:

Mean Highest High Water (MHHW)	+ 0.8 m
Mean Lowest High Water (MLHW)	+ 0.7 m
Mean Highest Low Water (MHLW)	+ 0.4 m
Mean Lowest Low Water (MLLW)	+ 0.3 m
Mean Sea Level (MSL)	+ 0.5 m

The storm surge heights calculated for various cyclones in the past were subjected to extreme wind conditions. Based on this, the storm surge height of 0.3m was calculated for the return period of 200 years.

30 days tide measurements for 3 seasons have been initiated by VISL and first set of measurements were carried in the sea off Vizhinjam for the period from 22nd January 2013 to 4th April 2013. EMCON automatic tide gauge was used for the measurement and was installed near the Coast Guard jetty, inside the fishing harbour for measuring the tides. The variation on tide levels was recorded at 10 minute interval and the recorded values were reduced to chart datum applicable for Vizhinjam. The recorded tides show that the spring tidal range is about 0.5m to 0.7m during the measurement period.

2.3.2.4.2 Sea Level Rise

Sea level around the world is observed to be increasing in the recent past due to global warming. The available satellite observations data with nearly global coverage taken from 1970's show that the sea level is rising at a rate of 3mm/yr and the same was confirmed from the coastal tide gauge measurements.

To arrive at the design deck level and onshore yard level, it is pertinent to consider the effects of sea level arise for waterfront structures over the port design life. In this regard, LTR carried out the model studies to assess this impact. IPCC Special Report on Emission Scenarios (SRES) projected that by mid 2090's the rise in global sea level will be about 4mm/yr and the same was considered to arrive at the project sea level rise. The projected sea level rise for the project location after 50,100 and 200 years will be 0.2, 0.4 and 0.8m.

2.3.2.5 **Currents**

Currents at the site are mostly of monsoon origin and tend to follow the trend of the coast. The current speed is about 1knot for the months of December to January with a direction of NW indicating the effects of north east monsoons and about 2knots during SW monsoon with direction as SE.

The data on currents was collected as part of the oceanographic investigations carried out at the project site by EGS Survey. The location plan of the current meter observations is shown in Figure 2.9. Current measurements were carried out at three locations (CM1, CM2 & CM3 at -10m CD, -16m CD & -23m CD respectively). Teledyne RDI Workhorse Sentinel 600 KHz Acoustic Doppler Current Profilers (ADCP) current meters were deployed at locations CM2 & CM3 and 600 kHz Rio Grande ADCP was deployed, fixed to the side of the vessel, at location CM1 in a downward looking mode to measure the speed and direction of the current. ADCP was used to measure the current speed and direction for 3 depths (near surface, mid-depth and near bottom) at each location. The ADCPs were programmed to record the currents at intervals of 10 minutes for a period of 30 days to cover one lunar cycle at each location.

The data reveals that the current flow was parallel to the coast and the surface currents are mostly wind driven. The maximum current of 0.89 knots was measured at the water surface and during the period of observation the current speed was mainly in the range of 0 to 0.5 knots.

Figure 2.9 Location of Currentmeter Observation

2.3.2.6 Littoral Drift

For the Indian South West Coast, swell waves from southern directions generate sand transport directed to the North and consequently sand transport from South to North occurs, whereby not all rock outcroppings extend into sufficiently deep water to block littoral drift completely.

Therefore at some locations along the southern shore, sand will be transported, mainly in the breaker zone from south to north during most of the year. Along the southern coast however, sea wave generated sand transport also occurs from north to south in the monsoon season. The conclusion is that sediment transport will occur in both directions along the coast. At the new port location, most rock outcropping extend into the sea sufficiently to substantially block the sand transport, but not completely as can be seen by the small sandy pocket beaches just north of the site.

2.3.2.7 Sea Bed Details

2.3.2.7.1 General

The sea bed engineering surveys were carried out by Fugro Geotech Pvt. Ltd. in May 2011. The survey maps were prepared in UTM co-ordinates (Universal Transverse Mercator) and supplemented by geographical co-ordinates (latitudes and longitudes in degrees, minutes and seconds), on WGS 84. The depths are indicated with respect to chart datum.

2.3.2.7.2 Bathymetry Survey

Odom Echotrac MK II dual frequency single beam echo sounder, with transducer operating at 33 kHz and 210 kHz frequencies was used for measuring water depths. R2 Sonic 2024 multi beam echo sounder system was used for acquiring swath bathymetric data within the survey area to study the extent and bed profile of rock outcrop within the survey area. Prior to commencing survey works the echo sounder was calibrated against a ‘Bar Check’.

The bathymetric survey covered an area extending upto 21m contour into the sea which is at a distance of approximately 1.5km from the shoreline and 5km along the shore. Water depths within the survey area were ranging between a minimum of 0.0 m (at the northern extreme of the survey area, near to shore line) and a maximum of 22.5 m (at the southern extreme of the survey area). The recorded depths within the survey area were reduced to chart datum using predicted tides. Figure 2.10 shows the bathymetric survey map for the project site. Contours/ Isobaths at 1m interval are depicted in survey map. Generally, Isobaths within the survey area are oriented parallel to the coast line, except the unevenness observed at the rock outcropping areas.

The following classification was generally adopted to define bathymetric gradients:

- <1° Very gentle
- 1° - 5° Gentle
- 5° - 10° Moderate
- 10° - 15° Steep
- >15° Very steep

In general, the seabed within the survey area was gently sloping down towards south west. The seabed between the shoreline and 10 m depth contour in the project site has a slope of 1: 36 (1.59°) is comparatively steeper than the seabed between 10 m and 15 m depth contours and these contours run parallel to the shoreline. Consequently the reverse trend is conspicuous in the deeper water i.e., along the seabed between 10 m and 15 m depth contours which has slope of 1: 110 (0.5°) which continues with the similar trend in the region beyond 15m depth in the study region.

2.3.2.7.3 Side Scan Sonar Survey

This survey reveals the sea bed features and any obstruction to the navigational operations. Geo-Acoustics Side Scan Sonar System SS941 Trans receiver159 DF with Tow fish 100 / 410 kHz transducers, soft and FUGRO's proprietary GLog /GPlot geophysical digital data acquisition system were used for acquisition of side scan sonar data within the area.

Seabed sediments within the survey area was classified into following types based on the acoustic reflectivity observed on the side scan sonar records.

- Type 1: Low to medium reflective seabed interpreted as Clayey / Silty Fine SAND
- Type 2: Medium reflective seabed interpreted as fine to medium SAND
- Type 3: High reflective seabed interpreted as Rock Outcrops

In general, Type 1 and Type 2 sediments were predominant within the survey area and were randomly distributed over the survey area. Rock out crops (Type 3) was predominant in areas close to the shore line. Distribution of various seabed types within the survey area is depicted.

Total five (5) sonar contacts were recorded within the survey area. All the sonar contacts were found without any measurable height and were classified as hard contacts.

No significant seabed features were identified within the survey area. No existing pipelines / cables were identified on the survey records within the survey area. The output of side scan surveys is presented in Figure 2.11.

2.3.2.7.4 Shallow Seismic Survey

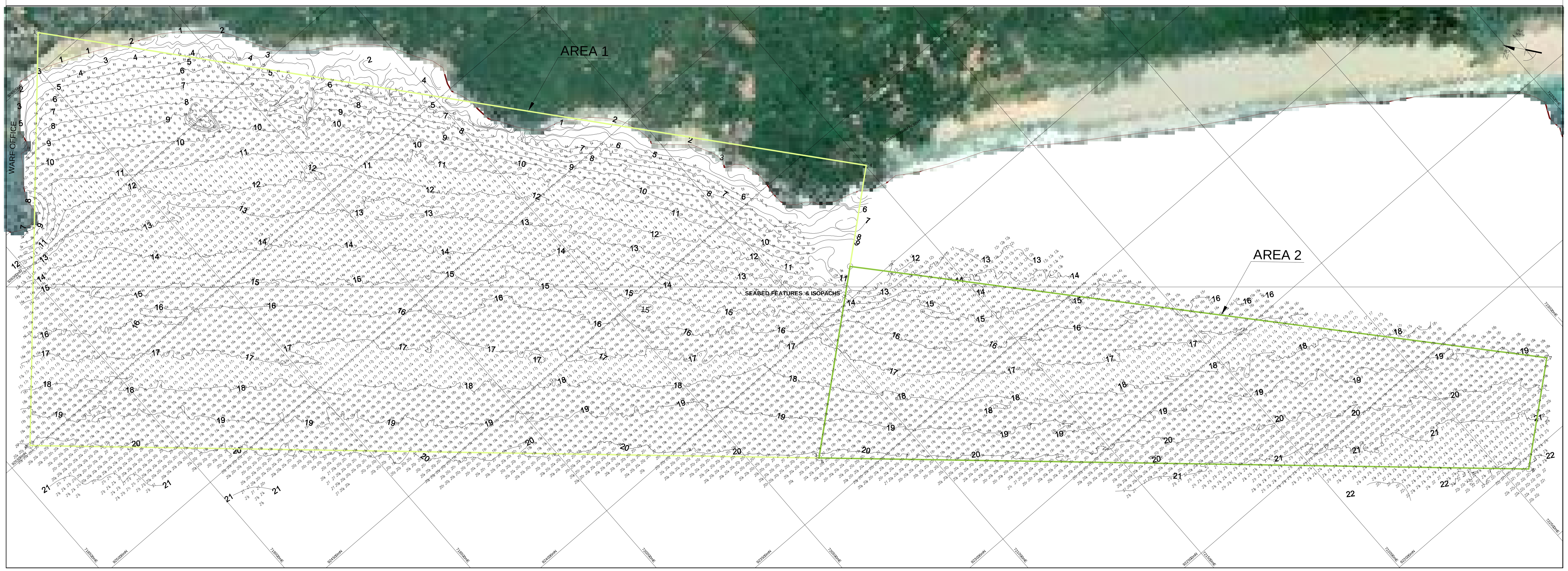
This survey is essential in order to assess the compactness of the seabed which could affect the dredging and/or navigation. Geo-Acoustics 5430A sub-bottom profiler (pinger) system was deployed to obtain the sub-seabed shallow geological information within the survey area. Boomer system was deployed for collecting the sub-seabed shallow geological information within the survey area. An Applied Acoustic Engineering CSP -1500 with Boomer Plate was used as the seismic energy source and the returning seismic signal was received by an Geo-pulse eight element hydrophone array. The penetration of acoustic waves primarily depends on the type of instruments, the frequency used and the geology of the surveyed area.

The compactness of the sediment derived from the seismic records, is presented in the form of Isopach map. Isopachs at 1m interval, showing the thickness of this unit, is as shown in Figure 2.12.

Isopachs are contours connecting points of equal thickness. Isopachs are true stratigraphic thicknesses; i.e. perpendicular to bedding surfaces. For example, the isopach contour of 9 m implies that the sediment column is present for atleast 9 m thickness without presence of any hard strata in between.

LIMITS OF SURVEY AREA

AREA	ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
		Easting (m)	Northing (m)
Area 1	1	719 585	926 611
	2	718 601	925 519
	3	720 694	923 647
	4	721 503	924 324
Area 2	5	720 694	923 647
	6	721 224	924 090
	7	722 885	922 220
	8	722 577	921 963



NOTES:

1) LOCALLY HIRED SURVEY VESSEL M/B PEARLS-1 WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY & MARCH 2011.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S STARFIX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
4) REFER TO FSINPVT SURVEY REPORT NO. J-MAR-11-006/MO 2011-060 FOR DETAILS ON THE RESOURCES MOBILISED AND METHODOLOGY ADOPTED FOR THIS SURVEY.
5) ATG WAS SET UP AT THE NORTH WEST OF JETTY AND LEVELED TO CLIENT SUPPLIED SOI BM ON A ROCK ADJOINING TO BASEMENT ON THE WESTERN SIDE OF VIZHINJAM MOSQUE (NEAR THE GATE OF HARBOUR ENTRANCE) WHICH IS 6.945m ABOVE CHART DATUM.
6) RECORDED DEPTHS WERE REDUCED TO CHART DATUM USING OBSERVED TIDES AT THE JETTY.
7) THE RESULTS OF SURVEY ARE PLOTTED IN WGS84 DATUM, UTM PROJECTION, ZONE 43.
8) THE COASTAL FEATURES SHOWN ARE SOURCED FROM GOOGLE IMAGE.
9) THIS IMAGE HAS BEEN RUBBER-SHEETED AND PLACED FOR RELATIVE APPRECIATION ONLY.
10) COORDINATES OF COASTAL AND LAND FEATURES IN THIS IMAGE ARE NOT RELIABLE AND HENCE NOT TO BE USED FOR ANY OTHER PURPOSE.

Geodetic, Projection and Grid Parameters

Global Positioning System Geodetic Parameters

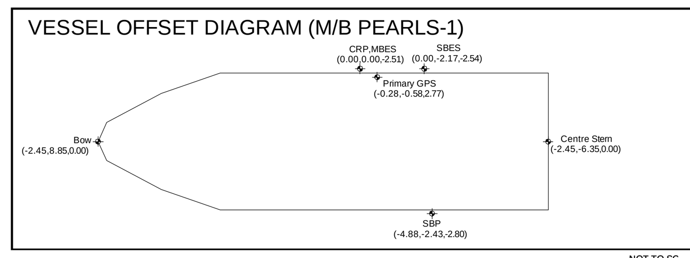
Datum	: World Geodetic System 1984 (WGS84)
Spheroid	: World Geodetic System 1984
Semi major axis	: a = 6 378 137.000 m
Inverse flattening	: 1/f = 298.257 223 563

Projection and Grid Parameters

Map Projection	: Universal Transverse Mercator

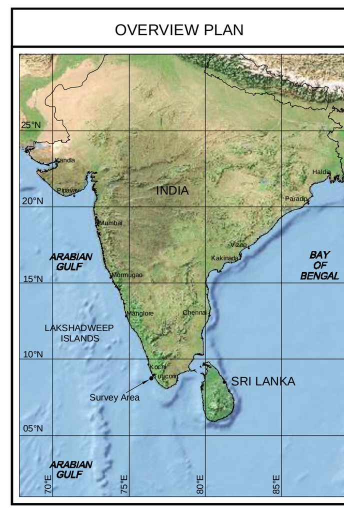
REFERENCE DRAWINGS

VESSEL OFFSET DIAGRAM (M/B PEARLS-1)

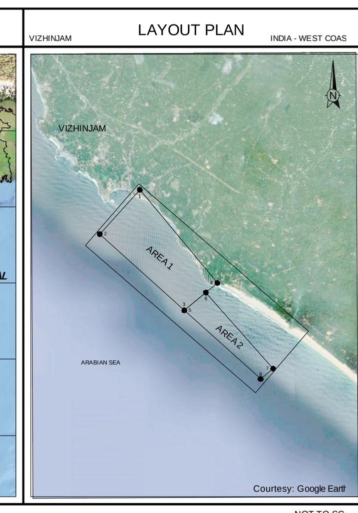


NOT TO SC

OVERVIEW PLAN



LAYOUT PLAN



NOT TO SC

CLIENT

FUGRO GEOTECH PVT. LTD
PLOT NO. 51, SECTOR 6,
SANPADA
NAVI MUMBAI - 400 705, INDIA
TEL: (91) (22) 6516 8662 FAX: (91) (22) 2762 0768

SURVEY CONTRACTOR

FUGRO SURVEY (INDIA) PVT. LTD.
FUGRO HOUSE
D-222/30, TTC INDUSTRIAL AREA, MIDC,
NERUL, NAVI MUMBAI - 400 706, INDIA.
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(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

CHART SHOWING

BATHYMETRY, SEABED FEATURES & ISOPACH

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

Vessel:- M/B PEARLS-1 — Project Ref: J-MAR-11-006

Rev. No:	Date:	Description:	Surveyed :	Interpr:	Drawn:	Chkd:	App
1	12/07/2011	FINAL ISSUE	AS	LPL	DD/DJ	AVD	SKF
0	30/03/2011	ISSUED FOR APPROVAL	AS	LPL	SD/MG	AVD	SKF

Drawing File No:	Drawing No:	Encl.
5320-01R1	J-MAR-11-006/MO 2011-060/FGEOTECH/VIZHINJAM/BS/BSI/01/5320	01 of 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BATHMETRIC SURVEY FOR PROPOSED VIZHINJAM PORT

AECOM
AECOM India Private Limited

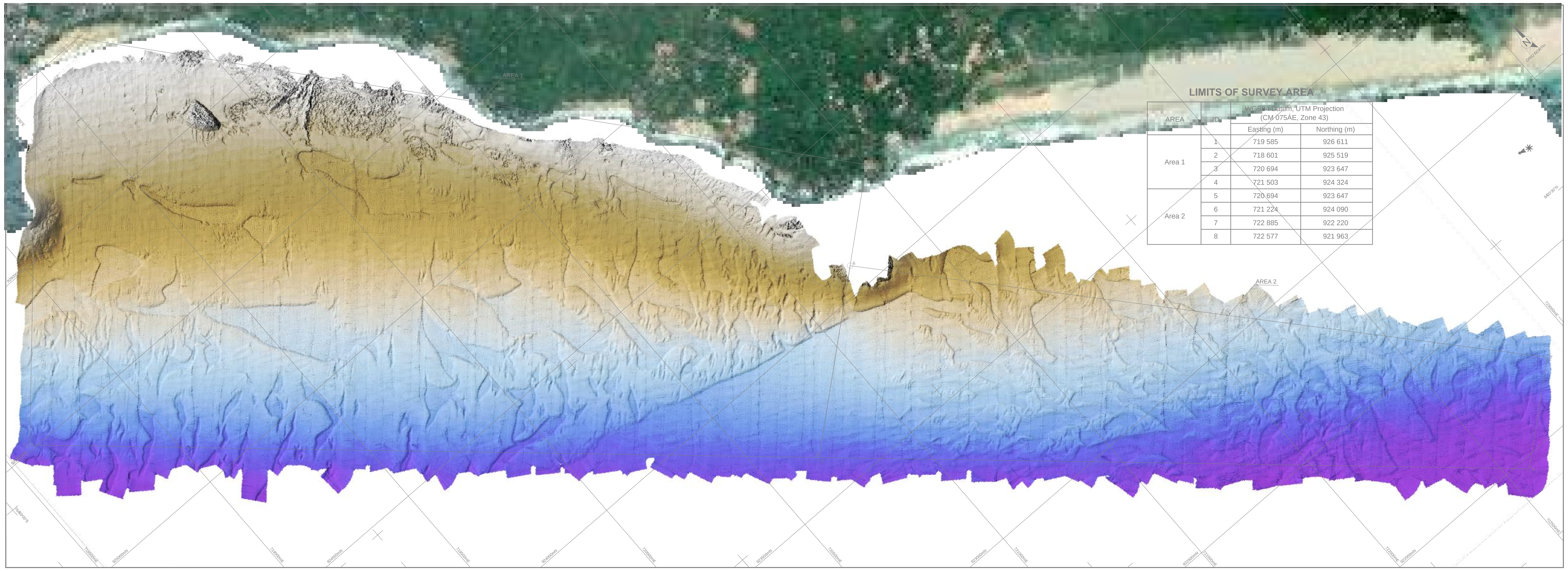
PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.10 REV 1

Last saved by: BHANOTV(2013-05-03) Last Plotted: 2013-05-03
Filename: M:\PROJECTS\2011\05-PORTS\DELD11137_VIZHINJAM\06_CAD (O)\DRAWINGS\DPR\CAD\FIGURES\DWG_DPR-FIGURE-2.10_REV A.DWG

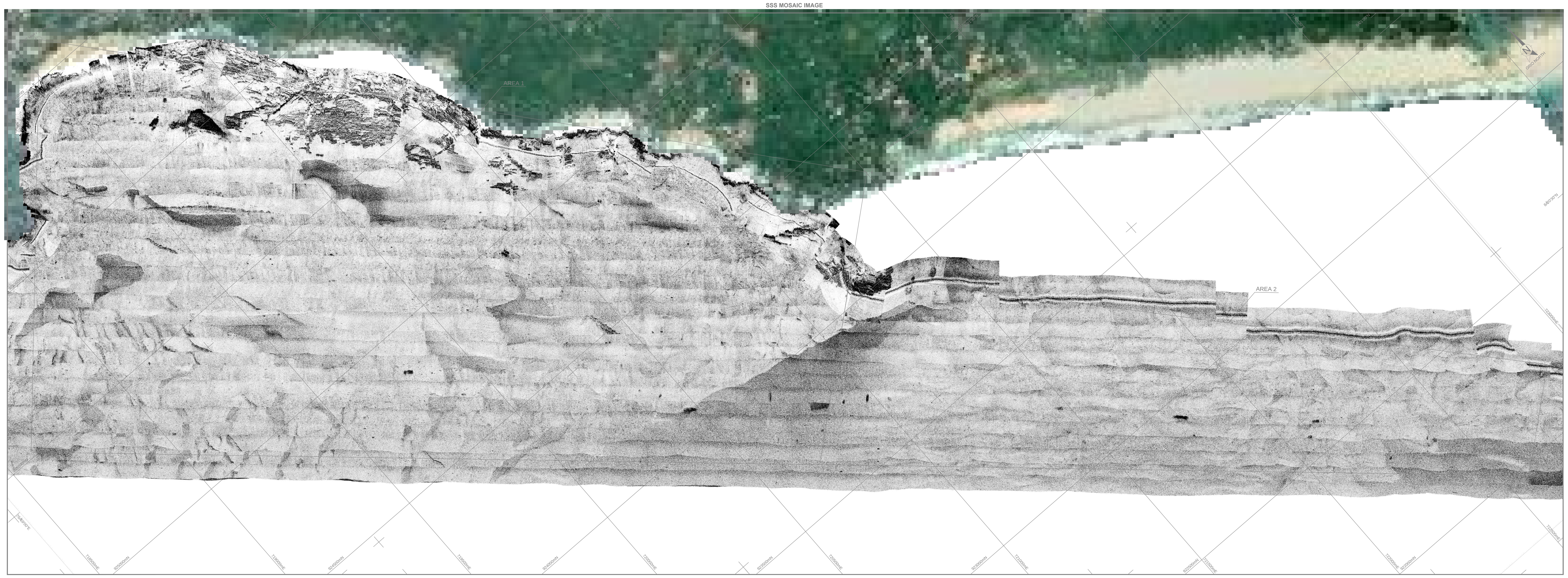
Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

MULTIBEAM IMAGE



AREA		WGS84 Datum, UTM Projection (CM 075ÁE, Zone 43)	
		Easting (m)	Northing (m)
Area 1	1	719 585	926 611
	2	718 601	925 519
	3	720 694	923 647
	4	721 503	924 324
Area 2	5	720 694	923 647
	6	721 224	924 090
	7	722 885	922 220
	8	722 577	921 963

SSS MOSAIC IMAGE



LEGEND:

FEATURES IDENTIFIED FROM CURRENT SURVEY

GENERAL

GEOGRAPHICAL INTERSECTION

SSS MOSAIC

DIRECTION OF ILLUMINATION AZIMUTH=283Á ELEVATION=55Á

DEPTH IN METERS (REDUCED TO CHART DATUM)

22.0, 20.0, 19.0, 17.0, 15.0, 12.0, 8.5

FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)

SURVEY AREA BOUNDARY

NOTES:

1) LOCALLY HIRED SURVEY VESSEL M/B PEARLS-1 WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY & MARCH 2011.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S STARFIX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
4) REFER TO FSINPVT SURVEY REPORT NO. J-MAR-11-006/MO 2011-060 FOR DETAILS ON THE RESOURCES MOBILISED AND METHODOLOGY ADOPTED FOR THIS SURVEY.
5) ATG WAS SET UP AT THE NORTH WEST OF JETTY AND LEVELED TO CLIENT SUPPLIED SOI BM ON A ROCK ADJOINING TO BASEMENT ON THE WESTERN SIDE OF VIZHINJAM MOSQUE (NEAR THE GATE OF HARBOUR ENTRANCE) WHICH IS 6.945m ABOVE CHART DATUM.
6) RECORDED DEPTHS WERE REDUCED TO CHART DATUM USING OBSERVED TIDES AT THE JETTY.
7) THE RESULTS OF SURVEY ARE PLOTTED IN WGS84 DATUM, UTM PROJECTION, ZONE 43.
8) THE COASTAL FEATURES SHOWN ARE SOURCED FROM GOOGLE IMAGE.
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10) COORDINATES OF COASTAL AND LAND FEATURES IN THIS IMAGE ARE NOT RELIABLE AND HENCE NOT TO BE USED FOR ANY OTHER PURPOSE.

Geodetic, Projection and Grid Parameters

Global Positioning System Geodetic Parameters

Datum	:	World Geodetic System 1984 (WGS84)
Spheroid	:	World Geodetic System 1984
Semi major axis	:	a = 6 378 137.000 m
Inverse flattening	:	1/f = 298.257 223 563

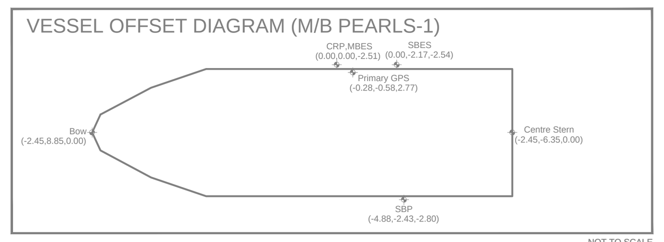
Projection and Grid Parameters

Map Projection	:	Universal Transverse Mercator
Grid System	:	UTM Zone 43 N
Central Meridian	:	075Á00' 00" East
Latitude of Origin	:	0Á00' 00" North
False Easting	:	500 000 m
False Northing	:	0 m
Scale factor on Central Meridian	:	0.9996
Units	:	metre

REFERENCE DRAWINGS

Rev. No:	Date:	Drawing No.	Source	Description
-	16/07/2010	0100.011	CLIENT	BOREHOLE INFORMATION

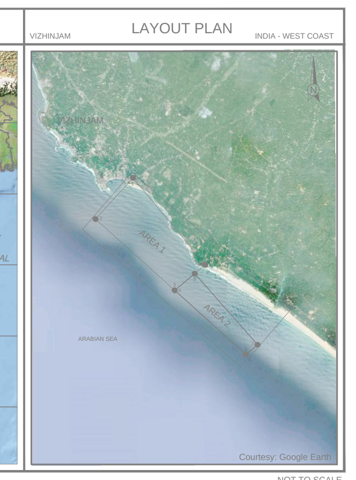
VESSEL OFFSET DIAGRAM (M/B PEARLS-1)



NOT TO SCALE

OVERVIEW PLAN

LAYOUT PLAN



NOT TO SCALE

CLIENT

FUGRO GEOTECH PVT. LTD
PLOT NO. 51, SECTOR 6,
SANPADA
NAVI MUMBAI - 400 705, INDIA
TEL: (91) (22) 6516 8662 FAX: (91) (22) 2762 0768

SURVEY CONTRACTOR

FUGRO SURVEY (INDIA) PVT. LTD.
FUGRO HOUSE
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NERUL, NAVI MUMBAI - 400 706, INDIA.
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(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

CHART SHOWING

MULTIBEAM AND SSS MOSAIC IMAGE

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

100m 0m 100m 200m 300m 400m 500m

Vessel:- M/B PEARLS-1							Project Ref: J-MAR-11-006	
Rev. No:	Date:	Description:	Surveyed :	Interpr:	Drawn:	Chkd:	Appr:
0	15/07/2011	ISSUED FOR APPROVAL	AS	LPL	SAC	GNH	SKR

Drawing File No: 5434-01R0
Drawing No: J-MAR-11-006/MO 2011-060/FGEOTECH/VIZHINJAM/BS/IM/01/5434
Encl. 08 OF 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

SIDE SCAN SONAR SURVEY MOSAIC IMAGE FOR PROPOSED VIZHINJAM PORT

AECOM India Private Limited

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.11

ISO A1 594mm x 841mm
Approved: VA
Checked: AM
Designer: DK
Project Management Initials:
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LIST OF SONAR CONTACTS

WGS84 Datum, UTM Projection (CM 075° E, Zone 43)				
ID	Easting (m)	Northing (m)	Dimensions (m) Length x Width x Height	Remark
SC01	719 487.50	924 797.76	1.7 x 0.7 x nmh	Hard contact
SC02	719 680.29	924 779.45	2.5 x 1.0 x nmh	Hard contact
SC03	720 066.23	924 430.04	1.6 x 0.7 x nmh	Hard contact
SC04	721 869.66	923 099.44	3.0 x 0.6 x nmh	Hard contact
SC05	722 234.78	922 465.61	1.3 x 0.7 x nmh	Hard contact

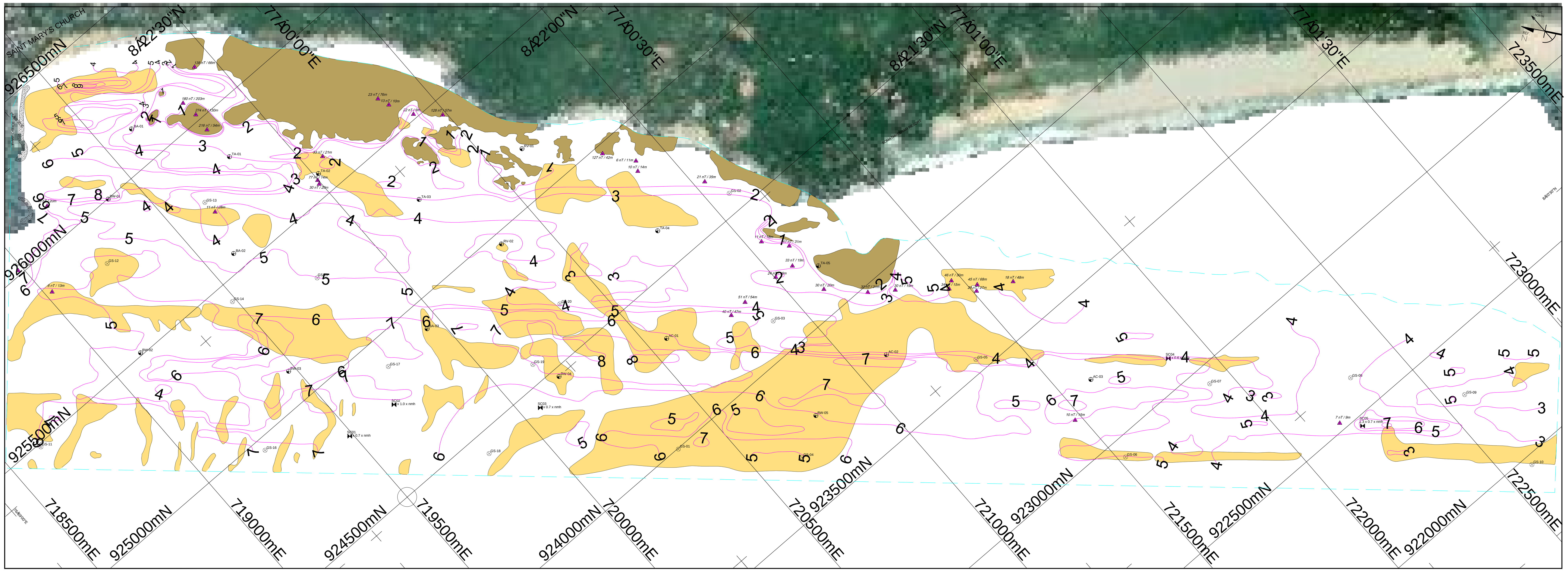
nmh - no measurable height

BORE HOLE LOCATION COORDINATES

ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
	Easting (m)	Northing (m)
AC-01	720 568	924 322
AC-02	721 121	923 767
AC-03	721 613	923 223
BA-01	719 617	926 132
BA-02	719 602	925 560
BA-03	719 946	924 906
BW-01	719 391	925 998
BW-02	719 120	925 509
BW-03	719 475	925 115
BW-04	720 190	924 470
BW-05	720 789	923 767
RV-01	720 621	925 170
RV-02	720 344	924 961
TA-01	719 816	925 830
TA-02	720 016	925 577
TA-03	720 226	925 273
TA-04	720 794	924 633
TA-05	721 145	924 164

GRAB SAMPLES COORDINATES

ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
	Easting (m)	Northing (m)
GS-01	720 341	923 997
GS-02	721 074	924 567
GS-03	720 895	924 121
GS-04	720 654	923 687
GS-05	721 350	923 545
GS-06	721 525	922 934
GS-07	721 922	922 935
GS-08	722 315	922 623
GS-09	722 582	922 312
GS-10	722 600	921 967
GS-11	718 632	925 488
GS-12	719 238	925 827
GS-13	719 643	925 764
GS-14	719 486	925 433
GS-15	719 769	925 299
GS-16	719 227	924 957
GS-17	719 754	924 895
GS-18	719 822	924 426
GS-19	720 147	924 564
GS-20	720 361	924 664



LEGEND:

SEABED FEATURES

SC02 Datum 2.5 x 1.0 x nmh — SONAR CONTACT WITH DIMENSIONS IN METRES (length x width x height) (nmh = no measurable height)

GS-11 — GRAB SAMPLE LOCATION

BW-04 — BOREHOLE LOCATION

73 nT/42 m — MAGNETIC ANOMALY IN NANO TESLAS / WIDTH OF ANOMALY IN METRES

TYPE 1:- LOW TO MEDIUM REFLECTIVITY (CLAY / SILTY FINE SAND)

TYPE 2:- MEDIUM REFLECTIVE SEABED (FINE TO MEDIUM SAND)

TYPE 3:- HIGH REFLECTIVE SEABED (ROCK OUTCROPS)

BREAK WATERS

ISOPACH

3 — ISOPACH OF TOP MOST SEDIMENTARY UNIT AT 1M INTERVAL

FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)

SURVEY AREA BOUNDARY

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False Northing	:	0 m
Scale factor on Central Meridian	:	0.9996
Units	:	metre

REFERENCE DRAWINGS

Rev. No:	Date:	Drawing No.	Source	Description
	16/07/2010	0100.011	CLIENT	BOREHOLE INFORMATION

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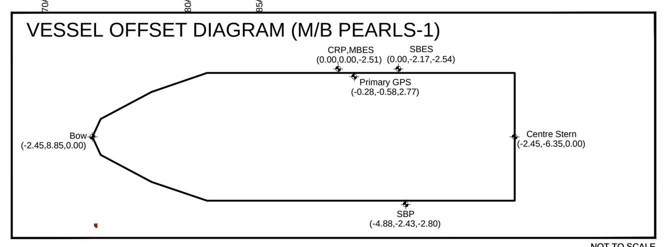
VESSEL OFFSET DIAGRAM (M/B PEARLS-1)



NOT TO SCALE

OVERVIEW PLAN

LAYOUT PLAN

VIZHINJAM — INDIA - WEST COAST

NOT TO SCALE

CLIENT

FUGRO GEOTECH PVT. LTD
PLOT NO. 51, SECTOR 6,
SANPADA
NAVI MUMBAI - 400 705, INDIA
TEL: (91) (22) 6516 8662 FAX: (91) (22) 2762 0768

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(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

BATHYMETRY, SEABED FEATURES & ISOPACH

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

100m 0m 100m 200m 300m 400m 500m

Vessel:- M/B PEARLS-1 — Project Ref: J-MAR-11-006

Rev. No:	Date:	Description:	Surveyed :	Interpr:	Drawn:	Chkd:	Appr:
1	12/07/2011	FINAL ISSUE	AS	LPL	DD/DJ	AVD	SKR
0	30/03/2011	ISSUED FOR APPROVAL	AS	LPL	SD/MG	AVD	SKR

Drawing File No:	Drawing No:	Encl.
5320-01R1	J-MAR-11-006/MO 2011-060/FGEOTECH/VIZHINJAM/BS/BSI/01/5320	01 of 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

ISOPACH MAP FOR PROPOSED VIZHINJAM PORT

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.12

ISO A1 594mm x 841mm

Approved: VA Checked: AM Designer: DK Project Management Initials:

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The investigation area covered an extent of approximately 5 km of waterfront parallel to the shore extending up to 21 m contour (bathymetric) into the sea. The area was distinguished in view of the necessary developments for the proposed port. All sedimentary units defined in the map are based on an assessment of the recorded acoustic characteristics of the seabed and sub-seabed nature of sediments.

The sub-seabed acoustic signal penetration achieved was variable within the survey area and the maximum penetration achieved was approximately 40 m below seabed. Scattering of the acoustic signals due to the thick layers of SAND and high acoustic impedance offered by the weathered rock layers were the limitations in achieving better acoustic signal penetration within the survey area. The nature of the seabed sediments within the survey area was classified primarily based on the reflectivity pattern of the seabed. Appropriate references from single beam & multi-beam echo sounder data, sub-bottom profiler data and soil samples taken by Grab Sampler were taken as and when required. From the sub-bottom profiler records, the stratigraphic sequence within the surveyed area can be broadly classified into two major sedimentary units – topmost Sandy unit underlain by weathered rock unit. However, the topmost Sandy unit was further classified into different sub-units based on the acoustic reflectors identified from the sub-bottom profiler records due to the variation in density / compaction of the sediments with depth.

Loose to medium dense Silty SAND unit was the topmost geological unit throughout the survey area except in areas wherever rock out crops was recorded. The thickness of this unit was varying between < 1m and 9 m within the survey area. Sedimentary unit underlying the topmost unit was interpreted as medium dense SAND. The intermittent parallel / sub-parallel internal reflectors within this unit can be attributed to presence of thin layers of Silt / Clay within this unit. This unit was present throughout the survey area except at the rock outcropping areas.

The very dense firm Sand unit was found underlying the Medium dense Sand unit and was identified mainly in the seaward side of the survey area. The weathered rock layer unit was overlain by the Sand unit throughout the survey area except at the outcropping locations. The outcropping areas were mainly close to the shore line. The top of the weathered rock was identified from the records due to the high seismic impedance offered by this unit to the seismic energies and little acoustic signal penetration beyond this unit. This unit was not traceable from the sub-bottom records throughout the survey areas, particularly wherever this unit was going deeper.

2.3.2.7.5 Magnetic Anomalies

In geophysics, a magnetic anomaly is a local variation in the Earth's magnetic field resulting from variations in the chemistry or magnetism of the rocks. Mapping of variation over an area is valuable in detecting structures obscured by overlying material. Marine Magnetics SeaSPY Marine Magnetometer was deployed for the magnetometer survey for identifying the magnetic anomalies within the survey limits. The system is an Overhauser magnetometer system which measures the ambient magnetic field using 'Nuclear Magnetic Resonance Technology'.

A value greater than 5 nano Tesla (nT) against the background magnetic intensity was used as the criteria to detect possible anomalous magnetic objects. The value of the magnetic anomalies depends on several factors such as distance from the source causing the anomaly, direction of magnetisation of the source with respect to the earth's field, ferrous content of the object, ambient magnetic noise etc. No conclusions could be drawn from the value of the magnetic anomaly alone regarding the nature or type of the source causing the anomaly. The positional accuracy of the interpreted magnetic anomalies depends on a combination of the vessel positioning, layback calculations for the tow fish relative to the vessel.

Total of thirty five (35) spots of magnetic anomalies, were identified by FUGRO within the survey area. As per the conclusion made by FUGRO, three anomalies were possibly associated with the electricity generator installed close to the new wharf/breakwater and eight were attributed to rock outcrops. The rest could not be correlated to any specific source and were not found to be important.

2.3.2.8 **Sediment Samples**

The sediment samples were collected during the oceanographic investigation for the proposed port by using Grab Sampler. The location of seabed samples collected in open sea of Vizhinjam is shown in Figure 2.13. The samples were analyzed in the laboratory for size distribution using sieve analysis.

The sample test results indicate that the seabed predominantly comprises of fine sand. As part of the sedimentation model study, LTR analyzed the Median sediment sizes (D_{50}) extracted from the grain size distribution curves. The distribution of D_{50} shows the presence of coarser sediments on both side of the fishing harbour and relatively finer sediments in front of the fishing harbour and the proposed port, indicating the possibility of a relatively calmer environment and settling of sediments brought by the currents near the project location. The spatial distribution of sediments around the project area is as shown in Figure 2.13.

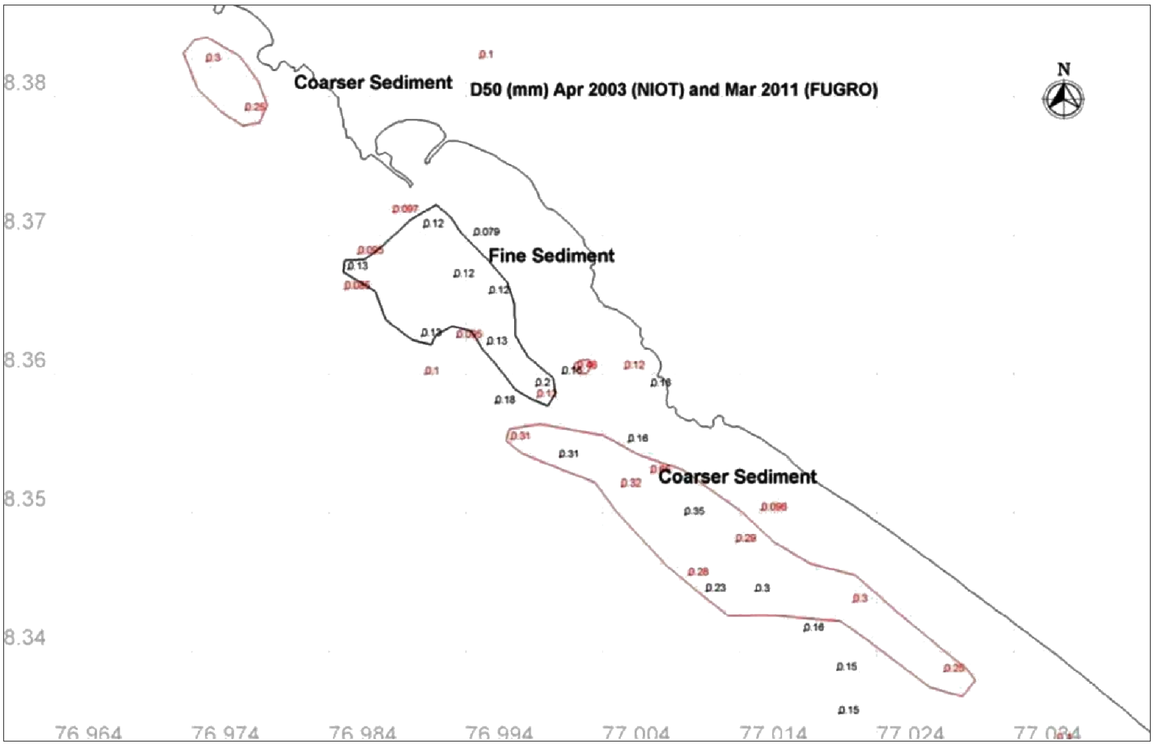

Figure 2.13 Grab sampling taken along the project site and D_{50} values

[Source: Updated Mathematical Modeling Study, LTR, May 2013]

2.4 Geotechnical Data

2.4.1 Historical Geotechnical Data

2.4.1.1 Historical Marine Data

As part of the site selection and Techno feasibility during early stage of the study (LTR May 2004), LTR conducted borehole investigations in the area of Vizhinjam Port Development. The following is the summary of sub soil strata based on these borehole investigations:

- Top soil is a layer of relatively loose to dense sand with shell fragments with varying thickness in the offshore region, followed with the layer of weathered rock or hard Khondolite.
- A layer of clay sandwiched between dense sand and rock was found in certain patch of the area of approximate thickness of 1.2 m.
- Rock was usually found beyond the depth of 12m below existing bed level in deep waters. Boreholes were terminated once rock was found, or 24m below sea bed level.

2.4.1.2 Historical Onshore Data

The locations of onshore boreholes were distributed along the coastline of the proposed project area. The location of these boreholes is as shown in Figure 2.14. From the land borehole data the surface soil is generally sandy type and relatively medium to dense. The subsurface stratification at shore generally consists of medium to dense sand varying from 1m on the northern side to 7.8m near the southern side followed by either weathered granite rock or hard granite rock. The rock exposed to the fury of the sea is metamorphosed into granite. Laterite deposits are seen at higher elevations away from the sea.

The generalized profile of the investigated boreholes is as shown in Figure 2.15.

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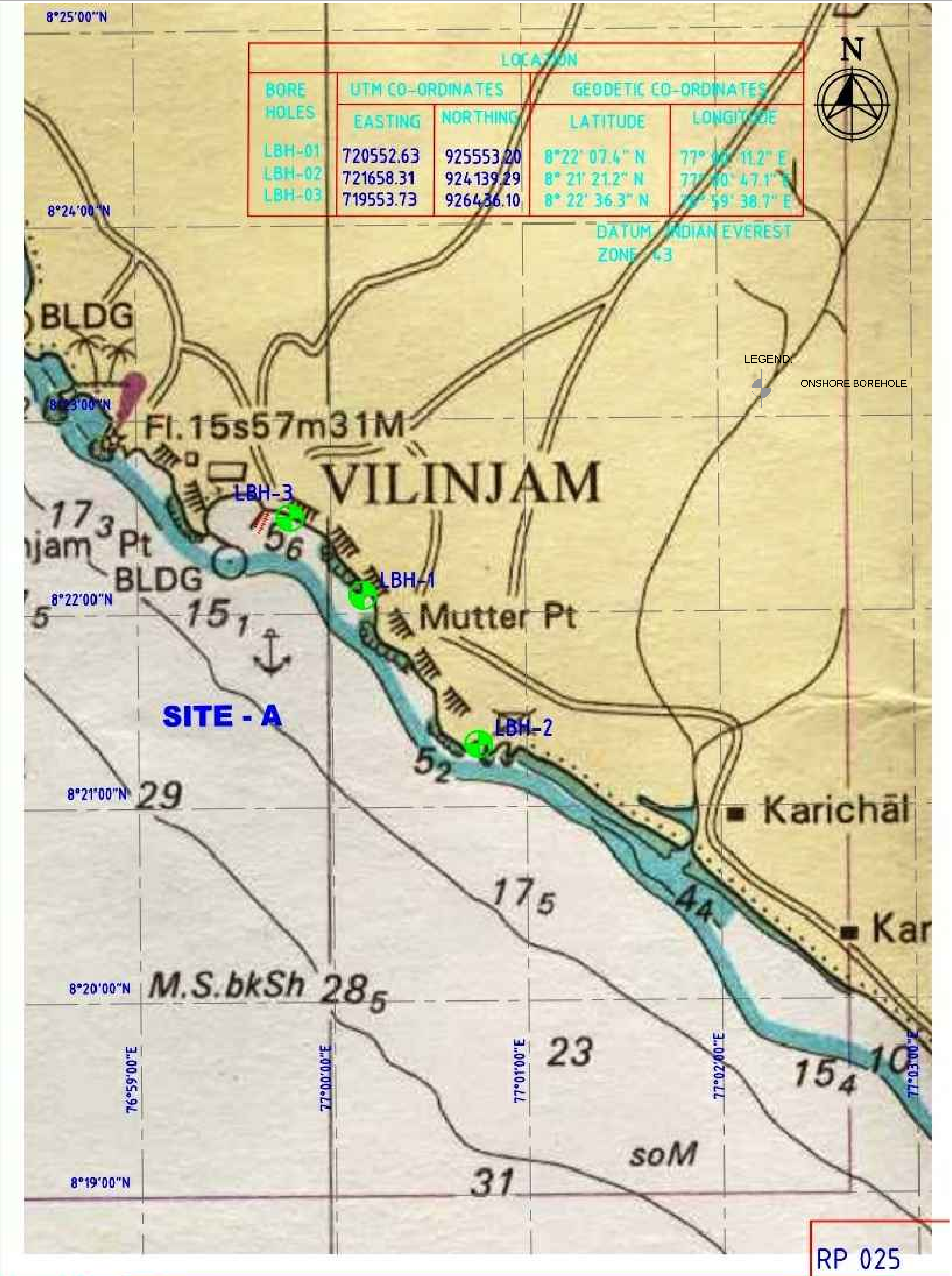
Filename: M:\PROJECTS\2011\05-PORTS\DELD11137_VIZHINJAM\06_CAD (O)\DRAWINGS\DPR\CAD\FIGURES\DWG_DPR-FIGURE-2.14,2.15.DWG

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm



BORE HOLES	UTM CO-ORDINATES		GEODETIC CO-ORDINATES	
	EASTING	NORTHING	LATITUDE	LONGITUDE
LBH-01	720552.63	925553.20	8°22' 07.4" N	77° 00' 11.2" E
LBH-02	721658.31	924139.29	8° 21' 21.2" N	77° 00' 47.1" E
LBH-03	719553.73	926436.10	8° 22' 36.3" N	76° 59' 38.7" E

DATUM INDIAN EVEREST
ZONE 43

RP 025

PROJECT: DEVELOPMENT OF VIZHINJAM PORT

PROJECT NO: C1021119

TITLE: LOCATION OF LAND BOREHOLES

DATE: 15/05/04

MADE: ESV

L&T-RAMBØLL CONSULTING ENGINEERS LIMITED

FIGURE NO: FD0201

REV: 0

PATH: J:\C1021119\DWGS.\ Fig_2.0.DWG

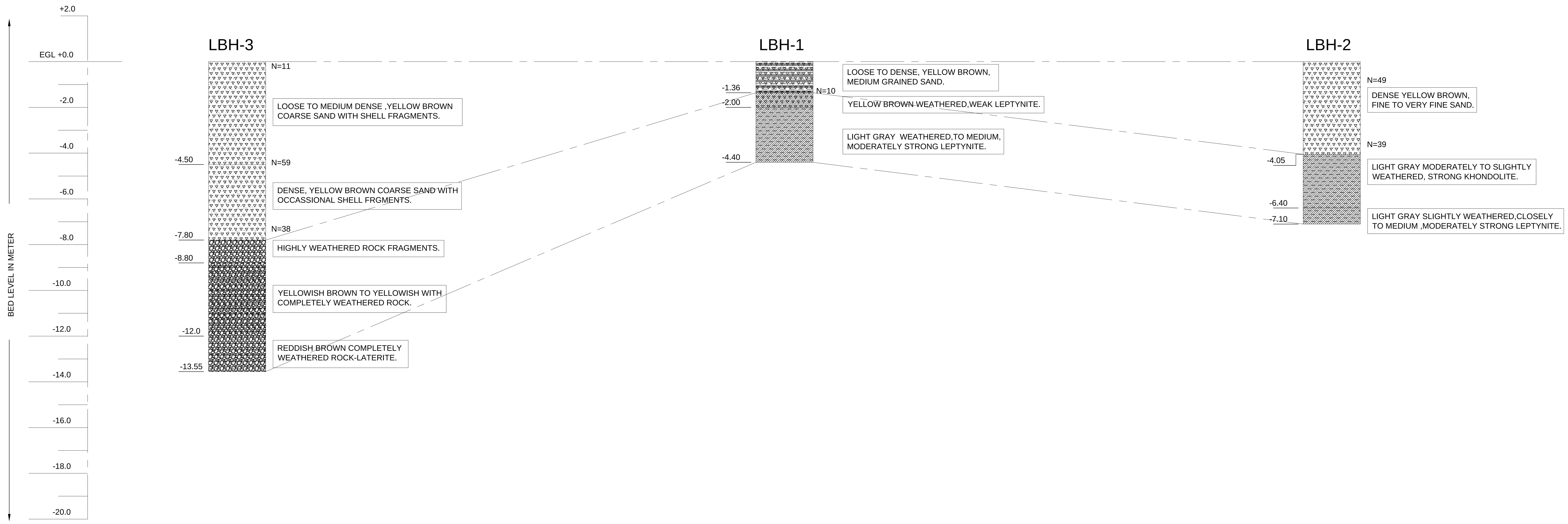
PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

LOCATION OF ONSHORE BOREHOLES

AECOM
AECOM India Private Limited

Vizhinjam International Seaport Limited

PROJECT No. : DELD12086 **DATE :** 08-01-13 **FIGURE No. :** 2.14



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN METRES.
3. EXISTING GROUND LEVEL (EGL) IS ASSUMED TO BE ZERO.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

ONSHORE BOREHOLES PROFILES

AECOM

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 08-01-2013

FIGURE No. : 2.15

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

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Filename: M:\PROJECTS\2011\05-PORTS\DELD11137_VIZHINJAM\06_CAD (O)\DRAWINGS\DPR\CAD\FIGURES\DWG_DPR-FIGURE-2.14,2.15.DWG

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2.4.2 Site Specific Geotechnical Data

2.4.2.1 Background

To assess and confirm the sub soil data available based on the above, VISL commissioned the geotechnical investigations through M/s Fugro Geotech Ltd. Mumbai (Fugro). The broad objectives of the investigation were as follows:

- To acquire detailed geotechnical information on the sub seabed
- To assess the engineering properties and classification of soil / rock samples
- To provide geotechnical parameters and interpretation of the lithology across the site

The scope of work for the geotechnical investigations comprised drilling of 16 boreholes with various field and laboratory tests generally in accordance with relevant India/ British/ American Codes in practice. The various components of the work were drilling using jack-up mounted drill rigs, conducting SPT, sampling, coring, laboratory testing on the soil and rock samples collected and preparation of report. The results of the data obtained from the above boreholes and laboratory investigations of the samples obtained are discussed and presented in the following paragraphs.

2.4.2.2 Marine Geotechnical Investigation

Based on the concept layout developed by RH, marine geotechnical investigations were undertaken by M/s. Fugro Geotech Pvt. Ltd as part of the investigation study. The location plan of marine boreholes conducted at site is presented in Figure 2.16.

Specific borehole data has been utilized to prepare soil profiles to study the distribution of the sub strata and assess the geotechnical conditions of the particular component. The various soil profiles along the important components of the port are shown in Figure 2.17 to Figure 2.21 respectively

Soil Profile 1: Along Northern Breakwater (BW 02, 03, 04, 05)

The top layer is loose to medium dense silty sand with shell fragments. The depth of this layer varies from 5 m at the north to 21 m along the south of the breakwater. This layer is underlain immediately by a layer of very dense clayey sand. This layer is underlain with very dense sand with gravels in borehole BW 02. The dense sub soil layer of very dense silty clayey sand is observed in all the profile boreholes which continue up to the termination depth of the borehole. The profile boreholes were terminated at an average depth of -50 m CD.

Soil Profile 2: Along Northern Breakwater (BA 01, BW 01, 02)

This profile is similar to Profile 1 with the top layer of loose to medium dense silty sand with shell fragments. The depth of this layer varies from 5 m at the north to 21 m along the breakwater. The profile boreholes were terminated at an average depth of -50 m CD.

Soil Profile 3: Along Basin and Approach channel (BW 01, BA 02, BA 03, AC 01, AC 02, AC 03)

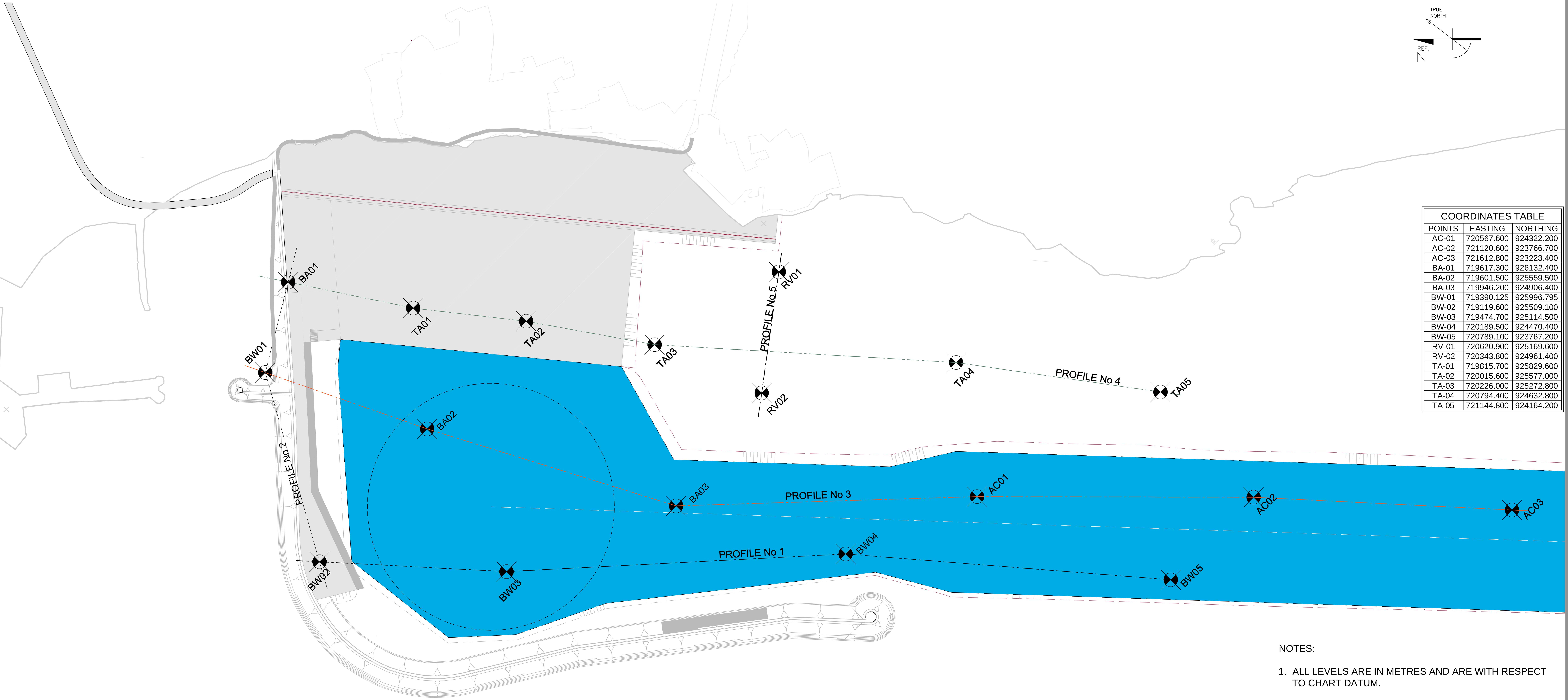
The top layer of all the boreholes along this profile is loose to very dense grey silty fine sand with shell fragments. This layer is followed with the layer of stiff to very dense silty clayey sand which continues up to the termination depth in BW 01. The borehole was terminated at the depth of -47m CD while, rest of the other boreholes in the channel were terminated at an average depth of -24m CD.

Soil Profile 4: Along Container Berths (BA 01, TA 01, TA 02, TA 03, TA 04, TA 05)

The top layer in this profile is loose to medium dense clayey sand with the shell fragments as well as some portion of weathered rock fragments. The subsequent layer in this profile is of weathered charnockite ranging from weak to strong in nature. Hard rock in the form of Gneiss and Khandolite is encountered in borehole TA 04. Borehole TA 02, 03 and 04 were terminated at an average depth of -50m CD where the refusal layer was encountered while in the other borehole the termination depth were at -30m CD.

Soil Profile 5: Along the Inner Southern Breakwater (South Breakwater not needed now) (RV 01, RV 02)

The top layer along this profile is of silty sand. The depth of this layer varied from 2m close to the shore to 12m near the tip of the breakwater. A layer of weathered moderately strong rock of gneiss is sandwiched between the top layer and the layer of moderately weathered rocky layer of Khandolite which continues up to the borehole termination depth. RV 01 was terminated at -31m CD while RV 02 was terminated at -52m CD where the refusal layer was encountered.



COORDINATES TABLE		
POINTS	EASTING	NORTHING
AC-01	720567.600	924322.200
AC-02	721120.600	923766.700
AC-03	721612.800	923223.400
BA-01	719617.300	926132.400
BA-02	719601.500	925559.500
BA-03	719946.200	924906.400
BW-01	719390.125	925996.795
BW-02	719119.600	925509.100
BW-03	719474.700	925114.500
BW-04	720189.500	924470.400
BW-05	720789.100	923767.200
RV-01	720620.900	925169.600
RV-02	720343.800	924961.400
TA-01	719815.700	925829.600
TA-02	720015.600	925577.000
TA-03	720226.000	925272.800
TA-04	720794.400	924632.800
TA-05	721144.800	924164.200

NOTES:

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

LEGEND:

MARINE BOREHOLE

BOREHOLE PROFILE

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

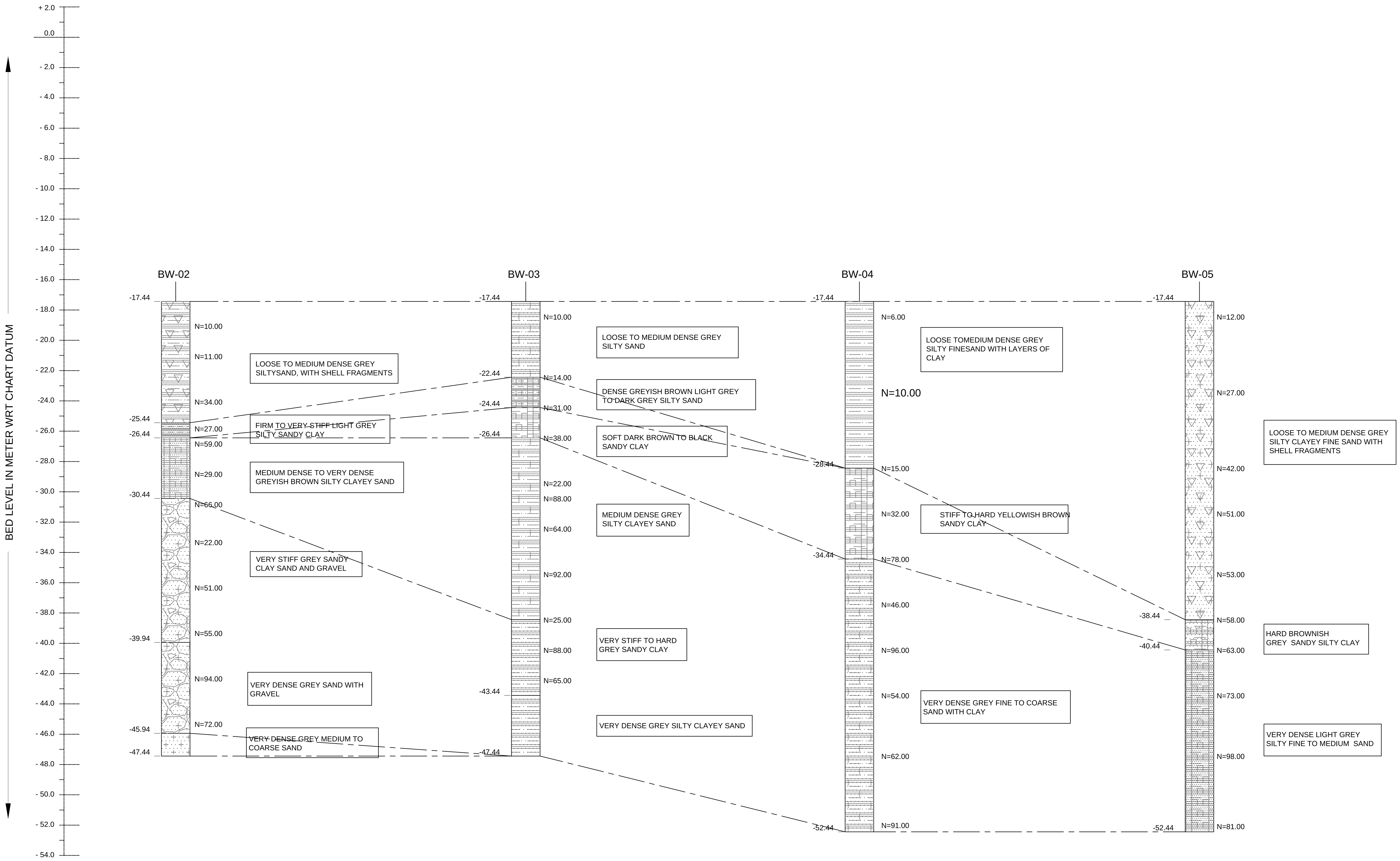
BOREHOLES LOACTION FOR MARINE GEOTECHNICAL INVESTIGATIONS

AECOM
AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 04-01-2013

FIGURE No. : 2.16 REV 2

ISO A1 594mm x 841mm
Project Management Initials: Designer: DK Checked: AM Approved: VA
Last saved by: BHANOTV(2013-05-24) Last Plotted: 2013-05-24
Filename: M:\PROJECTS\2011\05-PORTS\DELD11137_VIZHINJAM\06_CAD (O)\DRAWINGS\DPR\CAD\FIGURES\DWG_DPR-FIGURE-2.16 REV 2.DWG



NOTES:

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

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

SOIL PROFILE 1 - ALONG NORTH BREAKWATER

AECOM

AECOM India Private Limited

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.17

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

Last saved by: MISHRAV1(2013-05-03) Last Plotted: 2013-05-03
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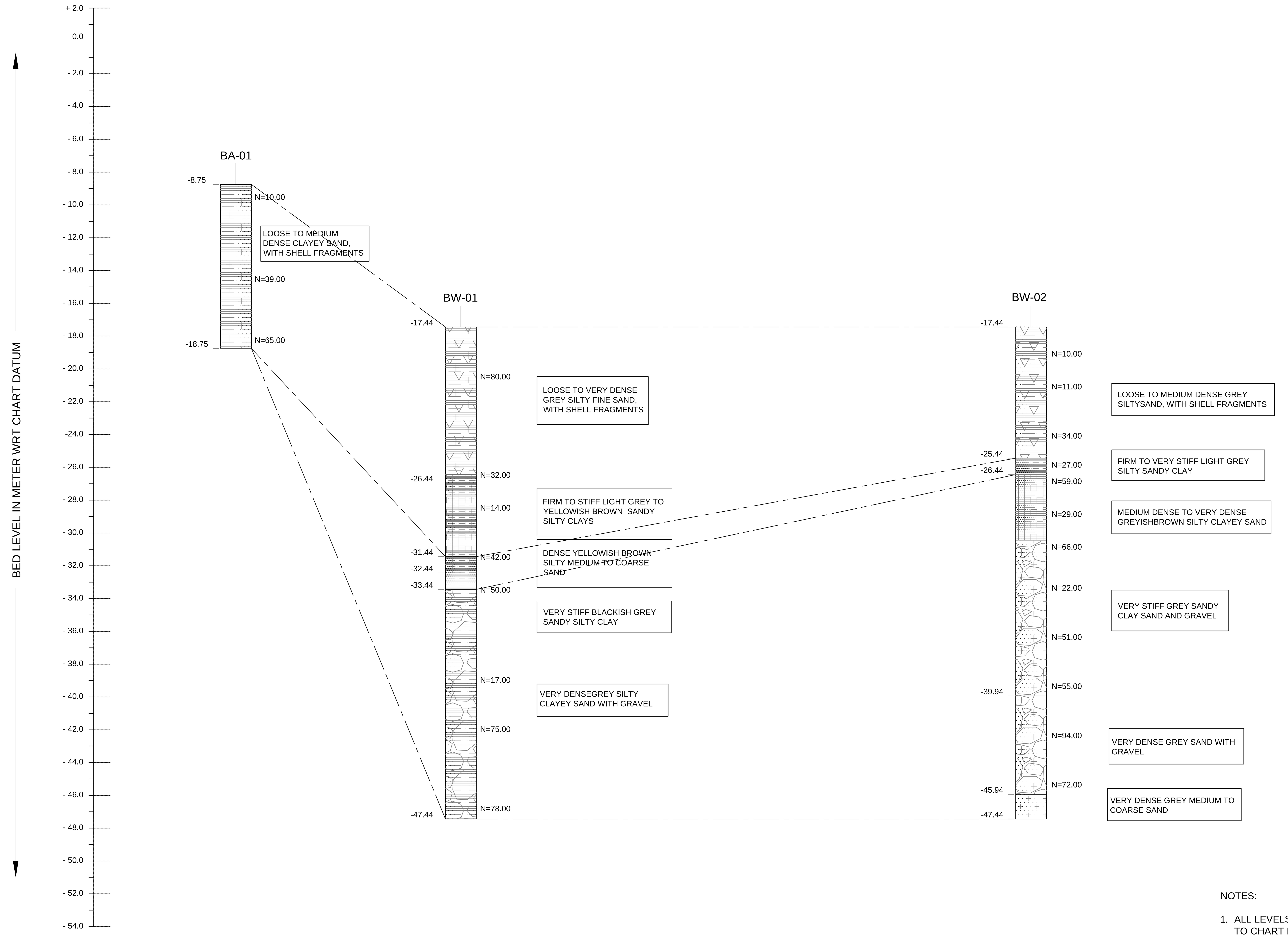

NOTES:

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

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

SOIL PROFILE 2 - ALONG NORTH BREAKWATER

AECOM

AECOM India Private Limited

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

PROJECT No. : DELD12086 **DATE :** 08-01-13 **FIGURE No. :** 2.18

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

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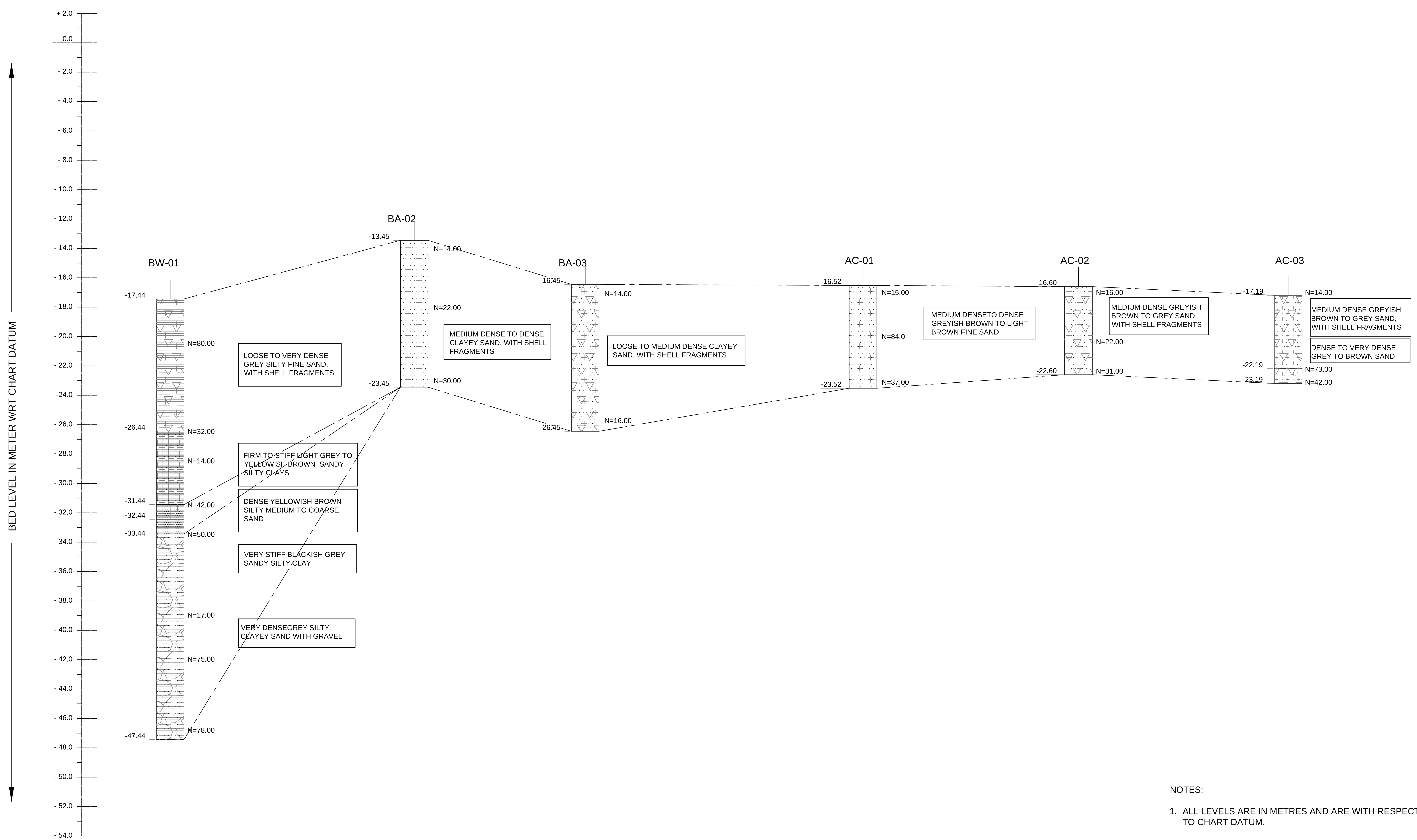


NOTES:

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

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

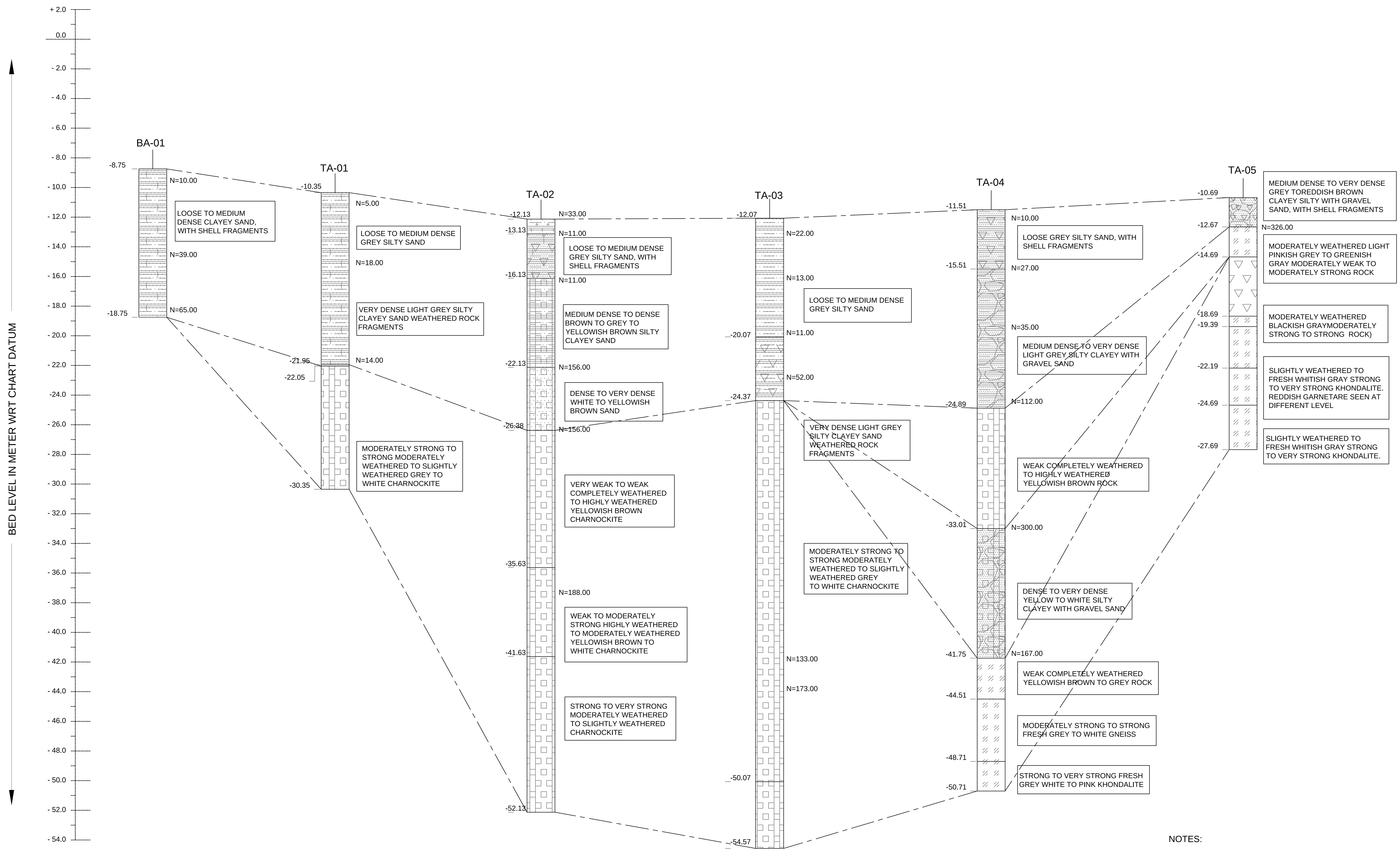
SOIL PROFILE 3 - ALONG APPROACH CHANNEL

AECOM

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.19



NOTES:

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

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

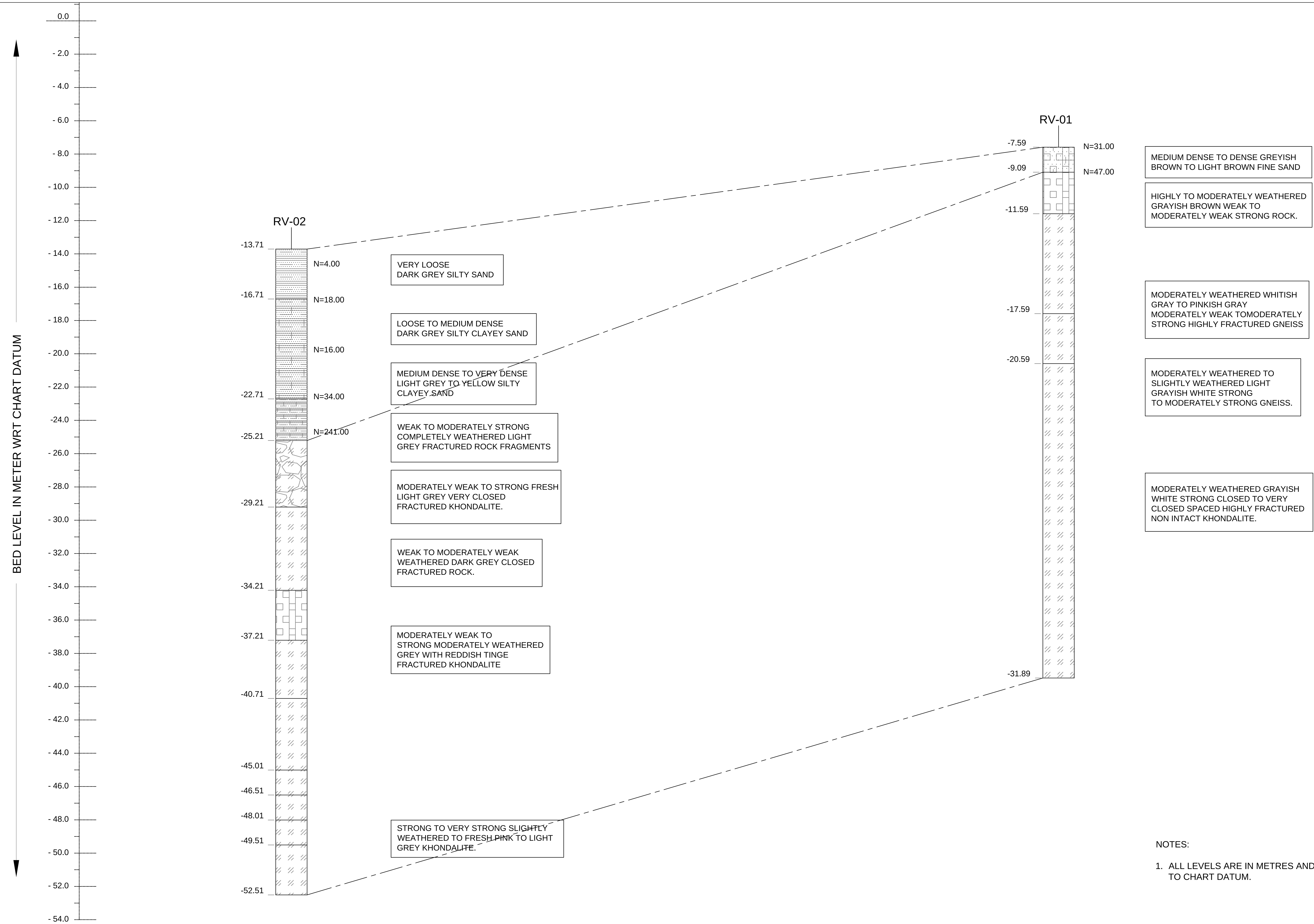
SOIL PROFILE 4 - ALONG THE CONTAINER BERTHS

AECOM

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.20



NOTES:

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

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

SOIL PROFILE 5 - ALONG THE PHASE-1 SOUTH BREAKWATER

AECOM

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.21

2.5 Topographic Information

Topography along the shore is very steep with weathered rock patches and high land areas. General topography of the port back-up land right behind the shoreline varies from +5m CD to up to +35m CD. The red arrows on the figure are showing steepness of the topography. The red arrow is connecting 10m & 35m elevation contours. Mulloor Naga Temple shown in the figure is located at approximately +12m elevation on a high land area.

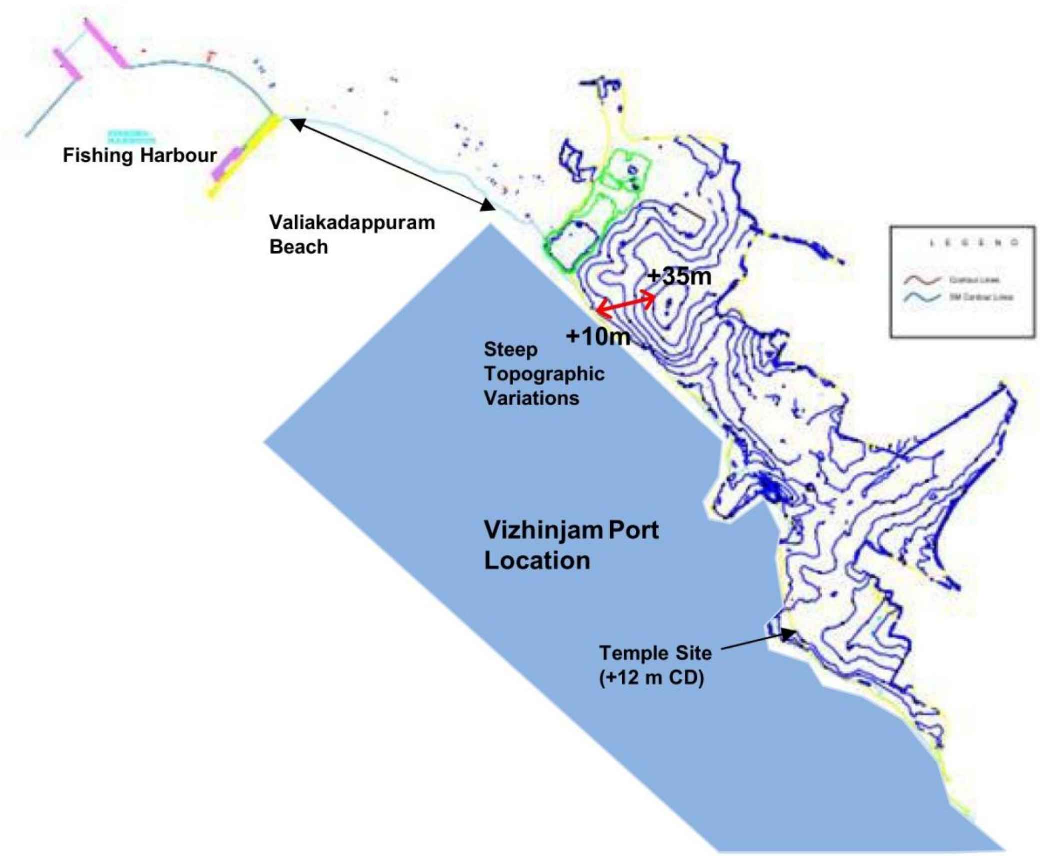
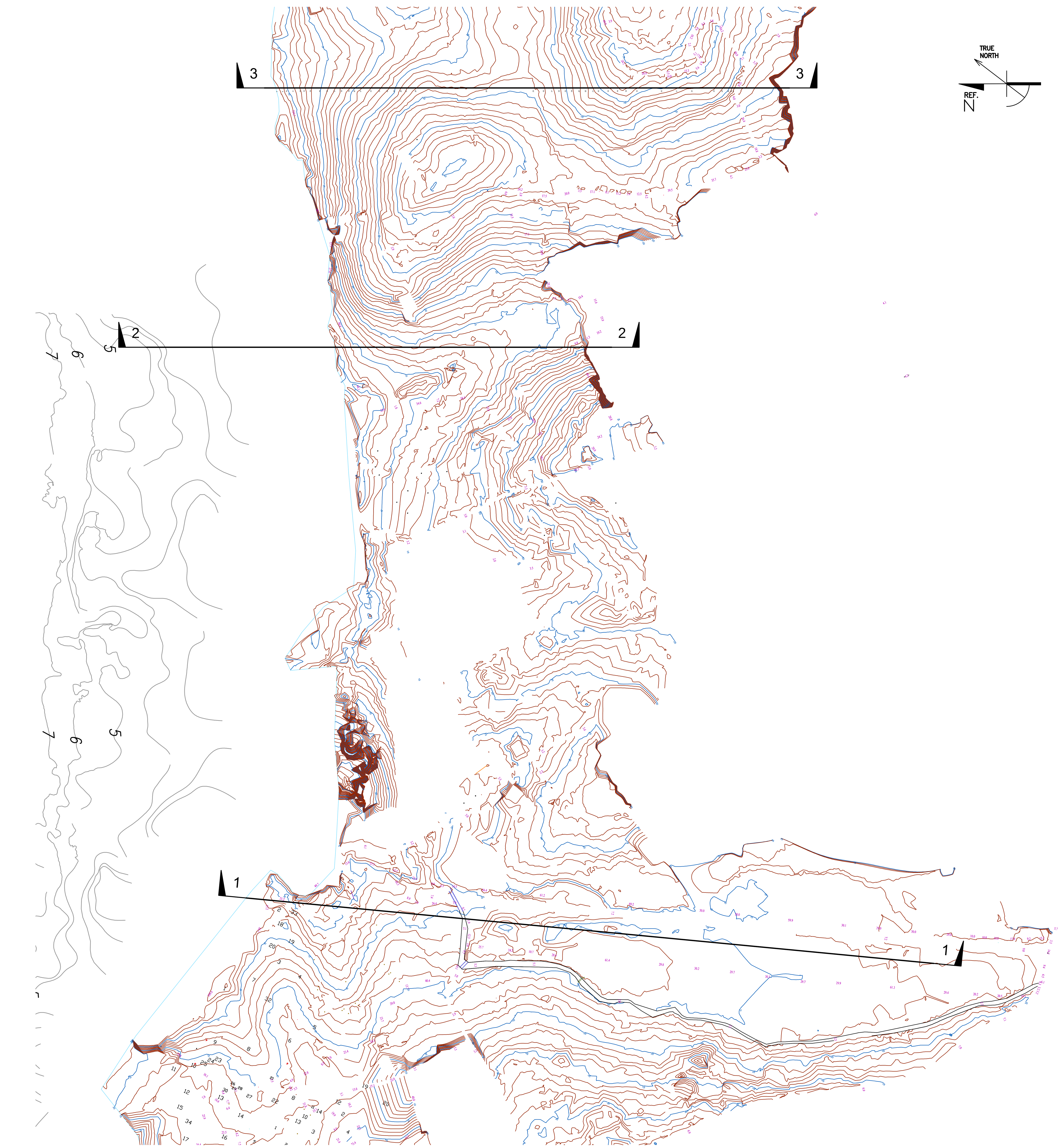
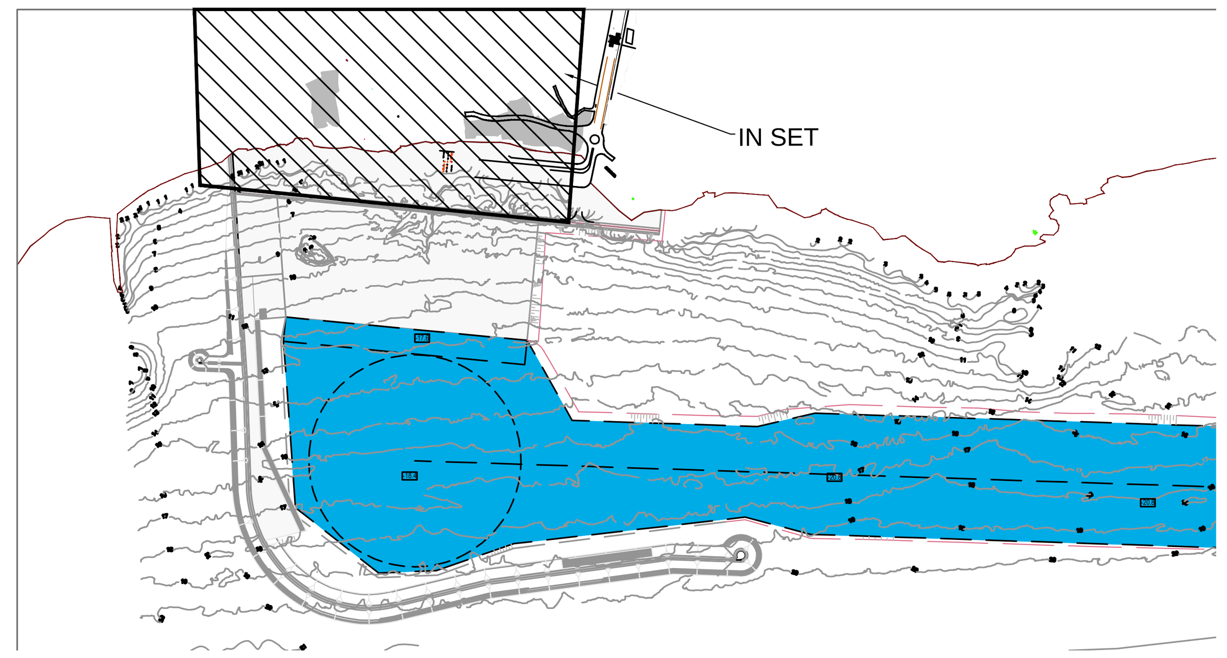


Figure 2.22 Topographic Map of Vizhinjam Port Site

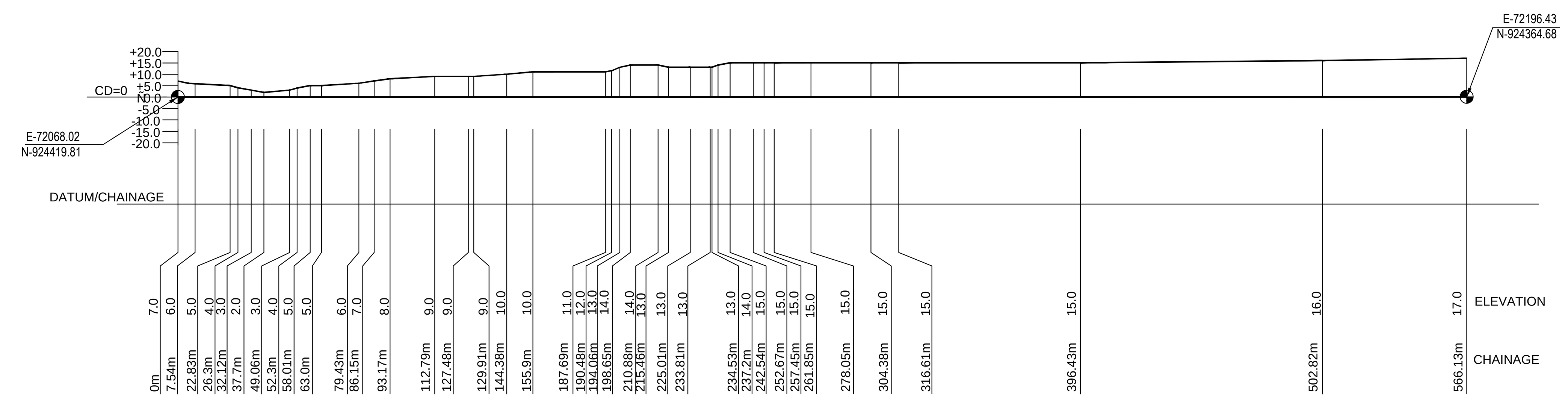
Figure 2.23 shows the location of the cross-sections obtained from the Topographic survey and the topography variation along these cross-sections.



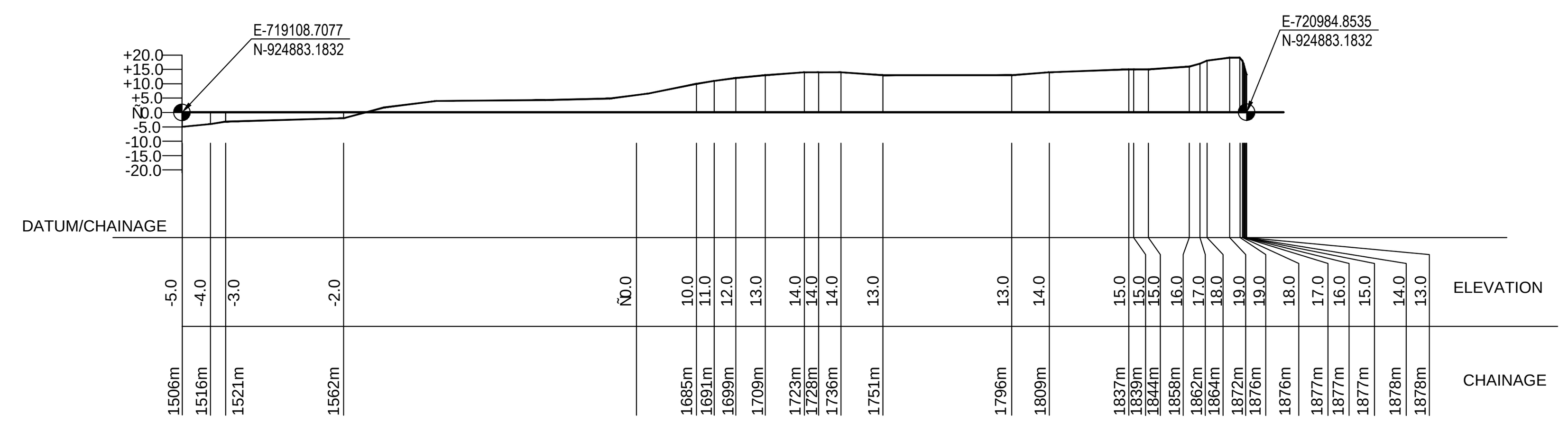
PLAN
SCALE 1:2000



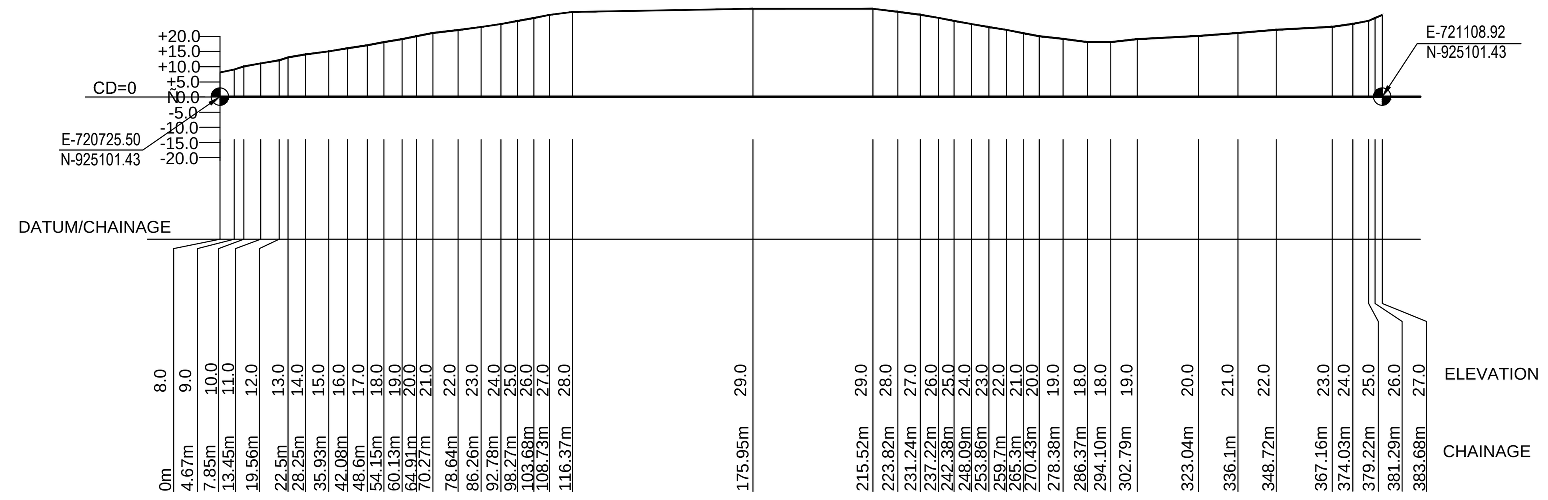
KEY PLAN



SECTION 1-1
SCALE 1:2000



SECTION 2-2
SCALE 1:2000



SECTION 3-3
SCALE 1:2000

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

TOPOGRAPHIC FEATURES AT VIZHINJAM PORT

AECOM India Private Limited

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

PROJECT No. : DELD12086 **DATE :** 08-01-13

FIGURE No. : 2.23

2.6 Seismicity

The proposed project falls under Seismic Zone III (moderate seismic disturbance up to 0-0.2) as per IS 1893 (Part I) of Indian Seismic Map. The zoning map as per Geological Survey of India is as shown in Figure 2.24.

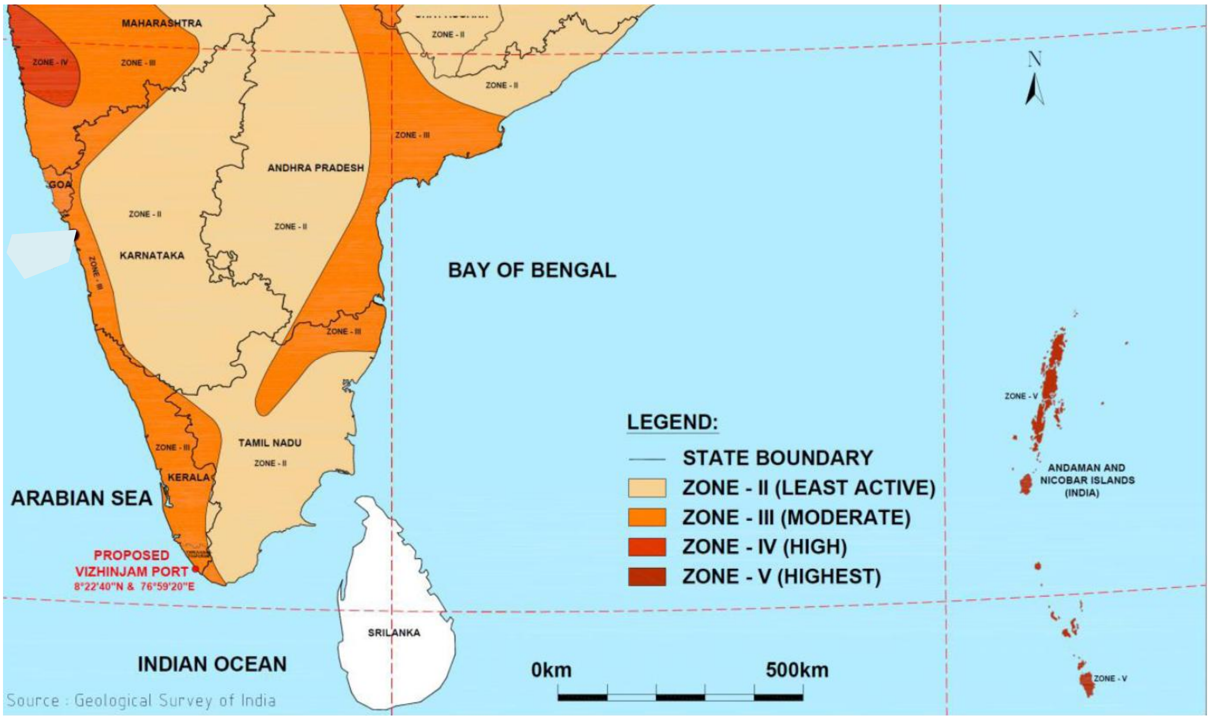


Figure 2.24 Seismic Zoning Map as per Geological Survey of India (GSI)

2.7 Transport Linkages and External Infrastructure

2.7.1 Road Link

The Thiruvananthapuram district is well connected by road, rail & airport to the rest of the country. National highway NH 47 passes through Thiruvananthapuram and is at a distance of approximately 8km and running almost parallel to the shoreline. NH47 connects Salem to Kanyakumari and is connected to Cochin Port through NH 47A. From Cochin to further north it is connected to Mumbai through NH 17. Thiruvananthapuram in North and Nagercoil & Kanyakumari in south are the nearest major urban centers on the NH 47. It is also connected to the major towns such as Thrissur, Palakkad, Kollam, Alappuzha in Kerala; and Coimbatore and Salem in Tamil Nadu. NH 47 is connected to Chennai and the rest of the country through NH 7 and NH 4.

NH 47 bypass road from Thiruvananthapuram extends upto Kovalam and construction works are in progress to extend it up to Parassala.

2.7.2 Rail Link

The only rail connection to Vizhinjam Port is the ‘Southern Railway Main line’. This southern central railway line is at a distance of approximately 8km from the port boundary. The existing railway line runs North-South parallel to the NH 47 and passes through major towns such as Thrissur, Palakkad, Kollam, Ernakulam and Alappuzha in Kerala and connects to Mumbai through Konkan Railway. This rail line connects southern part of Tamil Nadu through Nagercoil and Tiruchirapalli as well as to the North-West region of Tamil Nadu through Palakkad and Coimbatore. The main line of broad gauge passes through Nemom, Neyyatinkara and Balaramapuram railway stations. The broad gauge single rail line is running between Thiruvananthapuram and Kanyakumari. Beyond Thiruvananthapuram towards north, up to Kayamkulam double rail line exists.

Balaramapuram (Flag Station) and Neyyatinkara (Block Station) are located on the southern side of the proposed rail alignment whereas Nemom (Block Station) is on the northern side. These three stations are at a distance of approximately 9km, 13km and 10km respectively from the port boundary.

Figure 2.25 shows the existing rail and road connections to the Vizhinjam Port site. The existing road and rail connectivity have been discussed as above. In addition, the proposed rail access and road corridor for the port are also shown.

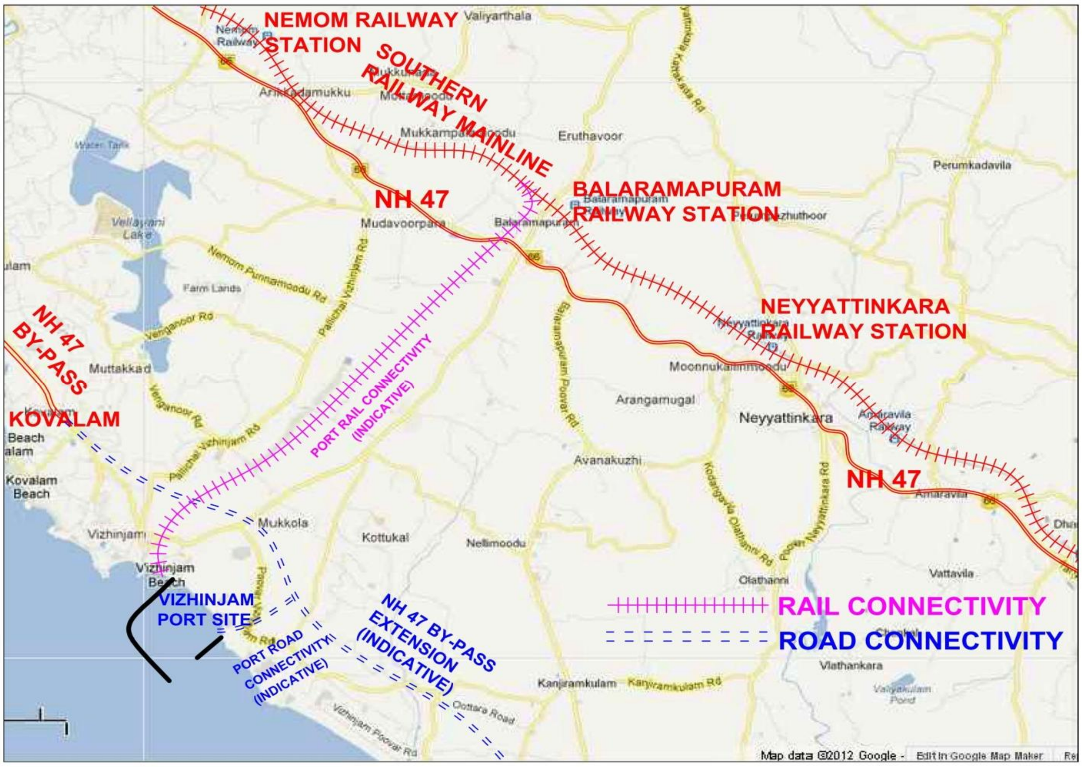


Figure 2.25 Rail and Road Connectivity to Vizhinjam Port

2.7.3 Power Supply

The main supply of power to Vizhinjam and nearby surrounding villages is from 66 KV substation located at Vizhinjam which is at a distance of approximately 5km from the port site. The supply to these lines is from the Kerala State Electricity Board (KSEB). This substation is already being utilized to the maximum at peak time and drawing the power requirement from the above substation was not found to be feasible.

Upgradation of the existing 66 KV lines and towers in the route between Balarampuram and Vizhinjam to the KSEB Vizhinjam substation to 220 KV is underway through double circuit line. In between this route, at about 9km from Balaramapuram (Tower No.VZM 27), one of the 220KV line will deviate 3km to the proposed VISL 220KV substation at Kdarakkuzhy.

The operation needs for the project development are proposed to be supplied by KSEB, by drawing a 220 KV double circuit line from Kattakkada to the proposed GIS substation of the Vizhinjam Project at Kdarakkuzhy adjoining the proposed NH47 bypass and the truck terminal area. This substation will act as the main receiving substation for which the state government will provide the power supply. KSEB has already carried out the feasibility study in this regard. Figure 2.26 shows the indicative location for the 220KV/66KV sub-station.

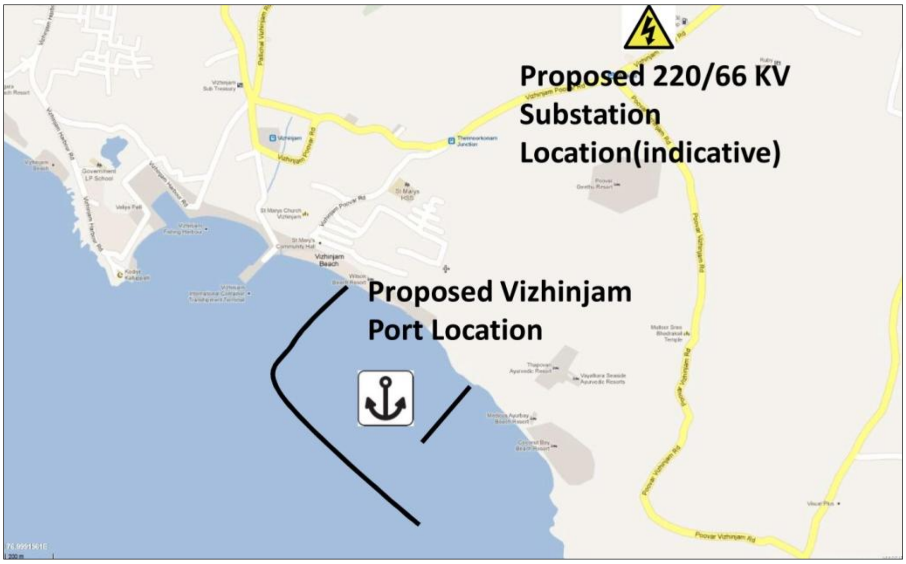


Figure 2.26 Indicative Location of Main Subs-station for Vizhinjam Port

2.7.4 Water Source

The GoK has committed to provide water supply to the port from the available natural water source of Vellayani lake. The water supply scheme designed by the Kerala Water Authority (DER, August, 2006) is for drawing 3.30 MLD of water from Vellayani Lake and to treat the same at a treatment plant located at Vizhinjam in the land available with the Harbour Engineering Department (HED). As per the report, 3.00 MLD of water will be available after treatment. Further, 2% (0.06 MLD) is required for backwash and 15% (0.45 MLD) is required for UFW (unusable flow water), resulting in a net availability of 2.49 MLD.

Of the total 2.49 MLD, 1.00 MLD has been allotted to Vizhinjam Port and 0.05 MLD to existing Vizhinjam Fishery Harbour, and remaining 1.44 MLD will be allocated as part of the Corporate Social Responsibility to the local community which is facing an acute drinking water shortage in the localities in and around the site of the proposed Vizhinjam Port.

The water supply scheme has been commissioned on 25th April 2013, by supplying water to the local community as part of CSR activities of VISL. The supply terminates at Karimpallikkara from where it can be connected to the port premises as per requirements. Figure 2.27 shows the location of the Vellayani Lake that will be the source of water for the Vizhinjam Port.

Figure 2.27 Indicative Location of Water Source for Vizhinjam Port

3 Traffic Potential and Forecast

3.1 Introduction

3.1.1 Background

VISL through IFC appointed Drewry Shipping Consultants for determining the traffic potential at Vizhinjam Port after assessing and analyzing the impact of various factors influencing the maritime trade globally. The cargo volume projections for Vizhinjam Port were forecast under three different scenarios viz. High case, Base case and Low case scenarios. AECOM presents the summary of Drewry findings in this chapter, which is the base for planning the facilities in the DPR. It is recommended to reference the Drewry study for additional information required on the Traffic numbers presented in this report.

3.1.2 Project Need

India's GDP is expected to grow at 6.6% over the forecasted period FY 2014-2044. During this period, India's container's gateway traffic is forecasted to grow at 7.5% from 7.3 M TEU in FY 09 to 91.0 M TEU in FY 44. North West India would continue to dominate the container traffic handling volumes with estimated 60% of the forecast traffic in FY44 handled at Maharashtra and Gujarat ports. The central and upper east coast would have a market share of 8%, a slight increase from 7.1% share in FY09. The share of lower west & lower east coast ports in India is likely to increase from 25% in FY09 to approximately 32% in FY 44.

Drewry carried out historical traffic analysis for the Indian Sub-Continent (ISC) to understand the regional trade and commodity profiles together with a hinterland assessment to map the key consumption areas and production centers in India and traffic potential for the Vizhinjam Port.

Drewry concluded that providing of container handling services at the proposed port would constitute as the primary opportunity justifying the need to build the Vizhinjam Port.

3.1.2.1 Container Business

The Indian Sub-Continent (ISC) gateway container volumes have increased from 4.3 M TEU in 1997 to 14.7 M TEU in 2008. The west coast of India contributes the largest share (50%) of container traffic in the region. Almost 2.5% of the total gateway traffic is regional ISC traffic, 66% of the gateway traffic is served through feeder services and rest 31.5% is carried on mainline vessels in the region.

In principle, container transshipment is needed to transfer the containers from a smaller feeder vessel to a much larger mainline vessels transiting along the East-West corridor and vice-versa. Larger (>10000 TEU) container vessels tend to provide cost savings of atleast 30% per TEU as compared to feeder vessels of sizes less than 4000 TEU. Note that almost 60% of the ISC transshipment cargo is being handled by Ports outside of ISC, who are fed from ISC feeder ports mostly using smaller container vessels of less than 6000 TEU.

Colombo is the largest transshipment hub for ISC traffic in the region and handles around 35% of the total ISC transshipment traffic, whereas 4.1% of the ISC transshipment volume is handled by ports other than Colombo within the ISC region, while it is important to note that almost 61% of the ISC transshipment traffic is handled by hub ports outside ISC, namely Singapore, Salalah, Jebel Ali, etc.

Cost of importing/exporting from India is relatively higher than in other developed countries, primarily due to inefficiencies in the logistics chain, lack of deep draft port facilities and capacity constrained hinterland cargo evacuation system.

Vizhinjam is strategically located along south of the Kerala coast and is only 10-20 nautical miles away from the East-West world shipping corridor. Its planned location is endowed with natural deep draft water and is estimated to have minimal maintenance dredging needs. The Greenfield location has enabled for the master plan to be developed to provide world class infrastructure for efficient services and to cater for future development potential of the region.

Vizhinjam has a good potential to capture the transshipment cargo from Colombo and outside of ISC region ports. With these advantages and planned facilities to handle the biggest container vessels (upto 18,000 TEUs), Vizhinjam will be able to attract mainline vessels to call directly instead of trans-shipment at other ports outside of the country. This will result in savings in overall import/export logistics cost for the Indian consumer.

3.1.2.2 Transshipment Business

In principle, container transshipment is needed to transfer the containers from a smaller feeder vessel to a much larger mainline vessels transiting along the East-West corridor. Larger (>10000 TEU) container vessels tend to provide cost savings of atleast 30% per TEU as compared to feeder vessels of sizes less than 4000 TEU. Note that almost 60% of the ISC transshipment cargo is being handled by Ports outside of ISC, who are fed from ISC feeder ports mostly using smaller container vessels of less than 6000 TEU.

Cost of importing/exporting from India is relatively higher than in other developed countries, primarily due to inefficiencies in the logistics chain, lack of deep draft port facilities and capacity constrained hinterland cargo evacuation system. To tap into the potential for handling ISC region's transshipment cargo, Vizhinjam port faces competition from the port of Colombo, International Container Trans-shipment Terminal (ICTT) at Kochi and major transshipment hubs outside the ISC region such as Aden in the west to Singapore in the east. Colombo accounted for traffic of 2.7 M TEU, having a market share of 38% of the total ISC regional transshipment traffic. Other "hubs" within the ISC region (mainly JNPT) handled 0.24 M TEU of transshipment. The majority of activity, representing 4.2 M TEU in 2008, was spread amongst hub ports outside the ISC region.

Container transshipment cargo has been identified as the primary cargo for the proposed Vizhinjam port, as it has a good potential to capture the transshipment cargo from Colombo and outside of ISC region ports, as it will be able to reduce the overall import/export cost.

3.1.2.3 Business Prospects for Vizhinjam

From a volume and market share point of view, Vizhinjam Port poses a very good business case. The Indian growth story will provide cargo for Vizhinjam and considerable cargo will flow through Vizhinjam, mainly due to its geographical advantage to the main cargo consuming and generating clusters in India.

Majority of the cargo that Vizhinjam port is planning to handle is currently not handled by any of the Indian port. As detailed in the Drewry report, currently the majority of India's container traffic is transshipped through ports outside of India. More than 60% of India's containerized import/export cargo is transshipped and handled on feeder vessels and only less than 40% of the containers are coming in directly to Indian Ports by mainline vessels, resulting in higher cost of import/export for Indian citizens and businesses. India's import/export cost per TEU is relatively much higher than many other developed countries in the West and Asia.

The Vizhinjam port has potential to become a world class trans-shipment hub primarily for ISC cargo servicing entire India. The port mainly faces competition from Colombo for the transshipment cargo and ICTT for gateway traffic. The gateway traffic will be limited to about 20% of total traffic sourced from Kollam and Trivandrum as the main hinterland of the Vizhinjam Port, resulting in overall reduction in congestion and air emissions by reducing the average truck travel distance.

3.2 Traffic Projection by Drewry

3.2.1 Containers

Drewry carried out study of the container traffic analysis and traffic trade trend/pattern of the Indian Subcontinent as bases of container traffic forecast for Vizhinjam port.

3.2.1.1 Transshipment Traffic Forecast

Container traffic forecast for India, Pakistan, Bangladesh and Sri Lanka was estimated based on the current traffic pattern and estimated GDP growth rate and container traffic growth. Forecasted container traffic was being analyzed with the international traffic fleets of mother vessel and feeder vessels.

3.2.1.2 Gateway Traffic Forecast

Gateway container traffic for Vizhinjam Port was forecasted based on linear equation considering estimated GDP growth. The average growth in import-export traffic in the region has been 12.9% p.a. in the last 11 years. The west coast of India has shown the strongest growth, nearing 15% p.a., whilst Sri Lanka has seen a more modest 6.7% p.a. growth rate. Total gateway traffic reached 11.6 million TEU in 2008, up from 3.1 million TEU in 1997.

Based on the analysis the transshipment and gateway traffic, forecasts for Vizhinjam are as below in Table 3.1.

Table 3.1 Projected Container Traffic for Vizhinjam Port

Projected Vizhinjam Container Traffic Forecast ('000 TEU)								
		2014	**2019**	**2024**	**2029**	**2034**	**2039**	**2044**
Low Case	Gateway (Loaded)	26	90	156	256	362	466	576
	Gateway (empty)	11	39	52	85	90	117	144
	Gateway (Total)	37	129	208	341	452	583	720
	Transshipment	111	547	834	1,142	1,446	1,679	1,881
	Total	**148**	**676**	**1,042**	**1,483**	**1,898**	**2,262**	**2,601**
Base Case	Gateway (Loaded)	26	92	160	266	379	493	615
	Gateway (empty)	11	39	53	89	95	123	154
	Gateway (Total)	37	131	214	354	474	616	769
	Transshipment	112	566	877	1,213	1,550	1,817	2,055
	Total	**149**	**698**	**1,091**	**1,567**	**2,024**	**2,433**	**2,823**
High Case	Gateway (Loaded)	27	100	182	305	442	583	738
	Gateway (empty)	12	43	61	102	111	146	185
	Gateway (Total)	39	143	242	407	553	729	923
	Transshipment	116	630	1,273	1,784	2,311	2,747	3,151
	Total	**154**	**774**	**1,515**	**2,191**	**2,864**	**3,476**	**4,074**

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2 Other Traffic

3.2.2.1 General

Traffic forecast for bulk cargo traffic was separately carried out by Drewry. Commodities considered for bulk cargo traffic forecast depending upon hinterland market study and opportunities with their respective traffic forecast is as under:

3.2.2.2 Coal Traffic

State of Kerala has neither coal based power plants nor steel plants, which are the key coal consumers. The power demand in Kerala is met by hydro power plants, wind power plants and diesel-based thermal power plants. Vizhinjam Port may have a chance to attract coal importers with proper road and rail connectivity like Tuticorin and Cochin Ports. Overall, the opportunity for coal cargo traffic at Vizhinjam Port is very small. Coal traffic forecast for Vizhinjam Port for base and high case scenario is given in Table 3.2.

Table 3.2 Coal Traffic Forecast for Vizhinjam Port

Forecast Scenario	Coal Traffic Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Base Case	0.14	0.14	0.14	0.14	0.14	0.14	0.14
High Case	0.71	0.71	0.71	0.71	0.71	0.71	0.71

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.3 Fertilizer

India is the third largest producer of the fertilizers, but still India has to import fertilizers to meet the demand. Over the last decade, India's fertilizer production has remained constant. One of the reasons for no increase in production capacity is unavailability of economically viable raw materials.

Considering the fertilizer production units of Kerala and Tamil Nadu, they are operating at the lowest production capacity utilization around 30%. The production capacity utilization rate is expected to go up after completion of the under construction gas grid connectivity. Fertilizer imports traffic forecast for Vizhinjam Port is given in Table 3.3.

Table 3.3 Fertilizer Imports Traffic Forecast for Vizhinjam Port

Forecast Scenario	Fertiliser Imports Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Low Case	0.0	0.0	0.02	0.09	0.11	0.14	0.18
Base Case	0.0	0.02	0.06	0.17	0.29	0.36	0.54
High Case	0.02	0.05	0.12	0.26	0.46	0.58	0.71

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.4 Chemical and Petro Products

Kerala state has very limited chemical consumption. It is expected to grow at the CAGR of 8.7% for year 2013-14 to 2043-44. The current demand of Kerala state for petro product is being served by Kochi port. Mangalore port is acting as the importer of LPG to cater to demand of the state. Table 3.4 and Table 3.5 represent the Chemical & petrochemical traffic and Petro products traffic forecast for Vizhinjam respectively.

Table 3.4 Chemical and Petrochemical Traffic Forecast for Vizhinjam Port

Forecast Scenario	Chemical and Petrochemical Traffic Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Low Case	0.005	0.006	0.011	0.012	0.016	0.025	0.036
Base Case	0.006	0.008	0.016	0.018	0.027	0.046	0.072
High Case	0.006	0.01	0.021	0.027	0.043	0.083	0.142

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

Table 3.5 Petro Products Traffic Forecast for Vizhinjam Port

Forecast Scenario	Petro Products Traffic Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Low Case	0.021	0.119	0.301	0.498	0.572	0.635	0.701
Base Case	0.064	0.149	0.321	0.498	0.858	0.952	1.051
High Case	0.106	0.238	0.402	0.747	1.144	1.269	1.401

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.5 Edible Oil

India is second only to China in edible oil imports. The competitive ports of Vizhinjam port themselves handle around 3.3% of the country's total import of edible oil. Government of Kerala had banned the import of all types of crude edible oil in year 2008-09 to protect interest of local coconut farmers. But the ban had not created much impact on production of edible oil refineries as they shifted their import to New Mangalore Port. Traffic forecast for Edible oil import is as Table 3.6. It is to be noted that Vizhinjam Port will not provide any significant advantage to existing oil refineries once the ban on imports is lifted.

Table 3.6 Edible Oil Traffic Forecast for Vizhinjam Port

Forecast Scenario	Edible Oil Import Traffic Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Low Case	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Base Case	0.0	0.01	0.01	0.01	0.03	0.03	0.03
High Case	0.0	0.01	0.03	0.03	0.05	0.05	0.05

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.6 Timber

Kerala is having 28% of the total land as forest land but state regulations control the harvesting forests. Currently 75% of the total timber demand of the state is fulfilled by import primarily from Myanmar, Indonesia and Malaysia. Currently importers prefer New Mangalore and Tuticorin ports due to ample storage space and reasonable handling charges. Timber demand of Kerala state moreover seems to be the same for next decades but presence of timber processing units may lead to this demand. The timber import forecast for Vizhinjam port is provided in Table 3.7.

Table 3.7 Timber Traffic Forecast for Vizhinjam Port

Forecast Scenario	Timber Traffic Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Low Case	0	0.015	0.025	0.045	0.047	0.05	0.052
Base Case	0	0.023	0.064	0.09	0.094	0.099	0.104
High Case	0.021	0.058	0.085	0.112	0.141	0.149	0.156

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.7 Raw Cashew

Kerala is leading with share of over 50% of the total country's raw cashew imports. Raw cashew is generally imported in containers or break bulk vessels. The centers of processing units of cashew are mainly in vicinity of Vizhinjam, creates trade opportunity for Vizhinjam. Table 3.8 represents the market forecast of raw cashew import for Vizhinjam port.

Table 3.8 Raw Cashew Forecast for Vizhinjam Port

Forecast Scenario	Raw Cashew Import Forecast (MT)						
	2013-14	2018-19	2023-24	2028-29	2033-34	2038-39	2043-44
Base Case	0.48	0.6	0.73	0.86	0.99	1.15	1.33

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.2.2.8 Cruise market

Kerala is one of the major tourist destinations in India. Tourism has significant contribution in economy of Kerala State. Location of Vizhinjam port has an advantage that it is in reach of many tourist destinations of the state, a potential for cruise business. The operational window for cruise vessels would typically peak in the non-monsoon period from November to April, with lower activity during the monsoon. It was concluded that World class cruise facilities will be needed at competitive rates to capitalize on this market niche and hence Drewry advised on a coordinated and collaborative marketing and promotion strategy to boost cruise vessel calls at Vizhinjam.

Key findings of the study are stated below:

- Kovalam is a major tourist destination in India. This can be leveraged to attract cruise vessels at Vizhinjam;
- High port dues and inadequate cruise vessel and passenger handling facilities are seen as a major deterrent for cruise operators in India;
- A marketing and promotion strategy along with world class specialized cruise facilities at competitive port charges can promote cruise tourism at Vizhinjam;
- Average passenger spend per port is around USD 100 to 120. This could bring in revenue of around USD 80,000 to 96,000 per vessel call;
- Collaborative effort of state government, players in the hospitality industry and cruise operators are a prerequisite;

Drewry estimated following number of cruise vessel calls based on the preliminary study:

Development Phase	No. of Vessel Calls
Phase-1	30
Phase-2	60
Phase-3	120

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

3.3 Traffic Projection for Vizhinjam Port

In 2010, VISL in consultation with IFC had decided to develop the proposed port for container handling and multi-purpose terminal with limited number of commodities handled at the port. Port will be developed under three phases and the phase wise cargo traffic forecast adopted for development is as shown in Table 3.9.

Table 3.9 Cargo Traffic Projection Adopted for Vizhinjam Port

Commodity	Unit	Phase-1	Phase-2	Phase-3
		FY14-20	FY21-30	FY31-44
Container Terminal				
Gateway Container Traffic	TEU	138,459	392,371	768,904
Transshipment container Traffic	TEU	683,798	1,292,842	2,054,545
Total	**TEU**	**822,256**	**1,685,212**	**2,823,449**
Vessel calls - main liners	**No.**	**156**	**312**	**520**
Vessel calls - feeders	**No.**	**260**	**312**	**468**
Multi-purpose Terminal				
Fertiliser and FRM	T	20,000	180,000	540,000
Timber	T	24,000	91,000	104,000
Raw cashew (break-bulk)	T	63,000	88,000	133,000
Total	**T**	**107,000**	**359,000**	**777,000**
Vessel calls	**No.**	**NA**	**NA**	**NA**
Liquid Terminal				
Petro-products	T	159,000	518,000	1,051,000
Total	**T**	**159,000**	**518,000**	**1,051,000**
Vessels calls	**No.**	**NA**	**NA**	**NA**
Cruise Terminal				
Vessel calls	**No.**	**30**	**60**	**120**

[Source: IFC/Drewry: Kerala Port PPP Market Study, November 2010]

On the premises of the traffic forecast, the proposed Phase-1 development at Vizhinjam is being planned to mainly accommodate the container vessels with majority of transshipment throughput. These vessels will include the mainline vessels traversing through the East-West shipping channel and the feeder vessels supporting the mainline vessels for distribution of the cargo to service the end markets.

Cruise berths will be added in Phase-1 as per the IFC/Drewry report and as part of the CSR program undertaken by VISL to mitigate the social impact of the project and add to the benefits of the project on Kerala tourism sector.

4 Design Ships

4.1 Introduction

Seaborne trade and traffic pattern have undergone tremendous changes due to technological advances. The shipping sector was more or less dormant since mid 70's, when suddenly there was a movement towards bigger oil tankers due to oil crisis. After that not much happened in shipping technology for next one and half decade. But in 90's due to separation between demand and supply regions and a huge surge in commodity, demand and willingness of parties to enter into long term contracts along with the opportunity of access to cheap capital, led to the making of bigger ships which brought economies of scale.

One of the main factors that influence the layout and sizing of the port facilities and therefore the costs is the size of ships for different commodities. The design ship is the largest ship for a particular commodity that is likely to be handled at the port and based on which the dimensions and the design of the berth, the basin, the approach channel will have to be finalised. This, in turn will influence the layout and alignment of the breakwaters, if required at a particular port.

When selecting the design ship size for a particular commodity, it is essential to consider the development trends in the international maritime trade driven by the scale of economics in freight. The size of ships calling at the port will also have a bearing on the facilities available at the ports of origin/destination.

The size of ships that would call at Vizhinjam Port will be governed by the following aspects:

- The trading route and distance between Vizhinjam Port and origin/ destination ports;
- The facilities available at the loading/unloading port including the draft;
- Availability of a suitable ship in the market;
- Future availability of vessel on the market including 'trickle down' effects from mainline routes to secondary routes;
- Volume of annual traffic to be handled and the likely parcel size;
- Balance between capital costs for Vizhinjam port development and freight transport costs.

The traffic study has projected the following main cargo commodities for Vizhinjam Port:

- Containers
- General Cargo
  - Fertilizer
  - Raw Cashew
  - Timber
- Cruise

Since ocean freight is a major component of the overall logistic costs for any consignee, the operator always look for a modern port with large draft for handling big parcels and with modern handling equipment which ensures faster and loss-free turnaround of ships.

4.2 Container Ships

4.2.1 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.

4.2.2 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.

The distribution of world fleet container vessel sizes is shown in Table 4.1.

Table 4.1 World Fleet of Container Ships and Order Books

Container Ship	Year end ('000' TEU)				2011		Order Book & Delivery Schedule					
Fleet (TEUs)	2007	2008	2009	2010	No	'000' TEU	No	'000' TEU	% Fleet	2012	2013	2014
100-999	611	664	690	723	1,203	740	6	6	1%	5	1	0
1000-1999	1,535	1,705	1,793	1,934	1,400	1,989	22	31	2%	24	7	0
2000-2999	1,592	1,760	1,849	1,916	768	1,952	14	38	2%	21	16	1
3000-7999	5,419	6,084	6,638	7,304	1,606	7,694	94	505	7%	381	124	0
8000+	1,228	1,664	1,999	2,685	371	3,678	98	1,117	30%	896	167	54
Total Fleet	10,385	11,877	12,969	14,562	5,348	16,053	234	1,697	11%	1327	315	55

[Source: Lloyds Fairplay Database, 2011]

Figure 4.1 depicts the distribution of world fleet container vessel sizes.

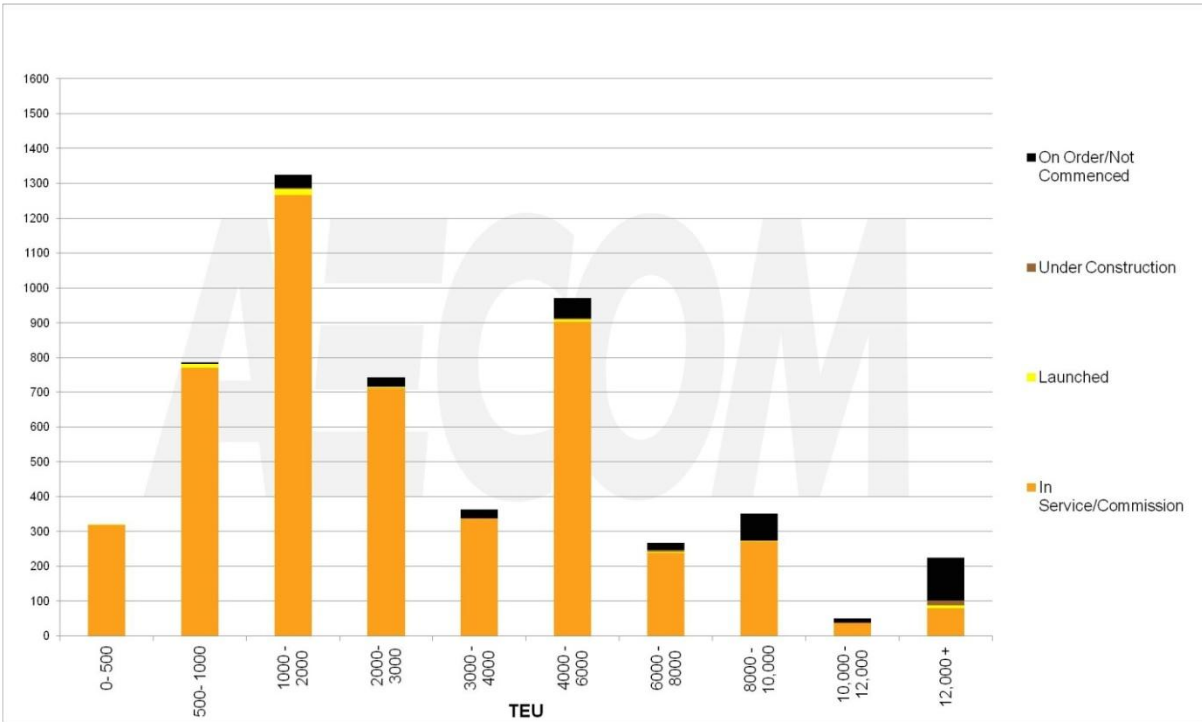


Figure 4.1 Distribution of Container Vessels by TEU

[Source: Lloyds Fairplay Database, 2011]

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 as of December 2012:

- 32 no. 12,500 TEU minimum ships ordered for delivery between 2010 and 2012.
- 8 nos. 13,100 TEU ships ordered by Hamburg based Nord Capital group on Hyundai Heavy Industries. Delivery between April 2010 and March 2011.
- A series of 16,000 TEU ships have been ordered from Samsung Heavy Industries.
- MAERSK Lines have ordered 20 new 18,000 TEU ships from Daewoo Shipbuilding.
- Other shipping lines like K-Line and United Arab Shipping Company are also looking at acquiring 18,000 TEU ships.

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 8,000 TEU will 'trickle down' to serve secondary or feeder routes in the future.

In order to establish Vizhinjam port's position as a Major Transshipment port, it will need to be able to handle ships normally in the range of 9,000 to 18,000 TEU.

4.2.3 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 4.2 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 4.2 Dimensions of the Smallest and Largest Ship

Category	Capacity	Dimensions (m)		
	(TEUs)	LOA	Beam	Loaded Draft
Feeder	1,000	175	27	10.0
Feeder Max	2,000	210	32	12.0
Handy to Sub-Panamax	6,000	285	40	14.5
>Panamax	8,000	335	42	14.5
Post-Panamax	12,500	397	56	16.0
Super Post-Panamax	18,000	400	59	16.0

[Source: Lloyds Fairplay Database]

4.2.4 Selection of Design Size of Container Ships

4.2.4.1 Transshipment Containers

Container transshipment is the primary cargo for Vizhinjam Port right from the Phase-1 development. Based on the projections, the maximum vessel size at the port is likely to be driven by the Transshipment traffic. During Phase-1, the design vessel considered is 18,000 TEU.

4.2.4.2 Import/ Export Container Vessels

The projected import / export trade through the port hinterland is relatively modest. In this case, it is likely that the vessel sizes for import/ export trade will be driven by the use of the transshipment vessels for carrying the import/export cargo as well. For other direct vessel calls serving the import/export cargo, the design vessels considered are in the range of 1,000 TEU to 6,000 TEU.

4.2.4.3 Summary of Container Design Vessels

Based on the outcome of ship size analysis for container traffic carried out in the preceding paragraphs, the design ship sizes considered for development of VISL port have been presented in Table 4.3.

Table 4.3 Design Container Vessels over Master Plan Horizon

S. No	Commodity	Average Parcel Size in moves	Design Ship Capacity		Overall Length	Beam	Loaded Draft
		Moves	TEU		(m)	(m)	(m)
1.	Containers (Transshipment)	2500	Min	9,000	350	46	14.5
			Max	18,000	400	59	16.0
2.	Containers (Feeder)	1200	Min	1,000	175	27	10.0
			Max	6,000	300	43	13.5

4.3 Multipurpose Cargo

4.3.1 General Cargo Vessels

It is difficult to predict the size or type of general cargo ship that will use the port as it depends on what industries establish in the free trade zone.

The traditional general cargo ship with central accommodation and a series of holds under deck mounted derricks has almost disappeared in favour of small bulk carriers with aft (rear of the ship) accommodation. The general cargo commodities such as Fertiliser, Raw cashew and Timber are likely to be handled in ships, which range from 25,000 DWT to 40,000 DWT discharged using shore cranes or slewing cranes mounted on the ship. For port planning purposes a 40,000 DWT is recommended as the maximum design size of general cargo ship to be calling at the proposed Vizhinjam Port.

4.4 Cruise Vessels

As per the Drewry report, the estimated size of the cruise vessel varies from 1200 passengers in Phase-1 to up to 3000 passengers in the Master Plan.

Since the cruise market assessment conducted during the planning process predicts increasing cruise ship lengths and larger cruise passenger populations on each ship, the cruise berths are planned in the start of Phase-1 port development and the requirements of the projected larger fleet are accommodated in the Phase-1 itself.

4.5 Design Ship Sizes

4.5.1 Range of Ship Sizes

Based on the outcome of ship size analysis for major commodities carried out in the preceding paragraphs, the design ship sizes considered for Phase-1 development of Vizhinjam port is presented in Table 4.4 .

Table 4.4 Summary of Design Vessels for Phase-1 Development

S. No	Commodity	Average parcel size	Design Ship Size		Overall Length	Beam	Loaded Draft
		TEU (DWT)	TEU/DWT		(m)	(m)	(m)
1.	Transshipment Containers	2,500 (23,000)	Min	9,000 (82,500)	350	46.0	14.5
			Max	18,000 (165,000)	400	59.0	16.0
2.	Import/Export Containers	1200 (11,000)	Min	1,000 (9200)	175	27.0	10.0
			Max	6,000 (55,000)	300	43.0	13.5
3.	Multipurpose Cargo vessels	(30,000)	Min	25,000	178	26.4	10.7
			Max	40,000	190	28.0	11.3
4.	Cruise	3000 pax (55,000)	Min	40,000	212	32	8.0
			Max	70,000	268	32	8.0

4.5.2 Governing Parameters of Design Ships

Parameters of design ship considered for estimating the navigational requirements (dredged depths, channel widths, safe stopping distance etc) of the channel and harbour basin for Phase-1 and Master Plan layout development of Vizhinjam port, are presented in Table 4.5.

Table 4.5 Governing Parameters of Design Ship

Development Stage	Vessel Size	Overall Length	Beam	Loaded Draft
	TEU/ DWT	(m)	(m)	(m)
Phase-1	18,000 (165,000)	400	59.0	16.0
Master Plan				

5 Port Facility Requirements – Phase-1

5.1 General

The Vizhinjam port Phase-1 development plan has been prepared to guide the development of the first phase of development of the port and identify the facility requirements in terms of number and length of berths, navigational requirements, terminal equipments, terminal storage area, road and rail access for the receipt and evacuation of cargo and other utilities and service facilities. The focus of the Phase-1 development is primarily on container cargo and other port requirements along with the expansion of the existing fishing harbour and addition of cruise terminal. Facilities are also provided to Coast Guard and Indian Navy in Phase-1. This section deals with assessment of the port facilities for the projected traffic at the Vizhinjam Port over the first phase of development.

5.2 Berth Requirements

5.2.1 General

The berth length needs to be sufficient to accommodate the length of the vessel plus an allowance at either end for mooring and clearances between vessels. The amount of clearance required at either end of the vessel depends upon the vessel size. Minimum single berth length for the design vessels are shown in Table 5.1.

Table 5.1 Minimum Berth Lengths

S. No	Berth Type	Average Design Ship Size	Phase-1	Phase-3 (Master Plan)
			m	m
1.	Container Berths	12,500 TEU	360 – 400	360 – 400
2.	Cruise/ Multipurpose Berth	70,000 DWT	300	300

AECOM used a spreadsheet-based capacity analysis model to determine Vizhinjam port's container terminal throughput capacity, which is defined as the amount of cargo a terminal can handle under given operating parameters. For containerized cargo, the capacity is calculated in either lifts or TEU per year.

The total amount of cargo a terminal can handle annually depends on the capacity of four main components: ship operations, yard operations, gate operations, and rail operations. AECOM evaluated each of these terminal-operation components independently to identify elements limiting the overall throughput capacity of Port facilities. If one component of the facility has a much lower throughput capacity than the others, then the entire facility must operate at the capacity of that lower-functioning component.

5.3 Container Terminal Capacity Analysis

AECOM conducted the Vizhinjam Port container terminal capacity analysis using the Preliminary Capacity (PRECAP) spreadsheet analysis model. PRECAP is a static model of terminal capacity that can be used to analyze capacity of the terminal berth, backland storage area (container yard and equipments), rail operations, and gate operations.

The primary outputs from PRECAP are annual capacity of each of these terminal elements, which can then be evaluated as independent features or as linked elements.

An important benefit of this model is its ability to identify the element that is constraining overall terminal capacity and to focus investments where the greatest capacity improvement can be achieved. For example, the model may be used to establish parameters for the container yard and for the gate to match available berth capacity so that the terminal has a balanced capacity across all elements.

The following table summarizes the key inputs to PRECAP for each terminal element.

Berth	Container Yard	Rail	Gate
– Cargo moved per vessel call – Cranes used per vessel – Crane productivity – Work hours – Non-work time at berth – Seasonal peaking factors – Maximum allowable berth utilization	– Mix of cargo types – Dwell time – Static storage capacity – Inventory peaking factors	– Number of rail cranes in use – Rail crane productivity – Working hours – Switching delay – Static working track capacity	– Gate to vessel move ratio – Hourly arrival pattern – Number of gate stages – Fraction of trucks that visit each stage – Truck processing time at each stage

AECOM often uses PRECAP to analyze a range of options, such as comparison of high/med/low capacity forecast based on specific input assumptions like crane productivity, or calculation of static density that is expected to increase as a result of a particular project, or evaluation of impacts of statistical factors – like working hours or vessel size – that are expected to change over time due to external trends.

PRECAP has been developed by AECOM over many years of experience at port facilities around the globe in the planning and analysis of dozens of marine terminals. PRECAP is currently used by the Port of Los Angeles, the Port of Long Beach, and Port Metro Vancouver (Canada) as the standard tool for determining their port terminal capacity.

5.3.1 Berth Requirements

5.3.1.1 Berth Capacity

Berth capacity is defined as the volume of cargo that can be handled across the berth, without concern for any backland constraints. As with all elements of capacity, berth capacity is not a single fixed number, but a range of plausible values. Higher berth capacity means higher cost (more equipment and more labour cost) and lower levels of service, because some vessels may have to queue for berth space. The potential maximum number of containers handled over the berth (measured in twenty-foot equivalent units or TEU), is primarily dependent on following factors:

Design Vessel Size: Size of vessels is increasing day by day to accommodate more number of TEU per vessel call. Considering the order-book of vessels and the vessels under construction, the typical average maximum size of the vessel for direct call at Vizhinjam port in Phase-1 is considered as 12,500 TEU (for capacity analysis).

Available Berth Length: The berth length should be optimized to be able to cater to the largest design vessel along with mix of average vessels.

Container Moves per Vessel Call: Based on a combination of mainline and feeder vessels, and market data relating to average number of containers handled per vessel call at peer transshipment ports, 1500 container moves per vessel call is used as the maximum average number of containers handled per vessel call. This includes a range covering small feeder vessels and large mainline container vessels. Once the traffic builds up, this number will increase for catering to Phase-2 and Phase-3 berths.

Dock Cranes Assigned per Vessel: Number of dock cranes deployed per vessel call varies based on the vessel size and number of containers to be handled per vessel call. For the vessel of size up to 12,500 TEU, up to six dock cranes are being used and for smaller feeder vessels two to three dock cranes will be deployed. On average, four dock cranes per average vessel call are considered for the capacity analysis.

Productivity per Dock Crane: As per prevailing practice in India, an average productivity of 25 moves per hour is used for initial development of the Vizhinjam port. Once the operation stabilizes and core traffic achieved at the proposed port, the productivity is assumed to be reaching 30 moves per hour.

Maximum Practical Berth Utilization: It is a key subjective variable in a Berth Capacity Analysis. No berth can effectively run at 100% full. Shipping lines expect a certain level of customer service when calling a terminal; they do not want to queue out at sea for too long waiting for a berth to become available. Conversely, shipping lines work on fairly rigid vessel schedules around the world and filling a berth on a given day of the week may prove difficult to accomplish by changing sailing patterns. Due to the variable nature of vessel arrivals (delays at berth, storms, etc.), and the market-driven need to service vessels in a timely manner, the maximum practical berth utilization should be limited to avoid vessel queuing. In some locations, especially in Asia where feeder vessels will in fact queue for berth space, terminals can operate at berth occupancy up to 80%. Longer contiguous berths allow for greater occupancy than shorter berths. Vessels start queuing on a two berth facility when average berth utilization goes over 65% on a gateway terminal, whereas for a single berth, it happens at around 50% to 60%. For a transshipment terminal, the overall productivity and berth utilization can be increased without impacting the operations. At Port of Vizhinjam, the initial Phase-1 development will comprise of two berths and hence a value of 60% has been used for capacity calculations, however upto 70% berth utilization will be feasible for the operator in longer run.

Operational Time: Being an all weather port, it is assumed that Vizhinjam Port will work seven days a week for 365 days. Further, it is assumed that the port will operate round the clock i.e. three shifts of eight hours each with allowance for one hour break between each shift. This result in an effective working of 21 hours a day used in the capacity analysis.

Unproductive Time at Berth: It accounts for ship tie-up and untie time, which represents time where the berth is physically occupied by a vessel (i.e. no other vessel can be in that berth position) but there is no crane activity, excluding breaks which are captured by the work hours per day input. This activity includes mooring, line fastening, unlashing prior to first container move, administrative clearance, etc. These activities are assumed to take, on an average, 4 hours per vessel call.

Peak/mean Week Seasonal Demand: It is assumed that a peak week demand of berth will be 20% higher than the average week demand to account for changes in seasonal demand and adjust peak week berth capacity down to an average week berth capacity for calculation of the annual berth capacity.

Table 5.2 describes step-by-step assessment of annual berth capacity for the Port of Vizhinjam Container Transshipment Terminal. The right most column provides formulas along with the variables description.

Table 5.2 Container Berth Capacity Analysis for Vizhinjam Port

Phase-1	Berth Capacity
12,500	Typical Max Vessel Class Size TEU
1,500	Container moves (Lifts) per vessel call [a]
4.0	Dock cranes assigned per vessel [b]
25.0	Productivity per dock crane (moves/hr) [c]
100.0	Vessel productivity (moves/hr) [d=b*c]
15.0	Work hours per vessel call [e=a/d]
4	Unproductive time at berth (hrs) [f]
19.0	Total vessel time at berth (hrs) [g=e+f]
21	Work hours per day [h]
1.14	Calendar hrs/ work hour [i=24/h]
21.7	Total vessel hrs at berth [j=g*i]

Phase-1	Berth Capacity
168	Calendar hrs per week [k]
7.74	Vessel calls per week at 100% berth utilization [l=k/j]
60%	Maximum practical peak week berth utilization [m]
4.64	Maximum practical vessel calls per week [n=l*m]
6,963	Peak week berth capacity (moves) [o=n*a]
1.2	Peak/mean week seasonal demand factor [p]
5,802	Mean week throughput capacity (moves) [q=o/p]
302,000	Annual unit berth capacity (moves) [r=q*52]
1.5	TEU per container [s]
450,000	**Annual unit berth capacity (TEU) [t=r*s]**
2	Number of berths [u]
900,000	**Annual total berth capacity (TEU) [v=t*u]**
450,000	**Capacity Per Berth (TEU)**
75,500	Annual lifts per dock crane [w=r/b]
800	**Total berth length (m)**
1,130	**Annual berth capacity per unit berth length (TEU/m)**

With two berths of total quay length 800m in Phase-1 Vizhinjam Port can minimum handle approximately 900,000 TEU over the berths. It is estimated that once a steady stream of bigger vessels are calling at the port (such as 18,000 TEU vessels) with higher parcel size per vessel call, additional throughput can be handled from the proposed two berth facility with potential to go upto 1.4 million TEU on two berths. This additional throughput will depend on the actual mix of different vessels calling at the port.

Another important factor in the capacity of a container terminal is the size and operation of the container yard. Ideally, the capacity of the berth and the container yard should be balanced to achieve maximum throughput from the terminal as a whole.

5.3.2 Storage Requirements

5.3.2.1 Container Yard Capacity

Container yard capacity is defined as the potential maximum throughput of containers handled inside the container yard (measured in twenty-foot equivalent units or TEU), is primarily dependent on following factors:

Mean Dwell Time: The number of days a container sits inside the container terminal (dwell), which significantly varies for transshipment (usually 2 to 3 days) vs. the gateway traffic (varies from 3 to 7 days). For the gateway traffic, it varies by import vs. export vs. empty container. For the capacity calculation, an average of 5 days is used.

TGS Capacity: Represents the static storage capacity in terms of total number of twenty feet ground slots (TGS) or net acres available to store those containers inside the container yard.

Mean Storage Height: A mean storage height is calculated which takes into account the peak stacking height of the machine and various utilization factors than can be applied. It represents the maximum overall desired height for grounded operations. Most operators feel that 70-80% of the peak theoretical capacity is a reasonable level for planning purposes in order to account for sufficient empty slots for reshuffling and yard marshaling moves. Mean storage height used for this case is 3.5 high for capacity calculations.

Seasonal Peaking Factor: It is assumed that a peak week demand of container yard will be 10% higher than the average week demand to account for changes in seasonal demand and adjust peak week container yard capacity down to an average week yard capacity for calculation of the annual container yard capacity.

Weekly Inventory Peaking Factor: During a week, when a vessel arrives or departs, there is a sudden surge of inventory of containers that needs to be handled in the container yard, based on the size of the vessel and number of containers handled per vessel call. The factor applied to account for this surge is 10%.

Table 5.3 describes calculation of container yard capacity and formulas used to derive it.

Table 5.3 Container Yard Capacity Analysis for Vizhinjam Port

Phase-1	CY Capacity
1000	Nominal TGS capacity available [a]
3.5	Mean storage height (containers) [b]
3,500	TEU static capacity [c=a*b]
5.0	Mean dwell time (days) [d]
73	Turnovers per year per TEU static capacity [e=365/d]
2,55,500	TEU capacity without peaking [f=c*e]
1.10	Seasonal throughput peak factor [g]
1.10	Weekly inventory peak factor [h]
2,10,000	Nominal Annual CY Capacity in TEUs [i=f/g/i]
4,286	**Required TGS to meet berth capacity**
5,710	**Available TGS**
1,199,100	**Container Yard Capacity TEU/year**

With available number of TGS in Phase-1 development, the Vizhinjam port will be able to handle the berth throughput from the planned container yard. The container yard capacity calculated in here is higher than the berth capacity at average five days of dwell time. However, with higher utilization of berth capacity if upto 1.4 million TEU is achieved on the berth, the additional throughput will be also possible from the container yard by reducing the average dwell time to 4 days, which is very much feasible and the current practice on existing transshipment ports.

The TGS is split into the following as indicated in Table 5.4 below to accommodate the empties and reefer storage to cater the required capacities.

Table 5.4 Container Yard Storage Split

S. No.	Container Storage	Total Ground Slots (TGS)
1.	RTG Storage	
	– Non Reefer Storage	4,270
	– Reefer Storage	300
2.	Empty Storage	1,140
	Total	**5,710**

5.3.3 Receipt and Evacuation of Cargo

5.3.3.1 Rail Throughput Capacity

This section describes the methodology that was used to determine the rail throughput capacity which is expressed as number of rail tracks required to handle the forecasted gateway container traffic that can be handled from the port.

For capacity calculations, AECOM has assumed 30% of the gateway traffic will be handled by rail as compared to 70% by truck. The gateway traffic estimated by Drewry is around 16% of total container traffic and hence the share of container traffic moving via rail is (30% of 16%) 5% of total container traffic.

Following factors impact rail throughput capacity:

Track Length: Track length is taken as 700m clear length for each track as per the nominal length of container train operated by Indian Railways.

Maximum possible number of cranes working to load/discharge containers from railcars: Based on the shortest track length available at the proposed rail yard, it is assumed that two Reach Stackers can be deployed to work simultaneously on the rail track during Phase-1 development.

Amount of railcar double cycling: It is assumed that for 90% of arriving railcars that bring in a container in the port will leave with a container while departing.

Crane Productivity: Reach stackers are assumed for loading/unloading of train racks over a single or double rail tracks respectively. Handling rate of 12 moves per hour is used for the cranes.

Work hours per day: 8 hours per day is assumed for initial Phase 1 development. In future, with increased demand, the work hours can be increased per day for rail yard operation.

Peaking factors: It is assumed that the peak month will be 20% higher than the average month and peak day throughput will be 20% higher than the average day throughput.

Switching time: It is defined as time between the first set of railcars getting ready to depart from the port rail yard and going to the mainline and a second set of railcars arriving in the port rail yard through the single rail track. For the capacity analysis purpose, the switching time of trains is considered to be 4 hours. This will account for all the delays incurred in bringing the set of rail cars from the mainline to the port.

Table 5.5 describes calculations to determine the number of working tracks to handle the forecasted demand.

Table 5.5 Rail Yard Capacity Analysis for Vizhinjam Port

Phase-1	Rail Capacity
5%	% of Total Container Traffic via Rail
44,611	Total Rail Throughput Goal (TEU) [a]
1	Nominal Number of Working Tracks [b]
700	Average Length of Each Track (m) [c]
16	m per one well railcar [d]
45	Static capacity (railcars) [e]
2	TEU per railcar at 100% utilization [f]
100%	Rail working track utilization factor [g]
90%	Railcar utilization factor [h]
1.50	TEU per container [i]
108	Discharge + load moves possible w/o switching [j = 2*e*f*g*h/i]

Phase-1	Rail Capacity
2	Max Rail Yard Cranes in use [k]
12	Moves per hour per Crane [l]
4.5	Train work time (work hours) [m = j/(k*l)]
16	Work hours per day [n]
1.5	Calendar hour per work hour [o = n/24]
6.8	Train work time (hours) [p = o*m]
4.0	Switch time to replenish working tracks (hours) [q]
2.2	Max turnovers per day [r = 24/(p+q)]
241	Max rail boxes/day [s = j*r]
120%	Peak/mean week throughput [t]
120%	Peak/mean day within week for rail [u]
167	Mean rail capacity per day (moves) [v = s/(t*u)]
350	Number of working days per year [w]
60,000	Annual rail capacity per module (moves) [x = w*v]
90,000	Annual on-terminal rail capacity per module (TEU) [y = i*x]
397	Total working track length required to meet vessel capacity (m) [z = a*y/c]
1	Number of Working Tracks Required (each track of 800 m. length) [a1 = z/c]
1	Number of Working Tracks Provided [b1]
90,000	**Annual Rail Capacity Provided TEU/year [c1 = y*b1]**

In order to meet the traffic forecast, one working track will be required in Phase-1 development. Just one working track will provide almost twice the capacity than the overall requirement. It should be noted that if the rail yard can be operated 24/7 then additional capacity can be achieved to handle even non-containerized cargo from the rail yard area.

Container will be stacked at container yard and brought to railway siding by Internal Transfer Vehicles (ITV). Reach Stackers will load/unload them on the railway rack.

5.3.3.2 Gate Capacity

Gate capacity analysis is essential feature to get essence of seamless inward and outward traffic movement including major share of trucks having containers. Following factors impact gate throughput capacity:

Throughput share handled by trucks: Share of throughput which is forecasted to be handled by truck is key factor for gate capacity planning. Amount of TEU handled by truck will determine the daily truck traffic at port and the movements at gate complex. For capacity analysis, it is assumed that 70% of the gateway traffic will be moved by trucks as compared to 30% by rail.

Peak Ratio: For weekly mean moves 20% peak factor is considered. For daily traffic movement 30% peak in daily traffic is considered. For hourly traffic, 50% peak is considered for mean hourly traffic.

Working Hours: Working hours of gate directly impacts the gate capacity. For Phase-1 development 8 hour gate shift is assumed. The gate working hours will be increased if additional demand for gateway traffic is experienced at the port and for future phases.

Moves per Truck visit: Moves per truck visit reflect the container handling movement per truck. It reflects the number of trucks which come with a container and leave port with a container. The amount of such truck traffic is assumed 10% of total daily truck traffic.

RPM Capacity: Radiation Portal Monitors (RPM) are passive radiation detection devices used for the screening of vehicles and cargo for detection of illicit sources at port gates. Number of trucks that can be screened by this device per hour determines its capacity, which is being considered as 120 trucks per hour for capacity calculation. This number can increase with reduction in screening time.

Table 5.6 describes calculations to determine phase wise the fraction of capacity required for seamless container truck traffic movement through the gate.

Table 5.6 Gate Capacity Analysis for Vizhinjam Port

Phase-1	**Gate Capacity**
600,000	Vessel moves/year [a] (from Berth Capacity calculations)
12%	% of Total Container Traffic via Truck [b]
69,395	Total throughput moved through Gate [c = a*b]
1,335	Moves per mean week [d = c/52]
1.2	Peak/mean week ratio [e]
1,601	Peak week moves [f = d*e]
7	Days per week operation [g]
229	Mean day moves [h = f/g]
1.3	Peak/mean day ratio [i]
297	Peak day moves [j = i*h]
8	Hours worked per day [k]
37	Moves per mean hour on a peak day [l = j/k]
1.5	Peak/mean hour factor [m]
56	Peak hour on a peak day moves [n = l*m]
1.1	Moves per truck visit [o]
51	Peak hour truck entries [p = n/o]
100%	Fraction of entries that have a container [q]
51	Trucks per hour at RPM [r = p*q]
30	RPM process including truck replacement (sec) [s]
120	RPM capacity per hour [t = 3600/s]
1.0	**RPM lanes required [u = r/t]**
180	Entry pedestal process time (sec) [v]
20	Gate capacity per hour [w = 3600/v]
3.0	**Gate entry lanes required [x = p/w]**
180	Exit process time (sec) [y]
20	Exit capacity per lane [z = 3600/y]
3.0	**Exit lanes required [a1 = p/z]**

Number of required lanes in above calculation relates to container truck traffic only. Additional two lanes are required for each entry and exit gate for the vehicles participating in port operation facilities such as port staff vehicles, vehicles of customs, vehicles for supporting services, oversize cargo etc. Therefore, total five lanes each for entry and exit gate will be required.

5.3.3.3 Container Terminal Capacity Analysis Summary

The container terminal has been sized to meet the market demand predicted by IFC/ Drewry in 2010. The following Table 5.7 summarizes the development needs of berths, gate, yard and rail elements for the Port of Vizhinjam. The Phase-1 plan has been prepared to meet this development needs.

Table 5.7 Terminal Development Summary for Vizhinjam Port

Port Components	Phase-1
Berths (400m each)	2
Container yard storage (TGS)	5,710
Rail sidings (800m each)	1
Entry/Exit Gate (lanes each)	5

Based on the port components planned for Phase-1 development, Table 5.8 shows a summary of the estimated traffic and the planned capacity for the Vizhinjam Port. As evident from the table, the Phase-1 development will provide optimum capacity for handling the projected traffic for Phase-1.

Table 5.8 Terminal Development Capacity Summary for Phase 1 Development

<table>
<tr><th rowspan="3">Description</th><th rowspan="2">Total</th><th rowspan="2">Transshipment Traffic</th><th colspan="2">Gateway Traffic</th></tr>
<tr><th>Truck</th><th>Rail</th></tr>
<tr><th>TEU</th><th>TEU</th><th>TEU</th><th>TEU</th></tr>
<tr><td>Phase-1
Container Traffic Forecast</td><td>8,22,256</td><td>6,83,798</td><td>96,921</td><td>41,538</td></tr>
<tr><td>Phase-1
Minimum Container Capacity Planned</td><td>9,00,000</td><td>7,61,541</td><td>1,16,305</td><td>90,000</td></tr>
</table>

5.4 Other Cargo Requirements

5.4.1 Cruise cum Multipurpose Cargo Berth

For the Phase-1 development, dedicated cruise berth will be constructed in order to optimize the container cargo handling berths and provide flexibility for phasing of the cruise berths on a need basis without interrupting the container cargo operations. The cruise demand based on Drewry report states that the size of the cruise vessel varies from 1200 passengers in Phase-1 to up to 3000 passengers in the Master Plan i.e., in Phase-1 the number of cruise ships calling to the port is 30 increasing to 120 over the master plan horizon.

The long term demand for general/ breakbulk cargo was provided by Drewry to be in the range of 0.1 MTPA in the Phase-1 to 0.8 MTPA over the master plan horizon.

The forecast of these cargoes is not significant that would require a dedicated berth and equipments in Phase-1. These commodities can be handled at the proposed cruise berth using the ship's gears until more dedicated need for bulk cargo is identified.

It is proposed to provide one berth of 300m to carry out the cruise and multipurpose cargo handling operations.

5.4.2 Coast Guard

The need for effective coastal security in the present security scenario was highlighted by Coast Guard during the February 2012 workshop held in Thiruvananthapuram. The same was communicated to VISL with reference to the letter dated on December, 2011, where Coast Guard had put requirement for development of a station at Vizhinjam.

The Coast Guard requested a dedicated berthing space at Port of Vizhinjam to enable operation of its ships. The present docking facility available within the existing Vizhinjam harbour is insufficient to cater to the increased needs in the region. The Coast Guard is planning to have station at Port of Vizhinjam for effective coastal security and monitoring of Sea Lanes of Communication which is located around 10 nautical miles off the south west coast of Thiruvananthapuram. It will also help in providing enhanced training to the Marine Police.

The Coast Guard at Vizhinjam requested for a dedicated berth having a minimum berthing space of 120m, alongside depth of 8m with 4-5 acres of area behind the berth for operations. A land parcel of 5 acre for construction of accommodation for staff of Coast Guard was also requested outside the CRZ near the Port of Vizhinjam. VISL and the State Government agreed to the above requirement on a cost sharing basis, considering the coastal security needs of the region.

5.4.3 Navy Berth

Taking the advantage of the strategic location of the port, Indian Navy (IN) has shown interest in the port proposing the requirement of a navy berth and associated operational facility area.

The requirement is to provide a mounting base for loading of amphibious vessels, troops and transports. This would require a berth length of 500m with a loading ramp to enable loading of vehicles through the bow ramps of Indian Naval Ships. The IN plans to utilize the berth mainly for loading of amphibious troops, transports and armored vehicles for joint operation with the Indian Army base at Thiruvananthapuram (where the only amphibian infantry brigade in the Country is stationed) and the Indian Air Force Base at Thiruvananthapuram. The above berth requirement and the requirement of 25 acres of land (10 acres behind the berth and 15 acres outside for colony requirements) was agreed to by VISL and the State Government on cost sharing basis, considering the larger interests of the security of the Country.

Table 5.9 Characteristics of Navy Crafts

S. No.	Ships	LOA	Beam	Draft
		(m)	(m)	(m)
1.	Design Navy Ship	175.0	32.0	8.0

5.4.4 Port Crafts Berth

The Ship Navigation study has recommended a minimum requirement of four tugs i.e. 3 Tugs with 70T bollard pull capacity and 1 Tug with 40T bollard pull capacity to assist the navigation of ships visiting the port, 3 Mooring launches and 1 Pilot launch. It is recommended that a back-up tug be procured for the port. A total of 100m of berth length is provided at the port for the port crafts mentioned above.

The characteristics of these support crafts are given in Table 5.10.

Table 5.10 Characteristics of Port Crafts

S. No.	Type of Craft	LOA	Beam	Draft	Freeboard
		(m)	(m)	(m)	(m)
1.	Tugs	30.0	9.0	2.5	1.5
2.	Pilot Launch	19.5	4.8	1.8	1.1
3.	Mooring Launch	10.3	3.2	1.2	0.8

5.4.5 Berth Length for Support Facilities

The table below provides the summary of the support facilities required for Phase-1 development of Vizhinjam port.

Table 5.11 Summary of Berth Length for Support Facilities

S. No	Type	Berth Length (m)
1.	Cruise cum Multipurpose Cargo Berth	300
2.	Port Craft Berth	100
3.	Coast Guard Berth	120
4.	Navy Berth	500

5.5 Fishery Landing Centre

The existing Vizhinjam fishing harbour has the berthing facility of 500m and is being utilized to its peak causing congestion in the utilization of the harbour. Apart from this, the harbour requires upgradation in terms of ancillary facilities.

In order to ease the congestion in the existing fishing harbour and provide additional facilities for the local population, VISL has proposed to provide fishery berths along the sea side of north breakwater of the proposed Vizhinjam port as part of Corporate Social Responsibility.

The facilities to be provided are broadly divided into two categories viz.

a) Waterside facilities
- o Proper access to the landing area from the sea
- o Landing, Outfitting Quay and berthing quay/ jetty
- o Navigational Aids etc

b) Landside facilities
- o Auction hall
- o Administrative building
- o Vehicle parking area
- o Access roads
- o Electric & Water Supply etc.

It is proposed to provide 500m Landing, Outfitting Quay and berthing jetty for the fishing trawlers and country boats.

5.6 Buildings

The Phase-1 development of port has identified the conceptual foot print and location for various terminal buildings required for the functional port operations.

Typical buildings common to a container terminal includes:

- Administration Building;
- Entry/Exit Gate Inspection Canopy;
- Security Guard Booths;
- Pre-gate and Customs Building;
- Maintenance Workshop and Repair Building;
- Quay Crane Maintenance and Marine Operations Building.

Apart from these terminal buildings, the other functional building required for the port operations include:

- VISL Port Administration Building for functioning of VISL in managing the port operations.
- Substation buildings to house the transformers and other electrical equipment as per the load requirements in the different parts of the port area.
- Fire Station building to house firefighting equipment, fire tenders, etc.
- Dispensary building to be located near the operational areas and provide minimum facilities required for the first aid.
- Other miscellaneous utility sheds as per requirements of particular terminal
- Canteen buildings to provide space for catering staff, messing facilities for the terminal personnel and for utilities.

Buildings not shown or considered in the Phase-1 development plan include those that may be needed to handle possible general/multipurpose cargo and port operator need based facilities. A provisional location for these buildings is shown on the plan but no additional details are provided to keep the flexibility for future expansion.

5.6.1 Administration Building

The administration building will be required to house the terminal operator's management, security, admin and customer service personnel.

The building is located on the site plan to allow visual access to the gate complex from the Customer Service Department and Control Room. Office areas will have visual access to the container yard, container ship wharf, rail yard, and all gate areas. The building location has been planned in such a way that additional annex can be added in the same location for future phases if needed.

Typical users/uses of the administration building include:

- Terminal Administration
- Customer Service
- Gate Equipment Control
- IT/Server
- Gate Control Clerks
- Offices
- Shipping Lines Offices
- Terminal Security and Communications Hub

The Administration Building generally equips the following systems:

- TOS Computer System
- Container Yard Lighting Controls
- Annunciation and Alarm Systems
- Gate Control and Systems (voice, data, scale, sign bridge etc.)
- Public Address System
- Telecommunications System

5.6.2 Entry/Exit Gate Inspection Canopy

The Entry Gate Inspection Canopy is used to process container traffic into the terminal and the Exit Gate Inspection Canopy is used to process container traffic out of the terminal.

Gate canopies provide weather protection for the gate activities and provide a mounting structure for gate cameras and infrastructure. Any statutory scanning of import as well as export cargo will also take place here.

The Entry/Exit Gate Canopy equipment shall include, but not be limited to the following:

- TOS and Gate Computer Systems
- Gate Camera Controllers
- Cameras with automatic vibration correction

- Sign Bridge Controllers
- Scales and Scale Interface Controls
- Communication antennae and associated hardware

5.6.3 Security Guard Booth

Security guard booth provides security surveillance at the main gate truck access and exit lanes. The guard booth serving the main gate should be elevated and provided with sliding windows so that communications with drivers within the truck cabs can be facilitated.

The Guard Booth equipment shall include, but not be limited to the following:

- Central Security Monitoring and Annunciation Panels. Panels shall accurately depict the site plan of the terminal.
- CCTV monitors and controls with split screen and view selection capability.

5.6.4 Pre-gate Building and Customs Clearance

This facility is provided for the administrative functions of the remote pre-gate facility. The Pre-gate Building houses the Customs and Customer Service Department. The Customer Service Buildings and Kiosks provide facilities for truck drivers to resolve problems they may have with their paperwork, as well as convenience facilities.

The Pre-gate Building is required to provide facility for following functions:

- Customs clearance
- Demurrage payment
- Customer service
- Trouble transactions
- Truck driver canteen
- Toilets and washrooms
- Public phone, fax and internet

5.6.5 Maintenance and Repair Building

This facility houses maintenance, repair and related activities for RTGs, yard tractors, top-picks, side-picks, truck chassis, and other container terminal operating equipment. It also supports other service areas such as tire changing, and equipment steam cleaning activities.

Typical users/uses for this building include:

- Maintenance Supervisors
- Power and Chassis Repair Mechanics
- Parts Storage and Control
- Mechanics' Lockers
- Genset Repair
- Offices
- Vendors

Parking for service vehicles and bad order equipment needs to be adjacent to the building. Adequate circulation is required to move vehicles to and from the service bays. Roll-up overhead doors are required in the parts room and service bays. Building location shall allow for the ease of vendor access through the perimeter fence.

5.6.6 Quay Crane Maintenance and Marine Operations Building

This facility houses ship loading/unloading operations and planning functions as well as break facilities for the ship operations. The building should be multi-leveled.

Typical users/uses of this building include:

- Marine Operations Supervisors
- Labor Breakroom and Restroom Facilities
- Crane Repair Mechanics (Spreaders, Ropes)
- Parts Storage and Control
- Mechanics' Lockers

The building equipment shall include, but not be limited to the following:

- TOS Computer System
- TV Supervisory System

5.6.7 VISL Port Administration Building

A separate building and land area will be required to provide for functioning of VISL in managing the port operations. This will include but not limited to office building for the VISL management and administration staff, office for government officials, security staff and customs and border protection officers. This will also include the facilities for port maintenance and engineering staff.

5.6.8 Rail Master Building

A separate building will be required to provide for functioning of rail operations within the terminal. This building will house the rail master and associated staff managing the rail operations within the port. This building will also house a small workshop for minor maintenance functions.

5.7 Water and Power Requirements

5.7.1 Water Requirements

Total water demand within the port is broadly classified in the following categories:

- Potable water for consumption of port personnel;
- Potable water for passengers using Cruise terminal;
- Other uses like gardening etc.

Based on the requirements of berths over the master plan horizon, it is expected that the water demand at the port shall increase from 0.5 million liters per day in the Phase-1 development to about 1.0 million liters per day over the master plan horizon. The exact water demand shall be governed by the actual usage of the terminal area.

Based on this, suitable size of underground and overhead storage tanks will be provided at appropriate places. The water supply system within the port will be designed for optimum services to all the port areas such cruise area, container area, housing areas etc.

5.7.2 Power requirements

The power is required at the port for the following activities:

- Mechanized cargo handling equipment;
- Lighting of the port area;
- Offices and transit sheds;
- Miscellaneous.

The required electrical system for the project will consist of:

- A substation containing transformers, switchboards, control equipment, etc. to allow the distribution of electrical supply to the various parts of the site at the required voltage levels;
- Monitoring and control systems;
- Power cabling and fiber optic communications from the substation to the quay cranes at 66kV;
- Power cabling from the substation to the reefer area. The cables should be run at medium tension with step-down transformers installed beneath reefer platforms in the reefer areas;
- Provision of power cabling to the buildings and gate complex;
- Provision of power cabling to terminal light towers.

The port will be supplied through a 220KV main receiving station located near the truck terminal through dedicated 66kV lines. The proposed new container terminal development will contain all the features of a modern first class terminal, and as such will require a reliable power supply system. Consideration of future electrical requirements of the terminal shall also be taken into account, and all necessary provisions shall be made in the design and installation of the electrical system, to take account of future requirements. This applies to switchboards, transformers, underground conduits and the like.

Based on the requirements of berths over the master plan horizon, it is expected that the power demand at the port shall increase from 33 MVA in the Phase-1 development to about 67 MVA over the master plan horizon. The exact requirement will have to be governed by the facilities proposed mainly in terms of handling system. The suitable electrical distribution system in the port area will have to be accordingly planned.

6 Port Facility Requirements-Master Plan

6.1 General

The Integrated Master Plan for the proposed port at Vizhinjam has been submitted by AECOM in November 2012. Considering the needs of the Indian Navy and considering the outcome of the ESIA and modeling studies, the master plan layout has been further optimized in May, 2013. This section provides a summary of the master plan. Please refer to the master plan report available through VISL for additional details.

The final Master Plan (also referred to as Phase-3 of development) results from identifying the infrastructure needed to achieve the projected market demand over the 30-year planning horizon for the Vizhinjam Port's two core commodities: containerized cargo and cruise. This is based on the traffic projections in the IFC/Drewry 2010 report, and considering the limited / utilizable shore length of 2.5 Km at Vizhinjam. This infrastructure will include:

- Ability to berth fully laden two 12,500 20-foot equivalent container units (TEU) vessels in Phase-1 itself with capability to handle up to 18,000 TEU vessels.
- Ability to handle 3,000 passenger capacity cruise ships.
- Additional fish landing berths on the sea side sheltered section of breakwater.
- Liquid bunker fuel berth in Master Plan.
- Container Yard on reclaimed land.
- Rail line to port and the railway yard.
- Berthing facilities for Coast Guard and Indian Navy.
- Other support and ancillary facilities.

The AECOM team applied the site-specific physical constraints, based on the infrastructure assessment, to identify the master plan while keeping VISL objectives in mind. These constraints include proximity to an existing fishing harbor and fishermen settlements in the north; a temple in the middle; a fishing village with long beach (*Adimalathura*) in the south (Phase-3 end) and steep topography of the backup area.

In summary the Master Plan addresses four main factors:

- **Market:** The master plan is based on the traffic analysis performed by IFC/Drewry (2010) and is planned to accommodate the 2044 high case scenario. In addition, expansion potential of the master plan will allow to port to expand beyond 2044. The master plan is flexible enough to accommodate various types of cargoes depending on the market situation (cruise, multi-purpose cargo). Based on the market forecast, it is recommended that Port of Vizhinjam be developed in three phases with Phase-3 bringing it up to the final master plan development.
- **Technical:** The master plan presents the most technically sound option after taking into due consideration the physical constraints at the site and providing a futuristic world class efficient facility with green design concepts.
- **Environmental:** The master plan takes into account various environmental aspects such as:
  - Provides a 300m clearance between the existing fishing harbor to avoid disturbing the existing facilities due to proposed port;
  - Minimizes the land cutting with efficient arrangement of terminal facilities;
  - Minimizes tree uprooting in the backland by locating terminal facilities away from existing shoreline;
  - Provides flexibility to incorporate green initiatives.
- **Social:** The Master Plan has been carefully arrived at to minimize impact on the adjoining population, some of the factors considered are:
  - Fishing community near the proposed port site;
  - Additional fishery berths are provided for the fishing community;
  - Rail access has been planned for minimal impact on the adjoining village;
  - Tourism industry to improve through cruise vessels and the proposed land use will match the current land use in the cruise terminal area;
  - Facilities for Indian Navy and Coast Guard to improve security of the country;
  - Master plan preserves the existing Mulloor Naga temple and provides for unimpeded access to it.

6.2 Future Development Requirements

6.2.1 Harbour and Breakwater Alignment

The harbour and breakwater alignment was maintained from the RH report as it was arrived at after due consideration and studies. However, some alterations were made such as maintaining the distance between the existing fishing harbor and the proposed port to be 300m (RH report had it 220m) considering the improved tranquility conditions of the fishing harbor as observed from the mathematical modeling studies.

The shape/ layout of the northern breakwater have been designed in such a way that bunkering vessels can also be berthed in future. The port design was made futuristic by considering 18,000 TEU vessels as the design vessel in Phase-1 itself with a turning circle of 700m diameter, to cater to tug assisted rotation of even futuristic vessels of 400+ m length. Considering that about 18m draft is naturally available at Vizhinjam (which will be deepened to about 21m), currently the biggest 18,000 TEU vessels (like MAERSK EEE class) will also be able to berth.

After modeling studies, it became evident that south breakwater was not needed for maintaining tranquility within the harbour and has been subsequently removed. The navigation studies have been used to further optimize and verify the navigational channel of the harbour. The harbour has been further optimized to accommodate Indian Navy and Coast Guard facilities.

The harbour and breakwater alignment for Phase-2 will be maintained as per the Phase-1 layout. LTR modeling studies have shown that a 200m extension of the breakwater will be required to achieve permissible level of tranquility for Phase-2 berths. For the Master Plan development a further breakwater extension of around 720m will be needed.

6.2.2 Container Berths

The master plan provides for a total of five, 400m each container berths. Phase-1 development will have a total of 800m berth length to accommodate two 12,500 TEU container vessels. Phase-2 development will add another 400m berth to have a total of 1200m berth length to accommodate up to three 12,500+ TEU container vessels. Phase-3 will add two additional 400m berths to have a total of 2000m berth length to accommodate up to five 12,500+ TEU container vessels. The berths have been planned so as to meet the traffic forecast. These berths will be designed to be able to berth 18,000 TEU vessels as well.

Each berth will be equipped with four quay container cranes. The Quay apron area has been planned to accommodate the crane rail (upto 35m rail gauge), circulation lanes as well as hatch cover laydown area. The apron area has been planned for a width of 70 meters.

6.2.3 Fishery Berths

The Phase-1 development plan provides for additional fishery berths for the local fishing community. A total berth length of 500m is provided for along the sheltered sea-ward side of the proposed north breakwater. The master plan report (2012), suggested that fish landing berths could also be situated on the sea side of the existing Vizhinjam harbour south breakwater. However, the modeling reports have shown that only 500m along the proposed port breakwater are feasible.

6.2.4 Cruise cum Multipurpose Berths

For the port master development, cruise berth will be constructed on the leeside along the northern breakwater, in order to optimize the container cargo handling berths and provide flexibility for phasing the cruise berths on a need basis without interrupting the cargo operations.

The master plan provides for two berths for Cruise vessels (300m length in Phase-1 with 200m length additional in Phase-3) along the northern breakwater. The depth required for maneuvering and berthing of cruise ships is naturally available at the proposed location and will not involve any capital dredging. The berths are located on the lee-side of the breakwater so as to utilize the structure and provide a wide area behind the berths.

These berths also cater the handling for multipurpose cargo traffic which is not significant that would require a dedicated berth.

6.2.5 Liquid Berth

A provision has been provided in the master plan for a dedicated liquid berth. This berth will be used to import bunker fuel for the vessels calling at the Vizhinjam port. The berth will be connected to the storage tanks through pipelines passing along the north breakwater. A provision for 250m long berth has been provided in the Master Plan and will be able to berth a 60,000 DWT liquid bulk tanker. The berth will be located south of the Indian Navy berth along the lee side of the north breakwater. This location would cause minimum interference between liquid berth operations with any other port vessel operations.

6.2.6 Container Yard

The master plan provides for around 100 hectares of Container Yard and support facilities. The container yard is located adjacent to the berths allowing for the efficient transfer of containers from the yard to the apron. The container yard has been planned for efficient handling operations providing for dedicated areas for full, empty and reefer containers. Dedicated circulation lanes have also been provided for quay to yard as well as within yard circulation. The mode of operation for the container yard will be Rubber Tired Gantry (RTG) Cranes in Phase-1 with provision for up gradation to Electric RTG's in later phases. Side Pick cranes are proposed for handling empty containers. Master Plan provides flexibility with adequate space provision for terminal operator to choose a different container handling operating mode such as RMG.

6.2.7 Railway Connectivity/Yard

Electrified railway lines (with two live & three service lines - one service line each in Phase 1, 2 and 3) with container handling facilities using Reach Stackers in Phase-1 and Phase-2, upgradable to RTG's or Rail Mounted Gantry's (RMG's) in Phase-3 have been planned. The proposed port is essentially a transshipment container terminal with around 30% of gateway container traffic. The split of gateway traffic coming through rail is assumed to be 30%. The number of rail lines has been sized to accommodate this traffic.

In future, the proximity of the planned cruise berths to the rail yard can also be utilized to handle the multipurpose/ bulk cargo from the cruise berths using rail for landside transfer.

Provisional future expansion space east of rail yard and north of the gate complex can be also used for bunker fuel storage, which can also avail the proximity of rail yard, for bringing in the liquid petroleum products in the port by rail.

6.2.8 Entry/Exit Gate Complex

The main terminal gate has been provided at the east end of the port. It will consist of a gate canopy with three entry and three exit lanes with one bypass lane and one lane for port vehicles on each side. It is planned that the gate operations in Phase-1 will consist of single shift increasing to two and three shifts in Phase-2 and Phase-3 respectively. The proposed port is essentially a transshipment container terminal with around 16% of total container traffic will be Gateway traffic handled by trucks.

The gate complex is designed for handling the master plan gateway traffic handled by trucks. Traffic forecast by IFC/Drewry has been considered for designing of gate complex. In case there will be any change in market statistics and increase in gateway traffic by gate, there will be possibility to expand gate complex further in north-east direction. In case of two or more terminal operators, gate complex will remain same and secondary check gates will be provided at terminal entry points.

7 Model Studies for Phase-1 Development and Recommended Development

7.1 General

Various model and technical studies have been performed to ascertain various oceanographic and coastal impacts of the proposed port Phase-1 development and to determine the optimum layout of the Phase-1 development. These studies are listed in Section 1.6. Some studies are described in Section 2.3, other site specific model studies conducted by VISL are listed below. The LTR studies have evolved during the study period and have been used to arrive at the final proposed layout.

- **Wave Modeling Study by RH/IFC August 2010:**
  - Near shore wave transformation for normal and extreme wave conditions
  - Wave penetration inside the proposed port for extreme conditions.
- **Updated Mathematical Model Study by LTR, May 2013:**
  - Sediment Transport and Shoreline Changes
  - Validation of model results with the measured data
  - Tranquillity Study for Proposed Fish Landing Centre
  - Tranquillity Study for Proposed Port
  - Design Wave Heights and Water Levels
- **Ship Navigation Simulation Studies, BMT CI, May 2013**

The summary of the findings of the model study are presented in following paragraphs. The detailed reports on the mathematical model studies can be accessed through VISL.

7.2 Studies carried out by RH/IFC

7.2.1 Wave Transformation Modeling

Wave modeling study was carried out by RH for transformation of offshore wave conditions to nearshore, for the overall sea state and for extreme conditions. For the overall sea state, hindcast wave and wind data were used by RH. SWAN (Simulating Waves Nearshore) wave model was used to translate the offshore conditions to nearshore. The 3rd generation fully spectral wave model SWAN includes all wave transformation processes such as refraction, diffraction, shoaling, reflection, transmission, bed friction etc. and was applied to simulate the propagation of waves from offshore to near shore and for the wave penetration studies inside the harbour.

7.2.1.1 Normal Conditions

A matrix with offshore wave conditions in terms of wave direction, wave height, wave steepness and wind speed was simulated to derive the normal and extreme wave conditions at the port location. A total of 1512 simulations were carried out by RH taking the above wave and wave parameters derived from BMT ARGOSS offshore data as discussed in Section 2 of this report. The results of all these simulations were combined in a transformation matrix which was used for the transformation of the offshore time series to nearshore based on multi-linear interpolation between the values at the nodes of the matrix. Based on the nearshore time series, the wave climate at the specified near shore location was derived.

Figure 7.1 shows the existing wave transformation without the breakwater while Figure 7.2 shows the wave transformation after the proposed breakwater. It can be seen that for points 4, 6 and 9 which are inside the harbour, there is reduction in wave heights due to the breakwater.

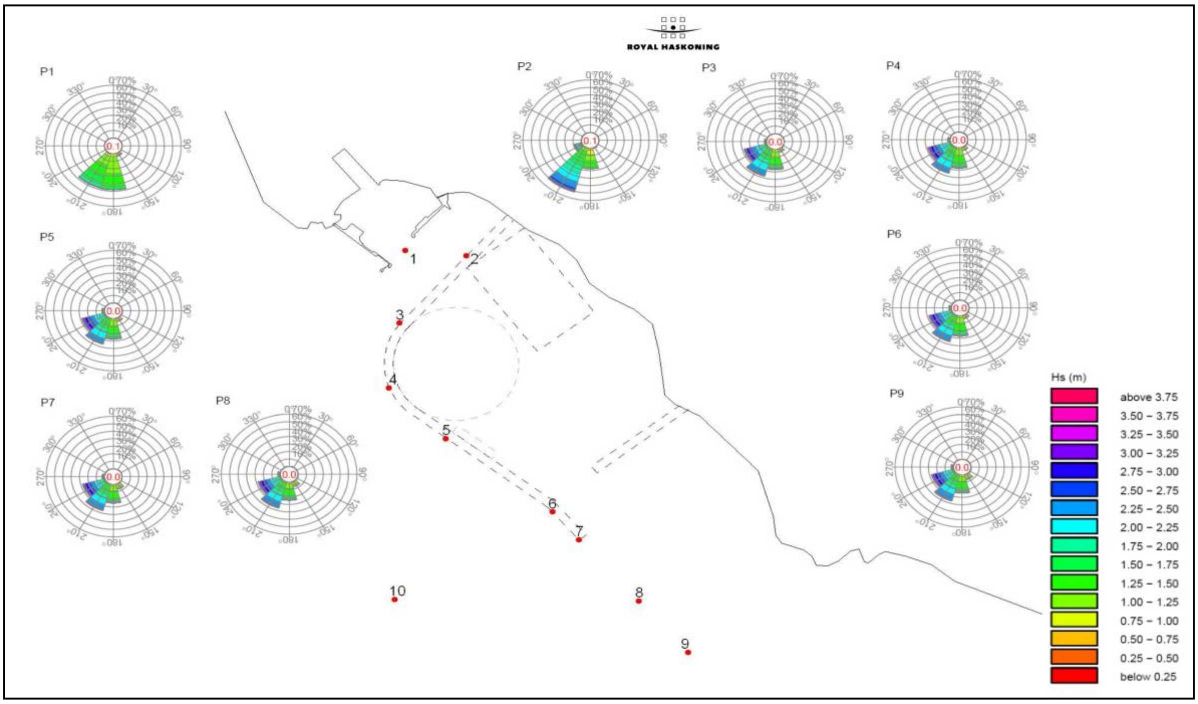


Figure 7.1 Normal Nearshore Wave Climate Without Proposed Breakwaters

[Source: RH Wave Modeling Report, August 2010]

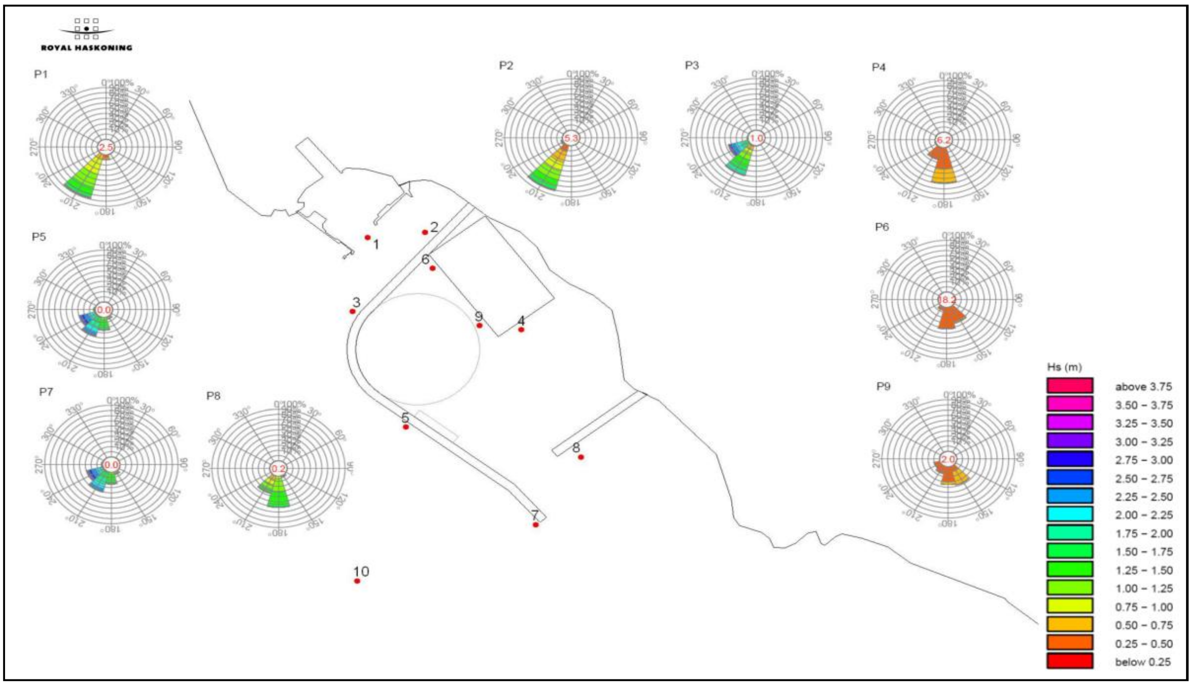


Figure 7.2 Normal Nearshore Wave Climate with the Proposed Breakwaters

[Source: RH Wave Modeling Report, August 2010]

7.2.1.2 Extreme Conditions

The effect of the breakwater in extreme conditions was investigated by RH by considering the extreme offshore cyclonic condition wave heights. Site specific studies were not performed by RH and data from an earlier study at Karwar was applied to the project site. Table 7.1 shows the transformation of the 1:100 year design wave as a result of a cyclone (Hs = 6.3m offshore) to near shore points 1 to 10. Points 1 to 10 in port region are shown in Figure 7.3. In the table the maximum of all (offshore) directions 180° to 300° is given for each point. For example, for point 1 with an offshore wave direction of 180° and a wave height of 6.30m, the maximum near shore wave height is reduced to 4.23 m. Only at point 5 and 7, it is observed that wave is getting amplified to 6.60m and

6.54m respectively. 1: 100 years design wave height of 6.3 m is considerably reduced inside the harbour due to the construction of the breakwaters for the port of Vizhinjam.

Table 7.1 Wave Transformation to Nearshore in Extreme Conditions

Point	Offshore				Nearshore			
	Wave Height	Wave Period	Wave Direction	Wave Steepness	Wave Height	Wave Period	Wave Direction	Wave Steepness
	H_s	T_p	H_s Dir	S_0	H_s	T_p	H_s Dir	S_0
1.	6.30	16.50	180	0.015	4.23	16.57	197	0.0098
2.	6.30	16.50	240	0.015	2.99	16.52	215	0.007
3.	6.30	16.50	240	0.015	6.15	16.51	229	0.0144
4.	6.30	16.50	150	0.015	2.21	16.45	186	0.0052
5.	6.30	16.50	210	0.015	6.60	16.50	217	0.0157
6.	6.30	16.50	150	0.015	1.57	16.40	164	0.0037
7.	6.30	16.50	180	0.015	6.54	16.50	201	0.0151
8.	6.30	16.50	150	0.015	5.58	16.50	194	0.0131
9.	6.30	16.50	150	0.015	2.24	16.42	161	0.0053
10.	6.30	16.50	240	0.015	6.30	16.49	235	0.0147

[Source: RH Wave Modeling Report, August 2010]

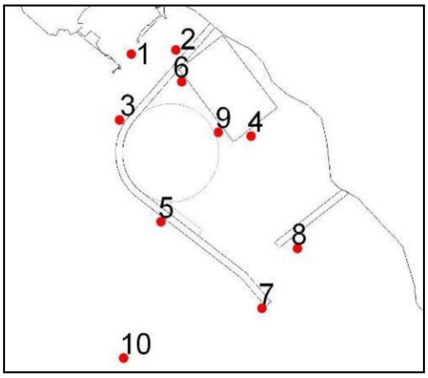


Figure 7.3 Locations of Points for Wave Transformation Study

[Source: RH Wave Modeling Report, August 2010]

From the near shore wave modeling analysis done by RH, it can be concluded that under extreme and normal conditions, both major and minor breakwaters effectively protect the harbour area from harsh wave conditions. Point 4, 6 and 9 which are within the harbour will experience considerable reduction in significant wave heights (Hs) from the offshore extreme wave height (Hs) of 6.3m.Wave heights at points 2, 3, 5, 7 and 8 which are along the breakwater, represent the significant wave heights which will be experienced by the breakwater under the extreme cyclonic conditions.

7.2.2 Wave Tranquility

RH also performed a persistency analysis for the Point 9 location (inside the harbour). The preliminary persistency analysis shows the overall wave action at a location as an exceedance probability and the duration of wave events. The results are shown in Figure 7.4.

The overall wave height exceedance at point 9 is shown in Table 7.2. It was found that 0.65m wave height (which is the operational limit for a container berth) has exceedance percentage of around 15% for all-year analysis. The exceedance percentage for 0.65m wave height is around 10% and 20% for monsoon and non-monsoon periods respectively. The reason of waves at point 9 being lower in monsoon than for all-year is that monsoon waves are coming from west or south-west which are effectively blocked by the breakwater.

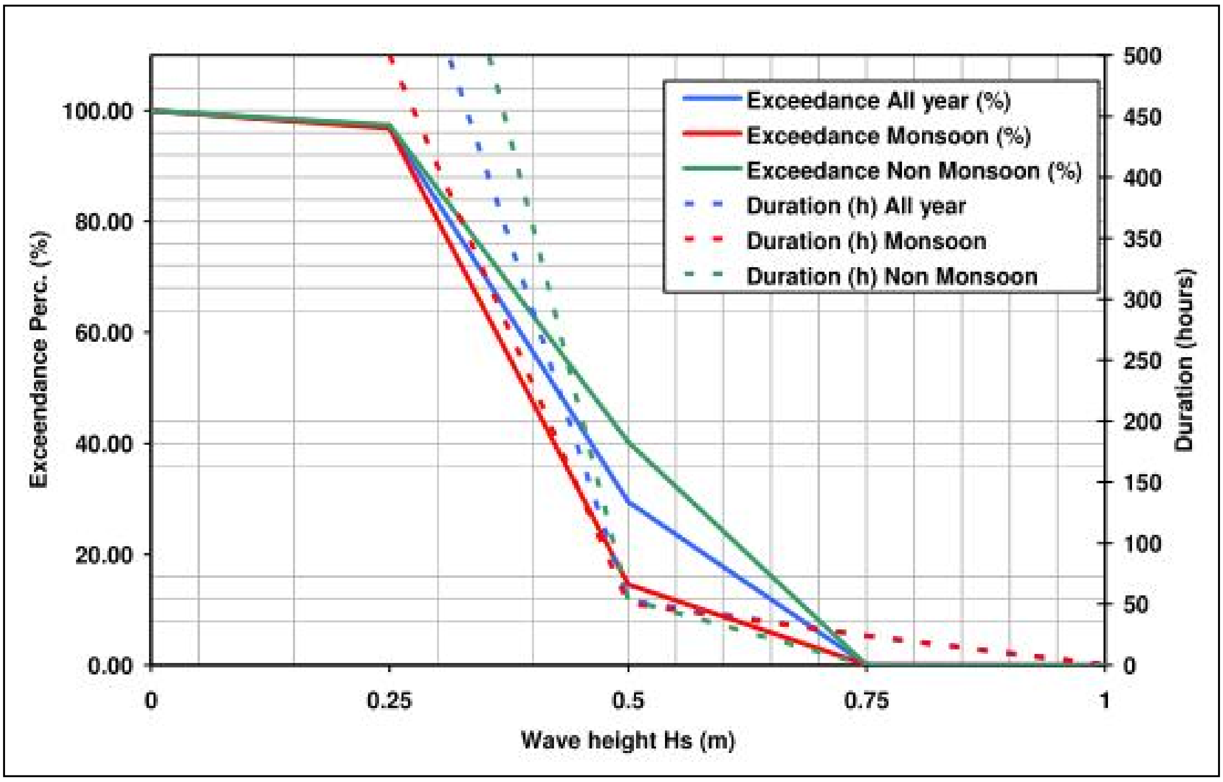


Figure 7.4 Exceedance (in % and duration) inside the Harbour at Point 9

[Source: RH Wave Modeling Report, August 2010]

Table 7.2 Wave Height Exceedence (%) and Duration inside the Harbour at Point 9

Hs(m)	All Year		Monsoon		Non Monsoon	
	Standard Duration	Exceedance (%)	Standard Duration	Exceedance (%)	Standard Duration	Exceedance (%)
0	>2000	100	>2000	100	>2000	100
0.25	647	97.18	500	96.85	820	97.41
0.5	53	29.44	51	14.52	54	40.2
.0.75	24	0.02	24	0.04	0	0
1	0	0	0	0	0	0

[Source: RH Wave Modeling Report, August 2010]

Wave penetrations studies for the extreme cyclone events (not site specific) were carried out by RH using SWAN Model. Results of the wave penetration modeling studies are summarized below. Here, U_w represent offshore wind condition which is taken as 20 m/s, s is the wave steepness, T_p is the peak wave period and H_s is the offshore significant wave height (extreme conditions like cyclone), direction represents offshore wave direction with respect to north. Color scheme and colored bar on right side represent significant wave height (Hs) at that location. A few results of the wave penetration modeling study are shown in Figure 7.5 to Figure 7.6.

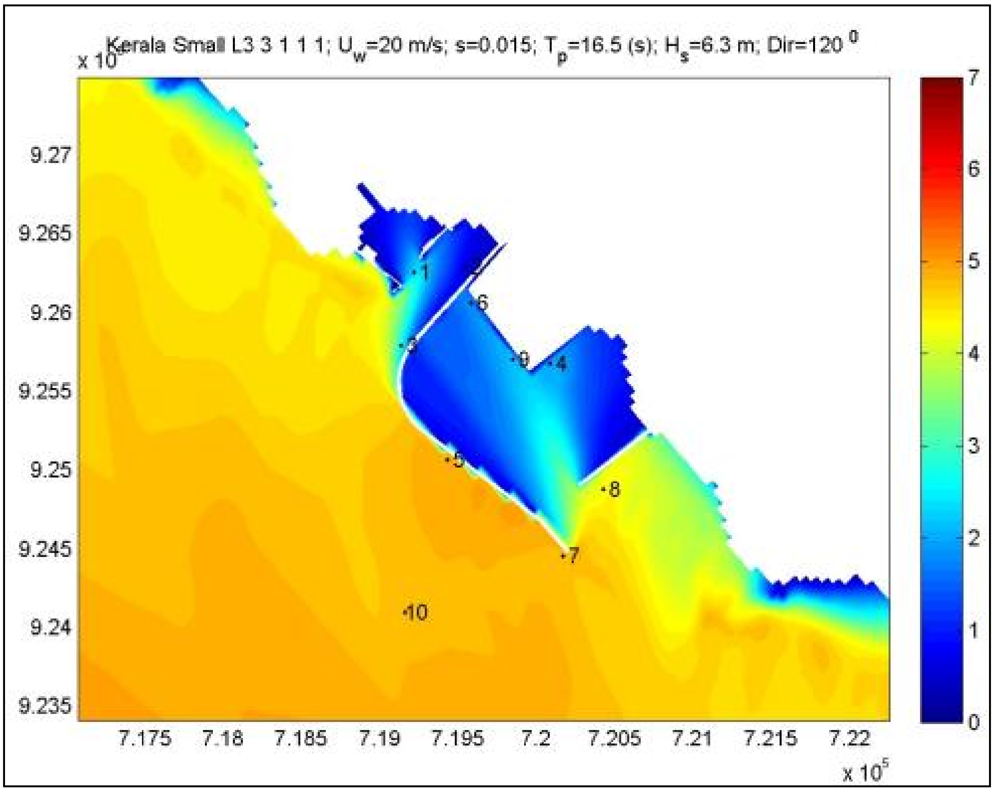


Figure 7.5 Wave Penetrations inside Harbour - Extreme Condition (Wave Angle 120°)

[Source: RH Wave Modeling Report, August 2010]

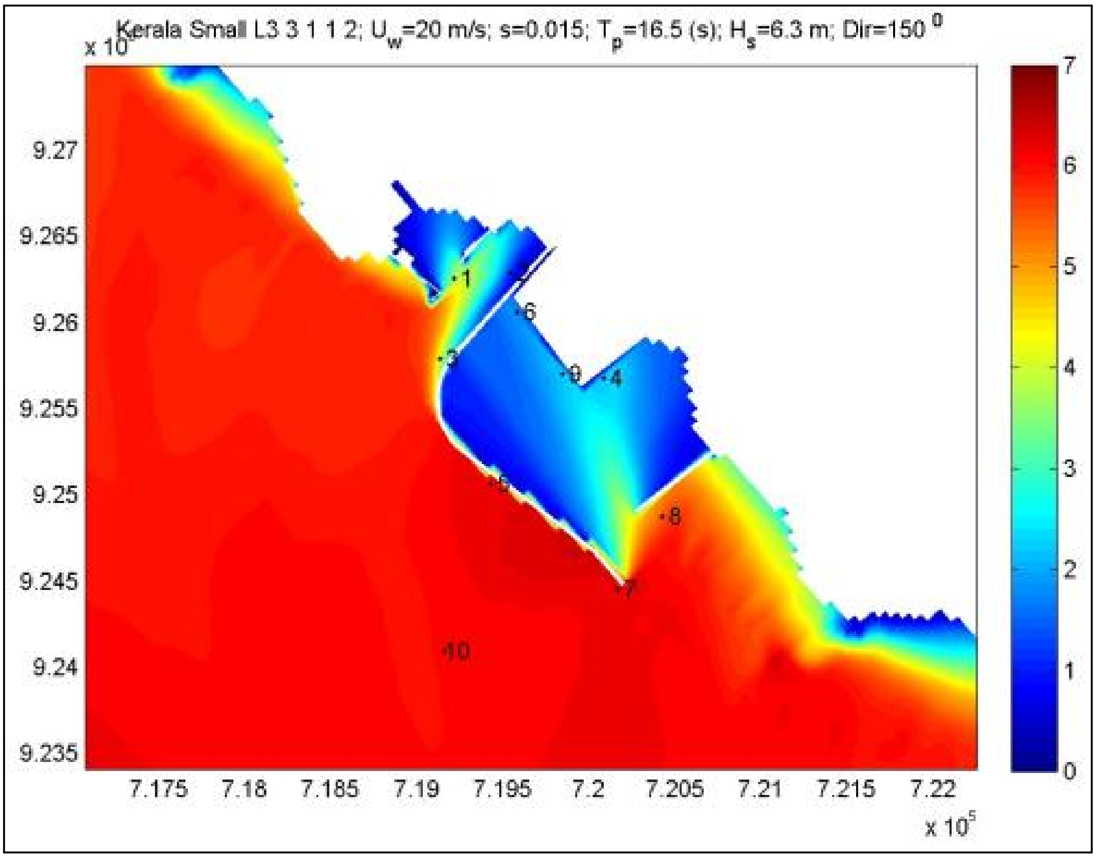


Figure 7.6 Wave Penetrations inside Harbour - Extreme Condition (Wave Angle 150°)

[Source: RH Wave Modeling Report, August 2010]

It was inferred from the modeling that the harbour design with the two breakwaters on the west and south side effectively reduce wave action in the harbour, both under extreme conditions and during normal overall sea state.

7.3 Model Studies Carried out by LTR

7.3.1 Hydrodynamic Modeling

The objective of the study was to setup a hydrodynamic model of the study area and to simulate the hydrodynamic conditions. Available information like bathymetry, tide, wind, current, wave (as discussed previously in section 2.3.2) and the proposed port layout was used. The model domain considered for the study was almost parallel to the coastline and it covers the region of about 10km×30km. Model bathymetry domain is shown in Figure 7.7.

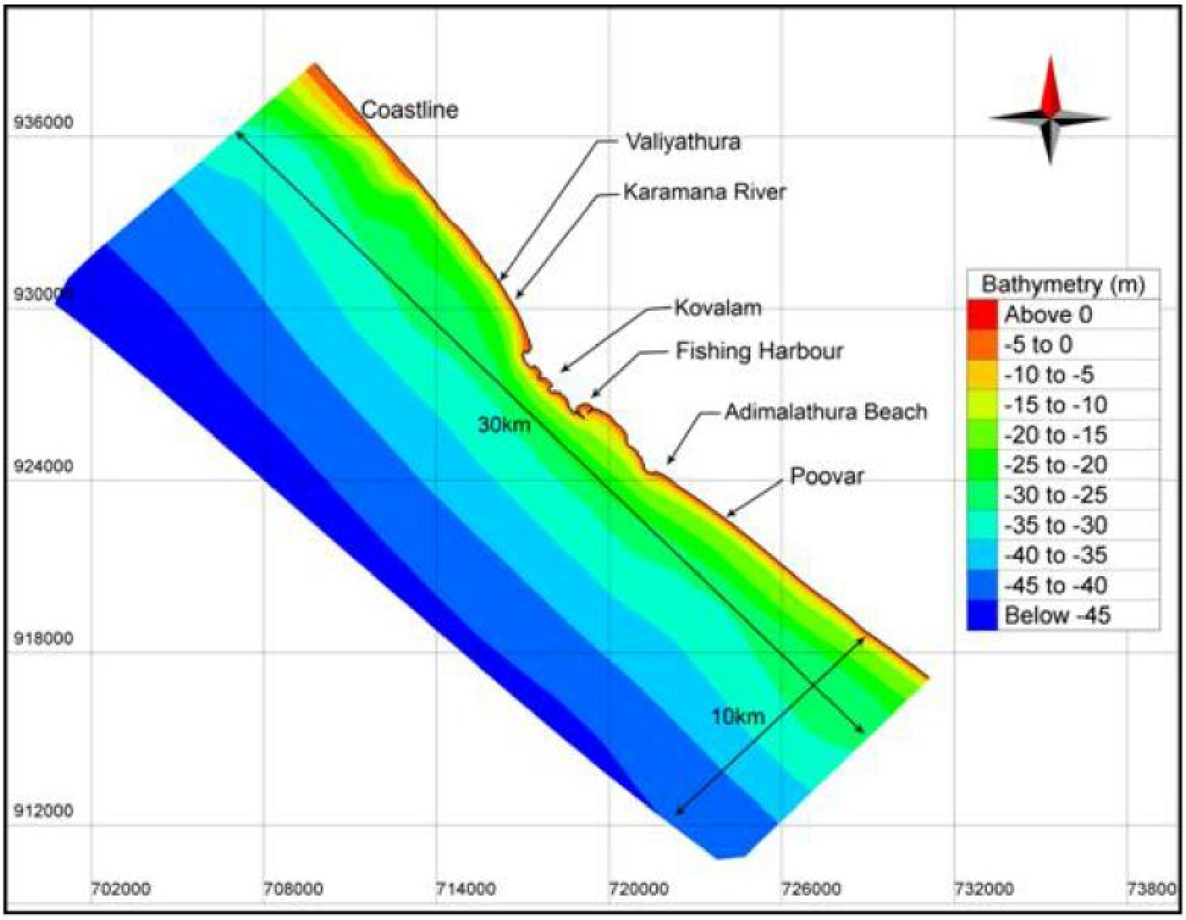


Figure 7.7 Model Domain around Vizhinjam Port Site

[Source: Updated Mathematical Model Study by LTR, May 2013]

For the modeling study parameters like Eddy Viscosity, Bottom Friction, Time Step and Solvers were adjusted to get a calibrated model. The calibration of the model was done by comparing the observed tide elevations (at 8° 22' 34.5'' N, 76° 59' 15.2'' E by Fugro for a period of two months beginning from April 2011) with the simulated tide elevations. Comparison of observed and simulated tidal variations is as shown in Figure 7.8.

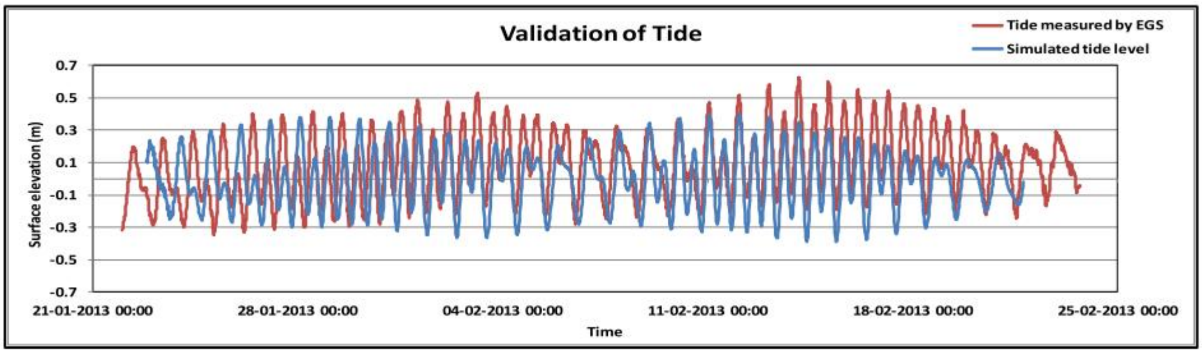


Figure 7.8 Correlation between the Simulated and Observed Tidal Elevation

[Source: Updated Mathematical Model Study by LTR, May 2013]

The model generated currents were also compared against the measured data by EGS for one month duration. Figure 7.9 shows the comparison of the observed and simulated current speed and directions for CM1 location. From the figures, it can be seen that the current components show reasonable comparison till 14th February beyond which there is some variation is observed in the current pattern. This may be due to the local meteorological disturbance, which was reported in EGS survey report for the period. The model result shows good comparison with the observed current and hence the model is considered validated.

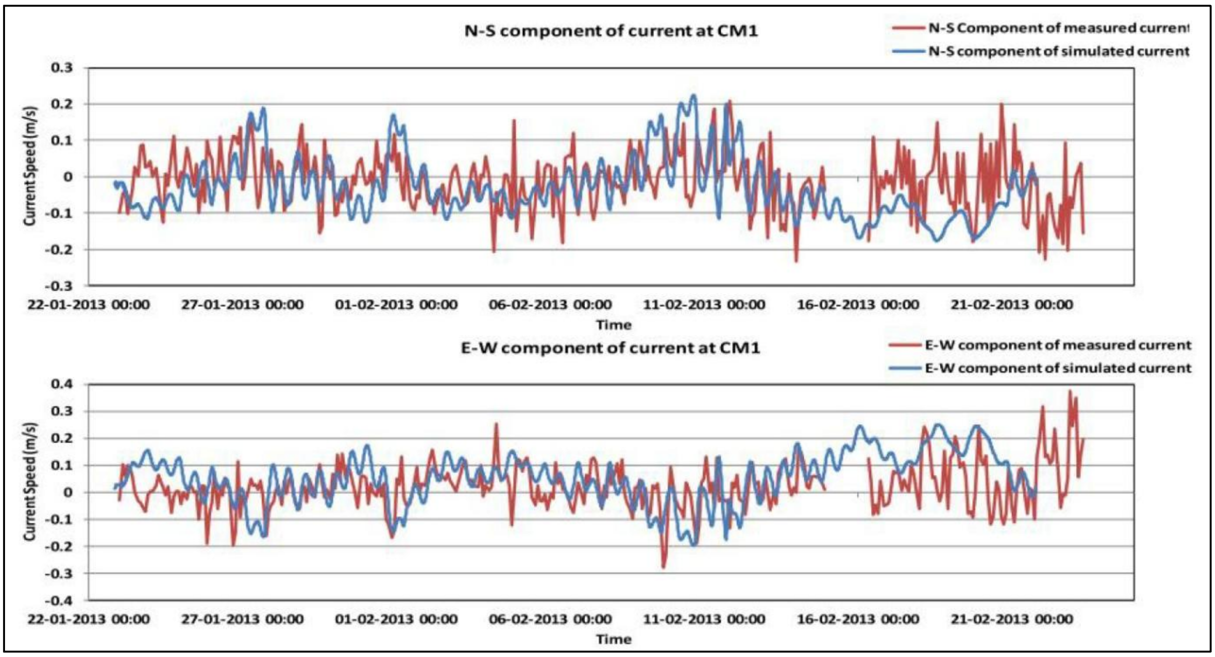


Figure 7.9 Comparison of Simulated and Observed Current Speed and Direction

[Source: Updated Mathematical Model Study by LTR, May 2013]

Current pattern obtained from the model run showing South-East and North-West flow is shown in Figure 7.10 . The result compares the effect of the proposed port breakwater on the current flow in the area. The darkening of the blue shade in the right figures (with proposed breakwater layout) represents reduction in current strength. This reduction is due to the presence of the breakwater which is creating a shadow region.

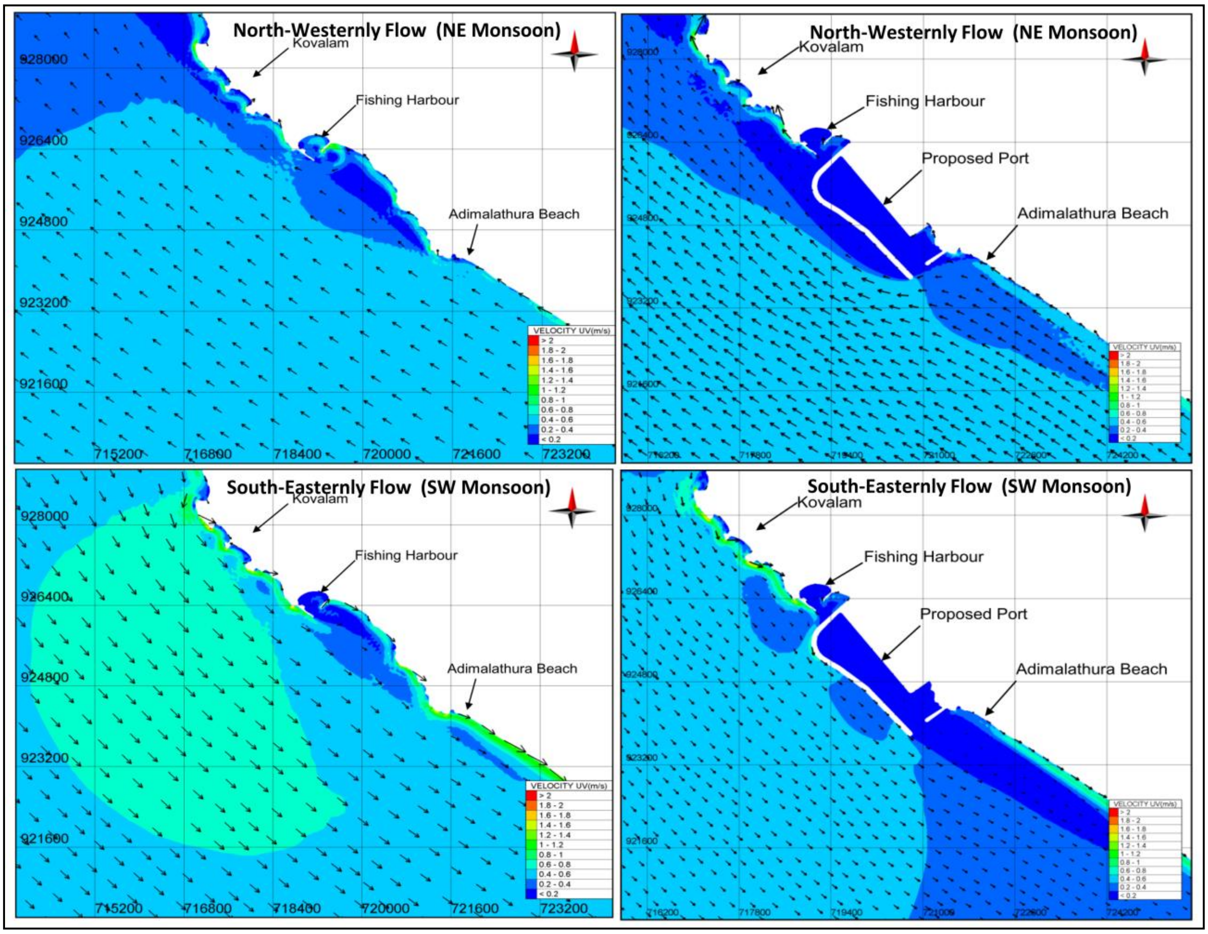


Figure 7.10 Current Patterns obtained from the Model Run with and without Breakwater Layout

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.2 Shoreline Change Study

LTR along with INCOIS have carried out the analysis of the existing shoreline changes around the Vizhinjam project site. The purpose of this study was to setup a shoreline evolution model for the project location in order to evaluate the shoreline change due to the construction of the proposed port. The following steps were adopted by LTR for the study:

- Review of available literatures for the area on shoreline change and littoral drift
- Temporal analysis of shoreline positions using long term multi-temporal and multispectral satellite data as well as Google Earth satellite data

7.3.2.1 Literature Review

As per the literature review done on the topic of net littoral drift along the Kerala coast, most of the researchers concluded that the net littoral drift is towards the North direction with erosion of beaches taking place during SW and NE Monsoon periods followed by accretion during pre- and post-SW monsoon months.

7.3.2.2 Geomorphology and Temporal Analysis of Shoreline based on Satellite Data and Images

The study has considered 30km coastline (15 km either side) around Vizhinjam for the shoreline change study. The shoreline around Vizhinjam is aligned in NW to SE direction with pocket beaches between headland of Kovalam. The project site typically has cliffs fronted by narrow sandy beaches. The stretch in the vicinity of Kovalam and fishing harbour has headlands with pocket beaches. The stretch at Adimalathura which is at south-east of the proposed port has sandy beach which develops during the non monsoon period and erodes with the onset of monsoon.

The shoreline evolution pattern around the project location was studied by analyzing the satellite data from Landsat TM and IRS-P6 LISS-III pertaining to the study period (1992-2011). The shorelines pertaining to individual periods were extracted using on-screen digitization techniques. The shoreline change rate pertaining to the periods 1992, 1997, 2001, 2006 and 2011 were estimated and maps showing the distribution of the spatial changes were prepared.

It was observed that the northern parts of the Vizhinjam show dominantly eroding tendency, whereas the southern parts show dominantly stable to accreting tendency during 1992 - 97. During the period 1997 – 2001, the results reveal the dominant accretion phase except few stretches near Vizhinjam, Kovalam and Puntura/Narakattara. However, during the period 2001 - 2006 shorelines recorded erosion in the northern and central parts of the study area. But, during the period 2006 - 2011 the shorelines were recorded with dominantly low erosion to no change except few stretches around Puntura/Narakattara, Adimulatura and south of Poovara in the southern parts. The net changes in the shoreline rate during 1992 - 2011 reveals dominantly stable to accreting tendency except few stretches around Puntura/Narakattara in the northern parts of the study area. Overall, the shoreline experienced maximum accretion (as observed) during 1997 –2001 and maximum erosion was observed during 2001 - 2006 and erosion comparatively reduced during 2006-2011. However the net shoreline change rate for most of the coastal stretch in the area is found to be accretion.

Analysis was also performed using historical satellite images obtained from Google Earth. Google Earth images available for the periods of 26-Jan-2003, 19-Jun-2006, 25-Sep-2009, 19-Mar-2011 and 05-Apr-2011 which cover the stretch from river Karamana to Adimalathura have been analyzed. The following summarizes the analysis:

7.3.2.2.1 Kovalam Pocket Beaches

LTR concluded that no significant shoreline changes are observed in the pocket beaches at Kovalam. Vizhinjam fishing harbour is located on a coastal stretch which typically has cliffs fronted by narrow sandy beaches in pockets and coastal stretches protected by seawall. Each pocket beach can be considered as littoral cell and does not contribute any significant littoral sediment to the adjacent coast.

7.3.2.2.2 Muthalapozhy Fishing Harbour

The fishing harbour at Muthalapozhy shows accretion and erosion pattern due to the presence of its breakwaters. As the net littoral drift is towards 30 kms north of Vizhinjam, the south breakwater traps most of the sediments, which causes accretion. Sediments which bypass the south breakwater are responsible for the blockage at harbour entrance. The stretch towards the immediate north of the north breakwater is observed to be accreting. But further north it is eroding and hence it is protected by seawall.

7.3.2.2.3 Karamana River Coast

The coast south of river Karamana is protected by the seawall as there is erosion along the stretch. The severity of erosion is intense as most of the fishermen community live within 100m distance from the coast. As observed from the Google Earth images, the rate of accretion is low on the south of the coastal inlet of Karamana river, at the short groins. The accretion rate at the groins is found to be lesser than that observed at Muthalapozhy. It is also observed from the analysis of shoreline position in the vicinity of the river Karamana that the sand spit at the mouth of the river is shifting its location continuously.

7.3.2.2.4 Adimalathura Beach

As per the analysis carried out by LTR, Adimalathura beach is formed mainly during the fair weather and erodes during both the monsoons. The building up of the beach takes place during the post-monsoon period which is prevalent for a coastal stretch of approximately 3.5km.

7.3.2.2.5 Muttom Fishing Harbour

Muttom fishing harbour is the next major fishing harbour about 45km south of Vizhinjam. The coast north of Muttom consists of rocky outcrops and sandy pocket beaches, similar to the coast at Vizhinjam fishing harbour. The breakwaters were constructed after 2005 due to which no major change has been observed towards the north of the harbour, while there is very minor accretion towards the south of the harbour.

7.3.2.2.6 Overall conclusion of Satellite Image Study

The study has concluded that shoreline change along the coast is experiencing accretion to no change at places. The following conclusions were obtained:

- Shoreline change rate in the study area (total 30km) assessed for the different time-frames shown large variations in their rates of erosion and accretion.
- The shorelines experienced maximum accretion (as observed) during 1997 – 2001 and Maximum erosion was observed during 2001 - 2006 and erosion comparatively reduced during 2006-2011. However, the net shoreline change rate for most of the coastal stretch in the area is found to be accretion.
- The southern parts of the coasts were reported dominantly stable to accretion.
- The current study confirms the shore as no change category (±2 m/y)
- The net changes in the shoreline rate during 1992 - 2011 reveals dominantly stable to accreting tendency except few stretches around Puntura/Narakattara in the northern parts of the study area
- Similar results were observed from shoreline change assessment of Kerala coast, prepared by National Centre for Sustainable Coastal Management and Institute for Ocean Management.
- The sediments from south of the project site is trapped at Adimalathura due to the headland and towards the north, at Kovalam, the headlands prevent the transport of the sediments from the pocket beaches. Hence, it is anticipated that the construction of the proposed Port at Vizhinjam may not have major impact on the littoral movement towards the pocket beaches at Kovalam.

7.3.3 Assessment of Shoreline Evolution with Proposed Port Development

The shore line modeling study carried out by LTR examines the effect of proposed port development on the nearby beach sites. The following steps were followed:

- Assessment of shoreline evolution with and without proposed development
- Model inputs, setup, calibration and simulation
- Model results and assessment of shoreline evolution from model simulations

Following sections summarize the key findings of the shore line change study carried by LTR.

The flow field and associated current speed in the coastal process govern the movement of fluvial, littoral and suspended sediments. LTR has utilized TELEMAC-2D to setup and calibrate the hydrodynamic flow field with reasonable accuracy as explained earlier. LTR used TOMAWAC model for near shore wave transformation as explained earlier in Section 2.3.2. The information of flow and representative waves were used to derive the wave induced circulation pattern near the coast during the various wave events. The flow field from combination of these environmental inputs is used to drive the sediment transport model for different sediment types and the results were merged to obtain the annual sedimentation pattern and the requirement of maintenance dredging at the fishing harbour due to the construction of the proposed port.

SISYPHE was used for estimation of sediment transport rate, decomposed into bed load and suspended load. LTR considered the 15 deepwater wave events for the sediment transport model. The sediment transport simulations were done for these events separately for typical sand type. The results were then combined to obtain the annual sedimentation in the region by accounting for the probability of occurrence of each wave event. Model domain and bathymetry considered for the sediment transport model was same as that of hydrodynamic model as shown in Figure 7.7. The resulting sea evolution obtained from the sediment transport model is shown in Figure 7.11 and Figure 7.12 which depict the sedimentation pattern for existing and with proposed breakwater respectively.

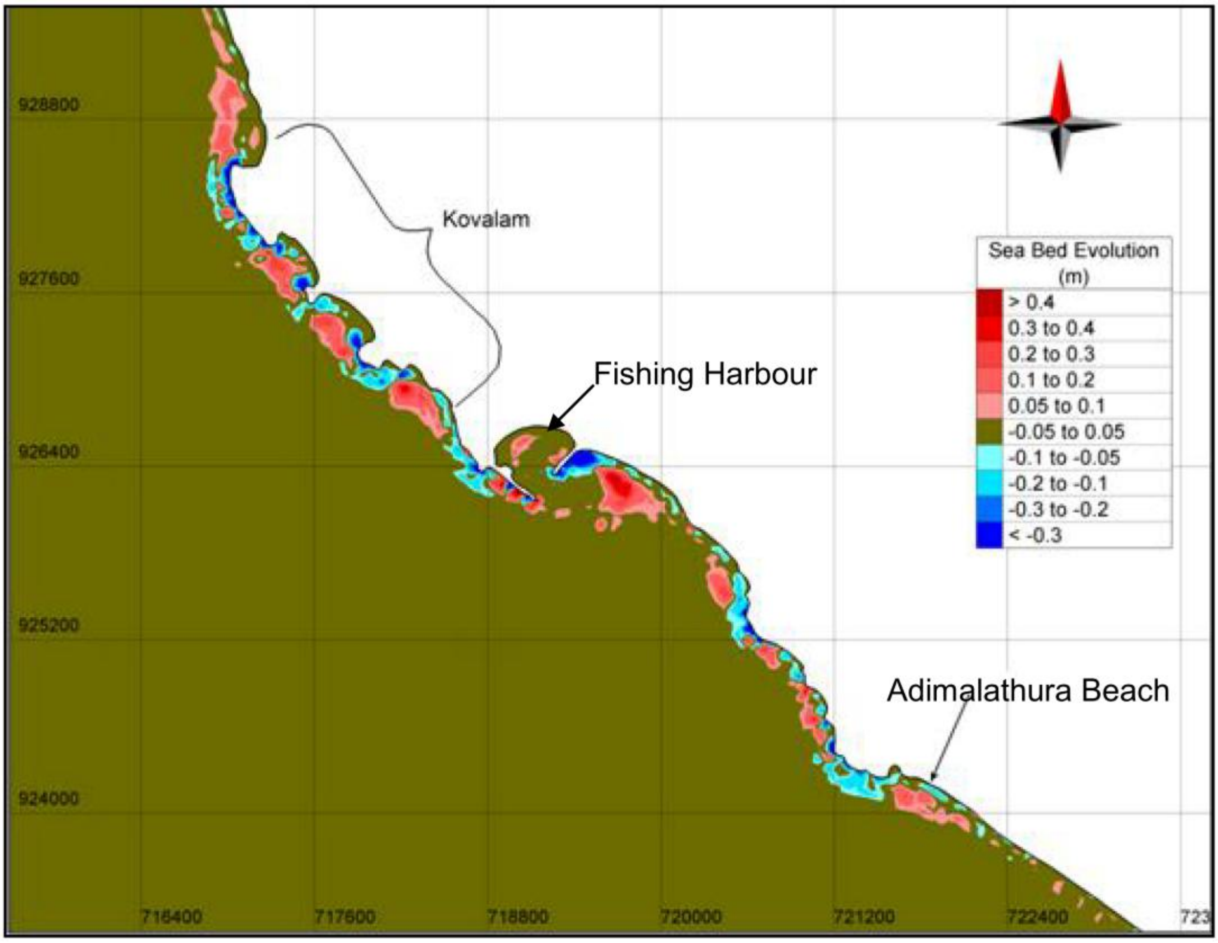


Figure 7.11 Annual Seabed Evolution for Existing Condition

[Source: Updated Mathematical Model Study by LTR, May 2013]

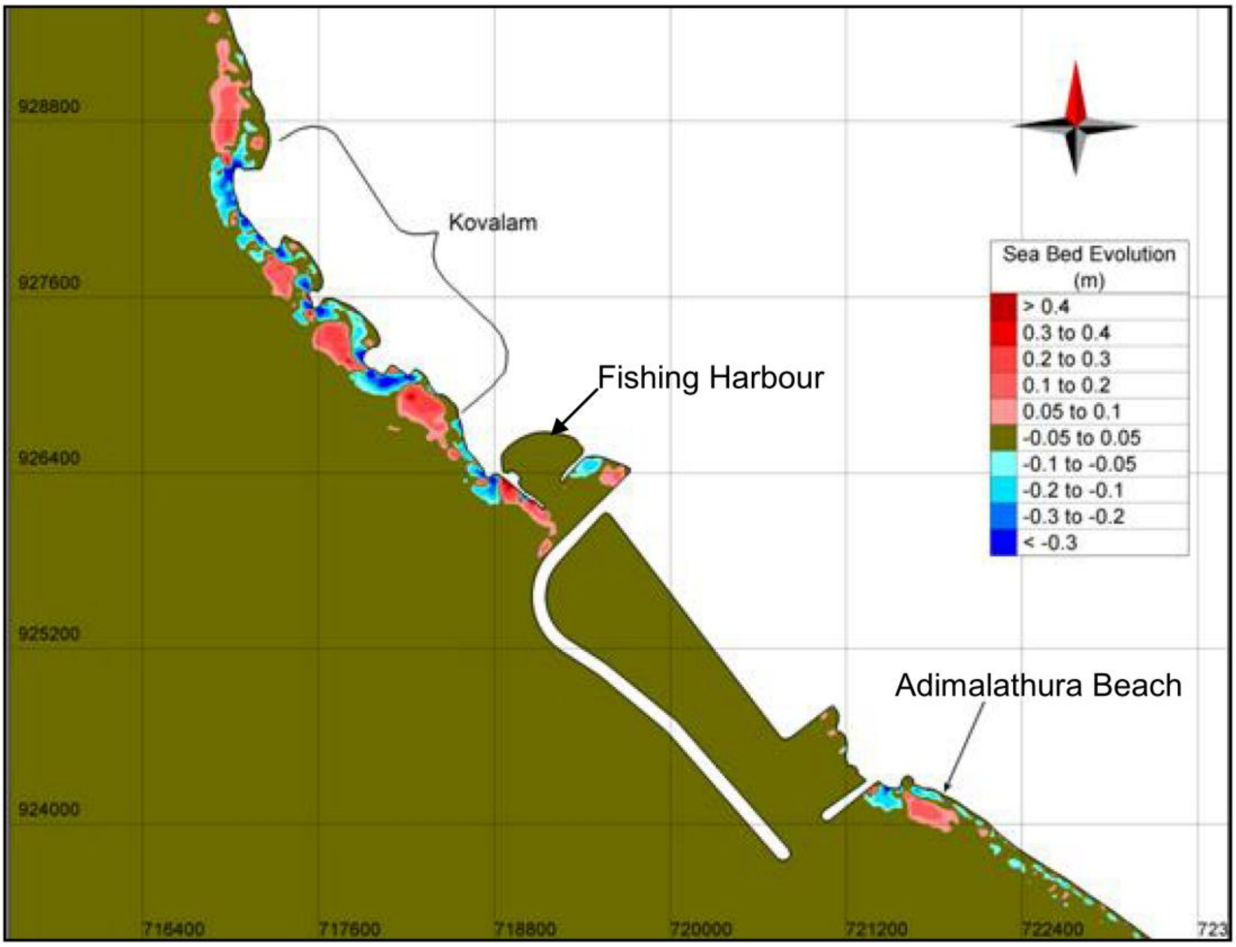


Figure 7.12 Annual Seabed Evolution with the Proposed Breakwater

[Source: Updated Mathematical Model Study by LTR, May 2013]

The following conclusions can be drawn from the sediment transport model study and seabed evolution pattern:

- The results show alternate accretion and erosion pattern along the coast. Portion in red shade shows accretion (positive seabed evolution) while blue shade shows erosion (negative seabed evolution)
- From the seabed evolution figures, it can be concluded that model study predicts reduction in sedimentation post construction of the breakwater.
- Annual sedimentation inside the fishing harbour is estimated to be very small. In the existing condition, sedimentation inside the fishing harbour was found to be 3800 m3/ year which is then reduced to 200 m3/ year after considering the effect of proposed port breakwater.
- Shoreline on either side of the study area shows no significant variations for both of the conditions.

7.3.3.1 Shoreline Change Assessment

LTR used GENESIS shore line change model to study the effect of proposed port's breakwater on the surrounding coastal areas. GENESIS is an elaborate one-dimensional numerical model, which simulates changes in shoreline position due to spatial and temporal gradients in longshore sediment transport.

7.3.3.2 Model Inputs used by LRT for Shoreline Modeling

- Bathymetry for the coastal stretch - Bathymetry for the study was prepared using NHO charts, NIOT and Fugro survey reports.
- Wave data - The wave data required for the study was extracted from SWAN model results at 60m contour depth. Then the extracted data was transferred to a depth of 25m near shore, using STWAVE model developed by USACE.
- Shoreline data - Initial shoreline position which is an essential input to simulate shoreline evolution was extracted from latest Google Earth Imagery for the project site.
- Sediment size - The D_{50} sediment grain size of 0.25mm was considered for the model study.

7.3.3.3 Shoreline Modeling Simulations

LTR carried out the simulation study for the 25km long shoreline stretch evenly distributed near the vicinity of the proposed port by considering all the existing coastal features (manmade and natural). The simulations were carried out for a period of ten years.

7.3.3.4 Results of Shoreline Modeling Study

- Results of the shoreline modeling study was then compared with the analyzed data from Google Earth imagery, and found to have similar trend.
- Significant shore line evolution was noticed at the two following locations
  - The north of Karamana River is eroding.
  - The beaches around Adimalathura are accreting.
- Based on the analysis of the results of existing condition, it was noticed that the average rate of accretion is 4.4m/year at Adimalathura, which is towards the south-east direction of the fishing harbour.
- In the north-west (north of Kovalam) of study area beyond the protected stretch, the rate of erosion was observed to be 1.4m/year. Apart from these two stretches the net shoreline evolution was insignificant. It was observed that the shoreline evolution along the coast is being influenced by the two monsoons which govern the direction of sediment transport and shoreline evolution rate. The coast is having the tendency to regain its beach during the non-monsoon season, even though it loses the beach during monsoon season. These results were verified with data from Google Earth.
- The year wise simulated shoreline evolution at south-east breakwater of proposed port over ten year is as per given in Table 7.3 and shown in Figure 7.13. The south breakwater of the proposed port is considered as" 0" chainage. The evolution is tabulated for a coastal stretch of 1.8km with 200m interval from the "0" chainage, further south-east. Accretion is taken as positive and erosion is taken as negative.
- The accretion at the south side of the proposed port is due to the presence of proposed port breakwater and revetments (south breakwater will no longer be needed as per the tranquility modeling study) and the rocky outcrops which block the sediment flow in the region. Thus because of south breakwater (no longer there) and revetments around the port, the further accretion inside proposed port is prevented. When comparing the results of existing scenario with the scenario incorporating the proposed port layout, no significant change in the shoreline pattern was observed towards north-west side (along Kovalam) of the fishing harbour and at Karamana river. The shoreline evolution to the north-east of the fishing harbour is not altered by the proposed port as the shoreline is either in the form of headlands or is protected by seawall.

Table 7.3 Predicted Shoreline Evolution Rates around Vizhinjam Port

Chainage in m(alongshore)	Shoreline evolution in m (cross shore direction)								
	0-200	200-400	400-600	600-800	800-1000	1000-1200	1200-1400	1400-1600	1600-1800
First year	20.9	7.3	0.1	-1.2	-0.1	0.4	0.5	0.4	0
Second year	23.1	9.9	2.3	1.8	2	1.8	1.1	0.2	-0.4
Third year	23.8	11.1	4.6	4.7	4.8	3.9	2.3	0.6	-0.3
Fourth	24.3	12.2	7	7.3	7.3	5.8	3.6	1.5	0.2
Fifth year	25.6	13.3	9.3	9.6	9.5	7.6	5.1	2.5	0.9
Sixth year	26.3	14.5	11.5	11.7	11.6	9.3	6.5	3.6	1.7
Seventh year	27.1	15.7	13.4	13.7	13.5	11	7.9	4.7	2.6
Eight year	28	16.9	15.3	15.6	15.3	12.5	9.2	5.8	3.5
Ninth year	29.5	18.2	17.1	17.3	17	14.1	10.6	6.9	4.4
Tenth year	30.4	19.3	18.7	19	18.6	15.5	11.9	8	5.4

[Source: Updated Mathematical Model Study by LTR, May 2013]

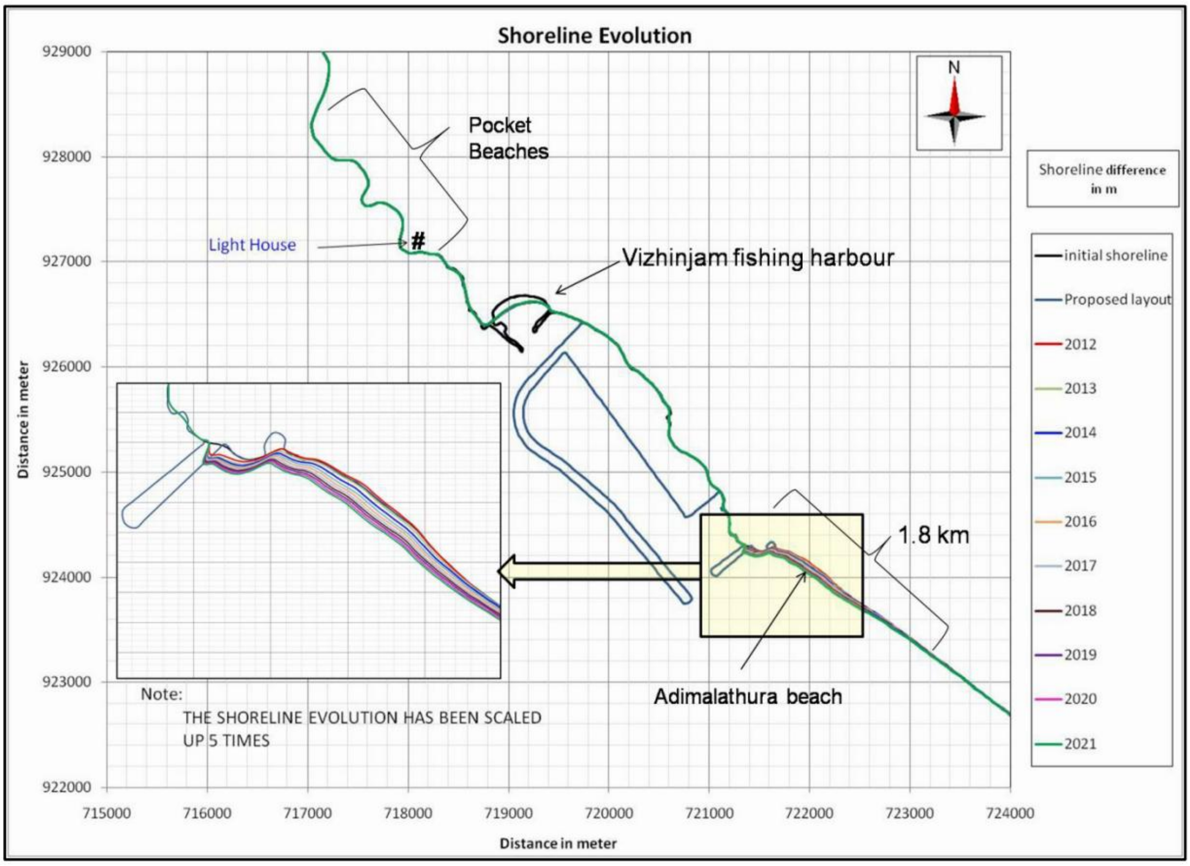


Figure 7.13 Predicted Shoreline Evolution around Vizhinjam Port

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.4 Offshore Dredge Disposal Site

7.3.4.1 Introduction

As per the preliminary dredging and reclamation quantity estimates for Phase-1 development, it is not expected to have a dredging-reclamation sand balance (i.e. sand required for reclamation purpose to be procured from dredging activity itself) and additional over-dredging will be needed for sourcing of reclamation material. In case disposal of unusable dredge material is needed, a dredge disposal site would be needed to dump the excess/unusable dredged material with least impact on the existing fishing harbour and environment. The following study examines the possible site selection for the dredge dumping location.

Particle Analysis (PA) module of MIKE was used by LTR to assess the fate of dredged material after disposal. The objectives of the study were:

- To assess the impact of dredging on fishing harbour.
- To identify a suitable offshore dumping location for dredged spoil disposal.
- To assess increase in sediment concentration and deposition pattern.

7.3.4.2 Criteria for Selection of Dredge Disposal Location

- Dumping ground should be located in sufficiently deep water, so that the sediment plume does not travel towards fishing harbour, recreational area, beaches, navigation channel and other environmentally sensitive areas (if any)
- The maximum distance of the dumping location should be such that the turnaround time to the disposal ground is minimal.
- Existing and proposed facilities close to the dumping grounds (if any) should not be affected by the proposed dumping.

7.3.4.3 Identification of Dredge Material Disposal Site

Based on the environmental conditions and criteria two dredge dumping locations were identified. Disposal site was located 3km from the shore line at water depth deeper than 30m with a spatial extend of 3km×1km. The distance between the dredging zone and disposal location ranged between 2.5km to 4km. Location of dumping ground site is shown below in Figure 7.14.

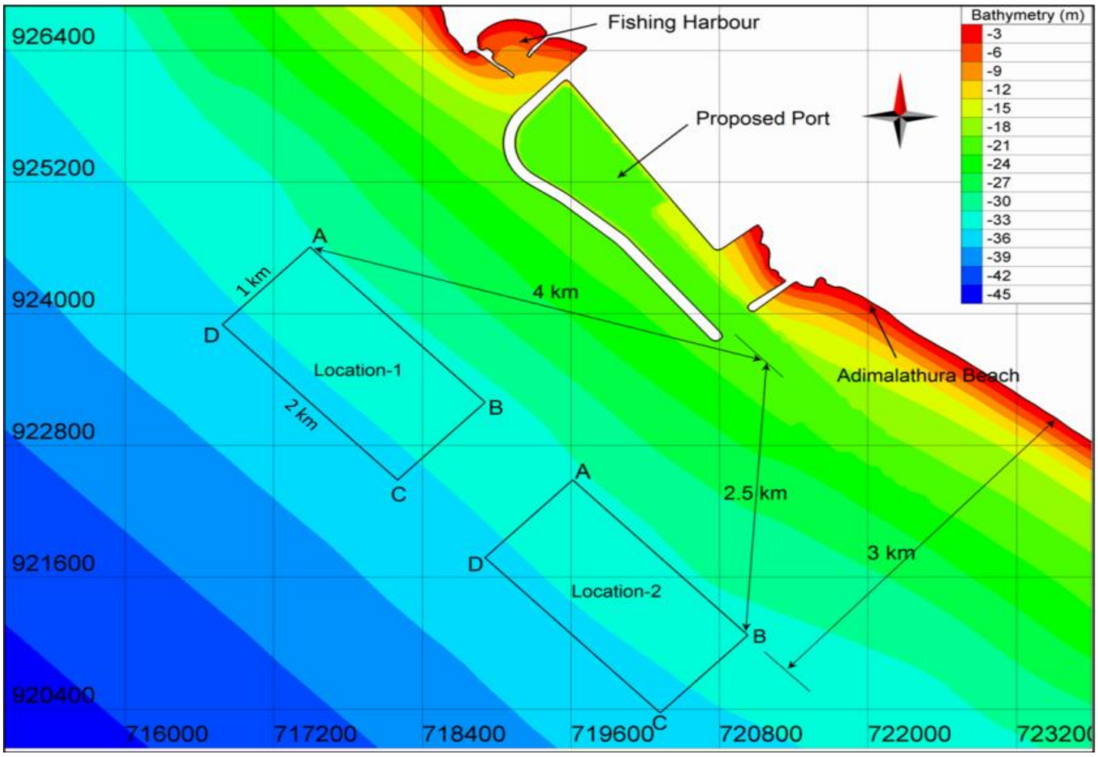


Figure 7.14 Proposed Dredge Disposal Site Locations

[Source: Updated Mathematical Model Study by LTR, May 2013]

Simulations were carried out for a period of 30 days. Results of the simulations are presented in Figure 7.15 to Figure 7.18 in the form of deposition pattern for the two environmental scenarios (i.e. SW monsoon and NE monsoon with non monsoon period) for the two locations.

Scenario 1: SW Monsoon

It was observed from the simulated results that during SW monsoon the dredge plume travel towards SE direction. The suspended particles traverse over a stretch of about 10km from the dumping location which is due to the presence of stronger currents in SW monsoon. The average deposition was observed to be less than 0.2m. Average concentration around the dumping ground was observed to be in the range of 0.2 to 0.3g/l for 22 days. On an average, it takes around two hours to reduce the concentration level to the back ground value.

Scenario 2: NE Monsoon with Non-monsoon period

The sediment plume travels towards NW direction for the simulations carried out for Non monsoon. The average thickness of deposition was observed to be in the range of 0.25-0.3m near the dumping grounds. The average concentration at dumping locations was observed to be less than 0.25g/l for a stretch of 3km from the dumping ground towards north. The concentration reaches to the background value within an hour. Due to presence of weak currents the sediments are settling near the dumping grounds without travelling to a larger extent and results in reduced concentration level within a short time.

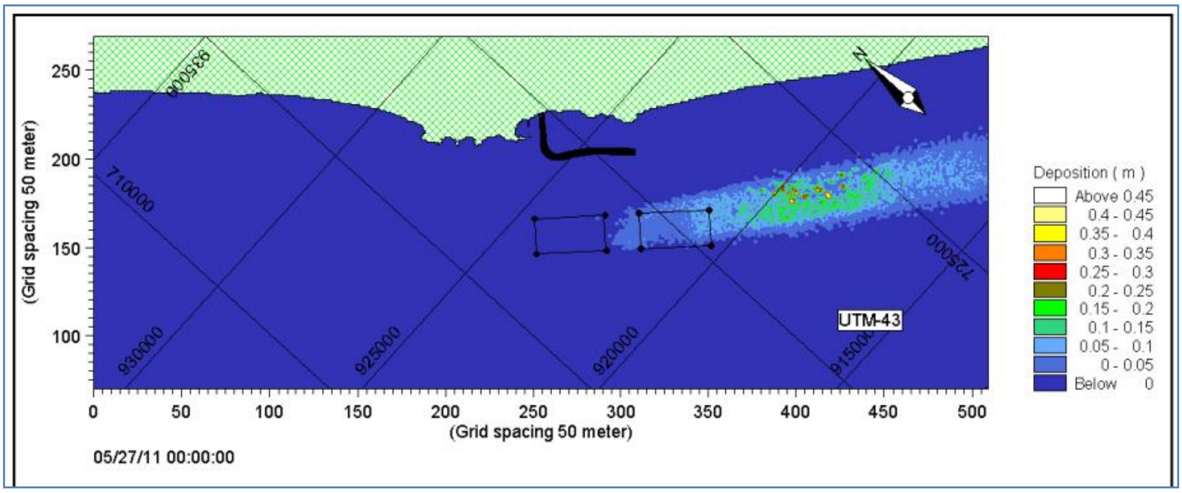


Figure 7.15 Deposition Pattern at Location-1 during SW Monsoon

[Source: Updated Mathematical Model Study by LTR, May 2013]

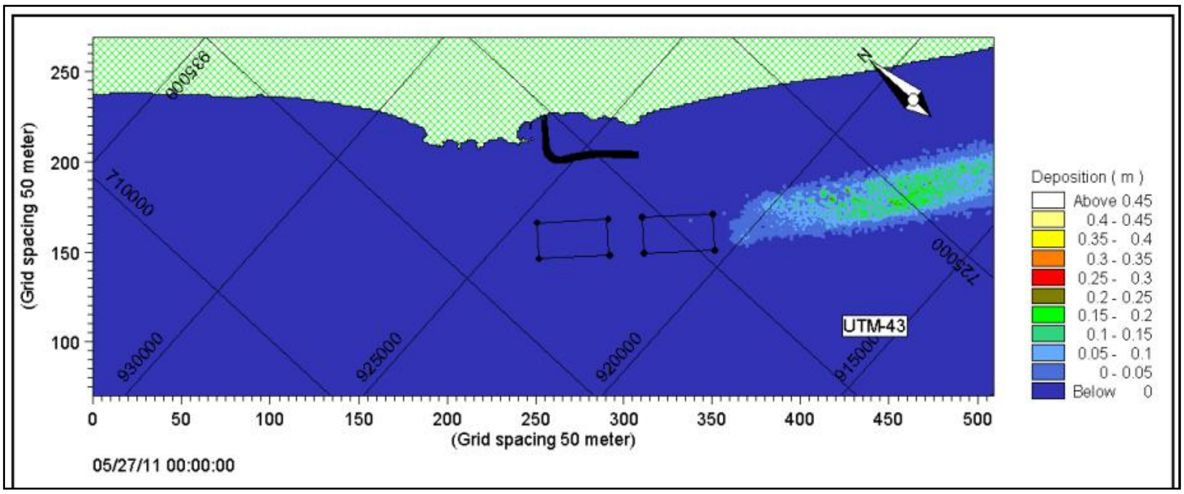


Figure 7.16 Deposition Pattern at Location-2 during SW Monsoon

[Source: Updated Mathematical Model Study by LTR, May 2013]

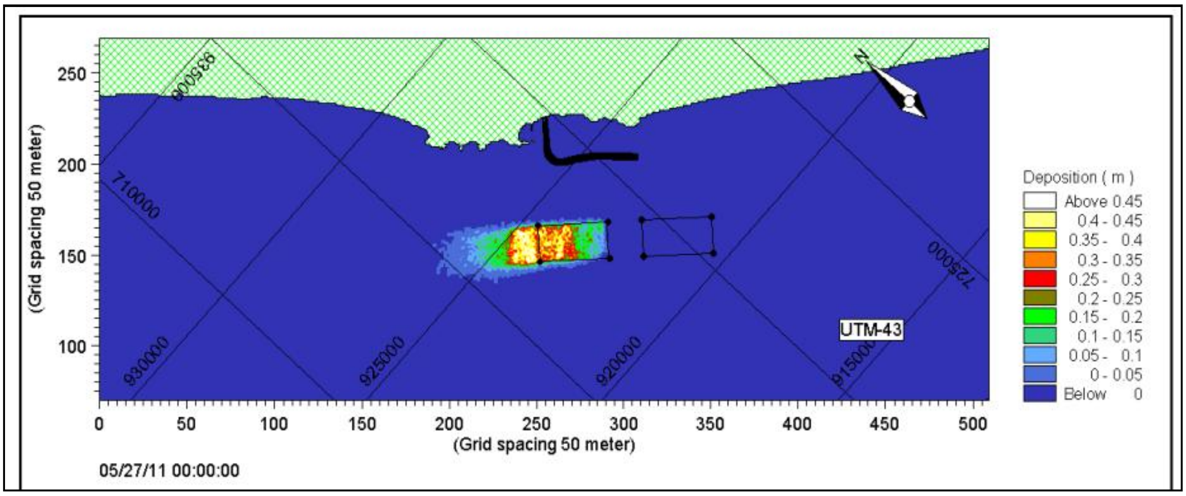


Figure 7.17 Deposition Pattern at Location-1 during NE Monsoon and Non Monsoon

[Source: Updated Mathematical Model Study by LTR, May 2013]

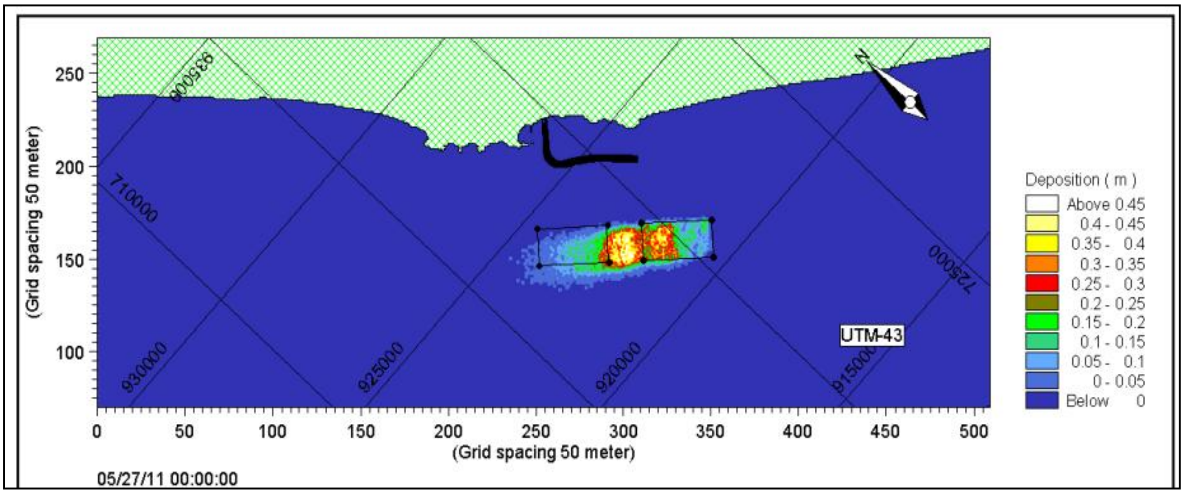


Figure 7.18 Deposition Pattern at Location-2 during NE Monsoon and Non Monsoon

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.4.4 Conclusion

The dredge spoil disposal study was carried out to assess the impact of dredge spoil dumping and to identify suitable locations. It was found that the sediment plume was confined to the deep water. From the simulated results, it is observed that there is no impact to the fishing harbour due to dumping operation. Considering the proximity to dredging area, dumping location-2 is recommended for dumping dredged spoils. It is recommended to schedule the maintenance dredging activity if any during the NE and non monsoon periods, considering stronger current prevailing during the SW monsoon.

7.3.5 Tranquility Study for Proposed Port

L&T-Ramboll Consulting Engineers Limited (LTR) have carried out model studies to assess the tranquility for the proposed port, to estimate the downtime for the proposed berths and to optimize the length of breakwaters required to achieve permissible wave heights as described by IS:4651 code.

7.3.5.1 Methodology used by LTR for tranquility studies

Input parameters for the port tranquility studies were model bathymetry, near shore wave climate, port layouts and limiting wave heights for estimation of the downtime (non operation days).

For bathymetric inputs surveys done by NIOT in 2003 and by FUGRO during March 2011 were used. For secondary inputs LRT used NHO chart no. 2012 and those from ETOPO1 global relief model of NOAA extracted for the project site.

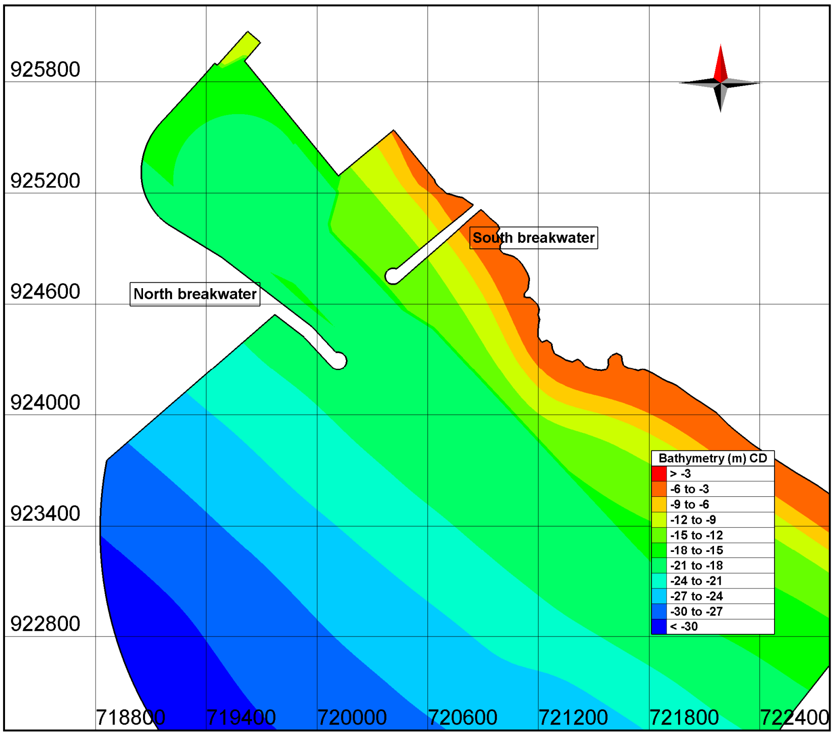


Figure 7.19 Bathymetry (m) for Phase-1 layout

[Source: Updated Mathematical Model Study by LTR, May 2013]

Nearshore wave data was extracted from the offshore wave data using SWAN modeling as described earlier. The limiting operational wave height considered for container vessels was 0.5m (Head or Stern) and 0.3m (quadrant 45 to 90 degrees) and for multi-purpose vessels was 1m (Head or Stern) and 0.8m (quadrant 45 to 90 degrees).

7.3.5.2 Wave tranquility model used by LTR

The study on wave tranquility for the proposed port was carried out using ARTEMIS model, which is part of the TELEMAC finite element hydraulic modeling systems. The model employs finite element technique to compute the wave heights throughout the area being modeled for each set of incident wave conditions. The model includes wave diffraction by surface piercing structures as well as due to features of the seabed, refraction and shoaling effect due to varying depths, and partial or complete reflection from the harbour boundaries. The energy dissipation process of wave breaking and seabed friction are also included in the model.

ARTEMIS model was set up to study the wave tranquility for the proposed port layout. Wave disturbance patterns inside the port were simulated for monochromatic waves approaching from predominant directions (S to W) for a series of wave periods ranging from 4 to 25 seconds with relative wave height of 1m given as boundary condition.

Two set of simulations were carried out by giving various reflection coefficients such as 0.40 (piled structure with rock slope) and 0.90 (vertical wall) for the berths. The reflection coefficient considered for breakwater is 0.40 (rubble mound) for all the simulations. The relative wave height distribution in the harbor obtained using modeling studies for piled structure with rock slope for the initial Phase-1 port layout is shown in Figure 7.20. The figure shows the distribution of wave heights inside the harbour for incident near shore wave height of 1m and time period of 8 seconds coming from south which is a dominant wave direction.

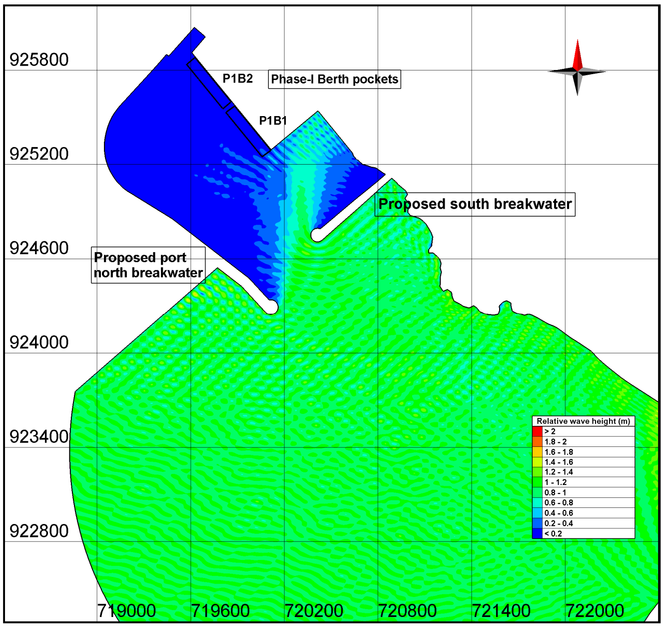


Figure 7.20 Relative wave heights (Inputs: H = 1m, Direction – S) for Initial Phase-1 Port Layout

[Source: Updated Mathematical Model Study by LTR, May 2013]

LTR concluded that harbor disturbance is mainly caused by waves coming from S and SSW west direction. Waves coming from SW, WSW and W are being blocked by port's northern breakwater.

The wave crest patterns for the most penetrative direction (waves at nearshore from South) for the layout is as shown in Figure 7.21. It was observed that, the wave angle with respect to the vessels berthed at berth pockets P1B1 & P1B2 will be less than 45°. Hence, the limiting wave height of 0.5m was considered for down time analysis for container berths.

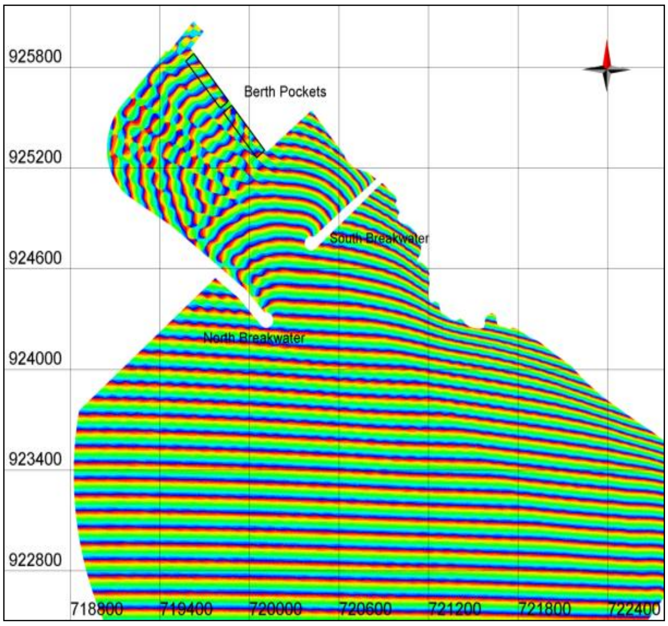


Figure 7.21 Wave phase plot for the initial Phase-1 Port Layout (Inputs: H = 1m, Direction - S)

[Source: Updated Mathematical Model Study by LTR, May 2013]

It was assessed that the Northern breakwater effectively protects the berthing pocket P1B1 and P1B2 from the wave attack and estimated downtime for both container berths is zero (i.e. berth will be operational throughout the year during normal wave conditions).

It was further observed that southern breakwater does not provide any additional tranquility and therefore it is not required. It was also seen from the results that there is a scope for reducing the length of the north breakwater. Therefore, LTR examined the layout by reducing the length of the northern breakwater by 100m.

The downtime was estimated for Layout shown in Figure 7.22 with northern breakwater length reduced by 100m and removal of southern breakwater from the model with rock slopes assumed for the berths. Two sets of simulations were carried out for the layout considering vertical wall and rock sloping berth configuration. Table 7.4 shows that the north breakwater provides full protection to the container berths. It can also be observed that other berths such as cruise berth on the lee side of the north breakwater will also be fully protected.

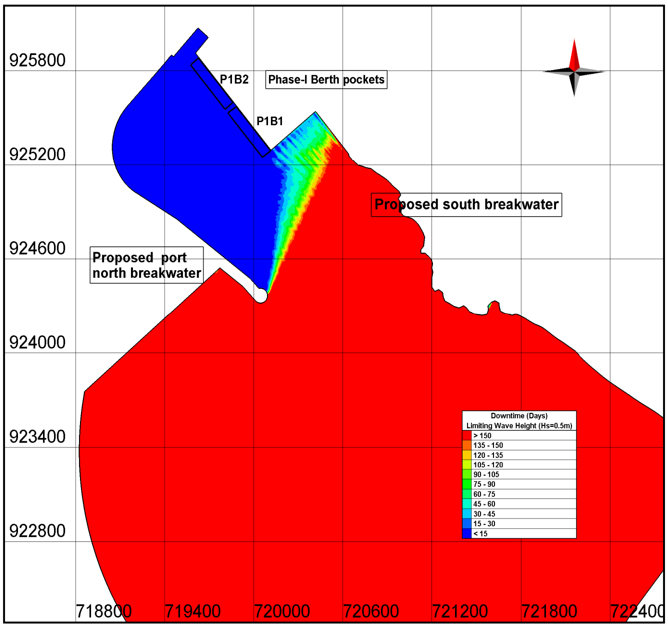


Figure 7.22 Downtime for Phase-1 Layout with north breakwater reduced by 100m

[Source: Updated Mathematical Model Study by LTR, May 2013]

Table 7.4 Annual Downtime (Days) for Updated Phase-1 Layout (Limiting Wave Height Hs=0.5m)

Phase-1	Type of structure considered	Downtime (Days) Limiting wave height (Hs=0.5m)	
		P1B1	P1B2
Layout (north breakwater reduced by 100m and without southern breakwater)	Berths (0.40 Cr) – rock slope Breakwater (0.40 Cr)- rubble mound Shoreline (0.10 Cr) and open sea (0.0 Cr)	<1	0
Layout (north breakwater reduced by 100m and without southern breakwater)	Berths (0.90 Cr) – vertical wall Breakwater (0.40 Cr)- rubble mound Shoreline (0.10 Cr) and open sea (0.0 Cr)	<1	0

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.5.3 Conclusions

LTR has concluded that even by reducing the length of the northern breakwater by 100m and completely eliminating the south breakwater, optimum tranquility within the port can be achieved. The downtime estimated for the both the berths (P1B1 & P1B2) was less than 1 day. It was further decided by VISL that with additional berths being considered such as navy berth on the lee side of the north breakwater, the full length (3,040m) of the north breakwater be kept and south breakwater be removed from the layout.

7.3.6 Tranquility Study for Proposed Fish Landing Centre

As a part of Corporate Social Responsibility, VISL is going to develop fish landing berths for fishing communities as part of the proposed port project. The potential locations considered for modeling studies were (i) along the existing fishing harbour breakwater and (ii) the sea side of the proposed north breakwater. Earlier studies were carried out to assess the impact of proposed port development on the existing fishing harbor in terms of operational downtime. As the proposed fish landing location is exposed to the sea waves, it needs to be protected by a breakwater. LTR has carried out wave tranquility study by considering different layouts of fish landing berths and breakwater alignment. The proposed locations of the fish landing berths are shown in Figure 7.23.

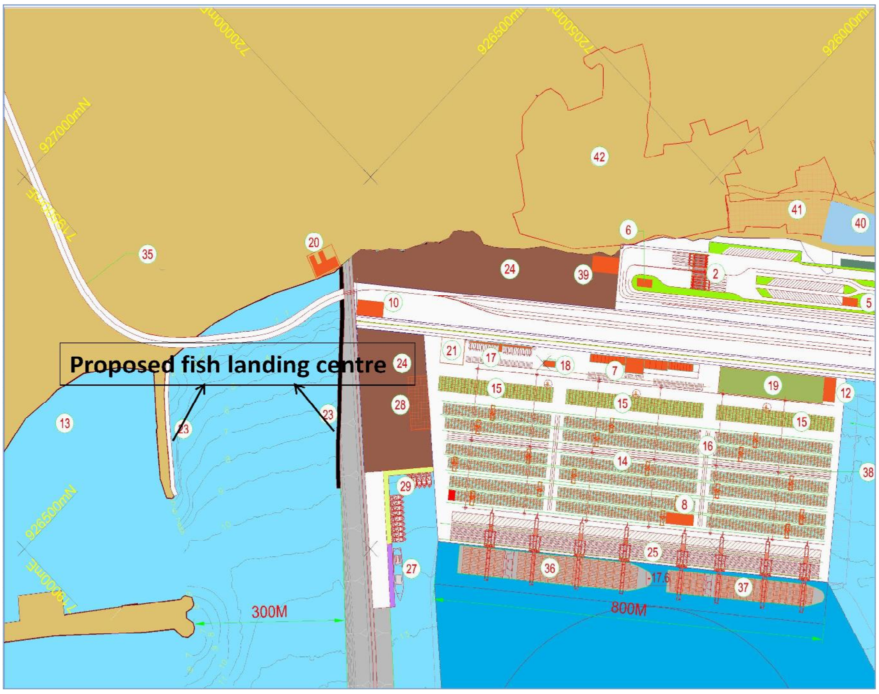


Figure 7.23 Proposed Fish Landing Center

The methodology used for wave tranquility analysis was similar to that used for the proposed port tranquility analysis. The model domain was set-up by identifying the area to be studied and mesh size to optimize the computation speed. Wave parameters were extracted along the open boundary of the domain (25m) from the SWAN model for all the waves occurring in the area. Simulation runs were carried out by providing reflection coefficients to the structures present in the domain of study. For the present study, runs were given for monochromatic waves of height 1m, for all predominant wave directions (S, SSW, SW, WSW and W) within the range of time periods 4 to 25s.The wave heights thus obtained were used to estimate the downtime with a limiting wave height of 0.5m and 0.9m as per IS:4651 code. Tranquility analysis was carried out for various breakwater configurations in order to achieve optimum tranquility for the proposed fish landing facility.

Out of the various configurations modeled by LTR, considering aspects such as navigation and constructability, the layout shown in Figure 7.24 was selected by VISL for further analysis. As shown in Figure 7.24, fish landing harbour breakwater is proposed in NW-SE direction and is almost perpendicular to the VISL's north breakwater. The proposed fishing berths are planned along the Vizhinjam port's north breakwater, starting from fishing harbor breakwater till the shore.

LTR carried out wave tranquility analysis using the proposed breakwater and berth alignment by considering limiting wave height of 0.5m and 0.9m. LTR did a sensitivity analysis by varying the length of the proposed fish landing harbour breakwater and provided recommendation on the optimum layout of the breakwater using downtime analysis.

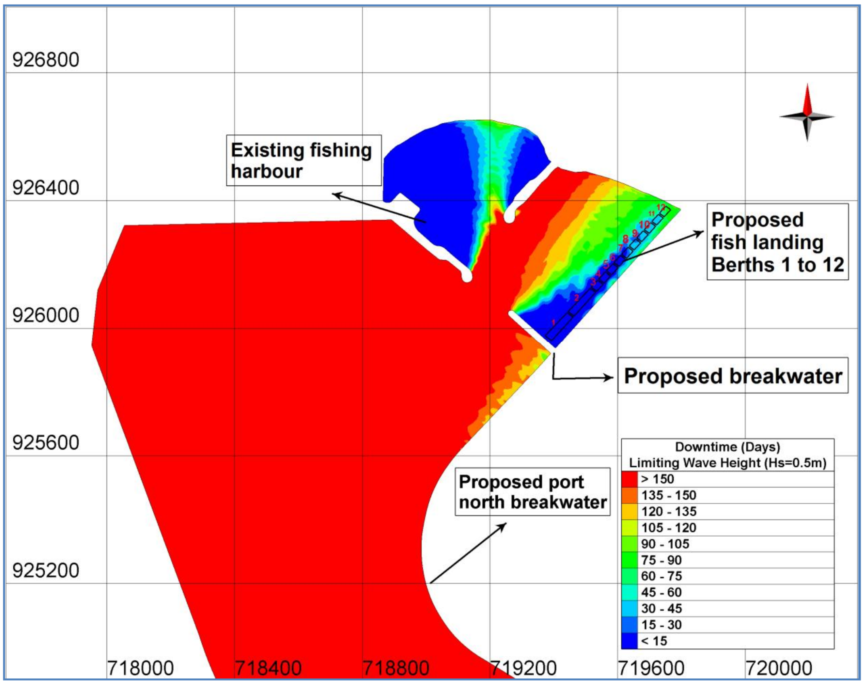


Figure 7.24 Layout of Fish Landing Harbour Breakwater Proposed by VISL

[Source: Updated Mathematical Model Study by LTR, May 2013]

From the downtime analysis as shown in Table 7.5, it can be observed that for the liming wave height of 0.9m, for berth B1 to B10 the operational downtime is less than 14 days. For berth B11 and B12, the operational downtime is estimated to be around 26 and 49 days respectively. It is thus concluded that as per the modeling studies, the proposed port layout that accounts for a 140m breakwater extension will provide adequate tranquility at the proposed fish landing berths.

Table 7.5 Downtime Analysis for Fish Landing Harbour Layout

Downtime Limiting Wave Height (m)	Berth Location and Downtime (Days)											
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
0.9m	0	0	<1	<1	<2	<2	<4	<7	<14	<14	26	49

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.7 Wave Disturbance Study inside the Existing Fishing Harbour

The proposed Vizhinjam port is adjacent to the existing Vizhinjam fishing harbour. The fishing harbour entrance and the north breakwater of the proposed port are separated by around 300m. The comparative study of the effect of the proposed port development on the wave climate inside the fishing harbour has also been carried out by LTR.

The wave disturbance study has been carried out using an ARTEMIS model which is a part of TELEMAC finite element hydraulic modeling system. This model considers the effects of diffraction due to the surface piercing structures like breakwaters as well as wave transformation due to the sea bed features like sea bed friction, refraction, shoaling, wave breaking and partial or complete reflections from the harbour boundaries.

The methodology used for wave tranquility analysis was similar to that used for the proposed port tranquility analysis. The model domain was set up by identifying the area to be studied and mesh size keeping in mind the need to optimize the computation speed. Wave parameters were extracted at the open boundary location (at 25m depth w.r.t. CD) from the SWAN model described earlier in Section 2.3.2.2.3. Simulation runs were performed by giving reflection coefficients to the structures present in the domain of study. For the study, runs were given for monochromatic waves of height 1m, from all prominent directions involved (S, SSW, SW, WSW and W) within the range of time periods 4 to 20s. The runs were performed for both existing condition and with the proposed layout.

For tranquility study two domains were chosen by LTR to compare the existing conditions and conditions inside the fishing harbour post construction of the North breakwater. Major near shore wave climate at 20m water contour is coming from 5 directions namely S, SSW, SW, WSW and W. The domains were chosen such that waves from S to W propagate to the harbour and the effect of the wave reflection from breakwaters of existing harbour and proposed port and other features (like rock cliff, artificial structures etc.) are simulated.

Relative wave height distributions were obtained as a result of the modeling for the five wave directions for both the existing port as well as with the proposed port development.

7.3.7.1 Comparative Study on Tranquility in the Existing Fishing Harbour

The diffraction coefficient obtained using the modeling results were then used for transforming each near shore wave event. The annual wave climate was created within and outside the fishing harbour for a comparative study. The results were then compared for the existing condition (without North Breakwater) and proposed conditions of post North breakwater construction.

Rays in the Figure 7.25 show the navigation path likely to be followed by the fishing vessels entering the harbour after construction of the proposed North breakwater. The annual wave climate was compared at the points shown in the figure. In addition to the points along the navigation path, two more points at the fishing boat berthing areas (point 4 and 5) were considered for annual wave climate.

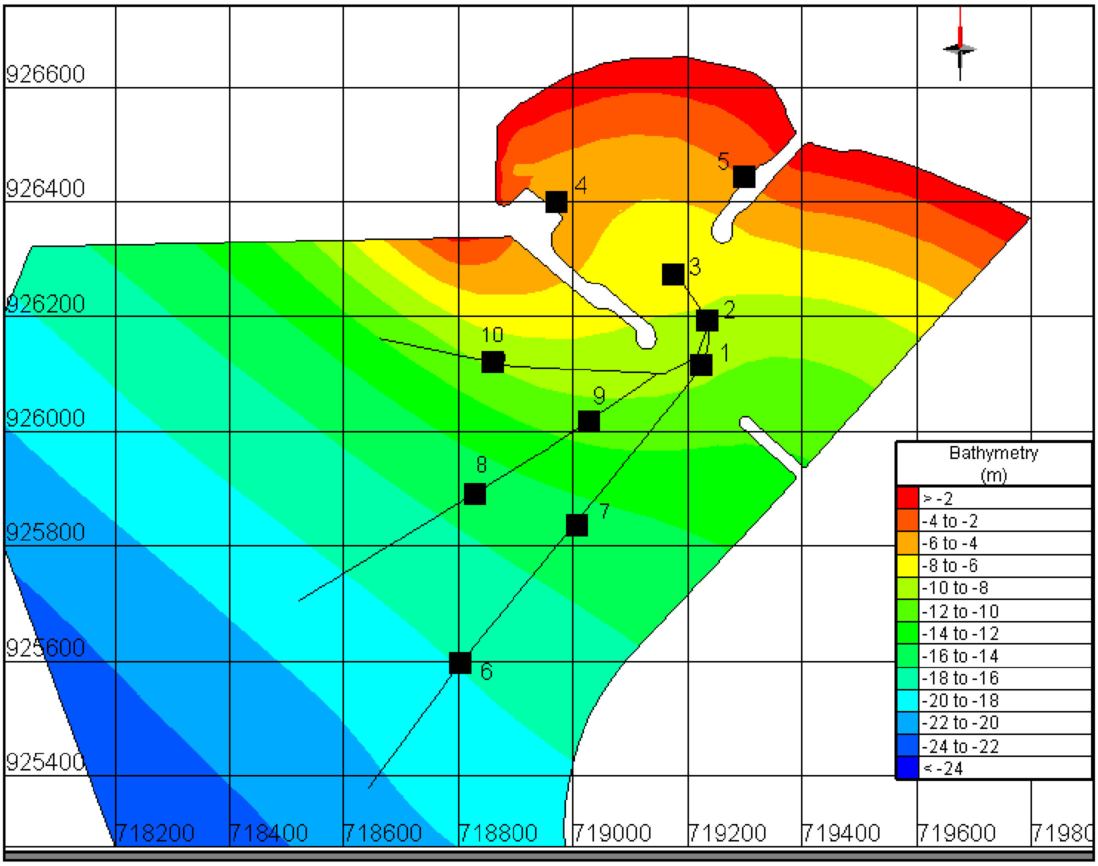


Figure 7.25 Navigation Path of Fishing Vessels and Points taken for Modeling Study

[Source: Updated Mathematical Model Study by LTR, May 2013]

Figure 7.26 shows the percentage of exceedance of wave height at points 1 to 5 for both conditions (i.e. existing condition shown in RED bar and post breakwater condition shown in GREEN bar. X axis represents the values of significant wave heights. From Figure 7.26, it can be concluded that the percentage of exceedance will not change much due to the construction of the proposed port breakwater. Lower values of the GREEN bars represent fewer waves will exceed that particular significant wave height (Hs) compared to the existing conditions. The proposed port breakwater will slightly improve the tranquil conditions at the fishing berths as well as just outside the entrance of the harbour.

Figure 7.27 shows the percentage of exceedance of wave height at points 6 to 10. From the figure it can be concluded that for the points 6 to 10, there is a very slight decrease in the tranquility conditions outside of the harbour possibly due to wave reflection off the proposed breakwater.

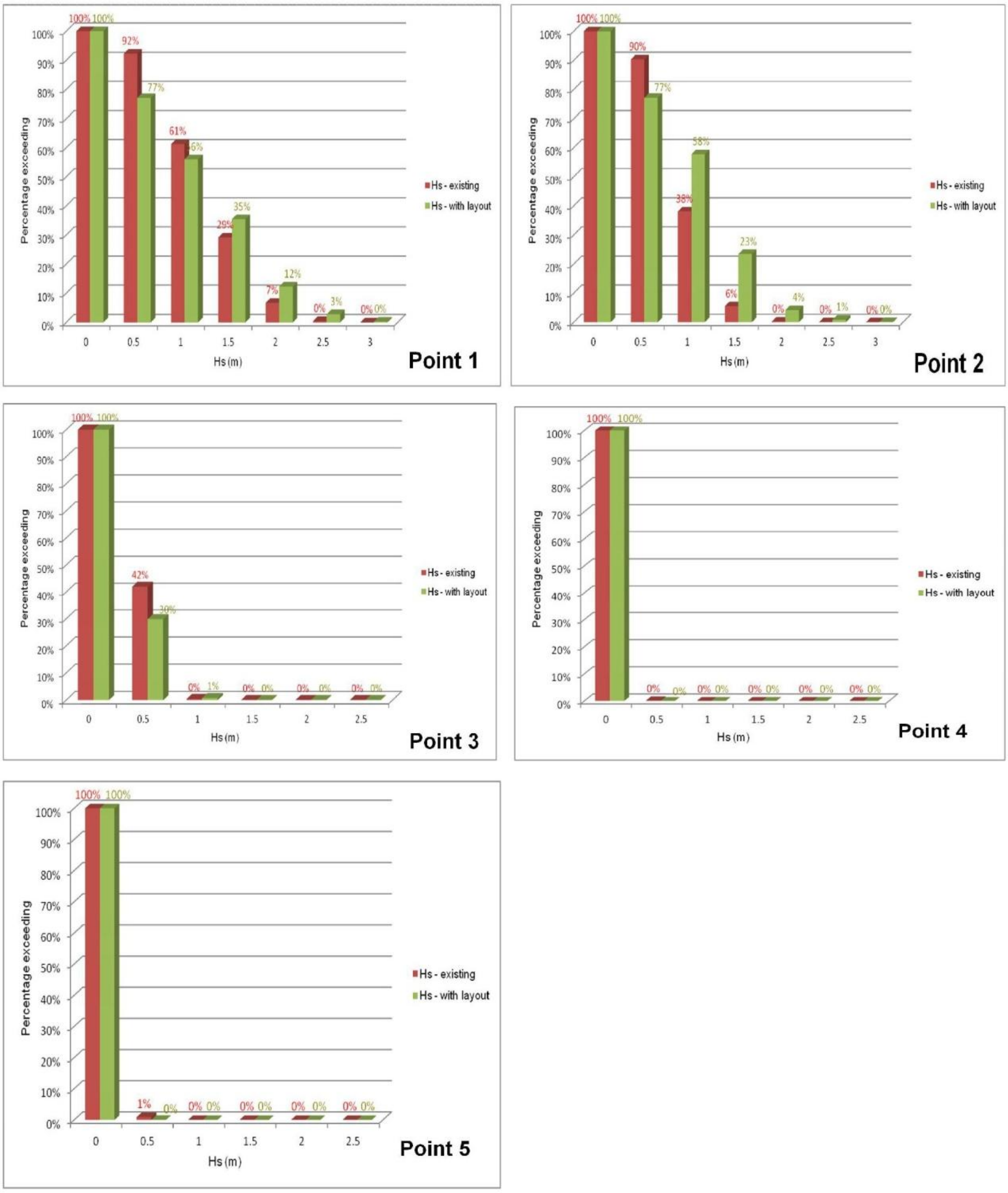


Figure 7.26 Percentage of Exceedance of Hs for Points 1 to 5 with and without North Breakwater

[Source: Updated Mathematical Model Study by LTR, May 2013]

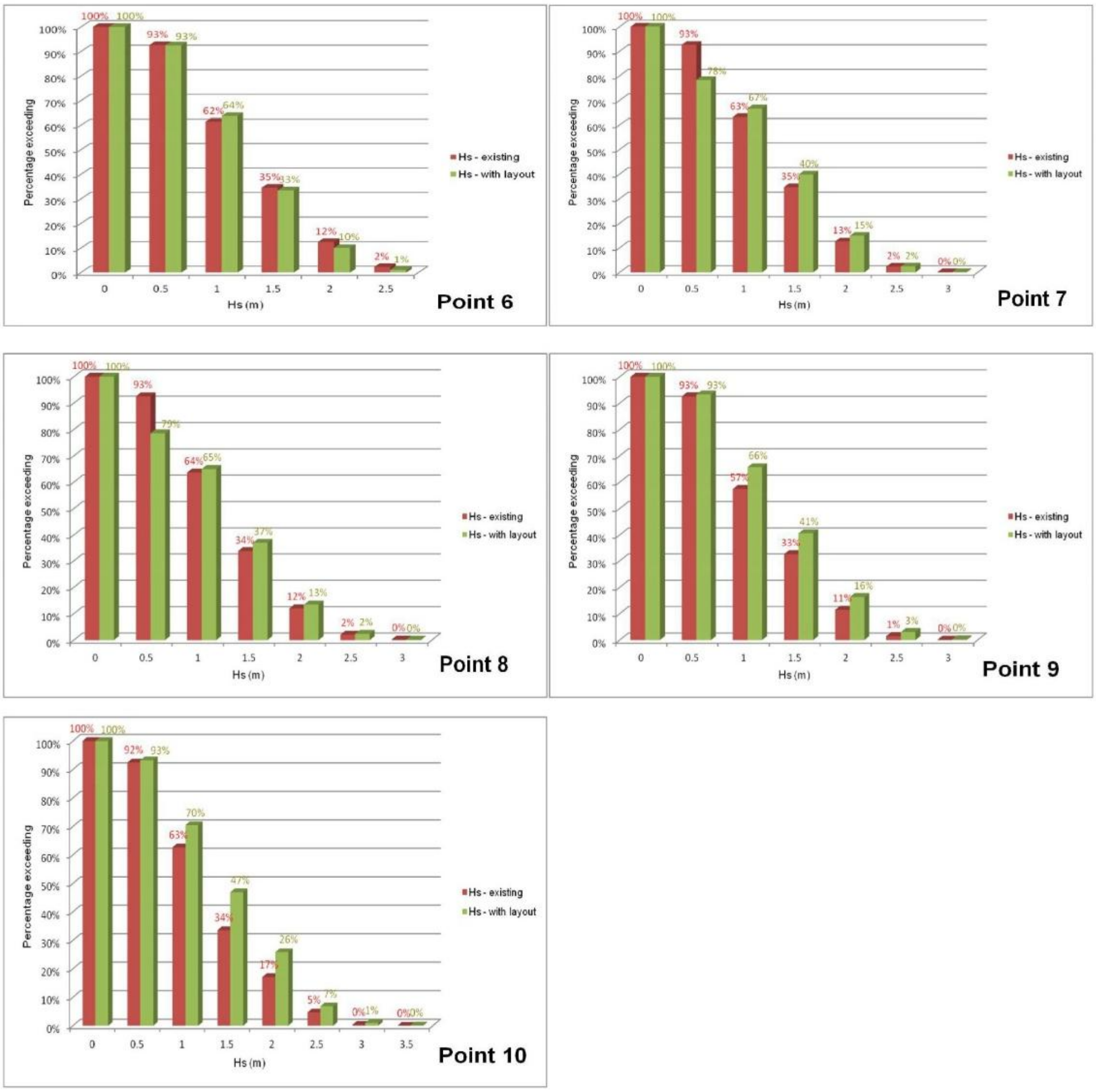


Figure 7.27 Percentage of Exceedance of Hs for Points 6 to 10, With and without North Breakwater

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.7.2 Estimation of Downtime in the Existing Fishing Harbour

The annual downtime for the fishing harbour (for both existing and with the proposed breakwater layout condition) was estimated based on the limiting wave height of 0.9m (IS: 4651 stipulates the wave height of 0.5m-0.9m as the limiting wave condition for trawlers and fishing boats). The downtime estimations were done using the annual wave climate conditions obtained using the above wave modeling study. Figure 7.28 shows the location of the existing fishing wharfs (W1 and W2) with the annual estimated downtime for existing and the proposed breakwater layout conditions. It is concluded from the analysis that the downtime for the wharf 1 and 2 has been reduced by almost 40 and 34 days respectively with the proposed breakwater layout. Due to the proposed the breakwater, the fishing harbour operating window will be increased because of additional tranquil conditions provided by the proposed breakwater layout.

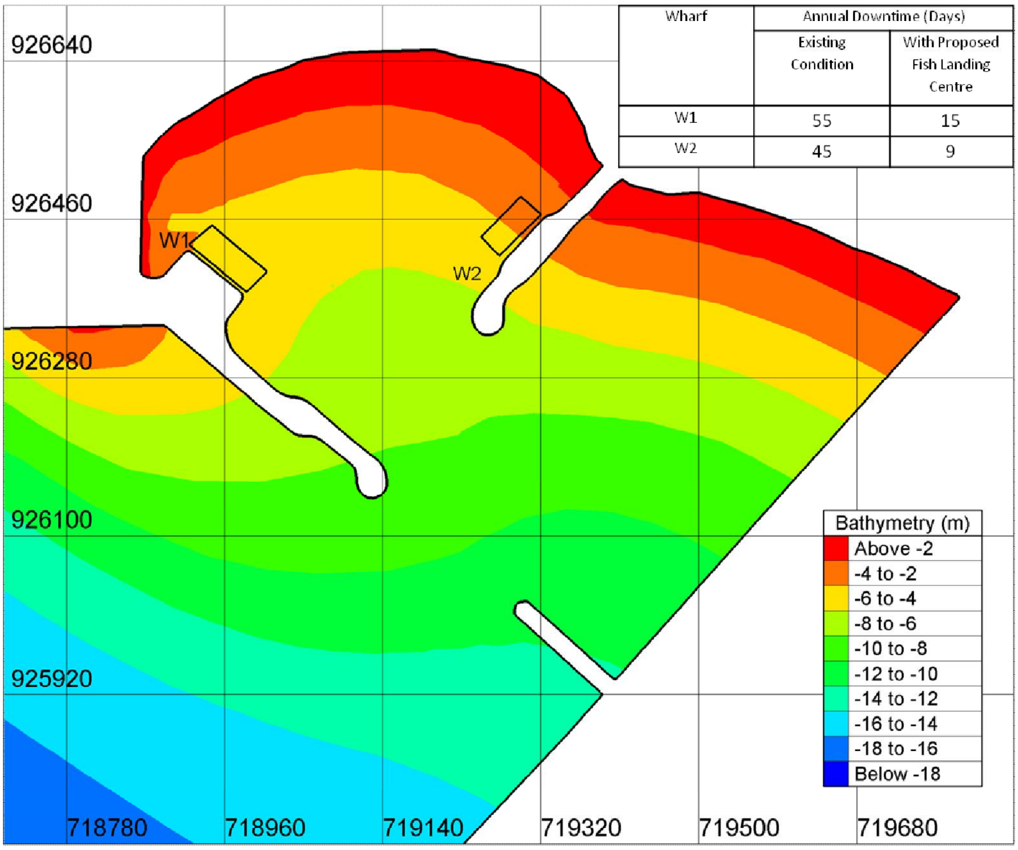


Figure 7.28 Annual Operational Downtime of Fishing Harbour for Limiting Wave Height

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.8 Design of Wave Heights and Water Level

LTR has also carried out design studies to estimate design water level by considering tides, storm surge, waves, sea level rise due to global warming, assessment of design wave heights for breakwaters, berths and revetments. The following section summarizes the results and conclusions of the report.

7.3.8.1 Estimation of Design water level

The design water level for the breakwater has been arrived at by estimating the highest astronomical tide (HAT), storm surge, sea level rise, and wind and wave setup for the project location

7.3.8.2 Estimation of Highest Astronomical Tide (HAT)

The measured tide data by NIOT has been used for this study. Tidal analysis of heights was further performed and the astronomical constituents were derived using MIKE21 software. Tidal prediction was performed with the derived astronomical constituents. The highest astronomical tide (HAT) was then estimated using the long term tide predicted for the project site.

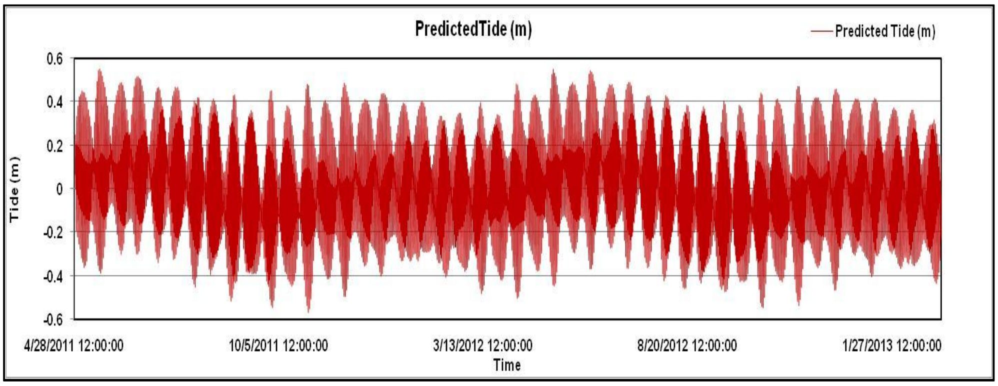


Figure 7.29 Predicted tide (m) – NIOT data

Figure 7.29 shows the predicted tide for the period 03rd November 2012 to 17th March 2013. The tide near the project area is found to be mixed, predominantly semi-diurnal in nature. Nineteen years of tide was predicted using harmonic analysis with MIKE21 and from the predicted data the highest astronomical tide was estimated as 1.20m with respect to CD.

7.3.8.3 Sea level rise due to global warming

LTR has referred to various data and reports available on sea level rise happening due to global warming. Estimates for the 20th century showed that global sea level rose at a rate of about 1.7 - 3 mm/yr. The available satellite observation data taken from 1970's onwards shows that the sea level is rising at a rate of 3mm/yr and has been further confirmed using coastal tide gauge measurements. It has been projected that the global sea level rise during 21st century will be at a greater rate than that during 1961 to 2003. Moreover, IPCC Special Report on Emission Scenarios (2012) projected that by mid 2090's the rise in global sea level will be about 4 mm/yr.

LTR has also analyzed the long-term monthly mean sea level measurements available from the year 1940 by PSMSL (Permanent Service for Mean Sea Level) for Kochi which is about 200km from Vizhinjam project location. LTR observed that the average mean sea level rise was 1.7mm/yr and the same can also be true for the project location. However, for this study LTR has recommended sea level rise rate of 4mm/yr projected for 21st century by IPCC, so the projected sea level rise for the project location after 50,100 and 200 years will be 0.2, 0.4 and 0.8m approximately.

7.3.8.4 Storm Surge

LTR has carried out simulations for the cyclones that have passed near the project location. Historical data of previous cyclone was analyzed by LTR. The wind and pressure fields for the respective cyclones were generated and applied for the study. Only four cyclones have passed in the vicinity of the project site (November-1992 and 1993, December- 1987 and 2005). Based on this historical data LTR concluded that project location is less prone to cyclones. Simulations were carried out for all the four cyclones that passed in the vicinity of the project location to find the maximum level of storm surge that can be experienced. The maximum water level that can occur at the site due to various cyclones is given in Table 7.6 and the typical result is shown in Figure 7.30. It would therefore serve as a worst case scenario. Based on the simulation results, maximum storm surge water level that can occur near the project site was estimated as 0.11m.

Table 7.6 Maximum Water Level due to Storm Surge

Month	Year	Maximum water level variation (m)
December	1987	0.06
November	1992	0.01
November	1993	0.05
December	2005	0.11

[Source: Updated Mathematical Model Study by LTR, May 2013]

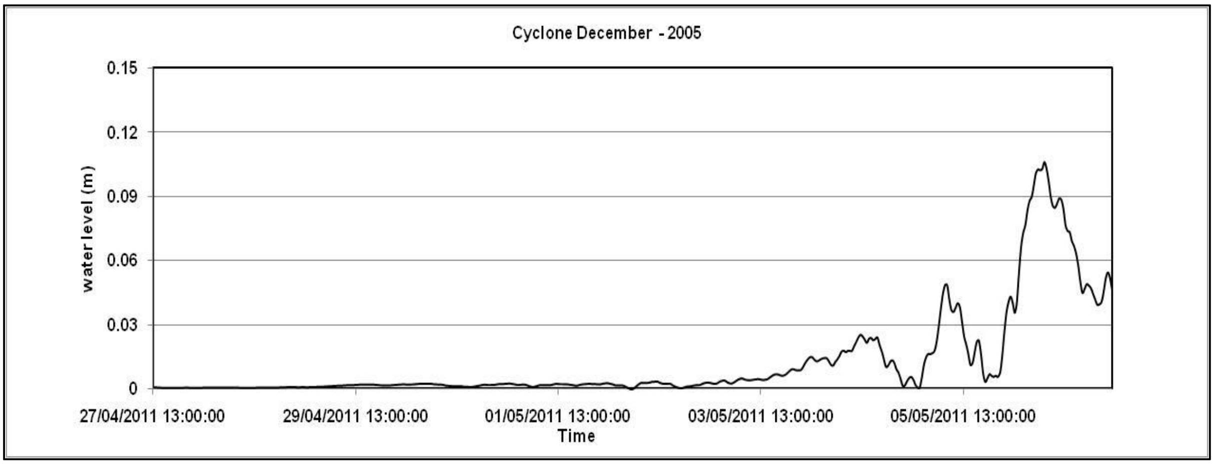


Figure 7.30 Surge Level During Cyclone Dec-2005

[Source: Updated Mathematical Model Study by LTR, May 2013]

In order to estimate the extreme water level due to wind setup, wind speed for 200 year return period was estimated by LTR for each direction using BMT Argoss offshore data. Simulations were then carried out for each of the predominant direction and the results were extracted near the project site. Maximum water level that can occur near the site was found to be 0.3m for the winds from SW and is shown in Figure 7.31.

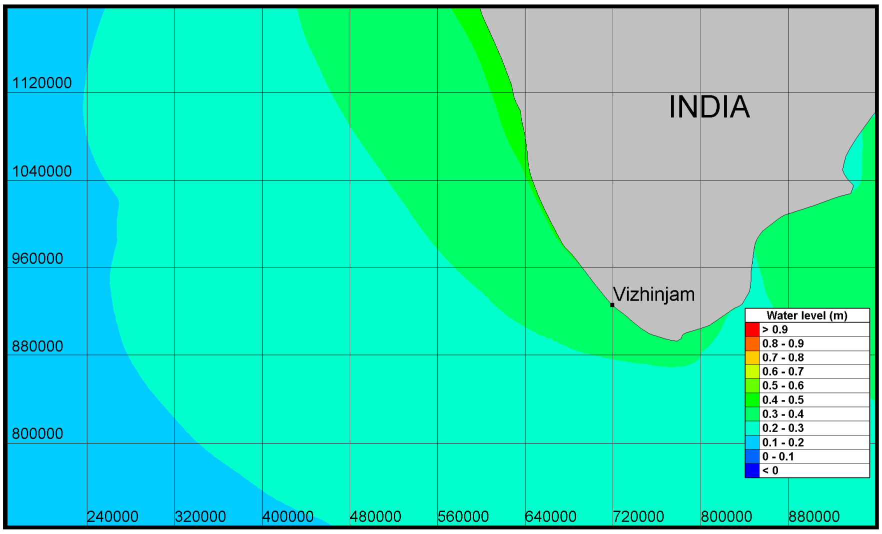


Figure 7.31 Water Level Rise due to Wind Speeds from SW for 200 Year Return Period

[Source: Updated Mathematical Model Study by LTR, May 2013]

LTR concluded that the increase in water level due to storm surge is less compared to wind set up estimated for the 200 year return period. The water level rise that can occur due to extreme wind conditions near the project site is estimated to be 0.3m and hence the same has been recommended by LTR.

7.3.8.5 Wave Setup

The mean water level in the shallow water rises due to the action of waves. This type of increase in water level is generally known as wave setup. The extreme value analysis has been done by LTR for offshore BMT wave data and the waves of 200 year return period were estimated. Waves from NW to S direction were found to be impacting the project site. Simulations were then carried out using TOMAWAC software for transforming extreme waves from these 7 directions to nearshore and estimate the rise in water surface. The results from these simulations were used in the MIKE-HD model to arrive at corresponding wave setup estimates.

Wave set up near the project site due to waves from different directions was compared. Maximum increase in surface elevation was observed for waves coming from West direction. The maximum wave setup obtained is shown in Figure 7.32.

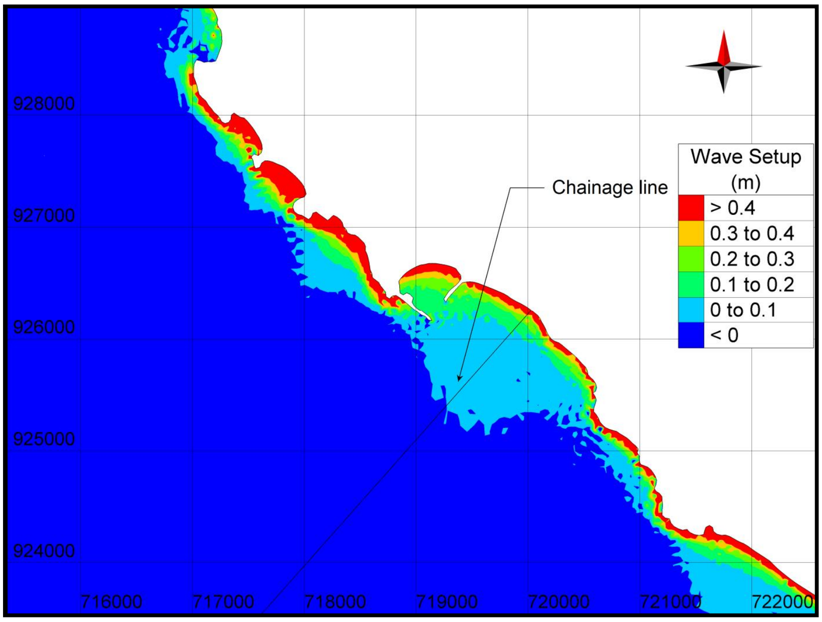


Figure 7.32 Maximum Estimated Wave Setup at Vizhinjam

[Source: Updated Mathematical Model Study by LTR, May 2013]

The wave setup is negligible beyond 16m water depth whereas it increases gradually and can reach a maximum of 0.5m at nearshore. The increase in wave height at nearshore may be caused due to the wave breaking phenomena. Variation of wave setup along the chainage line (chainage along north breakwater) shown in Figure 7.32 is shown in Figure 7.33.

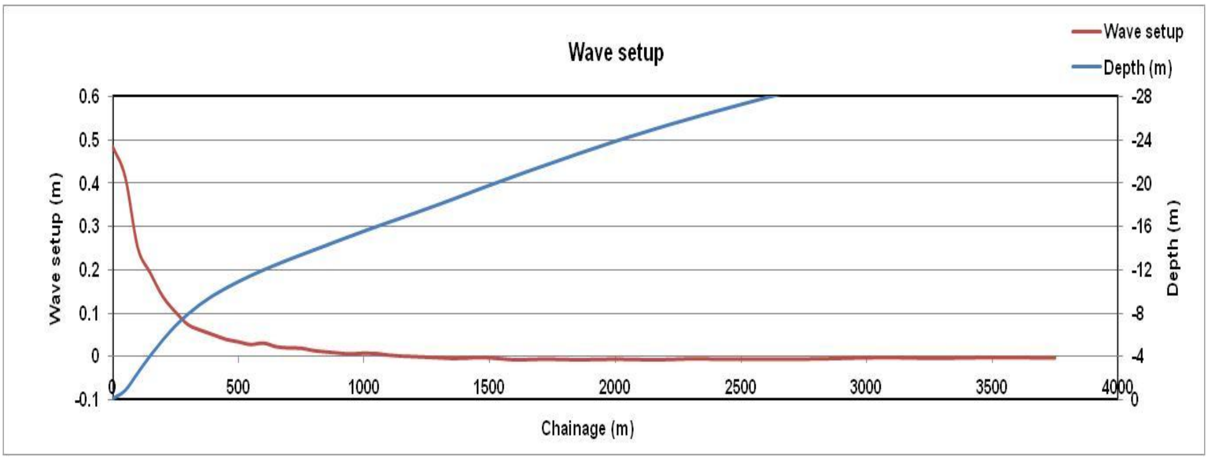


Figure 7.33 Water Surface Profile with Respect to Chainage (m)

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.8.6 Design water level - results

The estimation of the design water levels have been carried out considering effects of tide, storm surge and sea level rise due to global warming. The design water level for 5, 10, 50,100 and 200 years are provided in the Table 7.7. The design water level during construction phase would be 1.52m and 1.54m for 5 and 10 years period respectively and the projected design water level for 50,100 and 200 years would 1.70, 1.90 and 2.30m.

Table 7.7 Design Water Level for Various Return Periods

Name	Period (years)				
	5	10	50	100	200
Highest Astronomical Tide (HAT) in (m)	1.20	1.20	1.20	1.20	1.20
Sea level rise due to global warming in (m)	0.02	0.04	0.2	0.4	0.8
Wind setup and Storm Surge	0.3	0.3	0.3	0.3	0.3
Cumulative in (m)	**1.52**	**1.54**	**1.70**	**1.90**	**2.30**

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.8.7 Design wave heights for breakwaters

Based on the estimation of design water level, LTR has carried out nearshore wave modeling to arrive at the design wave heights which have been considered for the preliminary design of breakwaters.

Design wave heights at different depth interval were extracted from nearshore wave data along the breakwater and were used in preliminary design of breakwater. Inputs taken from the LTR nearshore wave modeling studies have been summarized in Table 7.8.

Table 7.8 Design Waves for various Return Periods without Fish Landing Breakwater Extension

Water Depth Contour w.r.t. CD(m)	Significant Wave Height (Hs) 50 Year period (m)	Significant Wave Height (Hs) 100 Year period (m)	Significant Wave Height (Hs) 200 Year period (m)
(m)	(m)	(m)	(m)
-3	2.4	2.6	2.7
-8	2.9	3.0	3.3
-11	3.2	3.5	3.7
-14	3.7	4.0	4.2
-18	4.1	4.4	4.6
-20	4.2	4.5	4.7

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.8.8 Effect of Fish landing breakwater on Leeward side of North breakwater

The design wave heights provided in the previous section were arrived at without considering the protection offered by the presence of the breakwater extension which has been proposed for the new fish landing berths. This projection will act as a protection for leeward side of the breakwater (i.e. North breakwater in shadow region of the projection). Due to this the, wave climate experienced by the leeward side of the breakwater will be less harsh and this will result in lesser design wave height for the breakwater. LTR carried out modeling studies to assess the impact of the projection on the wave climate which will be experienced on the leeward side leading to reduction in design wave heights.

It is observed that there is an increase in significant wave height in shallow water region due to the projection. LTR concluded that this may be due to the reflection. In the shadow region on the projection, reduction in significant wave height can be observed. However, for the design purposes, it is assumed that the design of the whole breakwater behind the extension be carried out with the wave heights predicted for the shallow region. Design wave heights for north breakwater adopted for design are given below in Table 7.9.

Table 7.9 Design Waves for Various Return Periods With Fish Landing Breakwater Extension

Water Depth Contour w.r.t. CD	Significant Wave Height (Hs) 50 Year period	Significant Wave Height (Hs) 100 Year period	Significant Wave Height (Hs) 200 Year period
(m)	(m)	(m)	(m)
-3	2.5	2.6	2.7
-8	2.5	2.6	2.7
-11	2.5	2.6	2.7
-14	3.7	4.0	4.2
-18	4.1	4.4	4.6
-20	4.2	4.5	4.7

[Source: Updated Mathematical Model Study by LTR, May 2013]

7.3.8.9 Design Wave Height During Construction Phase

Without the breakwater protection, the berths if constructed would be exposed to the direct impact of the wave climate. To estimate the worst possible wave height that the berthing structure may experience while under construction, LTR assumed that breakwater will not be complete. Normal practice is to adopt 1 in 5 or 1 in 10 year waves as design waves under these circumstances.

SWAN nearshore wave modeling studies were done by LTR to estimate the wave heights at the berth corresponding to 5 and 10 year return period. Offshore wind speed and wave data from BMT Argoss was utilized as input boundary condition. It has been estimated that if the construction of berths is carried out without the protection of the breakwater, the berths can be expected to experience wave heights of upto 3.4m and 3.6m for 5 and 10 year return period respectively.

7.3.8.10 Design Wave Height after Construction

The extreme wave heights at the berths and revetments after the construction of the breakwaters have also been estimated by LTR. The model ARTEMIS of Telemac-2D was used for this study. The model was simulated by providing the maximum wave height that can occur from each of the predominant wave direction. The return period of 50 years was considered for the Phase-1 development where as 200 years was used for the Master plan development. It is to be noted that as a result of tranquility analysis, south breakwater is not needed and hence not considered for this study, therefore the revetment and the berths may be exposed to waves from south direction.

The maximum wave height estimated at the container berths is 1.6m and for the revetments along the southern part of the terminal is 2.3m for a 50 year return period. For the 200 year event the wave heights expected are 1.7m for the berths and 2.5m for revetments.

7.4 Ship Simulation Studies

Real time ship navigation simulation studies were done by BMT CI (Mumbai) in May 2013. The results and conclusions of the trial simulation runs have been summarized in this section. The objectives of the study were:

- To test the outer approach channel alignment for environmental conditions.
- To test the ports navigability based on channel width, depth and alignment.
- Carrying out berthing and turning circle maneuvers and suggesting any layout changes if required.

7.4.1 Methodology for Ship Simulation Study

BMT utilized Vizhinjam Port's phase wise layout (from Integrated Master Plan Report, November, 2012 by AECOM). Based on the phase wise master plan layout BMT prepared the electronic navigation chart and modeled the port facilities like approach channel, breakwaters, berths etc.

As per the Master plan report suggested design vessels and using BMT's in house library of ship hull forms, ship models were finalized for the simulation runs. Met ocean conditions (Wind, Wave, Currents) were obtained from

LTR. Apart from the met ocean data given to BMT by LTR, BMT also referred data available in public domains such as West Coast India Pilot (WCIP) and NHO charts and compared it with the data provided by LTR. A run matrix was created with varying wave, wind and current parameters to carry out the navigation simulations.

7.4.2 Conceptual Design of Navigation Facilities

The analysis of the navigational facilities was done in two stages, conceptual design (theoretical assessment of navigation facilities based on international guidelines like PIANC) and final detailed design (based on navigation simulation trial runs)

The remarks made by BMT based on conceptual design of the outer channel are as follows:

- **Channel Width:** The channel width initially proposed (300m) for 12,500 TEU vessels was found to be sufficient for one way traffic.
- **Bend Radius and Width:** A bend is present at the entrance of the channel. As the channel entrance location has a deep natural water depth of 21m, there will not be any restriction on the final approach of the ship towards the channel. As per BMT's conclusion, ships can safely navigate to align with channel at the final approach towards the port.
- **Turning Circle and Basin:** As per BMT analysis, the turning circle of 700m diameter was found to be adequate. Conditions inside the harbour were found calm and tugs can be used so a 390m vessel could be swung in the available turning circle.
- **Stopping Distance:** At Vizhinjam the stopping distance for Phase-1 is around 1200m. The adequacy of stopping distance for various vessels has been checked with the simulation runs as the stopping distance varies considerably depending on the type of ship, the type and number of tugs used and the ship speed at entrance breakwater.
- **Channel Depths:** The depths were found to be suitable provided that channel wave heights are limited to 2.5m and ship transit speed in the channel was 8 knots on an average.

7.4.3 Trial Simulations

For the preliminary analysis, initial runs were carried out to check the alignment of the channel. The trial runs (seven) were carried out from the entrance of the channel till the harbour entrance. Ship maneuvering of design vessels at the approach of the channel and its transit through the channel was simulated in these trials. The following conclusions were provided from these trial runs.

- **Channel Alignment:** From the trial simulations the channel alignment was found to be ok. The effect of wind and current was found to be more than the effect of beam waves.
- **Stopping Distance:** Stopping distance available for the Phase-1 layout (about 1200m) was found to be adequate in the trial runs. However a tug had to be made attached at the stern of the vessel.
- **Channel Width:** The channel width of 300m was found just sufficient but not generous for the 390m vessel transit. In view of sufficient depth available on the sea side of the channel it was recommended that channel width should be increased to 400m. The channel width can then gradually taper down to 300m till the breakwater entrance.
- **Channel Bend Width:** The channel width at the bend was found to be inadequate for turning the vessel. It was advised that either the bend be made more gradual with its width increased to 400m or the vessel be aligned with the outer channel before entering the channel itself.
- **Turning Circle:** Turning circle diameter (700m) was found adequate for the biggest design vessel (390m long container vessel). Minor recommendations were provided for the basin boundary around the turning circle to provide more maneuvering space within the breakwater alignment.
- **Depths:** Depths in channel, basin and turning circle were found adequate.
- **Requirement of Tugs:** Based on theoretical calculations of bollard pull required (considering forces due to wind, wave, current and gust factor), power utilization of tug (80% of maximum rated power) BMT used the following tug suite for trial simulations:
  - 390m Container: 3 × 70T tugs and 1× 40T tug
  - 300m Container vessel: 3 × 70T tugs.
  - 268m cruise: 3 × 70T tugs.
  - 244m tanker: 1 × 70T and 1 × 40T tug.

- The tug suite was found adequate for tanker and cruise liner. However berthing of 300m and 390m vessel using the above tug suite against a NE wind of 25 knots was found difficult but doable. Vizhinjam port may seldom experience winds of 25 knots. Additional runs will be carried out with a wind speed of 20 knots.

7.4.4 Feasibility Simulations

In order to ascertain the initial feasibility of the layout, additional runs were performed and graded by BMT as per the parameters shown in Table 7.10.

Table 7.10 Initial Run Matrix Grading based on Parameters

1	2	3	4	5	6	7	8
Easy	Straight-forward	Comfortable	Not demanding	Not easy	Challenging	Difficult	Impossible

Safe for Routine Operations Occasional Unsafe

Run	Vessel type	Wind (speed x direction)	Current	Waves (ht. x dir.)	Tugs (no. x bollard pull)	Remark
8	300m Container	25 knots x 260 N	SE current	2.5 m x 225	3 x 70t	Phase1 layout; **Not Demanding**
9	390m Container	25 knots x 300 N	SE current	2.5 m x 225	3 x 70t +1 x 40t	Phase1 layout; **Challenging**
10	390m Container (with extended basin)	25 knots x 300 N	SE current	2.5 m x 225	3 x 70t + 1 x 40t	Phase1 layout; **Not Easy**
11	390m Container	25 knots x 045 N	NW current	2.5 m x 180	3 x 70t + 1 x 40t	Final Phase; **Not Easy**
12	268m Cruise	25 knots x 300 N	SE current	2.5 m x 225	3 x 70t	Final Phase; **Not Demanding**
13	268m Cruise	25 knots x 045 N	NW current	2.5 m x 180	3 x 70t	Final Phase; **Not Demanding**
14	244m tanker	25 knots x 045 N	NW current	2.5 m x 180	1 x 70t + 1 x 40t	Final Phase; **Comfortable**
15	244m tanker	25 knots x 300 N	SE current	2.5 m x 225	1 x 70t + 1 x 40t	Final Phase; **Comfortable**

[Source: Ship Simulation Study for Vizhinjam Port, BMT]

A final set of runs was performed with the finalized Phase-1 layout and the results are presented in Table 7.11.

Table 7.11 Final Run Matrix Grading based on Parameters

Run	Vessel type	Wind (speed x dir.)	Current	Waves (ht. x dir.)	Tugs (no. x pull)	Remark
16	390m Container Arrival	25 knots x 300 N	SE current	3.5 m x 225	3 x 70t +1 x 40t	**Challenging**
17	390m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t + 1 x 40t	**Comfortable**
18	390m Container Arrival	20 knots x 260 N	SE current	2.5 m x 225	3 x 70t +1 x 40t	**Not Easy**
19	300m Container Arrival	25 knots x 300 N	NW current	3.5 m x 225	3 x 70t +1 x 40t	**Not Demanding**
20	390m Container Departure	20 knots x 300 N	SE current	2.5 m x 225	3 x 70t	**Challenging**
21	390m Container Departure	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	**Not Demanding**
22	390m Container Arrival	20 knots x 260 N	SE current	2.5 m x 225	3 x 70t +1 x 40t	Engine Failure in Channel **(Not Demanding)**
23	300m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t	Tug Failure inside b/water **(Not Easy)**
24	390m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Engine Failure in Channel **(Not Demanding)**
25	390m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Steering Failure near b/wate **(Not Demanding)**
26	390m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Steering Failure near b/wate **(Not Demanding)**
27	390m Container Departure	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Engine Failure near b/wate **(Challenging)**
28	390m Container Departure	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Cold Move **(Challenging)**
29	390m Container Arrival	20 knots x 045 N	NW current	2.5 m x 180	3 x 70t +1 x 40t	Arrival Tug Failure **(Not Easy)**

7.4.5 Conclusions

It was concluded that ship navigation runs validate the safety aspects of the NW-SE channel alignment direction. The navigational parameters such as channel width, depths, turning circle diameter were found to be adequate and minor recommendations were provided in the navigational parameters by BMT.

7.5 Discussions on the Outcome of Model Studies

The outcome of the mathematical model studies conducted on the Phase-1 Vizhinjam port layout can be summarized in the following paragraphs:

7.5.1 Wave Tranquility

RH studies were performed during 2010 and have been updated with site-specific studies by LTR as discussed in this chapter earlier. These modeling studies have shown that south breakwater is not needed at the port. The proposed north breakwater itself provides complete protection from offshore waves. Since the biggest waves are monsoon waves, the breakwater alignment effectively provides full protection from the monsoon waves. The breakwater alignment may be further optimized during the detail design stage and after physical modeling studies during EPC stages.

The proposed port layout is expected to improve tranquility for the existing fishing harbour as the proposed port breakwaters will provide additional protection to the existing fishing harbour basin. The proposed fish landing harbour will be protected by the additional spur to the north breakwater.

7.5.2 Sediment Transport and Shoreline Change

The proposed port breakwater alignment is not expected to alter the sedimentation pattern around the shoreline significantly. The existing pocket beaches around Kovalam are not expected to be affected. The beaches south of the proposed port at Adimalathura are expected to see accretion due to the presence of the proposed bund structure at the south of container terminal. This accretion is estimated to equilibrate at around 20m at the end of ten years of simulation. The proposed bund structure is also expected to block any sediment from entering into the proposed harbour. Hence, maintenance dredging activities at the port are expected to be minimal. The proposed port is also expected to reduce sedimentation inside the existing fishing harbour.

Offshore dredge material dumping locations have been also identified and modeled. The sediment dispersion studies indicate that the most of the sediments dumped do not travel far from the proposed dumping ground and the concentration of sediments will be very minimal away from the dumping grounds.

7.5.3 Ship Navigation Study

The fast-time ship navigation study has validated various navigational arrangements at the port in respect of dredge depths, channel widths, turning adequacy, berth arrangements etc. The recommendation of 400m outer channel width has been adopted for the Vizhinjam port.

7.5.4 Design Environmental Conditions

LTR has performed site specific studies for various environmental parameters important for design such as wave heights, currents, sedimentation estimates, water levels etc. and have been discussed earlier in this chapter. These have been further used for design of various elements and described further in Section 10.

7.6 Marine Layout for Implementation

The summary of the marine layout for Phase-1 development is provided in Table 7.12 below:

Table 7.12 Summary of Phase-1 Marine Layout

S. No	Description	Unit	Value
1.	**Maximum Ship Size**		
	– Container Vessels	TEU	18,000
2.	**Breakwaters**		
	– Length of North Breakwater	m	3,040
	– Breakwater for fishery harbour extension	m	140
3.	**Number of Berths (Total length of berths in meters)**		
	– Container Berths	No.(m)	2 (800)
	– Cruise cum multipurpose cargo berth	No.(m)	1 (300)
	– Port Craft Berths	No.(m)	1 (100)
	– Coast Guard Berths	No.(m)	1 (120)
	– Navy Berth	m	500
	– Fishery Berths	m	500
4.	**Navigational Areas**		
	– Length of Outer Approach Channel	m	2,800
	– Width of Outer Approach Channel	m	400

S. No	Description	Unit	Value
	– Length of Inner Approach Channel (m)	m	1,200
	– Width of Inner Approach Channel (m)	m	300
	– Diameter of Turning Circle (m)	m	700

8 Phase-1 Development Recommendations

8.1 Introduction

Based on the outcome of the model studies mentioned in earlier section, the recommended layout for the Phase-1 development of Vizhinjam Port is as shown in **Drawing 12086/DPR/211**.

8.1.1 Breakwater

For carrying out cargo handling operations at the berths, there is a limiting wave conditions at the berths to ensure that there are no excessive movements of the ships that will hamper the loading/unloading operations. This limit varies with the handling system for the different types of cargo. Hence, the breakwater configuration and the overall port layout should ensure adequate tranquility 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 heights (Hs) for different wave directions for cargo handling operations are summarized in Table 8.1 below. These numbers are based on IAPH[3] guidelines and apply to the worst wave periods for each direction.

Table 8.1 Limiting Wave Heights for Cargo Handling

S. No	Type of ship	Limiting wave height (H_s)	
		Head or stern (0°) (m)	Quadrant (45°- 90°) (m)
1.	Container Vessels	0.5	0.3
2.	Multipurpose Vessels	1.0	0.8

The breakwater alignment for Phase-1 development have been chosen to maximize the operations time by effectively blocking all of the bigger South-West monsoon waves and providing enough protection against rest of the year waves.

The breakwater alignment consists of breakwater that is around 3,180m long. The deepest depth contour for breakwater is around -20m CD. The crest height of the breakwaters has been chosen so as to only allow industry standard overtopping discharges details of which is provided in Section 10.2.

[3] *International Association for Ports and Harbours*

8.1.2 Navigational Requirements

8.1.2.1 Approach Channel

The port approach channel consists of the two parts:

- The outer approach channel which is the section of the channel outside the breakwaters area; and
- The inner approach channel, which is the section of the channel from the head of the breakwaters area to the vessel turning area.

The outer approach channel would be unprotected with vessels in transit along this section sailing under their own power without tug assistance. The inner entrance channel would be protected and should be fairly sheltered from wave attacks. Tugs will be able to meet and fasten to the vessel before it enters the turning area and starts to maneuver towards the allocated berth.

The vessels will start slowing down after tugs are attached in the inner approach channel. As per PIANC[4] (1997) guidelines, sheltered inner approach channel should have around 4-5 times length of the design ship. However, considering the capital cost of longer breakwater, it is expected that breakwaters will provide an effective length of 3-4 times the design vessel length overall for Phase-1 operations which is deemed adequate. The vessel navigation study has further confirmed the inner approach channel length adequacy for the vessel operations for Phase-1.

8.1.2.2 Dredged Depth at Port

The depth of the approach channel is a very important parameter in approach channel design. The Vizhinjam port location has a very favorable bathymetry and natural depth. Water depth in the channel region is around 15 to 18m depth below CD. This will minimize the initial capital dredging cost involved. 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; the increase in draft of the vessel due to squat or bottom suction.

The dredged depths at the port entrance channel and maneuvering areas will be governed by the fully loaded draft of the design ship. Based on PIANC guidelines, the following dredged depths (after rounding off) are provided at different parts of the harbour for the design ships.

Ship Size	Approach Channel outside Breakwater (Loaded draft+30%)	Inner channel and Maneuvering area (Loaded draft+15%)	Depth at Container berths (Loaded draft + 15%)
18,000 TEU (16.0m draft)	20.8	18.4	18.4

Thus the outer approach channel which will be unsheltered will have a minimum dredging depth of 20.8m CD, whereas in the inner approach channel area, turning circle and harbor basin, a water depth of 18.4m CD will be provided. Berthing pockets will have a dredged depth of 18.4m CD. These dredge depths will also be able to accommodate the 18,000 TEU ships. The vessel navigation study has further confirmed the adequacy of the depths provided at various navigational areas.

8.1.2.3 Turning Circle Diameter

As per the PIANC guidelines, diameter of the sheltered turning circle with tug assistance should be 1.75 times length of the design ship. The design ship length is taken as 400m so the turning circle diameter required would be 1.75 times 400m which is 700m. The vessel navigation study has further confirmed the adequacy of the turning circle diameter and location.

[4] *Permanent International Association for Navigation Congresses; an international body establishing design guidelines for maritime*

8.1.2.4 Width of Harbour Entrance

The width of the single lane approach channel has been estimated considering the design ship beam of 59m. The various factors considering the base width of the channel have been taken from PIANC guidelines. A suitable factor for each parameter is taken and it is multiplied with design ship beam to get the total base width of the channel. Channel width calculations are shown in Table 8.2.

Table 8.2 Approach Channel Width Estimation

Factor description	Outer Approach	Inner Approach
Basic Width	1.5	1.5
Vessel Speed	0	0
Prevailing Wind	0.4	0.4
Prevailing Cross Currents	0.7	0.7
Prevailing Long. Currents	0.1	0.1
Sig. Wave Height & Wavelengths	1.5	1
Aid to Navigation	0	0
Bottom Surface	0.1	0.1
Depth of Waterway	0.1	0.1
Cargo Hazard	0	0
Bank Clearance 1	0.3	0.3
Bank Clearance 2	0.3	0.3
Total Factor (One-Way Channel)	**5**	**4.5**
Beam of Design Vessel	59	59
Channel Width	**295 m (=59*5)**	**266 m (=59*4.5)**

From the above table, it can be concluded that as per PIANC guidelines outer approach channel (unsheltered) and inner approach channel (sheltered) will need approximately 295m and 266m of base width respectively.

The ship navigation simulation study has recommended that the outer approach channel be widened to 400m and inner approach channel be maintained at 300m. For Phase-1 development, outer approach channel width is sized as 400m gradually reducing at the breakwater mouth to an inner approach channel width of 300m.

The approach channel can be a single lane or a two lane channel. For busy ports which handle very large throughput and have a large number of vessel calls, it is recommended to have a two way approach channel. In order to establish the approach channel width and number of lanes, AECOM has performed a spreadsheet analysis. Based on the operating assumptions made, Table 8.3 shows the impact of vessel traffic on the channel utilization rate for various phases.

The parameters considered for channel traffic level analysis are vessel speed (it is assumed that vessels would transit slowly in the approach channel at an average speed of 5 knots), length of the approach channel, time for operation such as pilot boarding, tug fastening and maneuvering operations in turning circle. Traffic parameters (total ship calls) are taken from Drewry report & AECOM’s PRECAP model.

Table 8.3 Approach Channel Lane Requirement Estimation

Parameters	Unit	Phase-1	Phase-3 (Master Plan)
Assumed vessel speed (knots)	knots	5	5
knots to km	km	1.852	1.852
Vessel Speed	kmph	9.26	9.26
Length of the channel	km	4	4
Time for transit	hr.	0.43	0.43
Time for pilot boarding	hr.	0.25	0.25
Time tug fastening	hr.	0.25	0.25
Average time from turning circle to berth	hr.	0.50	0.50
Total Channel + Turning Circle Operation Time	hr.	1.43	1.43
Average total operation time	**hr.**	**1.50**	**1.50**
Number of container berths	No.	2	5
Number of cruise berths	No.	0	2
Number of other berths	No.	0	3
Container vessels per week per berth	No.	5	5
Cruise vessels per week per berth	No.	0	2
Other vessels per week per berth	No.	0	0.5
Total vessel calls per week	**No.**	**10**	**30.5**
Total number of vessel trips through the approach channel per week	No.	**20**	**61**
Number of days per week	No.	7	7
Total vessels trips per day	**No.**	**2.86**	**8.71**
Operating time per day	hr.	20	20
Window of availability for each vessel trip	hr.	7.0	2.3
Channel Utilization	**%**	**21**	**65**

Approach channel utilization for Phase-1 and Phase-3 (Master Plan) are calculated at 20% and 65% respectively for commercial vessels. Phase-1 also includes navy and coast guard berths. The actual usage of these berths will vary and hence these are not currently included in the utilization calculations. With these utilization figures, it can be concluded that a single lane, one way channel will be sufficient to serve the expected number of ship calls up to the final phase of development along with the naval and coast guard vessels. In addition, with the removal of south breakwater and widening of approach channel to 400m, smaller vessels may be allowed to pass each other as deemed adequate by the pilot authorities.

8.1.3 Container Berths

The Phase-1 development provides for a total of two, four hundred meters container berths for a total of contiguous berth length of 800m berth which will be able to accommodate two 12,500 TEU container vessels. The berths have been planned so as to meet the traffic forecast. These berths will be designed so as to be able to berth 18,000 TEU vessels. The dredged depth at these berths is -18.4m CD.

Each berth will be equipped with four quay container cranes.

Table 8.4 provides a summary of Phase-1 key container terminal elements. The Quay apron area has been planned to accommodate the crane rail (35m rail gauge), circulation lanes as well as hatch cover lay-down area.

The apron area has been planned for a width of 70m. However, the gauge for the crane rail is kept open which would give the flexibility to the contractor onto choosing the type of quay cranes to suit his requirements.

Table 8.4 Phase-1 Container Terminal Elements

Development Phase	Phase-1
Total Berths	2
Berth Length (m)	800
Berth Capacity (TEUs)	900,000

8.1.4 Fishery Berths

The Phase-1 development provides for additional fishery berths for the local fishing community. A total berth length of around 500m is provided along the sheltered sea-ward side of the proposed port north breakwater. A 140m long breakwater provides the required tranquility for the fishing vessels. The access to the fishery berths will be provided from outside of the port and the proposed operations at the new port will not cause interference to the fishery berth access. Adequate landside facilities in terms of auction hall etc. are also planned for at the root of the new north breakwater.

8.1.5 Cruise cum Multi-purpose Cargo Berth

It is proposed to provide one berth of 300m to carry out the cruise and multipurpose cargo handling operations. The berth is proposed on the leeside of the northern breakwater. It is proposed that the pre-processing of passengers, resort, shopping areas and vehicle parking will be located in the cruise terminal area outside of the main port. The passengers will be escorted from that area to the cruise berth where final processing and embarkation and de-embarkation activities will take place. The DPR accounts for construction of the berth only and no other facilities other than providing space allocations. Depending on the cruise operator selected and their business plan, these facilities can vary significantly and hence not been estimated.

The multi-purpose cargo expected at the proposed port is around a total of 100,000 Tons spread across 3 commodity types (break-bulk) as per Drewry estimates for Phase-1 development. Due to a very limited amount of multi-purpose cargo expected at the port, no dedicated berths are planned. It is expected that these breakbulk vessels will be berthed along a section of the cruise berth and utilize vessel’s own gear for loading/unloading operations at the berth. The area behind the Coast Guard Navy area will be utilized for storage of these commodities. The proximity of this storage area will enable transport using road as convenient.

8.1.6 Port Craft Berths

A total of 100m of berth length will be provided for port crafts such as tugs. The 100m berth will be able to accommodate port crafts for the Phase-1 requirements. Over the master plan horizon, additional port craft berths would be required for which the cruise berth could be utilized intermittently to meet the requirement. Alternatively, a pontoon berthing arrangement could also be used intermittently. The location of these port craft berth has been carefully chosen so as to provide a sheltered location as well as at an optimum distance from all berthing areas, and having a provision for pilot office area adjacent to the berths.

8.1.7 Coast Guard & Navy Berth

A dedicated 120m coast guard berth will be provided in Phase-1. A total berth length of 500m is provided for navy. The first 200m of the berth with the ramp loading facility is provided on the leeside of the north breakwater near the northern edge of container berth while the other 300m berth is provided at the west of the port on the leeside of the north breakwater to segregate the operations as per the IN requirements.

8.1.8 Container Yard

The Phase-1 development provides for around 40 hectares of Container Yard and support facilities. The container yard is located adjacent to the berths allowing for the efficient transfer of containers from the yard to the apron. The container yard has been planned for efficient handling operations providing for dedicated areas for full, empty and reefer containers. Dedicated circulation lanes have also been provided for quay to yard as well as within yard circulation. The mode of operation for the container yard will be Rubber Tired Gantry (RTG) Cranes in the Phase-1 with provision for up gradation to Electric RTG's in future. Side Pick cranes will be utilized for handling empty containers. The container yard provides flexibility with adequate space provision for terminal operator to choose a different container handling operating mode such as RMG.

The numbers of ground slots have been provided so as to be able to meet the peak berth capacity. Storage for equipments and Internal Transfer Vehicle (ITV) has been provided along the northern side of the container yard. Most of the terminal roads will have two-way traffic. The truck lanes under the RTG as well as under the quay crane will have one-way traffic. The quay apron - yard movement will be anti-clockwise whereas the yard – gate/ railyard movement will be clockwise.

In addition, the yard has been planned such that the transshipment cargo stays closer to the berths than the gateway cargo. The container yard as planned has a width of around 400m and has a total of 5,710 Twenty Foot Ground Slots (TGS) in order to match the required storage capacity. Utility routes have been planned and incorporated into the yard to allow for minimal disruption during phased development as well as easy upgradation of diesel RTGs to ERTGs. A dedicated area has been provided for reefer support operations such as Reefer Wash Down, Reefer Service and Genset repair Building.

8.1.9 Container Freight Stations (CFS) & Warehousing

Suitably located CFSs are the integral part of a modern container terminal. CFS provides facilities for consolidation and distribution of small consignments either exported or imported in LCL containers. Though CFS facilities are primarily conceived for handling LCL containers but in realities large volume of FCL containers also move through CFS for various reasons convenient to the exporters and importers.

Ideally the CFS should be located within a distance of 5 to 15 km from port at a place which has a direct connectivity to the port. In the present case it is proposed that the CFS is located in the land parcel being purchased at Kottukal which is about 4 Km from the Project site lying on either side of the NH47 bypass road. This land parcel will be utilized for CFS, warehouse facilities as well as housing colonies for port staff, coast guard and navy personnel and totals to 41.5 Ha. The proposed NH 47 bypass will be bi-furcating the total land area in to two. The alignment of the NH 47 bypass that is being constructed/ planned will bypass the Thiruvananthapuram capital city through the warehouse area at Punnakkulam.

8.1.10 Truck Terminal

The truck terminal for the proposed port is located close to the end chainage of proposed road alignment and is designated as Truck Terminal Area - 1 and the one located northwest is close to the proposed rail alignment and is designated as Truck Terminal Area - 2. The area for the truck terminal comprises a total of 19.94 Ha. The proposed truck terminal is located at Mukkola on either side of the road connecting Vizhinjam and Poovar, and also adjacent to the proposed NH 47 bypass. Both the road and railway alignment traverse close to the proposed vicinity of truck terminals. The road alignment for Vizhinjam port practically ends at the proposed NH 47 bypass which is just adjacent to the entry for the truck terminal-2. This gives easy access of connectivity for the container truck traffic.

8.1.11 Gate Entry/ Exit Complex

The entry/exit gate has been planned as a two-step gate. A pre-gate will be constructed on the main terminal road which will have parking and facilities for truckers and autos. Only authorized vehicles will be allowed to leave the pre-gate area and enter the main terminal gate. The main terminal gate has been provided at the east end of the port. It will consist of a gate canopy with three entry and three exit lanes with one bypass lane and one traffic lane in each side. The bypass lane is to be used for out of gauge container trucks or break bulk trucks. The traffic lane is to be used by port staff and other users. It is planned that, gate will consist of single shift operations in Phase-1. The proposed port is essentially a transshipment container terminal with only 16% of gateway container traffic. The split of gateway traffic coming through road trucks is assumed to be 70%. The gate lanes have been sized to accommodate this traffic. Adequate queuing space has been planned for in the gate complex. Space has been provided for customs and other regulatory processes near the gate complex. Container scanning (Radiation etc.) if needed can be accommodated within the gate complex itself.

Each container gate lane will be equipped with a weigh bridge that is used to measure and assess truck axle weights for enforcement of axle load highway rules.

8.1.12 Rail and Road Connectivity

Rail connection to the port has been planned by Rail Vikas Nigam Limited (RVNL) from the north breakwater side in the form of a coastal bridge. Electrified railway lines (with two live & one service lines, one service line for Phase-1) with container handling facilities using Reach Stackers in Phase-1 development upgradable to RTG's or Rail Mounted Gantry's (RMG's) in future phases to commensurate with the traffic . The proposed port is essentially a transshipment container terminal with around 16% of gateway container traffic. The split of gateway traffic coming through rail is assumed to be 30%. The number of rail lines has been sized to accommodate this traffic.

Space along the service line will be used for container stacking before transfer to container yard. The port will provide for switching and yard services within the railway yard.

The road entry has been planned from the Mulloor end and the main terminal access is planned along the middle of the terminal from east. The land for proposed route of the 45m road corridor is under the ownership of VISL.

8.2 Phase-1 Expansion into Master Plan

The Phase-1 development is planned in such a manner that container berths can be expanded and additional berths for cruise and liquid bulk can be added at the port. This would involve extension of the breakwater and the harbor and require additional reclamation for creation of back-up land area. The requirements presented in Section 6 are met based on the expected traffic forecast prepared by IFC/Drewry. The recommended layout of the full development for Vizhinjam port (Phase-3) is shown in **Drawing 12086/DPR/212** and the Phase-2 development for Vizhinjam port is shown in **Drawing 12086/DPR/213** and

Drawing 12086/DPR/214 shows the overall development plan for the project along with different land uses planned.

9 Environmental Compliance

9.1 Background

VISL has appointed LTR to prepare the integrated EIA report for the Vizhinjam port. VISL appointed Royal Haskoning (RH) to perform the analysis for marine side impacts. LTR has performed the analysis for the land-side impacts and integrated the RH analysis to produce a comprehensive EIA report. This chapter presents a summary of LTR work on environmental compliance. It is recommended to reference the LTR EIA study for additional information required.

9.2 Environmental Baseline

The current state of the environment was studied (primarily for bench marking) in the project area and within a radius of 10 km from the project site (further referred to as the study area). The following components of the environment were taken into account: land environment, water environment, marine environment, air environment, noise, biological environment, infrastructure and public utilities and the quarry site. The outcomes are summarized in this report.

9.2.1 Land Environment

The study area consists of marine water and land that is partly covered under green coverage: mainly coconut plantations in between the cultivated land. The coastal area consists of multitude of rock outcrops/cliffs and few lateritic cliffs intermingled with beach pockets without any eco-sensitive areas like mangroves or coral reefs. The land behind the pocket beaches are intermingled with coconut trees and buildings. Behind the shoreline, at about 500 m inward, agricultural land and coconut plantations are present in-between human settlements. The Vizhinjam fishing harbour, which is a harbour (natural bay) with manmade infrastructures, is located at the northern side of the project site (at a distance of approximately 300 m). This region is densely populated predominantly by fishermen communities. To study the soil characteristics of the study area, five locations were selected from where the soil samples were collected and analysed for important relevant physico-chemical parameters. The soil fertility was observed to be high in the Vizhinjam, Nellimudu and Mulloor area and lower in the Nedumam and Karinkulam area.

Construction Material: For the reclamation of the land area for the project site as well as the construction of breakwater, rocks are required, which will be obtained from quarry sites. Four suitable quarry locations have been shortlisted for the proposed project based on the distance to the project site, size of quarry, quality of material and potential for environmental impact (at quarry and via access/transport routes). They are: Karavaram (Kerala), Kadavila (Kerala), Malayam (Kerala) and Thakala (Tamil Nadu). In August 2012, VISL confirmed that out of the aforementioned four shortlisted quarry sites, Kadavila and/or Thottyode brownfield quarries with barge access through Muthalapozhi and Colachel respectively (to minimise the impact of conveyance through trucks) will be used as source of the quarry materials. Nevertheless the final selection among the quarries will be carried out by the contractor. The contractor will be obliged to, among others, consider National/relevant guidelines for Construction Materials Extraction and the relevant legal framework of India as selection criteria.

9.2.2 Water Environment

The major surface water bodies present within the study area are the Karamana River, Neyyar River and Vellayani Lake. Vellayani Lake is a fresh-water lake, which is the source of water for Vizhinjam and nearby areas. According to the available project documentation so far water for the proposed project in the construction and operation phase will also be sourced from this lake. Neyyar River is along the 10 km distance boundary.

Both surface and groundwater qualities were analysed at six and five representative locations for three seasons respectively. The surface water samples were taken from the sources used by communities for domestic or agricultural purpose and were analyzed for a wide range of parameters.

The results indicate that the surface waters were devoid of pollution as for total phenolic compounds, heavy metals (Lead, Zinc, Chromium, Cadmium, Selenium, Mercury and Arsenic), cyanide, oil & grease and free ammonia. The results of groundwater quality analysis for heavy metals like Cadmium, Selenium, Arsenic, Mercury, Lead, Zinc and Chromium, cyanide, phenolic compounds and Boron, for all samples, signify that the groundwater is devoid of these kinds of chemical compounds. Total coliform and E. coli were absent in all the sampled water, which signifies that the water was devoid of bacteriological/sewage contamination.

Despite the fact that the groundwater table is recharged during the monsoon season (June to October) the groundwater in Vizhinjam area is being over exploited.

The high population density in the area and an indiscriminate extraction of groundwater for domestic and agricultural purpose through bore wells and dug wells contributes to water availability related problems. Selling of water (Water marketing) during summer, especially in the nearby Venganur Panchayat where it is an established activity, also leads to heavy withdrawal of groundwater. The groundwater in general, including the water that is used by communities for domestic or agricultural purposes, is devoid of pollution. The groundwater is thereby devoid of bacteriological (sewage) contamination as well.

9.2.3 Marine Environment

The seabed within the project area is gently sloping down in a South-west direction. Water depths within the survey area range between a minimum of 0.0 m and a maximum of 22.5 m. The Northern part of the Vizhinjam harbour area has a natural deep bay, whereas the southern side is dominated by rocky outcrops. At present the Vizhinjam fishing harbour has a total basin area of 16.4 Ha.

The waves approach majorly from two directions: South to South-West and West to South-West. Waves from the South to South-West direction approach the near shore in May to October, whereas in the rest of the year the waves come from the West to South-West direction. The highest wave in the offshore of the proposed project area is of about 4.0 to 5.0 m. Waves of about 1.0 m are most frequent (around 20% of all waves in a year are between 1.0 m. and 1.25 m).

The predominant current direction is south-east in the period between February and October. The speed of the current is highest during the monsoon season. The direction of the current is reversed during the post monsoon period (November to January). There are three different types of seabed in the project area: Clayey/silty fine sand, fine to medium sand and rock outcrops. The first two types of sediments are predominant within the study area. The rocky outcrop is predominant near the shoreline. No other significant seabed features were identified in the project area.

For a safe operation of the harbour and the terminals, the channel for the ships to approach and leave the harbour, as well as a turning space for the ships, needs to be dredged. That is, sand needs to be removed to deepen these areas.

The approach channel that needs to be dredged has medium dense to very dense dark grey silty sand, with occasional shell fragments on the top layer. Towards the deeper side of the borehole the sediment is more soft and sandy clay/silty/dense in nature. In the turning circle region the sediment is medium dense to dense clayey sand with shell fragments, and occasionally silty.

Sediment samples from six locations were collected in different seasons and were analysed for different physico-chemical parameters (heavy metals, etc.). From the results it can be concluded that the sediment was not contaminated with the parameters analysed for (within the rage of the standard limits prescribed by USEPA).

Most of the dredged material (approximately 80%) will be used for reclamation. The dredged material that is not suitable for reclamation will be dumped at two sites (Identified based on silt dispersion model studies) further offshore, parallel to harbour, at about 2.0 to 4.0 km from the dredging area.

The shoreline is not a fixed line and its position is dynamic. The shoreline changes naturally during the years because of the suspension of sediment and transportation of the sediment. The latter is caused by the current during the monsoon season.

If this natural cycle is disturbed by human intervention, an unbalanced sediment transport cycle will occur, which may lead to an unusual and irreversible shoreline dynamic. Since 1950 the shoreline erosion problem in the coast of Kerala has been a major issue for the State. Coastal protection measures were installed to protect the shoreline from significant erosion. Today about 53% of Kerala’s coast is artificial. Still the proposed site shows an accretion tendency, pocket beaches show a medium erosion trend, the north of Vizhinjam also shows erosion tendency and the coast near Karamana River (Panathura) is eroding heavily as is the case with most of the river mouths which have dams/sand mining in the river upstream, which disturbs the sediment inflow/balance at the river mouths.

Marine water samples were collected from six locations in different seasons. Relevant physico-chemical and biological parameters were analysed for. The seawater in the marine stretch of the proposed project area can be compared with the Water Quality Standards for Coastal Waters (Annexure 5 of EIA guidance manual for ports and harbours, MoEF, 2010), be classified under SW1.

As per the surveys conducted by CMFRI, amongst others in 2011 and 2012 it can be concluded that, although the fish catch in the whole Thiruvananthapuram PIA district is decreasing since 2010, there are 11 fish landing centres present in the project area, varying from large to small sites. The most fish is caught at the Vizhinjam harbour and Adimalathura beach landing. The Indian Mackerel, Mackerel Tuna, Bigeyescad and the Striped Pony fish are caught the most. Apart from fishes, mussels, squids and crabs are also significantly contributes to the catch. Mussel and lobster landing take place only at Vizhinjam; crab landing takes place mainly at Puthiathura. The local fisherman use both traditional and mechanized (outboard engines) fishing methods.

The wadge bank is a fertile fishing ground in the ocean and rich in biodiversity. Because the impacts of strong currents, waves and tides are rather low this area can build-up a wealth of nutrients and fish food. Subsequently, the congregation of different fish and other aquatic organisms is significant in the wadge bank compared to other fishing grounds. It is also a favourable spawning and breeding ground for fish and other marine animals. Throughout the world there are 20 wadge banks, out of which, one is situated in the South-West direction from the coastline of the Kanyakumari District, India. This is about 40 km away from the project site (South Western side). This is also visible in all satellite imageries and Google imageries as a continental platform. The International shipping route with several 1000s of ships movements per year is located at about 18 km from Vizhinjam is routed through this wadge bank. Based on all available data and distance to International shipping route (18 km) and the wadge bank 40 km Vizhinjam deepwater port is safely located. It can be inferred that endangered species like leatherback turtles, Olive Ridley turtles, Risso dolphins, Devil rays, Green turtles and Hawksbill turtles are rarely present around the project area. Only rare sighting of Olive Ridley turtle has been reported near these areas, whereas seasonal and regular nesting ground of these turtles were not established in the project stretch.

Dredging, dredge material disposal and reclamation: Fill material will also be required apart from rocks for reclaiming land from sea to develop the port area. In Phase-1, most of the fill material will be obtained from the dredged material itself. Two marine disposal sites have been identified based on model studies for the disposal of dredged material, which can neither be used as fill material nor for landscaping.

9.2.4 Air Environment

The entire Kerala being a **greenbelt**, the air quality problem in Kerala is highly ephemeral and localised in nature and is principally happen due to the occasional absence of wind movements or circulation. Nevertheless this is not applicable to highly industrialised areas or locations of Kerala where the problem aggravates during the absence of seasonal wind movements.

Further Kerala is enclosed between the Arabian Sea and the mountain spread over the Western Side of India, the Western Ghats. This determines the local climate, as the dry winds from the North are shielded by the mountains and the breeze from the ocean cool the temperature around the coast. The seasons of Kerala are generally divided into Winter, Summer, SW Monsoon and NE Monsoon.

The mean temperature during these seasons is more or less similar and around 27-28°C. During the summer and winter a north-east wind is dominant, with stronger winds during the winter period. During the monsoon season the South-West and North-East wind dominates, which depicts the two different seasons of monsoon (SW and NE monsoon). Hard winds in the form of cyclones are very rare in the project area.

The Thiruvananthapuram area is flood prone and the central part of the city at Thampanoor has always had serious drainage and flooding problems. This also happens several times during the monsoon. Similar to that in general, flooding is highly localised in nature and the low lying area gets flooded during the SW monsoon season. During NW monsoon this is a rare occurrence phenomenon.

The air quality monitoring was carried out in nine locations within a 10 km radius. Sampling was carried out twice a week for 45 days at each location for parameters like dust. SO_2, NO_2. The levels measured were below the standards prescribed by NAAQM Standard, 2009. The quality of the air in the project area is relatively good as it does abide to different (international) norms and standards.

To establish the ambient noise scenario in the study area, monitoring of ambient noise level was carried out at nine representative locations in the study area using a suitable portable sound level meter over a period of twenty-four hours, with uniform interval of one hour, in each season. The results were below the national/relevant general guidelines; mentioning a noise standard of 55 dB(A) Leq for day time and 45 dB(A) for Leq night time. But the level of noise at different places in the project area is rather high during the whole year, mainly due to intensive traffic.

9.2.5 Biological Environment

The study area falls under the coastal area (lowland) of the Thiruvananthapuram district. In this area various tree and plant species can be found. These species include Veppu, Kasumavu, Plavu, Arayal, Rubber, Mavu, Njaval, Teak, etc. Shrubs include Bougainvilla, Kallanmula, etc. and herbs include Adalodakam, Thulasi, Kattavanakku, etc. Local inhabitants use some of these species as medicines, fodder, food and firewood.

Although there are no forests present in or around the study area a lot of green coverage and undisturbed natural patches are present and form a habitat for various animals. Important mammals in the study area are, among others, Dogs, Jackals, Mice, Moles, Porcupines and Mongooses. Most common reptiles are, among others, Indian Cobra, Indian Chameleon, Python and the Russell Viper. Most common avifauna is, among others, Black Partridge, Red Vented Bulbul, Baya Weaver and the endangered Nilgiri wood-pigeon.

No declared eco-sensitive zones like a National Park, a Wildlife Sanctuary or Wetlands are present within a 10 km radius of the project site.

9.2.6 Infrastructure and Public Utilities

There are about 5,107,000 people residing in the 10 km study area. The source of water supply is surface water and groundwater. Several water supply and augmentation schemes are in operation to provide drinking water to the rural and urban areas at this moment. The existing water schemes are piped water supply networks that transport water to households, non-domestic connections; industrial connections and public stand posts. About 28.1% of the people in the study area have piped water system in their houses. The major source of drinking water is public tap (32.3%), house connection (41.6%) and others (31.9%) respectively. The areas that are not connected to these pipe networks depend on either dug wells or bore wells. Most of the areas in the PIA district suffer from acute shortage of water for domestic use during summer, however the study area has the highest water shortage in the district.

The project area lacks a good sewerage system as only the Thiruvananthapuram Municipal Corporation has a running sewerage system; several other sewerage systems in the area are under construction. Although based on population density Vizhinjam is also added to the corporation area it will take many years for the Corporation to extend these kinds of facilities to the Vizhinjam port area. Open sewage discharges into the sea are a common sight in the project area.

Solid waste is generated mainly by households. Other sources are commercial sources and waste collected via street sweeping. The Muncipal Corporation has established a centralized solid waste management plant in Vilappilsala, which is situated in the outskirts of the city area and processes the generated solid wastes only by composting and closed recently due to social issues. Apart from this plant there is no solid waste management facility in the project area. The Vilappilasala is located outside the 10 km radius of the study area of the proposed deepwater port. As most households lack a door to door collection facility or waste bin nearby the house, solid wastes are either openly burned or dumped in open places.

Apart from several tourism infrastructure (see the tourism section) and facilities other infrastructural facilities in the PIA district are NHs, SHs (State highways), a railway station, airport, harbours and various public offices such as a post office, telephone exchanges or cinema houses.

There are two nos. of fishing harbours and various fish landing sites in the coast of PIA district. Additionally three fishing harbours are under consideration over and above the existing; Vizhinjam fishing harbour. At the fishing harbour occasional (not regular) dredging is carried out in the basin to provide safe berthing for cargo ships. Other ships and boats that enter the harbours are canoes and vessels. The active fisherman in the PIA district is about 5,52,897. (Marine Fisheries Statistics, GoK, 2010). Deep sea fishing is thereby prohibited during the onset of monsoon period for 45 days from June 15th to July 30th every year; only near shore is allowed in that period. During monsoon season people from far way places also operate from the Vizhinjam fishing harbour. In the project core area except mussel fishing and shoresin fishing on the northern part of the proposed port and immediate south of the existing fishing harbour no other major activities are visible and noticed. Except few residents near the identified back up areas, there are no declared/approved fishing villages in the shadow area of the proposed deepwater port.

9.2.7 Quarry Sites

Quarry material is required for the construction of breakwaters. Quarry material can be sourced from two sites: Kadavila and Theviyodu. The former quarry site is located towards North-West direction from the project site in Kerala (about 60 km from the proposed port site) whereas the latter is located towards South-East direction from the project site in Tamil Nadu. The Kadavila quarry site is surrounded by thick vegetation comprising both of natural trees as well as rubber/coconut plantations. The plantations are intermingled with human settlements, on both sides of the roadway that is proposed to be used for the transportation of quarry materials. The quarry material from Kadavila is planned to be transported to Muthalapozhy harbour through Kallambalam and Kadakavur Junction. From Muthalapozhy harbour, the quarry material will be transported on barges to the project site.

The surroundings around the Theviyodu quarry area are sparsely vegetated with trees such as Coconut, Amla and Neem. Only a few mud houses of workers working in the quarry are present near the quarry area. Similar to the Kadavila quarry site, the quarry material will be transported through roadway and sea. The quarry will be brought from the Theviyodu to Colachel port, via Thottiyoodu and Monday market junction, from where it will be shipped in barges to the project site (total 55 km).

9.3 Socio-Economic Baseline

9.3.1 General Setting and Study Area

The project stretch, which is the footprint of the project layout, falls under the Thiruvananthapuram Municipal Corporation and Neyyattinkara Taluk, in PIA district. The study area for the socio-economic baseline description consists of 10 km radius around the project stretch and also coastal villages present between 25 km to 15 km distance from the project stretch in the Northern and Southern directions, respectively.

9.3.2 Social Survey

Socio-economic data pertaining to the study area (10 km radial distance from the project stretch) were not available. To collect study area specific socio-economic profile, a door to door social survey of about 5900 households was conducted from April to June 2012. Totally, 43 Focus Group Discussions (FGDs) were conducted in the aforementioned period to create public awareness about the project and to understand the apprehension of the local people. Especially Project Affected People (PAP) i.e. fishermen and people involved in tourism related activities in the shadow area of the project, have been involved.

28 FGDs for fishermen population were conducted in 22 coastal villages (located between 25 km to 15 km distance from the project stretch dotted with fishermen settlements in the Northern and Southern directions, respectively). Another primary goal for these FGDs was to understand the use of the project stretch as well as Vizhinjam fishing harbour by the fishermen (beyond 10 km region) and also by people involved in other economic activities, like tourism and beach-related activities in the study area.

The remaining 15 FGDs and other consultations were conducted related to tourism and other allied activities. 15 FGDs for people involved in tourism and its allied sector were conducted in nine resorts and in Kovalam, which is a world renowned tourist place located about 2.0 km towards the North West from the North of the project site. A separate structured questionnaire has been prepared and circulated among the 31 resorts/hotels located in the shadow area of the project to collect project site specific tourism data. Information was received from nine resorts only. In addition to this, two more FGDs were conducted in and around the Kadavila and Theviyodu quarry locations.

9.3.3 Population Profile

Total population count in the surveyed study area was 440,180 (Census of India, 2001, primary data collected from administrative offices like Panchayat, Municipality, etc.). Out of this total number of people, 25,850 people (total household count was 5,871) were covered in the social survey carried out for this project. Out of the total number of surveyed households, 3,167 households were from Zone 1[5] (0-2 km from project site), of which 2,112 fishermen households. A total of 8,159 people were surveyed in Zone 2 (2-5 km from project site), which constitutes 2,023 households. Out of these, 262 households belonged to the fishermen community. Similarly, 681 households were covered in Zone 3 (5-10 km from project site), which included 2,669 people residing in this zone. Out of these, only 12 households belonged to the fishermen community.

The surveyed households had an average of 4.2 members. In the surveyed settlements, about 53% of respondents were from rural areas, 29% were from semi-urban and the rest (18%) were from urban areas. The surveyed area was a medium (42.3%) to high (53.4%) densely populated region. The average gender ratio of the surveyed population was 935 (Male: Female).

It can be inferred from the survey that Zone 1 has a relatively high percentage of people <18 years old and 18 to 35 years old, when compared to Zone 2 and 3. Furthermore, in the study area the majority (70%) of the total surveyed respondents came under the Other Backward Caste (OBC). Whereas, Schedule Caste and Schedule Tribe accounted for 9.0% and 2.5%, respectively of the total surveyed households.

In the study area 77.16% of the people were literate, which is lower than the average literacy rate of the State (93.91%) and PIA District (92.66%) for the year 2011 (Official Web Portal of GoK)). Moreover, Christianity, Islamism and Hinduism are the three major religions prevalent in the study area.

9.3.4 Economic Activities

As the project site is located in the coastal region, the main occupation of the local people is fishing and fishing-related activities. Apart from fishing, tourism and agriculture are also important economic activities in the study area. There were no major industries in the study area. A small percentage of people were depended on services mainly in the Government sectors, educational institution or other commercial establishment of the area.

From the local surveys carried out it can be concluded that the majority of people in Zone 1 (67%) were occupied in fishing (including mussel and lobster collection) and its allied activities. In Zone 2 and 3 most people (about 58% and >95%, respectively) were self-employed or employed in the private/public sectors, or were working in the Gulf countries. Agriculture forms another major sector of occupation in Zone 2 about 28% of the surveyed respondents were farmers/farm owners. In the study area >75% of the surveyed respondents had average income of less than ` 10,000. The average monthly income for Zone 1, 2 and 3 was ` 5121, ` 5837 and ` 7207, respectively. In the study area, the major expenditure was on food, followed by expenditure on '*other category*' constituted by fuel, festival, marriage, loan repayment etc.

9.3.5 Fishing and Fishermen Villages

Out of 26 surveyed villages in the study area large proportion of population was found directly or indirectly involved in fishing or fishing related activities except in villages of Kanjirakulam, Athinoor, Thirupuram, Kalliyoor, Pallichal, Peringamala, Kottukal and Thiruvananthapuram municipal area. Only 13 villages in the coastal stretch of the study area are officially registered as fishermen villages, (Marine Fisheries Census, Kerala Part 2, 2010), they are Poonthura, Panathura, Kovalam, Vizhinjam North, Vizhinjam South, Chowara, Adimalathura, Pulluvila, Pallom, Puthiyathura, Kochuthura, Karumkulam and Poovar . Out of which, Adimalathura and Chowara are located towards the southern end of the project stretch. 55,677 fishermen were residing in these 13 designated fisherman villages (Marine Fisheries Census 2010).

Since, the shore of Nellikunnu, Mulloor, Pulinkudy and Azhimala are aligned with resorts/hotels, the fishermen settlements of this stretch were found to be in a scattered manner about two to three kilometres towards the

[5] Zone 1 is 2.0 km radii, Zone 2 is 5.0 km radii and Zone 3 is 5-10 km radii; identified for fisheries survey

landward side from the shoreline. It is inferred that most of the isolated fisherman must have sold their coast lands for the tourism and moved interior. This is particularly true when some individuals hold large chunks of land preparing to construct resorts.

Indian mackerel (26.9%), Bullet Tuna (20.6%), Brown mussels (9.2%) and Indian oil Sardines (7.6%) constituted to the major portion of the catch, which comprises about 58 different species in the project area[6]. The average fish catch was lower for fishermen in Zone 2 compared to fishermen in Zone 1. In Zone 1, approximately 40% of the fishermen respondents had a pre-monsoon catch between 501-1000 kg/month, while during the monsoon season only 32% reached this level of catch. In Zone 2, approximately 40% reported a catch between 251-500 kg/month, in the pre-monsoon season. During the monsoon season the majority (73%) has a catch of 0 – 100 kg/month. –In other seasons except the monsoon, most fishermen (>80%) in Zone 1 and 2 use the beaches to land their catch. During the monsoon season however, fishermen in Zone 1 predominantly use the existing Vizhinjam fishing harbour (70%), while the majority (60%) of the fishermen in Zone 2 use the beaches for landing their catch.

9.3.6 Tourism

Kerala's Tourism industry is one of the State's significant revenue generating sector. The total revenue generated in 2011 through the Tourism industry (including direct and indirect means) was ` 19,037 Crore, out of which ` 4,222 Crore (around 22%) was earned through foreign exchange (Kerala Tourism Statistics, 2010). Total tourism revenue increased significantly in 2011 compared to 2010 (by 9.74%). Thiruvananthapuram the only PIA District, in which the project area is located, was visited by 15% of the tourists who visited Kerala in 2011. Kovalam, a world renowned tourist destination, is located about 2.0 km (boundary to boundary nearest distance) in NW direction from the proposed project stretch. The project shadow area, which encompasses Nellikunnu, Mulloor, Pulinkudi, Azhimala, Chowara and Adimalathura beaches has many tourist establishments, mainly based on Ayurvedic tourism. In these, the Chowara and Adimalathura beaches are located in the shadow zone of the approach channel of the proposed port where no physical infrastructure is envisaged.

During the social survey, it was established that up to 31 resorts were present at the project stretch including the approach channel, i.e., Nellikunnu to Adimalathura. Only eleven resorts will be impacted directly; out of this only three are bigger size with more than ten rooms. From the eleven resorts, three are currently in possession of VISL. About 30% of these resorts were represented through the Focus Group Discussions. Such FGDs included owners, employees, visitors and travel agents. In addition to this, specific information about each individual resort was collected through a separate questionnaire which was circulated to these resorts. Out of 31 questionnaires only nine with details were regained.

The data collected on the resorts also includes the information received from Kerala Hotel & Restaurant Association and Pulinkudy ward of Kottukal Gramapanchayat. The details about revenues generated in these resorts, information on tourist inflow, tourist season, employees and implication of Coastal Regulation Zone (CRZ) on these Resort/Hotels in the shadow area of the proposed project is also analyzed and presented.

9.3.7 Stakeholder Consultations

Stakeholder meetings have been conducted since the scoping stage of this EIA study. The stakeholders, who were consulted during the meetings, were the local people including fishermen, people involved in tourism, local religious leaders, biologists, researchers, etc., Government officials, NGOs etc. Meetings were also carried out for Rail and road corridors and also for backup areas.

43 FGDs were also conducted apart from several formal and informal stakeholder meetings relating to rail and road terminal EIA studies. During these meetings people seemed to be partially supportive and partially against the project. Efforts were made to provide clarification on the questions raised by the public and to provide information about the impacts of the project, both positive and negative.

The following concerns were raised by the people:

- Generation of noise and air pollution, which will alter the calm and aesthetic nature of the region;
- Marine ecological imbalance due to project execution;

[6] As per the catch statistics of Vizhinjam fishing harbor and Adimalathura fish landing centers

- Both direct and indirect loss of employment in the fishing communities;
- Decrease in employment opportunity in the tourism sector;
- Invasion of new diseases and pests in the area; and
- Possibility of change in the wave and current patterns leading to increase in soil erosion/accretion, thereby change in existing coastline.

The benefits of the project as perceived by the local surveyed residents were as follows:

- An opportunity to develop the area and improve the quality of life of local people;
- Agricultural development through better irrigational facilities;
- Better infrastructural development, including transportation and improved accessibility through roads and railways;
- Increase in the value of property;
- Better employment opportunities;
- Development of small scale industries; and
- Overall development of the local economy and communication system.

The surveyed residents also felt that the project developer should contribute to the community development and suggested the following:

- Infrastructure to be improved - drinking water, sanitation, sewerage, better drainage system and solid waste management, road and street light facilities, widening of pavements, under pass shopping facility, clubs, park/playground, auditorium, better postal services, banking facilities, better electricity supply, transformer, etc;
- Health facilities – local communities are in need of good government hospital, veterinary hospital, mosquito control;
- Educational facilities also need attention;
- Job opportunities need to be created;
- New fishing harbour and fish marketing area need to be considered;
- Better transport facilities could be developed under the project - passenger trains, bridge, bus services with proper facilities, car parking.
- Tourism – this sector needs new infrastructure for tourists and development of tourist townships.

Additional consultations: In addition to the above consultations several other formal and informal consultation were also held for road/rail connectivity and other ancillary sites EIA studies. As a part of overall project development Social Impact Assessment (SIA) and Resettlement Action plan (RAP) is also prepared.

9.4 Environmental Impacts and Mitigation/Avoidance Measures

The identification and assessment of potential environmental impacts is at the core aspects of any EIA. The EIA focuses on activities during the construction and operation/maintenance phases of the project.

9.4.1 Identification of Potential Impact Categories

9.4.1.1 Potential Impacts

Activities during the port construction phase include construction of breakwaters, terminals and labour camps, dredging and reclamation, disposal of dredged material into marine disposal area, and quarrying (including transportation of quarry materials). Activities during the port operation and maintenance phase include the operation and maintenance of container terminals, multi-purpose terminals and cruise terminals. Activities during the port decommissioning phase are all about decommissioning all installations and infrastructure.

The following potential impact categories are taken into account:

- Land Environment
- Water Environment
- Marine Environment
- Air Environment
- Noise Pollution
- Flora and Fauna
- Marine Ecology
- Raw Materials
- Visual Amenities
- Occupational Health and Safety

- Climate Change
- Community Health and Safety
- Solid Waste Management

Below the interactions between the project phases related activities and the impact categories are discussed.

9.4.1.2 Impact Mitigation and Avoidance Measures

For each of the identified impacts specific mitigation measures were defined in terms of avoidance or reduction of negative impacts, repair of damage or compensation for irreversible loss. Below mitigation measures are subsequently defined for impacts on the land environment, water environment, marine environment, air environment, noise, climate change, solid waste management, biological environment, raw material use, visual amenities, occupational health and safety and community health and safety. For many categories different environmental management plans are described as proper mitigation measures.

Analysis of Alternatives & Avoidance: Avoidance (just avoid major potential impact) being the best mitigation measure several site alternatives, location alternatives and engineering alternatives were studied in detail to finalise various aspects of the project. By doing these alternatives several impacts were avoided along rail, road and port location. The site alternatives questioned by tourism community has been reworked and unequivocally established the importance of the Vizhinjam site selection. All stakeholder representations were very useful and helped VISL/GoK and the consultants to see things realistically and worked out all possible mitigation measures to compensate, reduce, minimise the possible and probable impacts. GoK has endorsed the fact that due to this project construction and operation all PAPs should at least live with the same standard of living if not a better standard. In other words no PAPs should suffer due to this important National project that is being implemented by the State Government.

9.4.2 Land Environment

9.4.2.1 Impacts

Construction Phase: Due to the construction of the port and all other associated infrastructure (rail and road, Truck parking area, Residential area and the warehouse area) the local landscape will positively change for better, with a different and denser spatial organization of buildings, installations, tanks and infrastructure on the reclaimed area and backup area. The area will be developed in a far more industrial manner compared to the current situation. The increased activities in the area will disturb and disperse the (top) soil. The soil will thereby suffer an increased vulnerability for contamination via spills and leakages as well. Furthermore, an improper construction might hamper proper water runoff, flooding and local ponding with potential undesired and even unsafe consequences. Also, the coastline will change due to the reclamation. Area has been modelled; this change will induce increased accretion to the South but will stabilize after certain period of time. But no significant change in the shoreline pattern was observed towards northern side.

Operational Phase: This situation will continue in the operational phase due to the port activities.

9.4.2.2 Mitigation and Avoidance Measures

Construction Phase: Monitoring of changes related to the land environment is important and therefore a Monitoring Plan has been prepared. A proper drainage system should be realised to prevent water problems and associated consequences for the land environment. Where ever possible top fertile soil shall be collected and stock piled to spread it on the top surface for landscaping after construction work is completed. An area development plan is thereby important as well, including landscaping to improve the aesthetics after the construction activities are finished. Contractors should be prepared and responsive to possible tsunamis. Sewage and wastes (incl. domestic, construction and ship wastes) should be collected and treated properly and according to National and international guidelines. Contingency plans need to be drafted and executed by the contractors, including spill prevention and control procedures.

Quarry Sites: A Land Reinstatement Plan/Rehabilitation Plan (part of contractors EMP) and for quarry areas should ensure that the land environment is restored in a proper manner, via for instance active reforestation and the planting of vegetation to prevent erosion (quarry sites will be developed as greenbelts after finishing the works). All aspects of quarry operation will be documented (e.g. agreement with land owner of the quarry in case of a new quarry)

Operational Phase: Port sewage and wastes (including ship wastes) should be collected and treated properly according to National and International guidelines (Waste Management Plan/Emergency Contingency Plan need to be drafted including spill prevention and control procedures where the role of communities and community infrastructure is taken into account). Port operators should be prepared and responsive to possible tsunamis. Over the whole area being nearer to Kovalam a tourist grade quality need to be maintained in all areas of the project. For the purpose of the operational EMP and decentralized environmental management, ten such land use zones have been delineated and provided in the EMP. All operation environmental management aspects of these units will be treated separately. Except during the first phase of operation, VISL is to develop all such facilities and institutional strength to carry out all EMP implementation through a full-fledged EMP cell.

9.4.3 Water Environment

9.4.3.1 Impacts

Construction Phase: The area already suffers from acute water shortages and the new proposed construction activities will further could impoverish the water availability in the region if not managed properly. The port construction might (partly) block natural water outlets and drains. Ponds and flooding in and behind the port area, a changed local drainage pattern, higher groundwater levels and potential water contamination due to the piling up of sewage discharges in the drain ponds might be the consequences. The groundwater quality could be affected by spills or leakages, or a poor waste handling in the area, especially from labour camps.

With very high rainfall the project area is flood prone and the area could be flooded (localised flooding) during monsoon season

Operational Phase: The water availability could be a problem in the operation phase due to a higher water demand. If not taken care of properly in the design and construction phase the drainage situation and with that also the groundwater situation will be a continuous negative aspect during the operation phase as described above. Moreover, the terminals for liquid bulk and the operational activities related to liquids and to some extent solid waste could impact the groundwater negatively.

9.4.3.2 Mitigation and Avoidance Measures

Construction Phase: To prevent the occurrence of flooding and undesired and unplanned discharge of (polluted) water sufficient structures for adequate drainage should be installed. The new port design has taken into account the undesired and unsafe flooding with proper drainage design provisions. The natural outlets should be properly rerouted and surface run-off should be managed via interception channels, earth bunds, etc. In addition proper arrangements should be in place to ensure that adequate surface protection measures can be safely carried out well before rainstorms. Emergency management plans, spill prevention and control plans (by contractors) and adequate facilities with emergency shutdown possibilities for processes with hazardous materials (such as fuels) are important mitigation measures as well. Waste waters should be recycled as far as possible, keeping discharge at a minimum. Other wastes should be handled according to a contractor waste management plan, encompassing proper sanitation facilities, sewage treatment plants, collection and disposal mechanisms and ship wastes management options.

Operational Phase: A Water Management Plan should safeguard a sustainable water balance in the region, whereby water use is limited via, for instance, recirculation or the provision of alternative sources for water consumption. This water management plan also recommends for a detailed reassessment of all possible water resources within a ten km radius of the project area. This requires geological and hydro geological mapping including structural and linear mapping due to the peculiar nature of the study area where in hard rock areas are intermingled with recent formations. Recommendations of the study will be implemented through various line department/institutions (groundwater department, CWRDM, etc.) of GoK. Monitoring of water quality and quantity is thereby important and should be executed according to a water monitoring programme. Emergency management plans, spill prevention and control plans (by the port operators) and adequate facilities with emergency shutdown possibilities for processes with hazardous materials (such as fuels) are important mitigation measures as well. Waste waters should be recycled as far as possible, keeping discharge at a minimum. Other wastes should be handled according to a Waste Management Plan, encompassing proper sanitation facilities, sewage treatment plants, collection and disposal mechanisms and ship wastes management options. Rain water harvesting and where ever possible artificial recharge also will be practiced in all the land ward side facilities. This could be a better option and necessary budgeting has been provided.

9.4.4 Marine Environment

9.4.4.1 Impacts

<u>Construction Phase</u>: Due to the construction of the breakwaters the current and wave power in the fishing harbour will decrease leading to a more tranquil harbour. The sediments can get contaminated due to spills and leakages of oil and chemicals, wastewater overflows, waste from ships and windblown dust during construction. The sediments can be re-suspended and dispersed due to the construction activities.

<u>Operational Phase</u>: Due to the breakwaters the current and wave power in the fishing harbour will decrease which leads to a more tranquil harbour. When onshore water outlets discharge wastewater in the harbour, where the water is sheltered by the breakwater and cannot flow easily in and out, the water quality will decrease and the marine environment will suffer from this impoverishment of sediment quality in the breakwater area. The sediments can get contaminated due to spills and leakages of oils and chemicals, wastewater overflows, waste from ships and windblown dust. The sediments can be re-suspended and dispersed due to the harbour activities and maintenance dredging activities.

9.4.4.2 Mitigation and Avoidance Measures

<u>Construction Phase:</u> Most of the mitigation measures mentioned above apply here as well. In addition an Oil Spill Contingency Plan should be obligatory for the contractors. The port design should take a proper discharge of sewage water and sediments seriously into account, to prevent pollution of the marine basin, especially in the breakwater area. Furthermore, turbidity during dredging should be kept to a minimum to prevent dredged materials to be transported away from the designated marine dredge area. Last but not least the construction activities should be organized and communicated with environmental care, such as: only store fuels/chemicals if needed and away from drainage systems and the shoreline, handle and store the fuels/chemicals in an impermeable base with a bund and sufficient temporary storage capacity, comply with good operational practices, abide to rules and the international marine conventions, follow standard operational procedures, handle and store hazardous materials away from active traffic, ensure proper labelling and marking of all handled materials, set-up and execute routine maintenance and testing procedures, raise awareness among workers and key stakeholders for environmental care procedures, etc. Proper planning of the construction activities should prevent possible negative flood impacts. The work plans should therefore incorporate a section on the prevention of flooding. The contractors EMP should have a detailed Dredge management plan and Oil spill contingency plan duly approved by the VISL with systematic dredging and reclamation procedure without affecting the turbidity level in the nearby waters.

For dredging a Dredge and Dredge Disposal EHS Management Plan together with a Dredge and Dredge Disposal Monitor Programme will be executed.

<u>Operational Phase:</u> Most mitigation measures mentioned above apply here as well. In addition an Operational Oil Spill Contingency Plan should be obligatory for the port operators. The port design should take a proper discharge of sewage water and sediments seriously into account, to prevent pollution of the marine basin, especially in the breakwater area. Furthermore, turbidity during dredging should be kept to a minimum to prevent dredged materials to be transported away from the designated marine dredge area. Last but not least, the port activities should be organized and communicated with environmental care, such as: only store fuels/chemicals if needed and away from drainage systems and the shoreline, handle and store the fuels/chemicals in an impermeable base with a bund and sufficient temporary storage capacity, comply with good operational practices, abide to rules and the international marine conventions, follow standard operational procedures, handle and store hazardous materials away from active traffic, ensure proper labelling and marking of all handled materials, set-up and execute routine maintenance and testing procedures, raise awareness among workers and key stakeholders for environmental care procedures, etc. Proper planning of the maintenance activities should prevent possible negative environmental impacts. The Emergency Plan to be prepared by the contractor should incorporate a section on the prevention of and dealing with localised drainage/flooding issues during monsoon season.

For dredging a Dredge and Dredge Disposal EHS Management Plan together with a Dredge and Dredge Disposal Monitor Programme will be executed.

9.4.5 Air Environment

9.4.5.1 Impacts

Construction Phase: Due to the construction activities in the project area, dust generated from traffic on unpaved roads, losses of material from construction traffic carrying aggregates and air pollutants from combustion engines emitted, will negatively impact the air quality.

Operational Phase: Air emissions are generated by machineries, engines and boilers in ships and land vehicles, storage and handling of bulk (cargo) and movements on sandy undergrounds (dust).

9.4.5.2 Mitigation and Avoidance Measures

Construction Phase: Dust suspension techniques (no open storage, wetting of sand via sprinkler systems, blasting at quarry areas only at calm weather conditions, etc.), handling dusty materials with environmental care (for instance no unloading from great heights) and smart traffic patterns and management (including speed reduction) should mitigate major emissions of dust and other air polluting particles. Only allowing vehicles and machinery with low emission profiles, promoting the use of good quality fuel and lubricants, maintaining and servicing vehicles and machinery regularly and properly, and the use of heavy generators and combustion plants only at times when lacking alternatives (during power cuts), control unnecessary polluting air emission further. Restraining dredging and reclamation during the monsoon seasons is also an important and effective measure. As are solid barriers or wind screens around construction sites avoid impacts on neighboring communities. All measures and their effects should be included in an air quality monitoring programme, which is specifically relevant during dust generating activities. Volatile spills and leakages should be detected via leak detection systems and monitoring programmes. Last but not least, air quality management procedures should ensure great environmental care.

Operation Phase: Only allowing vehicles and machinery with low emission profiles, promoting the use of good quality fuel and lubricants, maintaining and servicing vehicles and machinery regularly and properly, and the use of heavy generators and combustion plants only at times when lacking alternatives (during power cuts), control unnecessary polluting air emission further. Restraining dredging during the monsoon seasons is also an important and effective measure. All measures and their effects should be included in an air quality monitoring programme, which is specifically relevant during dust generating maintenance activities. Volatile spills and leakages should be detected via leak detection systems and monitoring programmes. Last but not least air quality management procedures should ensure great environmental care, taking into account, for instance, port access navigation at partial power by ships or only achieving full power after leaving the port area. In addition the docked ships are to use 'cold ironing', a method to connect to external power after switching of the engine operated by bunker fuel. Also, use of electric cranes in the yard for cargo handling will reduce the emissions as compared to diesel driven cranes.

9.4.6 Noise and Vibration

9.4.6.1 Impacts

Construction Phase: The construction equipment's, machinery, installations etc. will emit noise. The exact noise levels depend on the location, duration, source and atmospheric conditions such as wind. Nevertheless the noise levels are expected to be high. Noise and related vibrations potentially cause nuisance to local populations, local fauna and marine mammals (vibrations can be transported underwater to considerable distances, depending on the current patterns and strength). It will be clear that the closest settlements as Vizhinjam fishing village, Mulloor and Pulinkudi and nearby resorts will potentially be impacted most.

Operational Phase: The operation equipment's, machinery, installations, etc. will emit noise. The noise levels depend on the location, duration, source and atmospheric conditions such as wind and are expected to be on the higher side. Nevertheless the noise levels are expected to be high. Use of electric RTGs, which will be used for Vizhinjam port, will produce less noise than the diesel RTGs. Noise and related vibrations potentially cause nuisance to local populations, local fauna and marine mammals. During the operation and maintenance phase of the port underwater noises will be emitted (mainly by ships and maintenance dredging) but these are expected to be insignificant. It will be clear that the closest settlements as Mulloor and Pulinkudi and nearby resorts will potentially be impacted most.

9.4.6.2 Mitigation and Avoidance Measures

Construction Phase: A noise monitoring programme should be set-up and implemented. A change management process should thereby be applied to modify construction activities, if necessary, to address noise issues. Noise and vibration mitigation measures, including equipment on all installations, machineries, plants, etc., should be installed prior to any construction activity. All contractors and subcontractors should comply with the relevant National/international noise standards. Activities that take place near residential or sensitive receptors will be carefully planned (restricted to daytime, taking into account weather conditions, outside sensitive season for marine species, etc.) and indicated on clear signs.

Residents in the vicinity are to be notified about construction schedules and activities. Vehicles and machinery should be maintained and serviced regularly and properly. Workforce working in noisy environment will be made to wear proper safety gear (PPE - Personnel Protective Equipments) to avoid any adverse impact of noise on them.

Operational Phase: A noise monitoring programme should be set-up and implemented. A change management process should thereby be applied to modify operations, if necessary, to address noise issues. Noise and vibration mitigation measures, including equipment on all installations, machineries, plants etc., should be installed prior to any operational activity. All port users and maintenance contractors should comply with the relevant international noise standards. Activities that take place near residential or sensitive receptors will be careful planned (restricted to daytime, taking into account weather conditions, outside sensitive season for marine species, etc.) and indicated on clear signs.

Residents in the vicinity are to be notified about operational schedules and activities. Vehicles and machinery should be maintained and serviced regularly and properly. Employees working in noisy environment will be made to wear proper PPE (ear muffs/ear plugs) to avoid any adverse impact of noise on them.

9.4.7 Climate Change Vulnerability

9.4.7.1 Impacts

Construction Phase: These emissions are generated by the import and consumption of fuels and electricity that are used for, for instance, construction vehicles (trucks, cranes, dredging equipment, quarrying equipment, etc.), heating, ventilation and air conditioning, energy conversion and energy distribution systems. During construction these emissions will be limited in time. During construction phase poor institutional capability and project management capability could lead to poor environmental performances. Poor contractor selection, unrealistic timeframes and unplanned procedures, etc. will help to increase emissions of all kinds and due time and cost over runs.

Operational Phase: Greenhouse gas emissions into the atmosphere contribute to climate change. These emissions are generated by various port activities like the handling and consumption of fuels and electricity used for transport equipment (trucks, cranes), maintenance dredging, heating, ventilation and air conditioning, energy conversion and energy distribution systems. Increased climate changes increase the local vulnerability to extreme weather events (such as storms) and sea level rise.

During Operational phase also poor institutional capability and project management capability could lead to poor environmental performances. Unrealistic time frames and unplanned procedures etc will lead to increased emissions of all kinds and due time and cost over runs. Consumption of all resources (water, electricity, paper, plastics, etc.) within the port shall be controlled and shall be of highest efficient with regards to environmental performances achieved by close environmental monitoring of all port activities.

9.4.7.2 Mitigation and Avoidance Measures

Construction Phase: The most significant contribution to climate change, air pollution, is mitigated according to the measures as described above. All these are part of good project management and construction management and therefore good Environment management with a highly committed Environmental management team of VISL.

The most significant contribution to climate change, air pollution, is mitigated according to the measures as described above sections. No direct mitigation measures are possible to implement to avoid or mitigate the increased exposure to sea level rise and the possibility of more intense storms in the long run.

During construction phase good institutional capability and project management capability could lead to excellent environmental performances. Realistic time frames and planned procedures etc will help to increase emissions of all kinds and to avoid due time and cost over runs. All these can be addressed by the proper procumbent of the qualified and experienced contractors with proven skill and abilities for implementing large scale projects. VISL need to include clauses and conditions to ensure all subcontractors and suppliers are in line with all required Environmental Standards. This is to avoid subcontractor's spoiling the entire construction scenario.

No direct operational mitigation measures are possible to implement to avoid or mitigate the increased exposure to sea level rise and the possibility of more intense storms in the long run. However, the entire port with all facilities should be designed to cover for negative impacts related to climate change. Moreover, all equipments and installations machineries and vehicles shall be procured with highest environmental standards. The contractors and sub contractors could be selected based upon his proven environmental performance. The contractors shall be allowed to subcontract only after ensuring the minimum environmental standards, regulatory compliances labour law compliances, etc.

<u>Operational Phase:</u> The most significant contribution to climate change, air pollution, is mitigated according to the measures as described above.

Application of all latest environmental friendly technologies, green building concepts and increased generation and use of alternate sources of energy such as wind and solar and also increased rain water harvesting etc could help in a very big way to achieve low carbon footprint. Implementation of these is important to achieve the green port standards for Vizhinjam port. Innovate to improve could be the mantra for all these kind of development. This can be achieved by putting the right persons for the right job concept. Zero waste concept and waste to energy conversion need to be seen carefully to absorb and implement successfully.

No direct major operational mitigation measures are possible to implement to avoid or mitigate the increased exposure to sea level rise and the possibility of more intense storms in the long run. However, the entire port with all facilities should be operated to cover for negative impacts related to climate change. Furthermore, the work force will be informed and trained about the risks and manners to operate and should act accordingly. A risk management plan and the Emergency Response Plan should incorporate the occurrence and management of such events as well.

These are part and parcel of operational procedures. However, the entire port with all facilities should be designed to cover for negative impacts related to climate change. Moreover, all equipments and installations machineries and vehicles shall be procured with highest environmental standards. The port operator could be selected based upon his proven environmental performance. The contractors and equipment operators shall be allowed to subcontract only after ensuring the minimum environmental standards, regulatory compliances labour law compliances etc.

Being a port with facilities for docking 18000 TEU vessels in the first phase itself, this project could be one of the lowest in terms of carbon footprint. The project is also planning battery operated vehicles for all internal movement within the port premises. The solar, wave and wind energy will be explored to tap during the operational phase of the project. This is also to highlight the green port concept in letter and spirit.

<u>Institutional strengthening Capacity building and Training</u> throughout the project cycle this is very important to keep everything environmental friendly and also to reduce the carbon footprint to an acceptable level and achieve the minimum standard of Green port.

9.4.8 Solid Waste Management

9.4.8.1 Impacts

<u>Construction Phase:</u> Construction wastes can be expected from vegetation clearance, construction materials (incl. packaging), oil, fuels and other chemicals, excavation materials, food waste, office waste, human waste, waste from ships (like oils, packaging and food) and from maintenance of vehicles and installations (incl. terminal tanks). There is no sanitary landfill that abides to international standards, which is a significant concern. Hazardous waste should thereby be dealt with separately from non-hazardous waste. The negative environmental impacts related to an improper solid waste management by the construction contractors can be rather substantial.

Operational Phase: Operation wastes can be expected from packaging materials, oil, fuels and other chemicals, food waste, office waste, human waste, waste from ships (like oils, packaging and food) and from maintenance of vehicles and installations (incl. terminal tanks). There is no sanitary landfill that abides to international standards, which is a significant concern. Hazardous waste should thereby be dealt with separately from non-hazardous waste. The negative environmental impacts related to an improper solid waste management can be rather substantial. . The negative environmental impacts related to an improper solid waste management by the port operator can be rather substantial.

9.4.8.2 Mitigation and Avoidance Measures

Construction Phase: The construction contractor's sewage/solid waste/hazardous wastes will be treated and disposed of in an appropriate way, or sold to legitimate and authorized recyclers and waste processing enterprises. Waste generation needs to be kept to a minimum, separated according to type of waste and disposed/discharged in a proper manner in line with a predefined approved Waste Management Plan to be prepared (part of contactors' EMP) and executed by the contractors. The latter should take relevant Indian and international laws and regulations into account. A **'scavenging boat'** will thereby be available at all times for collection of windblown rubbish within the harbour basin itself. Burning of waste (not using an incinerator) on site will not be permitted.

On Operational Phase: The sewage/solid waste/hazardous wastes generated during the operation phase will be treated and disposed of in an appropriate way by the Port Authorities or sold to legitimate and authorized recyclers and waste processing enterprises. Waste generation needs to be kept to a minimum, separated according to type of waste and disposed/discharged in a proper manner in line with a predefined Waste Management Plan. The latter should take relevant Indian and international laws and regulations into account. A **'scavenging boat'** will thereby be available at all times for collection of windblown rubbish within the harbour basin itself. Burning of waste (not using an incinerator) on site will not be permitted.

During operational phase the entire port area will be a declared as a zero waste area and therefore necessary personnel and equipment will be employed for decentralized solid waste management. Similarly in all identified ten (10) sectors (See EMP section) it is necessary to arrange localized solid waste collection transport and disposal facilities. This can be implemented with local employment generation (participation of Kudumbasree for example) and necessary waste management mechanism will be implemented.

9.4.9 Flora

Construction Phase: Due to the removal of vegetation a habitat loss of flora is foreseen (mostly at the backup area). However, the impact is expected to be low because the major part of the port will be built on reclaimed land and because of the low ecological value of the site.

With regards to all other land side developments all the trees cut will be replanted with two for every tree cut and removed. This will be in addition to those planted as avenue plantation.

Operational Phase: As a minor impact, emissions from port related activities could affect the growth of local flora.

9.4.10 Fauna

Construction Phase: Due to the increased levels of noise, light, traffic movements the local fauna will be affected by the proposed project. However, the impact is considered to be low because of the low ecological value of the area and the expectation that no significant amount of fauna will permanently settle in the project area. Moreover the construction will be of a limited time.

Operational Phase: The impact during operation will be confined to some species that can survive in the area. None of the impacts to the fauna can be seen as potential impacts for initiating any kind of necessary mitigation measures.

9.4.11 Marine Ecology

9.4.11.1 Impacts

<u>Construction Phase:</u> The marine ecology will potentially be affected due to impacts on the marine waters, sediments and marine life and organisms. Dust and re-suspension, generated by dredging and reclamation activities, will increase the turbidity of the water (i.e. less oxygen in the water) what creates difficult circumstances for particular marine species and organisms to survive.

Marine biological activity will temporarily reduce to a minimum due to various construction activities in the proposed port area. With regards to mussel collection during construction phase the fishing in the area could be temporarily affected. The mussel habitant and the shoresein fishing along the Valiyakadapuram will be affected. This is mainly due to the reorganization of the biological activity away from the dredging and construction areas.

<u>Operational Phase:</u> During operational phase it is expected that the mussels and other similar specious could flourish due to the hard surfaces on the break water and other construction surfaces especially on the out ward portions. This could help the fisherman again to work on this part of fishing activity. Maintenance dredging is along very limited areas and this is only a temporary activity and the natural conditions are expected to come back again. Due to a tranquil harbour (breakwater has less current and wave power) even more different species might settle in the harbour area also. Of course this also depends on impacts from for instance spillages.

9.4.11.2 Mitigation and Avoidance Measures

<u>Construction Phase</u>: Dredging is only a temporary activity and the natural conditions are expected to come back again. The land and seabed is changed permanently though, what affects the habitats of marine life. However re-colonization is possible.

<u>Operational Phase</u>: Maintenance dredging is along very limited areas (and that too expected to the barest minimum) and this is only a temporary activity and the natural conditions are expected to come back again. Due to a tranquil harbour (breakwater has less current and wave power) even more different species might settle in the harbour area also. Of course this also depends on impacts from for instance, accidental spillages.

9.4.12 Raw Material Use

9.4.12.1 Impacts

<u>Construction Phase:</u> During the operation phase, the raw materials to be used are mostly oil and water. Oil will be used for vehicles and other maintenance purposes and will be imported; water will be sourced locally.

<u>Operational Phase</u>: During the operation phase the only raw materials to be used are mostly oil and water. Oil will be used for vehicles and other maintenance purposes and will be imported; water will be sourced locally. The unmanaged use of water may lead to shortages elsewhere in the region.

9.4.12.2 Mitigation and Avoidance Measures

<u>Construction Phase:</u> The design and construction contractor should limit the use of quarry run and other raw materials. Detailed studies have been under taken to avoid major impacts due to construction material sourcing and transportation. As stated earlier, the project is one of the most ever studied port project (during pre-construction phase) with all environmental friendly activities and environmental planning.

<u>Operational Phase:</u> A proper Water Management Plan should be developed and implemented. If surface/groundwater resources are limited the project has to provide alternative source of water to users. In order to augment the water supplies the project VISL will fund a detailed water resources (surface and groundwater) study with budget sourced from CSR as the port related studies has revealed inadequacy of various studies carried out in the area especially along the valley areas of the 10 km radius area. The detailed study will focus on remote sensing, structural mapping for lineaments in addition to geological mapping and hydro geological mapping of the ten km area. All existing and future sources of contamination of water will also be mapped. The recommendations of this study will be provided to all line departments/agencies (CGWB, State Groundwater department, CWRDM, etc.) for faster implementation of schemes especially to augment the existing systems and practices. This study is important for the operational phase of the port project.

9.4.13 Visual Amenities

9.4.13.1 Impacts

Construction Phase: The construction activities have a significant impact on the aesthetics of the surrounding of the proposed Vizhinjam port area. This is a micro level impact.

Operational Phase: The new port will have a significant impact on the aesthetics of the surrounding of Vizhinjam port area as a micro level impact. Most parts of the new proposed port (except existing Vizhinjam fishing harbour) are thereby inharmonious with the current surrounding.

9.4.13.2 Mitigation and Avoidance Measures

Construction Phase: The port area during construction will have a significant visual impact. Various construction activities and materials will dominate the scene which cannot be mitigated. Lighting however can be mitigated: the Contractor should reduce off-site glare and emissions to the surrounding. Only green light for general background should thereby be used. Night-time work should be prohibited. The quarry sights will change the scene during the construction phase as well, but will be left as green belts afterwards, according to reinstatement management plans. As a part of landscape design and planning very few trees will be removed from the back up areas adjoining the proposed port area to ensure the **tourist grade standards** (careful/limited felling of trees not to alter the visual aspects of the coastal vegetations) for all operational aspects of the port.

Operational Phase: The port area during operation has a significant visual impact. Terminals with storage tanks and transport units and large ships approaching the terminals and mooring along the jetties will dominate the scene which cannot be mitigated during operation. Lighting however can be mitigated: the design, location and material should reduce off-site glare and emissions to the surrounding. Only green light for general background should thereby be used. Loud noise generating activities during night-time working shall be avoided especially with regards to the National noise regulations.

9.5 Social Impacts and Mitigation/Avoidance Measures

9.5.1 Identification of Potential Impacts

The activities during the construction phase, which might have potential impact on the socio-economic environment, are dredging, reclamation, transportation of quarrying materials through barges, construction of terminals and breakwater as well as establishment of labour camps. During the operation phase, the operation of terminals, marine traffic and establishment of labour/employee colony might have potential impact on the socio-economic environment of that region.

The decommissioning phase might have impact on the project area through increased traffic during the period when the equipment and materials are dismantled and taken away from the site, removal of labours' and workers' camps and restoration of the area as far as possible close to its pre-project state.

VISL has already carried out a Social impact Assessment (SIA) for the port, roads, and railways and for all other ancillary sites that are to be developed in addition to the focused environmental studies of these areas.

9.5.2 Mitigation/Avoidance for Socio-Economic Impacts

In this section mitigation measures are provided for all potential socio-economic impacts identified. The following social management plans to be prepared and implemented by the Construction Contractor are outlined: Prior approval of VISL is required for implementation of such social impact management plans

- Stakeholder Engagement Plan (SEP)
- Local Hiring and Purchasing Plan;
- Community Development Plan;
- Community Grievance Mechanism.
- Livelihood Restoration Framework;
- Labour Contractors' Management Plan;
- Labour Camp Management Plan;
- Labour Influx Management Plan;

A **Stakeholder Engagement Plan (SEP)** has been developed and covers a summary of regulations and requirements regarding stakeholder engagement procedures and activities. The SEP also outlines the stakeholder engagement activities that have taken place during the EIA process and what kinds of issues were raised during these activities. The SEP furthermore identifies and analyses the key stakeholders, lists the responsibilities and presents an approach and schedule for the construction and operation of the project.

The project activities covered as part of this draft EIA will lead to economic displacement of fishermen community in the project area this include a small portion of the fishermen during the construction phase (three years) and initial operations phase (another three years) of the project. Prior to construction phase, a **Livelihood Restoration Framework (LRF)** (especially for project affected mussel collectors at Mulloor and shoresein fishermen at Valiya kadappuram) including displacement mechanism needs to be developed. This needs to be enumerated prior to construction phase. The entitlement framework already prepared as a part of the RAP and EMP will also address the various social impacts and issues. This LRF will establish the goals, principles, structures and procedures that will be followed for mitigating economic displacement impacts of the project. LRF will be developed by the Project developer, in consultations with the State Fisheries Department and the affected stakeholders, to address potential economic displacement. The key guiding principles for the same will be as follows:

- Improve the living conditions of those economically displaced by the project;
- Conduct consultation processes that achieve free, prior, and informed participation;
- Aim to maintain or restore catch per unit of effort or catch per unit of cost;
- Recognize variability in participation rates and inherent variability in resource use intensity;
- Design and implement, in a timely manner, culturally sensitive and economically sustainable income restoration measures;
- Provide measures to livelihood diversification
- Identify and provide special assistance to people who are especially vulnerable to economic displacement impacts; and
- Monitor and evaluate to ensure that livelihood restoration measures are meeting the needs of affected people to identify the need for and implement corrective measures.

The project will create substantial job opportunities as it is expected that approximately 2,000 jobs will be generated during the construction phase of Phase-1. Prior to construction phase to ensure that the local community will benefit from these opportunities, the Project developer should develop a Local Hiring Plan as per the framework suggested in EIA report. This plan will include a demand and supply side analysis to identify the opportunities for employment and provision of services; it will include an outline of the hiring process, an approach and schedule of activities for a supplier development program and outline the roles, responsibilities and implementation of the Plan.

The **Community Development Plan (CDP)** will be developed by the Client in order to enhance living conditions in neighbouring communities. It sets out how investment opportunities are identified, assessed, selected, planned, implemented and supported over the entire lifespan of the Port as a long term commitment. The Community Development Plan explicitly adapts National legal framework with sectoral and cross sectoral regulations.

This Greenfield port project is susceptible to affect communities like fishermen, people involved in tourism (Health/Ayurvedic/Beach resorts) and nearby human settlement in the Nellikunnu and Mulloor beaches; and during later phases Pulinkudi, Azhimala and Chowara beaches. The primary objective of the Grievance Mechanism is to delineate a response mechanism to social concerns and complaints raised due to this project. Port Authority will be responsible for the implementation of this grievance mechanism. Public Relations Officer (PRO) of VISL will organise such meetings once in three months or whenever needed due to special reasons such as an emergency situation in the port.

A **grievance management plan** increases the likelihood of resolving minor disputes quickly, inexpensively, fairly with solution that reasonably satisfies both sides.

9.5.3 Potential Socio-Economic Impacts

9.5.3.1 Land Use

9.5.3.1.1 Impacts

Land will be acquired for road connectivity, back up area, PAF zone, warehouse, etc., out of which 48.16 Ha had already been acquired. This area will be converted to port area.

9.5.3.1.2 Mitigation Measures

- A comprehensive area development plan will be developed.
- The existing fishing harbour will be properly developed and integrated into the port infrastructure that has the potential to improve the quality of land use in the fishing harbour.

9.5.3.2 Employment

9.5.3.2.1 Impacts

Construction Phase: The construction of the breakwater and terminals will create about 2000 numbers employment opportunities, out of which 50% is recommended to be reserved for the local inhabitants (based on the availability of people) and can result in an increased level of the quality of life for those employed by the project. Indirect effects of increased employment and associated rise in quality of life, relate to increased sales in local shops. About 20% of the workers in the construction phase will be skilled and the rest will be unskilled.

During this phase approximately 750 people will be employed indirectly besides the 1000 local people as described above; for breakwater construction. Depending upon the available local skilled and unskilled workers, local people will be given priority. Further, indirect employment opportunities in loading, unloading, transportation etc. will be generated during the operational phase of the project.

As a part of best practice VISL will ensure a special mechanism to provide Personnel Protective Equipments (PPE) and also to improve the labour related resource supplies and qualities to intentional standards and best practices. All contractor payment related to Labour camp, PPE and resource supplies will be on a monthly basis based on the quality of such services actually implemented. A special budgetary provision will be earmarked for this activity.

Operation Phase: There will be positive impacts during the operation phase by direct and indirect employment. Direct employment will be in port and port related infrastructure and indirect employment will be in the induced development related infrastructure.

9.5.3.2.2 Mitigation Measures

- All loss of employment during the land acquisition and construction phase will be appropriately compensated.
- There will be numerous employment opportunities opened due to the CSR provisions like seafood/agriculture Food Park, skill development centers, etc.

9.5.3.3 Livelihood

9.5.3.3.1 Impacts

9.5.3.3.1.1 Fishing

Construction Phase: The following potential impacts are envisaged during the construction phase of the project:

- Restriction to fishing activities in the marine areas up to approximately 1500 m from the shorelines of Nellikunnu and Mulloor (Phase-1).
- Restriction to direct fish landing on the aforementioned beaches.
- Reduction in the availability of fishing resources due to increase in turbidity, which might result in decrease in catch; and

Operation Phase: The potential impacts during operation phase are listed below:

- Permanent loss of beaches and fishing ground at Mulloor;
- Loss of income;
- New longer route of access to the fishing harbour from the villages located south of the breakwater during monsoon season

9.5.3.3.1.2 Tourism and Tourist Resorts

Construction Phase: The potential impacts during construction phase are

- Loss of public beaches of Nellikunnu and Mulloor,
- Increased noise and air pollution.

- Transportation of quarry materials in barges, if done closer to the shore may have a visual impact on the serenity and aesthetics of the near shore area.
- Resorts located adjacent to the backup areas will be affected.

__Operation Phase__: The cruise terminal (the first in Kerala, in fact the first in India) will also attract tourists. Therefore, it is expected that there may be a paradigm shift in the local tourism business.

- There will be visual impacts to the tourists, especially foreigners
- Air and light pollution
- Resorts located adjacent to the backup areas will be affected

9.5.3.3.2 Mitigation Measures

9.5.3.3.2.1 Fishing

- A new fishing harbour is part of the proposed port infrastructure that could double the capacity of the existing fishing harbour.
- A new breakwater will be constructed to improve the tranquillity in the new and old fishing harbours that could reduce the siltation also.
- The improvement to the existing fishing harbour while integrating into the port infrastructure. New facilities for fish drying processing will improve the livelihood.
- Mussel collectors who lose employment will be compensated appropriately.

9.5.3.3.2.2 Tourism and Tourist Resorts

- A cruise terminal is proposed in the Phase-1 itself to improve the tourism inflow in the region and the country.
- Ancillary facilities for the cruise terminal and the cruise operators will also improve the economy of the region
- The improved tourism infrastructure will enhance the tourism sectoral opportunities of the Thiruvanathapuram-Kochi-Thoothukudi tourist circuit that includes Kanyakumari also.
- Resorts impacted will be appropriately compensated as per the regulations.

9.5.3.4 **Existing Infrastructural Facilities**

9.5.3.4.1 Impacts

__Construction and Operation:__ A port like Vizhinjam port will need road and railway infrastructure to connect it with its hinterland and transport goods to and from the port area. During the construction and operation phases materials (needed for the construction of the port) and various goods and cargo (transported during the operation phase) will not only arrive from the sea, but also via the road and rail network. The current capacity of the road network is already stretched to its maximum on some locations and will be further impacted upon by the construction and operation of the port. The construction and operation activities could put a pressure on the local water resources such as groundwater if tapped. This will increase the production of solid and liquid waste leading to losses (natural landscape beauty) with regards to tourism if not mitigated properly.

Project will not tap on groundwater for any activities including for construction camps and labour camps. The entire requirement will be met from the Vellayani lake water supplies. During operational phase Rainwater harvesting in huge reservoirs towards Mulloor beach will ensure good water supplies during lean period.

9.5.3.4.2 Mitigation Measures

- As a part of development and integration of the existing fishing harbour, the quality of fishing infrastructure in the region will be improved.
- The road and rail connectivity, warehousing and development in the backup areas together with the port will be a major infrastructure facility added to the National development. This is particularly important due to the addition of defence facilities like defence berth and coast guard berth.
- Additionally the cruise facilities will be a major infrastructure improvement to the region.

9.5.3.5 Community Cohesion

9.5.3.5.1 Impacts and Mitigation Measures

Construction and Operation: Social competition could occur due to disparity between already educated local residents, who will be able to en-cash this opportunity arising out of the port development and resident dependent on the traditional profession like fishing and allied activities.

9.5.3.6 Cultural Heritage

9.5.3.6.1 Impacts and Mitigation Measures

Construction and Operation: Impacts on cultural heritage are expected to include disturbance of religious rituals and decreased access to cultural heritage sites. The first impact will mainly relate to Mulloor beach where the Hindu ritual Vavu Bali is carried out annually and this beach will be converted into port area. Since Vavu Bali ritual is not location specific this activity will be shifted to Adimalathura region or to other areas based on the individuals choices. This impact will be felt during the first phases of operation only.

Shiva temples in Mulloor and Azhimala are located in the shadow area of the proposed project layout. Both of them are located on cliffs. Impact like damage to these structures is not envisaged during construction and operation phases. Proper access to these cultural building and properties are part of the mitigation strategy.

9.5.3.7 Occupational Health and Safety

9.5.3.7.1 Impacts

Construction and Operation: Workers are exposed to various hazards during construction of the proposed project. Emissions of dust and other air pollutants form respiratory hazards. The construction noise is a hazard too. Physical hazards are formed by the construction in general, the use of (heavy) machinery and vehicles, cargo handling, unplanned fire and explosions, uncontrolled chemical incidents, confined spaces, exposure to (in)organic dust, etc. This could lead to injuries or even death. Hazards increase when exposure endures over a longer period of time. Proper safety management plans drafted by the contractors are therefore essential.

9.5.3.7.2 Mitigation Measures

Construction Phase: The general EHS Guidelines are applicable here and should be incorporated in an Occupational Health and Safety Management Plan. Preventive and protective measures should be introduced according to the following order of priority: eliminating the hazard by removing the activity from the work process, controlling the hazard at its source, minimizing the hazard through design of safe work systems and administrative or institutional control measures and providing appropriate personal protective equipment (PPE) together with training.

All safety measures will be undertaken that include provision for Personnel Protective Equipment (PPE) for all the labourers working at various project sites. In order to ensure its implementation, VISL is planning to include this activity as a separate itemised budget in the contract provisions.

During construction activities safety measures can be implemented that prevent accidents with people and vehicles/machinery (for example: one way streets or safety nets to avoid people from falling between ship and quay), accidents due to ill constructions (adequate strength, hole and crack free, etc.), accidents due to ill modes of operation (for instance loading cargo above people/traffic or workers near trimming machines in operation), accidents due to ill handling of machineries or ill signing and marking.

Operational Phase: The general EHS Guidelines are applicable here and should be incorporated in an Occupational Health and Safety Management Plan. Preventive and protective measures should be introduced according to the following order of priority: eliminating the hazard by removing the activity from the work process, controlling the hazard at its source, minimizing the hazard through design of safe work systems and administrative or institutional control measures and providing appropriate personal protective equipment (PPE) together with training.

During general port operation and maintenance activities safety measures can be implemented that prevent accidents with people and vehicles/machinery (for example: one way streets or safety nets to avoid people from falling between ship and quay), accidents due to ill constructions (adequate strength, hole and crack free, etc.), accidents due to ill modes of operation (for instance loading cargo above people/traffic or workers near trimming machines in operation), accidents due to ill handling of machineries or ill signing and marking. A fire response plan supported by the necessary resources and training is thereby important as well.

9.5.3.8 Community Health and Safety

9.5.3.8.1 Impacts

Construction Phase: The health and safety of the nearby communities is endangered by most of the above described potential impacts, namely: land instability (of the reclamation and at the quarries), water related problems, unsafe situations (also due to uncontrolled access to construction/quarry sites), improper decommissioning of the quarry (leading to physical failures), exposure to water-associated diseases, exposure to increased traffic (mainly transport from and to quarry and directly around the port, increased susceptibility to landslides or collapse that are caused by uncontrolled disposal of spoil-materials (predominantly at the quarries), water ponds or mined land areas (drowning/water-associated diseases), the alteration of surface or groundwater regimes that are used by local communities and lead to a lower water quality and availability, unplanned fire and explosions and uncontrolled and unplanned spills and leakages of oil and chemicals.

Operation Phase: The health and safety of the nearby communities is endangered by most of the above described potential impacts, but mostly to: unsafe situations (also due to uncontrolled access to the port), exposure to increased traffic, unplanned fire and explosions and uncontrolled and unplanned spills and leakages of oil and chemicals.

9.5.3.9 Mitigation Measures

Construction Phase: To safeguard community health and safety the mitigation measures related to water and air as presented above are applicable here as well. In addition, international life and fire safety standards should be incorporated in the design, a traffic management plan (also including transport from and to quarries) should be developed and disease prevention measures and an emergency preparedness and response plan should be drafted and implemented by the construction Contractor.

These all can be reduced significantly by well-designed construction activities, installations and infrastructure. Moreover the risks of negative impacts can be reduced by a proper emergency preparedness and response plan where the role of communities and community infrastructure is taken into account.

The latter two can be reduced significantly by well-designed operation activities, installations and infrastructure. Moreover the risks of negative impacts can be reduced by a proper emergency preparedness and response plan where the role of communities and community infrastructure is taken into account.

- Investigating means of reducing waste production and using biodegradable materials as much as possible:
- Investigating opportunities for waste recycling initiatives;
- Ensure that adequate reception facilities are provided for visiting vessels and that the onward disposal of the waste is managed to minimize the impact

Operational Phase: To safeguard community health and safety the mitigation measures related to water and air as presented above are applicable here as well. In addition, international life and fire safety standards should be incorporated in the design, emergency preparedness and response plan should be drafted and implemented. Before operation starts the mitigation measures for community health and safety can be listed in more detail in an integral Community Health and Safety Plan that needs to be drafted and executed appropriately.

The improvement of the design in terms of its community health and safety that include:

- Inclusion of significant fish landing facilities, improving current fish landing facilities.
- Addition of the cruise terminal, leading to additional employment and economic growth.
- Modification of the rail access to the site reducing impact on the local population.
- Shifting of the port 80 m south so as to make the gap 300 m to improve tranquillity in the existing fishing port.

Composting: Composting of biodegradable waste is planned along the greenbelt area. Typical design drawings have been prepared. The entire facility will ensure avoidance of contamination to the groundwater thereby avoiding community health issues. More or less the area will be surrounded by lush green vegetation completely sealing from all possible visual impacts.

9.6 Corporate Social Responsibility (CSR)

As a part of the Corporate Social Responsibility (CSR) a water supply scheme has been commissioned recently for the Vizhinjam fishing village. Further a fish landing centre that could be able to double the capacity of the fishing harbour is going to be implemented. This has already been included in the Phase-1 design and a realistic budget estimated.

Planned activities included (but not limited to) in the CSR are the following:

- Seafood park
- Skill development centre for marine port and fisheries sector
- Up-gradation of UP school in Mulloor to a High School
- Refurbishment of infrastructure facilities at Vizhinjam Fishing Harbour to International Standards
- Preparation of a "port city" area development plan to be integrated with Thiruvanathapuram city and Kovalam development plan
- Health clinic and Yoga centre (recreational facilities)
- Two types of Scholarship for meritorious students and poor students

9.6.1 Adoption of Vizhinjam Fishing harbour

As a part of the CSR the consultants strongly recommend VISL and the Government for Kerala (GoK) to adopt the fishing harbour for the proper integration of the old and new establishment to happen without any environmental and social issues. This has the potential to holistically address all fishery sector specific impacts and issues. The master planning of the area with stringent environmental planning component need to be carried out as a priority for the old fishing harbour operation, maintenance and visual integration to other newly constructed infrastructure facilities to happen. Otherwise, the management of this area will be difficult. This alone could address all issues relating to the old fishing harbour.

9.7 Management Action Plans

There are three important components with regards to EMP implementation during all phases of the project these are:

- **Construction Phase Contractor Selection:** Contractors will be selected with proven ability and experience in environmental management and compliances. Specific estimated budget will be included for labour colony and Personal Protective Equipment (PPE). This budget will be separately provided/accounted after acceptable compliances and standards.
- **Instrument/Equipment/Vehicle Procurement and Selection:** One of the main criteria for procurement of machineries equipment and vehicles will be Environmental criteria with regards to energy efficiency and pollution control.
- **Institutional Framework, Capacity Building Training and Logistics**: There will be proper budgetary provision on these entire aspects. For example, a safety/environmental officer who will have to move around the port premises must have vehicles whenever required. There must be sufficient trained staff with good experience and knowledge available to execute EMP with its entirety of spirit and scope.

The Management Action Plans (MAP) encompasses both EMP and RAP to address all issues comprehensively. While RAP is the outcome of Social Impact Assessment (SIA) carried for all components of the port project, the EMP is the outcome of all EIA carried out for all components of the project.

9.7.1 Resettlement Action Plan (RAP)

As a part of mitigation work, VISL has already prepared an RAP. As per this the, following is the entitlement framework prepared. The local communities are highly satisfied with the framework and steps taken for proper compensation of the PAPs.

Table 9.1 Entitlement Matrix for PAPs as per VISL/GoK policy for Vizhinjam Project

Sr. No.	Impact Category	Type of Loss	Unit Considered for Entitlement	Entitlement
1.	Title holders of private property	Loss of land	Project affected/ displaced families	• Land value through negotiated direct purchase • Value of structures (compound wall/shed/basement/well/latrine/tank, etc.) in the property, as fixed by the District level Purchase Committee (DLPC) • Income restoration as per RAP • Income tax deducted at source will be exempted/born by Govt.
2.	Title holders of private property	Loss of residential buildings	Project displaced family	• Land value through negotiated direct purchase • Replacement value of the displaced residential structure as per enhanced PWD schedule of rates (minimum value fixed as 3 Lakhs) • 5 cents of land (resettlement site) free of cost to the owners who surrender land with building, in nearby areas • Hardship allowances which includes livelihood allowance (one time) and rent for 6 months, as fixed by DLPC • Tax exemption for source deduction (for land and structure value)
3.	Title holder of Private Property	Loss of commercial building	PDP	• Land value through negotiated direct purchase • Replacement value of the displaced structure as per enhanced PWD schedule of rates • Hardship allowance as fixed by DLPC • Tax exemption for source deduction (for land and structure value)
4.	Titleholder Trust/ cooperative/ NGO, etc.	Loss of Cultural property/ common property	PDP	• Land value through negotiated direct purchase • Replacement value of the displaced structure
5.	Property/ residence/ building, etc. partially affected	Loss of portion of land/ property (partially affected)	Project Affected Person	• Value of the land acquired through negotiated direct purchase • Compensation for the portion of the structure impacted as per valuation
6.	Partially impacted common property resource	Private/ public ownership	Community	• Enhancement supports to reconstruct and recreate the lost/impacted portion • Provision of approach roads etc • Replacement/reconstruction at project cost in case of religious/cultural properties.
7.	Non titleholder	Loss of land/ residence without pattas/ documents	Encroacher	• No compensation amount for land • Replacement value of the displaced structure as per enhanced PWD schedule of rates (minimum value fixed as 3 Lakhs) • 5 cents of land free of cost, for rehabilitation • Hardship allowance as fixed by DLPC
8.	Non titleholder	Loss of livelihood	Squatter	• Hardship allowance • Skill training if required
9.	Non titleholder	Loss of Livelihood	Employees of displaced shops	• Hardship allowance to employees as fixed by the committee proposed in RAP • Skill training if required
10.	Non title holders	Loss of livelihood	Project Affected Persons	• Hardship allowances as fixed by the committee proposed in RAP • Income restoration programs as per RAP • Skill training if required

9.7.2 Environmental Management Plan (EMP)

For the purpose of operational EMP and decentralized environmental management, the Table 9.2 provides the delineated EMP zones for 10 sectors/zones identified. All operation environmental management aspects of these units will be treated separately.

Table 9.2 Areas/Zones Identified For Decentralised Environmental Management

S No	Identified Homogenous Zones /Sectors	Sector No	Identified Homogenous Zones/Sectors
1.	Old/New Fish landing Centre	6	Rail Connectivity
2.	Backup Areas (four sectors)	7	Port or Marine Side Activities
3.	Entire Road Network of VISL	8	Port Operators Colony
4.	Truck Terminal Area	9	Warehousing Area
5.	Sub-station Area	10	Defence/Coast Guard/Cruise Berth

9.7.3 Contractors EMP

Contractor is to prepare an implementable contractor EMP to address all construction related environmental impacts. This has to be approved by VISL prior to implementation. Environmental monitoring consultant (MoEF/NABL accredited) appointed by VISL for the implementation of EMP will ensure the finalization of an implementable contactors EMP during construction phase. The same environmental consultant will supervise the implementation of the EMP as well. The major activities under the EMP are:

- Labour camp with basic amenities like water, power, sanitation and medical etc
- Dust suppression/pollution control measures
- Personal protective equipment
- Health & safety measures
- Dredge Management Plan
- Quarry Management Plan
- Natural Resource Management Plan
- Transport Management Plan

9.7.4 Corporate Social Responsibility (CSR)

The estimated total project cost for Phase-1 is Rs. 4,110 crores (excluding the land & EMP/CSR costs) out of which 2,833 crores is the expenditure by VISL and the rest by the private operator. About 5% of the VISL expenses amounting to 140 crores is suggested to be set apart under the head of EMP (40 crores) & CSR (100 crores). These budgets exclude the land cost.

Table 9.3 Identified Items under Corporate Social Responsibility

S. No.	Details of activity	Cost Heads of Environment & CSR	Cost (Crores)
1.	Water supply scheme for fishing village already commissioned	Already implemented	7.3

S. No.	Details of activity	Cost Heads of Environment & CSR	Cost (Crores)
2.	New fish landing centre	Properly designed and estimated	16.0
3.	Balance budget for CSR activities	General	76.7
		Total	**100**

9.7.5 Environmental Budget

A budget described cost section has been earmarked for the EMP and Environmental Monitoring Plan to address all environmental management requirements.

- Environmental (terrestrial and marine) monitoring in both construction and operation phase
- Monitoring of Shoreline changes in Vizhinjam coast in both construction and operation phase
- Water & wastewater management
- Solid waste management
- Storm water management
- Tree plantation plan
- Environmental enhancement such as landscaping
- Focused water supply augmentation study in the ten km study area

10 Engineering of Major Civil Works

10.1 General

Preliminary engineering analysis for various civil infrastructures for Phase-1 development has been carried out. This analysis is based on studies described earlier in this report. AECOM are making recommendations based upon information that has been made available to them from these studies; such recommendations are subject to many factors that are beyond the control of AECOM; and AECOM thus make no representations or warranties with respect to such recommendations and disclaim any responsibility for the accuracy of estimates and recommendations.

It should be noted that later design stages by VISL and by the EPC contractor may modify or optimize this engineering analysis along with associated layouts.

The preliminary engineering makes certain assumptions as to the structure types for various port components whereas the contractor may make modifications based on adopted final design, construction methodology and equipment availability.

10.2 Breakwaters

10.2.1 Basic Data for Breakwaters Design

10.2.1.1 Tidal levels

Highest Astronomical Tide (HAT)	+1.20m
Highest High Water Spring (HHWS)	+ 1.01m
Mean Highest High Water (MHHW)	+ 0.84m
Mean Lowest High Water (MLHW)	+ 0.66m
Mean Highest Low Water (MHLW)	+ 0.43m
Mean Lowest Low Water (MLLW)	+ 0.26m
Lowest Low Water Spring (LLWS)	+ 0.08m
Mean Sea Level (MSL)	+ 0.5m

10.2.1.2 Design Water Level

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) is considered to be relatively small. However, the combined probability estimates are hard to predict.

Based on the storm surge studies carried out for the site and as discussed in Section 2.3.2.4.1, a 200 year storm surge/wave setup value is found to be 0.3m. The wave runup predicted by LTR is negligible at the breakwater locations and hence has not been included. For the preliminary design included in this section, the storm surge is used at the highest astronomical tide to arrive at the design water level for the breakwater design, as given below:

Design Water Level = Highest Astronomical Tide + Storm Surge + Expected Sea Level Rise

= +1.2 m CD + 0.3m + 0.8m = +2.3 m CD.

10.2.1.3 Design Wave Conditions

As discussed in Section 7, LTR has studied the design wave heights that can used for various project elements such as breakwater, berths and revetments. For the breakwater design, the design conditions of 1 in 200 years have been considered.

A summary of the predicted wave conditions at various contour levels along the breakwater is provided in the following Table 10.1.

Table 10.1 Extreme Wave Condition at Project Site

Structure	1 in 200 year Return Period	
	Hs (m)	Tp (s)
North Breakwater – Head and trunk (-20m)	4.7	9.9
North Breakwater – Head (-18m)	4.6	9.9
North Breakwater – Head (-14m)	4.2	9.9
North Breakwater – Head (-12m)	3.9	9.9
North Breakwater – Head (-12m to shore)	2.7	9.9
Revetments	2.5	9.9

Source: Report on Design Wave Heights and Water Levels, April 2013, LTR

10.2.1.4 Other Design Assumptions

- Stones up to 6.0T are economically available with density of 2.65 T/m^3;
- The minimum density of concrete armour units will be 2.39 T/m^3;
- Concrete slab with a wave wall will be provided at the crest of the breakwater;
- The normal design life of the breakwater is 100 years;
- The breakwater design is for the environmental event return period of 200 years;
  The breakwater construction will be by end-on dumping method as well as barge dumping. However, there will be no restriction/ limitations of crane for laying armour units.

10.2.2 Crest Elevations and Widths

The primary purpose of the breakwaters at the port is to provide the required tranquility conditions in the manoeuvring areas and berths. The port is not considered to act as a survival port to allow shelter for ships during cyclone. The required minimum crest height of the breakwater is determined by the allowable wave penetration by overtopping during extreme conditions and stability of the rear face of the breakwater.

The crest level has been decided based on limiting the overtopping discharge to 1 lt/m for the 200 year return period event and checked for 0.4 lts/m for the 50 year return period event. This criterion has been adopted as per EurOtop Manual to provide no damage to equipment for the 50 year event and no damage to building structure elements during the 200 year design event. A wave wall of clear height varying from 1m to 1.5m has also been provided. The calculations have been performed using HR Wallingford tools for overtopping discharge.

North Breakwater

S. No	Bed Level	Design Water Depth	Min. Crest Level	Min. Crest Width	50 Year Discharge	200 Year Discharge
	(m)	(m)	(m)	(m)	(lt/s/m)	(lt/s/m)
1.	-12m to shore	14.3	6.0	3.6	0.06	0.3
2.	-12m roundhead	14.3	7.0	4.5	0.07	0.8
3.	-14.0	16.3	6.0	4.5	0.07	0.8
4.	-18.0	20.3	7.5	5.0	0.12	0.8
5.	-20.0	22.3	7.5	5.6	0.12	1.0
6.	-20m roundhead	22.3	7.5	5.6	0.12	1.0

10.2.3 Armour Units

For the armour units following options have been considered:

- Rock as armour layer
- Concrete Armour Units considered
  - TETRAPOD
  - ACCROPODE
  - CORE-LOC
  - XBLOC

Due to greater depths at the proposed breakwaters, concrete armour are primarily used for armour and rock up to 5T is used as secondary armour and smaller filter layers.

The tetrapod have been successfully used as concrete armour layers over the years. These are placed in double layers. The size of the structure and the exposed location lend the breakwater design to the use of single layer concrete armour units on the seaward face. Accropode, Xbloc and Core-loc are the latest concrete armour units, which are placed in single layer at much steeper slopes as compared to the tetrapod. These units allow the use of a revetment slope at 1 vertical to 1.33 horizontal. All three armour units offer similar performance and have similar construction requirements. As a result, breakwaters with these armour units require lower quantity of rock. Further these units have higher stability due to better inter-locking capability as compared to tetrapod resulting in reduced weight of the armour unit. However these units require assessment of very precise design wave conditions at site and have stringent placement requirements.

Accropode have been successfully used in India in Ennore and Gangavaram projects and these have the advantage of ease in placement at greater depths, where heavy armour units are required.

For the proposed port, Accropode armour units have been chosen for the breakwater design. The EPC contractor may substitute these with a suitable alternative that provides similar or better performance. Based on the design wave heights adopted, the size of Accropode armour units were evaluated as described below.

10.2.4 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 200 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 H_s) for 200 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:

Breakwater Portion	K_D values ACCROPODE
Trunk	15
Head	11.5

The breakwater dimensions are based on the calculations above. Various calculations related to sizing of the cross-section are taken from Design Guidance Document for Accropode (2012).

North Breakwater

S. No	Bed Level	Design Water Depth	Calculated ACCROPODE Size
	(m)	(m)	(m^3)
1.	-12m to shore	14.3	1
2.	-12m roundhead	14.3	4
3.	-14.0	16.3	4
4.	-18.0	20.3	5
5.	-20.0	22.3	6
6.	-20m roundhead	22.3	8

The cross sections of the north breakwater at various water depths are presented in **Drawing 12086/DPR/221**. The breakwater design will be further reviewed and optimized during detailed design stage and by physical modeling using flume tests.

10.2.5 Geotechnical Assessment of Breakwater

The seabed level at the breakwaters increases from +1.0m CD near the shore to a maximum of –20.0m CD. The crest level at the maximum depth is about +7.5m CD.

The subsoil at the breakwater locations is loose to medium dense silty sand with shell fragments. The depth of this layer varies from 5m at the north to 21 m along the south of the north breakwater. This layer is underlain immediately by a layer of very dense clayey sand. This layer is underlain with very dense sand with gravels. The subsoil is considered to be suitable for providing the breakwater foundations. An allowance has been used to account for some consolidation of original sea bed material when the initial core is placed. Suitable geotextile material will be provided at the seabed before placing of bedding rock.

10.2.6 Shore Protection Works

Shore protection works will be along the port waterfront covering the south of the container terminal and the stretch parallel to the shore. The reclaimed ground will be protected by providing rubble mound bund on all sides. This reclamation bund will be designed for a design life of 50 years using a 200 year return period event. For shore protection that will be incorporated into the container yard in future phases, similar design methodology may be adopted. The wave modeling discussed in Section 2.3 and Section 7 are used for design of the shore protection works using methodology described in Section 10.1. The waves mentioned in Table 10.1 are used for design. The crest level for the revetment has been arrived considering 10lt/s/m allowable overtopping discharge as per EurOtop Manual for Driving at low speeds for the 200 year event.

The reclamation bund will comprise of quarried rock / stones from a suitable source. Use of dredged sand to form the core of the bund will also be investigated further in the detailed design stages for economy of construction. It will include a geotextile membrane on the rear face to enhance its fill retention properties. The outer face will be protected against wave action with suitable protection. The stones required for the construction of bund could be supplied by local quarry through barges and road trucks similar to breakwater construction.

The shore protection around the southern face of the terminal will need additional protection against waves coming from south. Armour stones will be used in the construction of these shore protection works. Figure 10.1 provides a section for the shore-protection at the south side of the terminal.

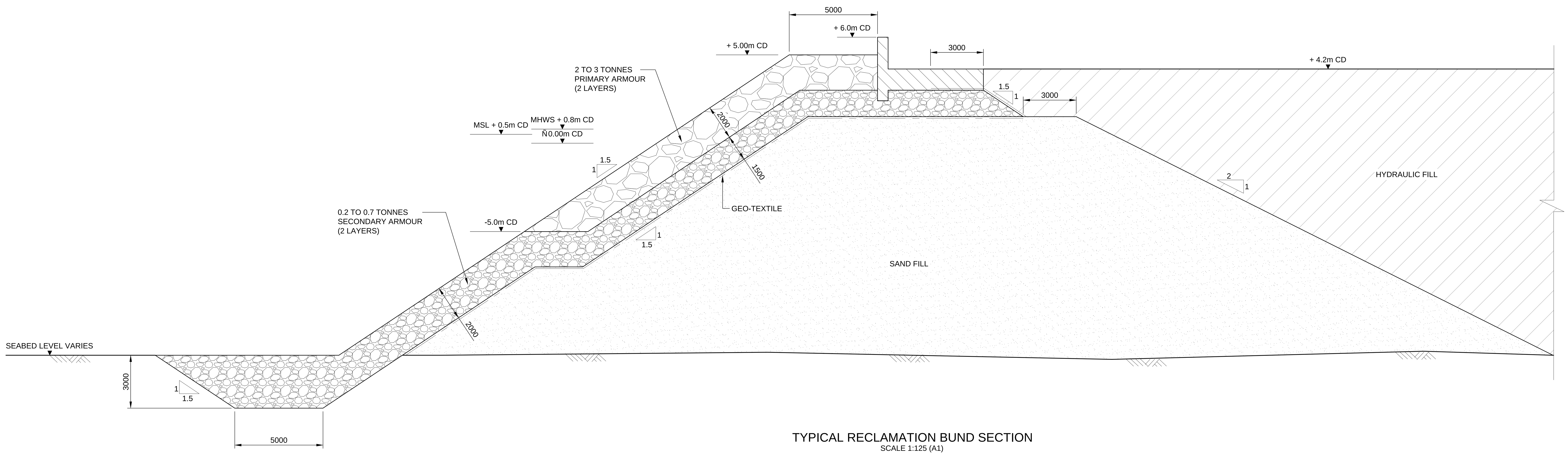
10.2.7 Rock Quarrying and Transportation

The viable option for rock quarrying and transportation which is socially acceptable, environmentally benign and technically feasible is transportation of rocks to the site through barges. The potential quarry areas which have been zeroed in are Kolachal fishing harbour in Tamil Nadu (about 36 Km (via sea) south of Vizhinjam) and Muthalappozhi fishing harbour (about 36 km (via sea) north of Vizhinjam).

The quarry sites selected shown in Figure 10.2 are below:

- Thottiyodu/ Theviyodu Quarry site at Kaduvathopu, around 8 km from NH 47 at Thackalay (Tamil Nadu) (about 13.5 km by road to Kolachal fishing harbour)
- Velimudi quarry site (near Nooral Islam University Engineering College) around 4 Km from NH 47 at Thackalay (Tamil Nadu) (about 15 km by road to Kolachal fishing harbour)
- Kadavala quarry site, around 5km from NH 47 at Attingal (Kerala) (about 20 Km by road to Muthalapozhi fishing harbour)
- Vellaloor quarry site, around 8 km from NH 47 from Attingal (Kerala) on NH 47 (about 25 Km by road to Muthalapozhi fishing harbour)

The transportation operation will involve development of roads from quarry to temporary barge loading facility at either the Kolachal fishing harbour or the Muthalapozhi fishing harbour. The contractor will also need to construct a temporary barge unloading facility at the project site.



TYPICAL RECLAMATION BUND SECTION
SCALE 1:125 (A1)

NOTES:

1 ALL LEVELS ARE IN METERS AND WITH RESPECT TO CHART DATUM.

2 ALL DIMENSIONS ARE IN MILLIMETERS.

NOT FOR CONSTRUCTION

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

TYPICAL RECLAMATION BUND CROSS SECTION

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 03-05-13

FIGURE No. : 10.1 REV 1

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

Last saved by: KUMARD3(2013-05-24) Last Plotted: 2013-05-24
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Figure 10.2 Selected Quarry Sites

The final selection of quarry will depend on the EPC contractor. Figure 10.3 describes the transportation process assumed for rock required for breakwater and shore protection construction.

Figure 10.3 Transportation from Quarry Site

Some localized 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 truck.

10.3 Berthing Facilities

10.3.1 General

10.3.1.1 Location and Orientation of Berths

The Phase-1 development of Vizhinjam port has been planned with major development of two continuous container berths of 800m quay length, a coast guard berth, Indian Navy berths, cruise berth, berthing facility for tugs and port crafts and fishery berths. Container berths have been planned in North-West to South-East direction parallel to shore line. Berthing line is oriented at an angle of 140° N.

10.3.1.2 Deck Elevation

The maximum wave height expected at the berths under design conditions have been taken from the LTR design wave height report. The deck of the berths should be high enough to prevent the wave slamming underneath during extreme weather conditions. Sea level is currently rising and is expected to continue rising during 21st century. This would mean about 0.2m increase in sea levels over life of the structures (50 years). Therefore the deck elevation has been fixed based on the following considerations:

Highest High Water Springs (HHWS)	1.01	m CD
Add for Wave Crest Height (0.6 *Design wave)	0.95	m
Add for Storm Surge/Wind Setup	0.3	m
Clearance for Sea level rise (50 Yr)	0.2	m
Clear freeboard allowance	0.25	m
Add for Deck Thickness	1.5	m
Total	**4.21**	**m CD**

It is therefore proposed to keep the deck elevation at +4.20 m CD. However, this may change as a result of studies during the detailed design stage.

10.3.2 Design Criteria

10.3.2.1 Design Ships and Dredged Levels

The structural design of the berths shall be carried out for the design dredged level in the ultimate stage based on the design vessel sizes to be handled at these berths:

Table 10.2 Design Ships and Dredged Levels at Various Berths

S. No.	Vessel Type	Design Vessel Size	Design Vessel Dimensions (m)			Minimum Designed Dredged Level at Berth
		(DWT)	LOA	Beam	Loaded Draft	(m w.r.t. CD)
1.	Container Vessel	165,000 (18,000 TEU)	400	59	16.0	-18.4
2.	Port Craft /Coast Guard Crafts	1,500	30	9	2.5	Natural Depth
3.	Indian Navy	6,000#	175	32	8.0	Natural Depth
4.	Cruise cum Multipurpose	70,000	268	32	8.0	Natural Depth

Size of the ship considered is the estimated one

10.3.2.2 Geotechnical Criteria

The brief description of the existing geotechnical information at site has been provided in Section 0 of this report. Preliminary design of the berths has been carried out considering relevant subsoil profiles at the location of berths.

The following safety factors are used to establish the safe geotechnical working load capacities of the piles.

Table 10.3 Adopted Values for Factor of Safety for Piles

End Bearing	SF = 3.0
Skin Friction on compression piles	SF = 3.0
Skin Friction on tension piles	SF = 4.0
Lateral Load	SF = 3.0

The design pile penetration depths would be estimated based on the generalised soil profile in order to develop adequate capacity to resist the maximum computed axial bearing and pull out loads, if any. In the present case the piles will mainly be end bearing onto rock.

10.3.2.3 Design Loads

10.3.2.3.1 Dead Loads

It comprises the self weight of the structure plus superimposed loads of permanent nature are considered as per IS: 875 (Part-I) 1987.

10.3.2.3.2 Live Loads

Uniformly distributed load of 5 T/m^2 have been considered for container berths on the deck and also on the fill behind.

10.3.2.3.3 Vehicle and Crane Loads

The following loads are considered on various berths:

Load Type	Container Berth	Cruise cum Multipurpose Berth	Port Craft and Coast Guard Berth	Navy Berth
Live Load	5.00 T/m^2 UDL OR Single lane of IRC class AA Vehicle OR Loads due to quay cranes, whichever is critical	5 T/m^2 OR Single lane of IRC class AA vehicle, whichever is critical	2 T/m^2 OR Single lane of IRC class AA vehicle, whichever is critical	5 T/m^2 OR Single lane of IRC class AA vehicle, OR Loads due to quay cranes, whichever is critical

10.3.2.3.4 Seismic Loads

The seismic loads on the structures are computed in accordance with the seismic code of India IS: 1893-2002. Vizhinjam falls under Zone III as per seismic map of India with the following factors:

Zone factor	0.16
Important factor (I)	1.5
Response reduction factor (R)	3

The seismic horizontal coefficient shall be determined in accordance with IS1893.

10.3.2.3.5 Wind Loads

As per IS Code 875 – Part 3: Code of Practice for Design Load (Other Than Earthquake) for Buildings and Structures for calculating the wind loads on the structures a design wind speed of 43.5m/s has been used as per the Indian standards.

However, during design studies the wind pressure shall be determined from the design wind speed in accordance with BS 6399 Part 2:1997.

10.3.2.3.6 Current Loads

The current loads on the structure have been applied on the submerged parts of the structure assuming the maximum current velocity as 1.5m/s. The current load shall be determined in accordance with BS 6349 Part 1, Section 5.

10.3.2.3.7 Wave Loads

A design wave height of 1.6 m will be considered for the container berths. These are the maximum wave heights that could be expected at these berth locations under the extreme conditions.

10.3.2.3.8 Mooring Loads

As per IS 4651: Part III, the bollard pull of 200 T at each bollard location will be considered for the design of the container berths. In the design stage, the capacity of bollards shall be determined in accordance with BS 6349 from the mooring loads generated by the design maximum vessel when in ballast and at full displacement under the combined action of the maximum current flow, the operational wave conditions at the berth and the design wind conditions.

10.3.2.3.9 Berthing Loads

Berthing Energy

Based on the design ships to be handled at various berths, the approach velocity perpendicular to the berths has been assessed based on the design vessel size under favourable conditions at an angular approach of 10°. Based on this the design berthing energy for various design ships has been worked out.

Fender System

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.

It is required to provide a suitable fender system, not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure below the limit of 20 T/m^2. PIANC suggests abnormal impact safety factors be applied to the design (normal) energy. Accordingly, it is recommended to design for 150% of normal berthing energy so as to prevent the damage to the fenders and the ship's hull. Based on these criteria the suitable fendering system has been proposed at the different berths.

10.3.2.3.10 Fender Reaction (berthing force)

Corresponding to the energy to be absorbed and the fender selected, the design reaction force has been worked out based on the standard fender design catalogues.

The berthing energy, fender selection and the berthing force applied at the container berths is given in the following table:

Components	Container Berths	Cruise cum Multipurpose Berth	Port Craft	Coast Guard / Navy Berth
Berthing Energy	210 Tm	55Tm	8 Tm	14 Tm
Fender	Bridgestone Cell Type Fenders SUC 2000H (RS grade) or equivalent	Bridgestone Dyna Arch Type Fenders DA - A600H or equivalent	Bridgestone Dyna Arch Type Fenders DA – A400H or equivalent	Bridgestone Dyna Arch Type Fenders DA - A600H or equivalent
Berthing Reaction	284T	226T	65T	129T

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.

10.3.2.3.11 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4): 1989 have been applied on the different components of the berths.

10.3.2.3.12 Materials and Material Grades

Concrete of grade M 40/50 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

10.3.3 Options of Berth Structure

The port facilities are proposed on reclamation area. Considering this aspect and also the requirements of keeping the berth structure contiguous to the shore, two alternative structures were considered.

10.3.3.1 Alternative I: Berth Supported on Piles with a Protected Slope Underneath and a Block Wall at the Rear

In this alternative it is considered to provide the deck structure on the piled foundation. A stable slope of 1.5 H: 1 V from the design dredged level at the berth face to the rear end is provided. The width of the apron in this case is considered as 42 m. A retaining wall of suitable height would be provided in the rear end to make the structure contiguous. It is proposed to provide bored cast-in-situ piles for reasons of economy.

The berth face is dredged only after the piles are tied by grid beams but before the construction of the deck, the opening for which is utilized for trimming of the slope underneath. Once the design slope and slope protection is formed, the deck is cast.

10.3.3.2 Alternative II: Block Wall at Front

In this type of structure, the face of the berth will be a continuous block wall comprised of massive pre-cast concrete blocks. The quay apron comprises a hard stand pavement. The dredging is carried out once the wall is built. These block wall structures are often constructed at sites where they can be founded on rock or very dense sands at or just below dredge level.

10.3.3.3 Alternative III: Sheet pile Wall at Front with Tie backs

In this type of structure, the face of the berth will be a continuous sheet pile wall with king piles. The quay apron comprises a hard stand pavement. The sheet pile is tied back to a concrete deadman.

10.3.3.4 Preferred Alternative

All of the alternatives mentioned above are technically feasible for the construction of the berths. The choice depends primarily upon the construction time and costs. Considering the site conditions and design parameters of the berth Alternative I with retaining wall at rear seems to be most appropriate.

Sheetpile Wall has the following drawbacks:

- In Indian conditions, sheet pile wall will be susceptible to large corrosion and will have to be over-designed. They would also result in high maintenance costs.

Block wall berthing structures have the following technical drawbacks:

- The review of geotechnical data shows that the top layer (including founding level of -18mCD) of existing sea bed only has a average N value of 15, which is not suitable for founding a 22m high block work wall. The hard stratum is only available at -22m CD. To found the block work at -22m CD we will need to dredge additional 5m depth at foundation trench and fill that volume by rubbles/stones.
- Avoidance of construction work that must be carried out underwater is an important goal in modern berth design. Emphasis is placed on the application of construction method that allow as much work as possible to be carried out from a position above water, thus keeping the amount of diving at a minimum. Pile structures are ideal in this respect.
- In India all container berths are built as an open pile (bored cast in situ) structure and the local contractors are highly experienced in this type of construction. The equipment required for block work berth construction will need to be transported from outside the country and hence require high transportation and installation cost.
- The current berth line will need to be expanded going into the Master Plan development. With block work wall, It is difficult and will involve high construction risk with need to dredge foundation trench close to existing block work berth. It is not impossible but the operations will need to be suspended for the duration.

In view of all of the above, pile supported deck structures have been recommended. The contractor may explore some of these or other alternatives to arrive at a technically and economically superior option during detail design.

10.3.4 Container Berths

Basic engineering of the proposed scheme was carried out based on the design criteria established above. The proposed scheme consists of five rows of bored cast-in-situ piles, spaced at 7.0 m c/c in the longitudinal direction. Cost is provided by considering rock bund below the container berths over a stable slope.

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 and last rows of piles, are designed for the quay crane loads. A 400mm thick deck slab will be provided supported over the intermittent longitudinal beams. A 75mm thick wearing coat will be provided over the RCC deck slab.

Bollards and rubber fenders will be provided @ 21m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities. The total length of the quay provided is 800 m.

Drawing 12086/DPR/231 presents the structural arrangement and cross-section of the container berths.

10.3.5 Coast Guard and Navy Berth

The navy berth of 200m proposed at the junction of the northern bund of the reclamation area of the container terminal and the coast guard berth of 120m located adjacent to the navy berth consists of four rows of vertical bored cast-in-situ piles of 0.75m diameter, spaced at 6m c/c in the longitudinal direction. A 250 mm thick deck slab will be provided supported over the intermediate longitudinal beams and stone pitching would be provided over a stable slope below the berth. The 300m navy berth proposed along the lee side of the north breakwater south of the proposed turning circle consists of five rows of vertical bored cast-in-situ piles of 0.75m diameter, spaced at 6m c/c in the longitudinal direction. A 250 mm thick deck slab will be provided supported over the intermediate longitudinal beams and stone pitching would be provided over a stable slope below the berth.

The required berth furniture will be provided along the berthing face and service trench would be provided on the berthing side to accommodate cables/utilities.

Drawing 12086/DPR/233 presents the structural arrangement and cross-section of the Navy/Coast Guard berth along the north side of the container terminal. **Drawing 12086/DPR/234** presents the structural arrangement and cross-section of the 300m Navy berth along the south side of the port.

10.3.6 Port Crafts Berth

The port craft berth of 100m would be built on the leeside of the north breakwater adjacent to the coast guard berth. They will have the same structural arrangement as the Coast Guard and Navy berths. The berth fixtures like fenders, bollards, mooring rings, stairs/ladder etc would be provided within this length.

Drawing 12086/DPR/233 presents the structural arrangement and cross-section of the Port Crafts Berth.

10.3.7 Cruise cum Multipurpose Berth

For the above established design criteria, the proposed berth consists of four rows of vertical bored cast-in-situ piles of 1.2m diameter, spaced at 7.5m c/c in the longitudinal direction.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. A 300 mm thick deck slab will be provided supported over the intermediate longitudinal beams. Stone pitching would be provided over a stable slope below the berth.

Bollards and rubber fenders will be provided @ 15 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities. The provision for crane rails is provided at a spacing of 15m c/c for cargo handling through mobile harbour cranes if the cargo attains the desirable throughput in the near future.

Drawing 12086/DPR/235 presents the structural arrangement and cross-section of the cruise cum multipurpose berth.

10.3.8 **Fishery Berth**

The fishery berths will be built along the seaward side of the proposed north breakwater after the breakwater extension. It is estimated that around 500m berth length will be provided. The berth structure consists of 12m wide pile supported deck along an 8m wide road formed over the breakwater. The berth consists of three rows of vertical bored cast-in-situ piles of 0.45m diameter, spaced at 5m c/c in the longitudinal direction. A 200 mm thick deck slab will be provided supported over the intermediate longitudinal beams and stone pitching would be provided over a stable slope below the berth. **Drawing 12086/DPR/236** presents the structural arrangement and cross-section of the Fish Landing Berths.

A typical cross-section of the rail bridge crossing over the fish landing berth road is shown in **Drawing 12086/DPR/237**.

10.4 Dredging and Reclamation

10.4.1 Capital Dredging

Dredging and reclamation is one of the major costing parameter for any port project. The proposed port site is characterized by naturally available deep water depths with 20m contour located at a distance of less than 800m from the shore. This substantially reduces the dredging cost and hence enabling the port to provide berthing ability for the largest container vessels (up to 18,000 TEU). The port intends to utilize reclaimed land for most of the onshore port facilities. The dredging operations are expected to meet most of the demand for reclamation material.

Based on the navigational requirements, **Drawing 12086/DPR/241** depicts the various dredging and reclamation areas for the proposed port. Table 10.4 provides the various dredge depths and the calculated dredging volumes. The volumes have been calculated based on the bathymetry information of the site explained earlier in Section 2 and the required navigational aspects in Table 8.3.

Table 10.4 Dredge Areas for the Vizhinjam Port

S. No.	Dredge Area	Dredge Depth	Dredge Volume
		(wrt CD)	(m^3)
1.	**Approach Channel**	**Outer - 20.8 m** **Inner - 18.4 m**	**3,254,953**
2.	**Turning Circle**	**18.4 m**	**904,300**
3.	**Berths and Harbour Basin**	**18.4 m**	**883,320**
	Total		**5,042,573**

10.4.2 Characteristics of Dredged Material

As explained earlier in Section 2, geotechnical and geophysical investigations along the approach channel and port basin have been conducted.

The geotechnical investigation borehole data at the site reveals that the subsurface generally consists of marine deposited silty sand for the full depth of exploration in the approach channel area while layers of sand and rock were encountered in the terminal area. Rock was not encountered during borehole investigations in the proposed dredged area with exception of rock found at a depth of around -25m CD in front of proposed container berths.

The borehole profiles show that the dredge spoils (except the initial surface material up to the depth of approximately 0.5-1m below the existing seabed) comprise of good quality sand and is suitable for reclamation for the development of the onshore facilities.

However, geophysical survey shows that we may encounter a very dense sand layer beyond depth of -22m CD in the outer approach channel. It is also observed that rock can be expected along the container berth face at around -20m CD to -22m CD. In other areas, very dense sands or weathered rocks are expected to be found at depths at or below -24m CD. The dredge depths proposed for the port are shallower than rock levels and very dense sand layer levels and hence it is not expected to encounter any hard material.

10.4.3 Dredging Methodology

10.4.3.1 General

This method statement is prepared based on the information available at this stage the aim of not to freeze the methodology but to consider possible alternatives and feasibility of the dredging and shall be modified /revised by the specialised dredging contractor to be appointed through EPC tendering process. The final approach has to be developed by the contractors who are experienced and innovative in the field of marine dredging operations.

10.4.3.2 Work Method

The prevailing site conditions and equipment properties dominate the selection of the equipment and work method. The materials to be dredged consist of layers varying from coarse sand to silty clay at the top. Separate dredging of suitable and unsuitable materials will be carried out. The suitable sandy and gravel material will be placed in the reclamation area for container yard construction. The unsuitable material, such as slity clay, will be dredged and discharged to the designated offshore disposal area. Considering the variety of soils (soft and hard) in combination with a limited pumping distance between the dredging- and reclamation areas, the work method utilizes a large Cutter Suction Dredger (CSD).

A large Cutter Suction Dredger will be deployed to dredge the materials and hydraulically transport these to the required reclamation areas. The dredged suitable materials will be pumped ashore by means of a system of onboard dredging pumps in combination with floating, submerged and land lines. The suitable materials will be pumped ashore into the reclamation areas A, B, C & D. All the dredged unsuitable materials will be discharged into a split bottom barge and transported and dumped to the designated offshore disposal area.

The suitable and unsuitable soil layers will be placed in a soil model which will be loaded into the onboard dredge computer. The dredging will take place in several cuts. Based on this plan the dredge master can determine his dredging strategy and synchronize this with the reclamation crew.

10.4.3.3 Dredging by Cutter Suction Dredger (CSD)

The CSD is deployed for dredging and pumping materials directly into the reclamation area. The pipeline may consist of a combination of floating, submerged and shore lines. In this particular situation, the CSD is connected directly to a shore connection point by means of a floating pipelines where required in combination with a submerged line and there off to the reclamation area, by means of a shore pipeline. As the reclamation progresses, the shoreline will be extended. Two different pipeline configurations are schematized in the figure below.

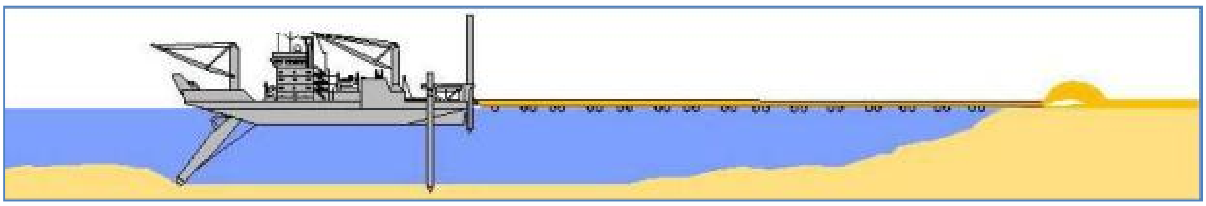


Figure 10.4 CSD Discharging Onshore through Floating Pipe

Figure 10.5 CSD Discharging Onshore through Submerged Pipe

Depending on the layer thickness to be dredged and the characteristic of the materials, the CSD will cut and dredge the material in one and more layers. On an average 0.5m vertical over depth will be dredged by the CSD. The dredging will be carried out by using the box-cut method and slopes will be allowed to fall to natural angle of repose. The example of box-cut cross section is as shown below.

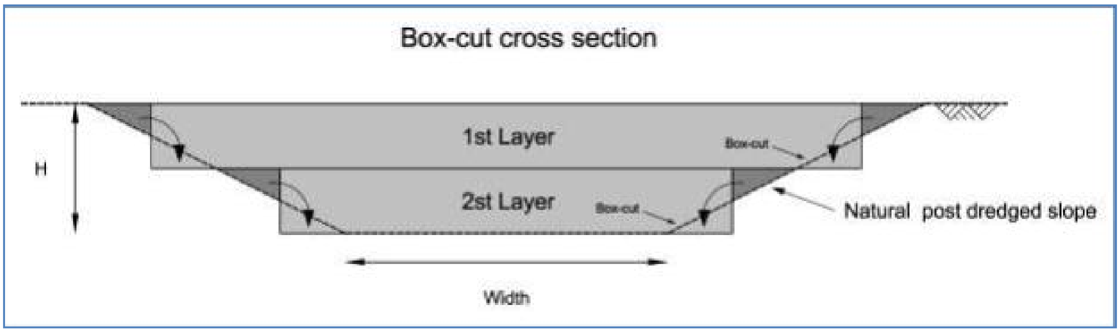


Figure 10.6 Principal of Box Cut Method

10.4.3.4 Reclamation works

It is estimated that around **6.9 million m^3** of material will be required for reclamation. This would require total dredging to be of the order of around **7.6 million m^3**. This additional dredging of around 2.7 million m^3 over the required dredging reported in Table 10.4 may be obtained by over-dredging the navigational channel.

The suitable dredged materials will be discharged by the CSD into one of the reclamation areas.

Prior to commencement of the dredging and reclamation works, land based equipment will be used to install water boxes in between the sea and reclamation bunds (where deemed necessary). Bunds will be constructed around each of the reclamation areas prior to start filling.

Permanent bund will constructed partly by dredged materials and armour stones. The borders/edges (temporary bunds) of the various reclamation areas between A to D are pumped in by using hydraulic filling methods. As a result the reclamation slopes will become natural angle of repose and will be in the order of approximately 1:7 in steepness.

After preparation of the reclamation area, the CSD will be connected to the shore connection point by means of a floating pipeline where required in combination with a submerged line. The shore connection point is installed as close as possible to the reclamation area. From this point, shore pipelines will transport the soil/water mixture to the reclamation area. The layout of the total pipeline trajectory will depend on the location of the shore connection, the local circumstances, the number of earth moving equipment available.

The reclamation areas to be filled in maximum two layers to final fill level (+3.50mCD near the berth increasing to +5.3m CD to the shore). Suitable sub-grade and pavement will be used on top of the fill level for a depth of around 0.70m. Land-based equipment will be used to spread and level the delivered materials. During the progress of the reclamation works the shore pipeline will be extended as the reclamation area is being filled with material and bunds will be raised. A cross-section for the raising of bunds is given below.

Figure 10.7 Typical Cross section of Raising of the Bunds by using Bulldozers/ Excavator

On reaching the design fill level of +3.50m CD, vibrating roller compaction is applied before placing of the surcharge loads (if required). This is in order to reach the required 95 % MDD (Maximum Dry Density) for the top 1.5m of the fill. After a fill area is completed, parts of the shore pipeline can be disconnected and used at the next fill area.

In order to ensure continuity of dredging and reclamation process, the reclamation area is generally laid out in such a way that there are always different discharge points available. The pipeline trajectory is arranged in such a way that switching from the suitable to unsuitable reclamation area can be made quickly by the use of valves system. This will create certain flexibility and provide the ability to respond to external factors.

Figure 10.8 Splitting of shore pipeline to different areas

Figure 10.9 Extension of pipeline at reclamation area

The transport water will be guided through the reclamation area and in order to control the outflow of transport water from the reclamation area, Weir Box (or water boxes) is installed. With Weir boxes, the water level inside the reclamation areas can be controlled by means of changing the elevation of the weir box boards (refer Figure 10.10). By adjusting the weir level, the outflow of fines into the sea can be controlled. As a result, significantly more fines can be retained. A cross section of a weir box is shown below. This will also control the turbidity level of the sea water.

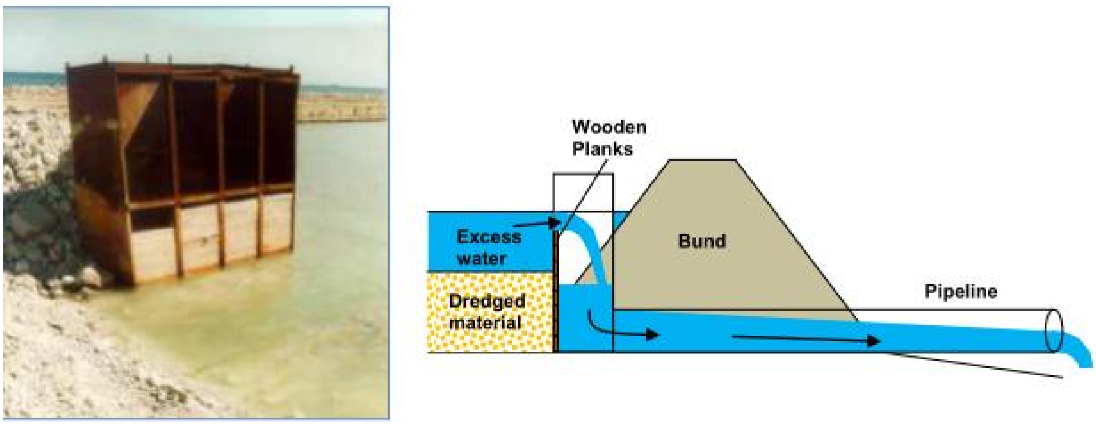


Figure 10.10 Weir box and cross section of Weir box

10.4.4 Work Sequence

The following figures reflect the sequence for execution of the works. It is remarked that the figures are indicative and can be modified based on the contractor's equipments and execution method. The pipeline trajectory or sequence can deviate from the presented figures. Important aspects that can influence the sequence of works are shipping traffic (if any), currents, stratification of suitable and unsuitable materials. (Refer Figure 10.11 for each stage of work sequence)

10.4.4.1 Work Sequence Stage 1

- One of the first activities at the site is to start building the breakwater which will help the dredger to work in adverse weather condition.
- Breakwater will start from the landside and will provide permanent bund for the reclamation area A at the north end.
- Permanent reclamation bunds to be constructed parallel to the berth alignment (north to south).
- Temporary bund will be created by hydraulic fill in between area A & B by land based equipment.
- Dredging will be carried out at the basin and turning circle area as shown in the figure above.
- Dredged material will be pumped to area A through the combination of floating and land based pipeline.

10.4.4.2 Work Sequence Stage 2

- Extension of permanent bund towards south to cover Area B as shown in the figure above.
- Temporary bund will be created by hydraulic fill in between area B & C by land based equipment.
- Dredging will be carried out at the basin and turning circle area as shown in the figure above.
- Dredged material will be pumped to area B through the combination of floating and land based pipeline.
- Ground improvement works will start at Area A

10.4.4.3 Work Sequence Stage 3

- Extension of permanent bund towards south to cover Area C as shown in the figure above.
- Temporary bund will be created by hydraulic fill in between area C & D by land based equipment.
- Dredging will be carried out at the inner approach channel as shown in the figure above.
- Dredged material will be pumped to area C through the combination of floating and land based pipeline.
- Ground improvement works will start at Area B

10.4.4.4 Work Sequence Stage 4

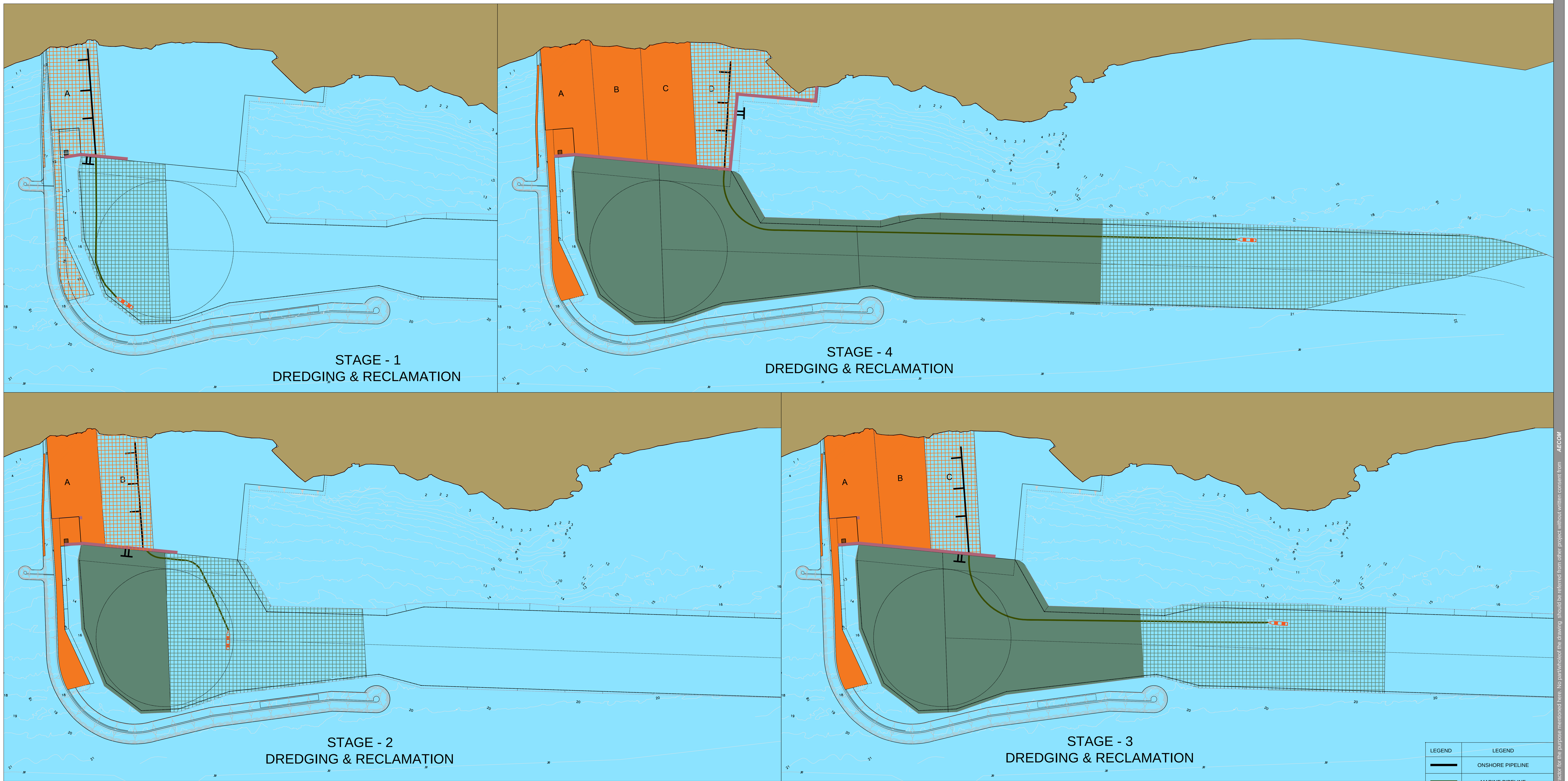
- Extension of permanent bund towards south to cover Area D as shown in the figure above.
- Further extension of permanent bund towards east to connect the land.
- Dredging will be carried out at the outer approach channel as shown in the figure above.
- Dredged material will be pumped to area D through the combination of floating and land based pipeline.
- Booster pumps may be required to pump the dredged material to Area D
- Ground improvement works will start at Area B

10.4.5 Ground Improvement

Ground improvement may be required for the expansion of the container yard in the areas A to D. Several techniques are available for ground improvement, such as:

- Placement of surcharge loads;
- Installation of vertical wick drains,
- Installation of vertical vacuum wick drains;
- Execution of vibro compaction;
- Execution of dynamic compaction;
- Execution of surface compaction, such as Roller compaction.

Based on the reclamation material and time available the contractor will decide the actual method to be used for ground improvement.



LEGEND	LEGEND
	ONSHORE PIPELINE
	MARINE PIPELINE
	WEIR BOX
	DREDGER
	TEMPORARY BUND
	RECLAIMED AREA
	DREDGED AREA
	RECLAMATION AREA
	DREDGING AREA

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

WORK SEQUENCE FOR DREDGING & RECLAMATION

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

AECOM
AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 03-05-13

FIGURE No. : 10.11 REV 1

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

Last saved by: BHANOTV(2013-05-07) Last Plotted: 2013-05-07
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10.4.6 Maintenance Dredging

Based on the mathematical model studies on siltation, the siltation that would be expected in the channel entrance and the harbour basin is negligible.

10.5 Ground Improvements and Foundations

The proposed Phase-1 development will require significant ground improvement in the reclaimed areas as mentioned in above section. The following describes options for stabilization.

10.5.1 Overview of the Options

10.5.1.1 Soil Improvement by Band Drains & Preloading

Improvement of the subsoil properties by installation of band drains, also known as Prefabricated Vertical Drains; which are in essence, vertical drainage channels serving to expedite release of pore pressures developed in the subsoil on account of loading. They are normally installed in a square or triangular grid at a spacing of 1 to 2 m, depending upon the permeability of the subsoil and the time period that can be allowed for strength gain in the subsoil.

Building up a preload can cause consolidation of the subsoil, hence causing gain in strength of the subsoil. The strength gain is a function of the intensity of preload intensity. Usually, this process is employed where the primary requirement is to eliminate potential settlements. The cost of building and removal of preloading is an added cost.

Generally, preloading requires to be done in stages so that the subsoil strength is built up gradually and failure due to rapid loading is avoided. This time needs to be factored into the schedule.

10.5.1.2 Soil Improvement by Stone Columns

Stone Columns are columns formed in the ground using stone aggregates, 75mm & down. Special equipments are required to ensure proper construction. The process is also known as “Vibro Replacement”. While in sandy strata stone columns serve to increase the φ value, in Clays, they impart a “φ” values to the strata on an overall basis, owing to their granular composition.

The ratio of the area of one stone column to its command area is known as “replacement ratio”. The closer the spacing, the higher the replacement ratio and consequently higher improved soil parameters are achieved. Based on the replacement ratio, the improved parameters “C” and “φ” are computed.

Stone columns are installed in a square or a triangular grid. For the same grid spacing, the triangular grid gives a higher replacement ratio.

10.5.1.3 Soil Improvement by Vibro-Compaction

In this method the soil particles are rearranged in to a denser configuration by the use of powerful depth vibrators. By vibro compaction there will be reduction in settlement. This method is more applicable in the strata comprising of silty sand. The reclamation at the port is estimated to be dredge spoils and will consist of silty sand. Thus, Vibro-Compaction will be the preferred method for soil improvement.

10.5.1.4 Shallow Foundations and Piled Foundations

In the event of concentrated loads being applied it is preferable to use the shallow foundations to evenly distribute these loads to the soil strata underneath. However if the bearing capacity of the strata below is inadequate piled foundations would need to be provided.

10.5.2 Container Yard

Since the yard would be developed, by reclaiming the suitable dredged material comprising of, dense sand with shell fragments as well as gravels. In order to consolidate the area surcharge fill would be required. The surcharge is placed in various section of the reclaimed area for consolidation to avoid any liquefaction in conjunction with vibro-compaction. Apart from this no ground improvement would be required for the yard development.

10.5.3 **Port Buildings and Covered Storages**

Most of the port buildings are low rise buildings and it is expected that these can be safely founded on shallow foundation comprising of a combination of strip and isolated footing. However the port operations and administration building would be supported on the piled foundation.

11 Terminal Equipments

11.1 Container Handling System

11.1.1 General

It is important to note that all container moves either begin or end in the container yard. No containers go directly from vessel to rail or from gate to vessel for example. Figure 11.1 shows a schematic of each container flow at Vizhinjam Port.

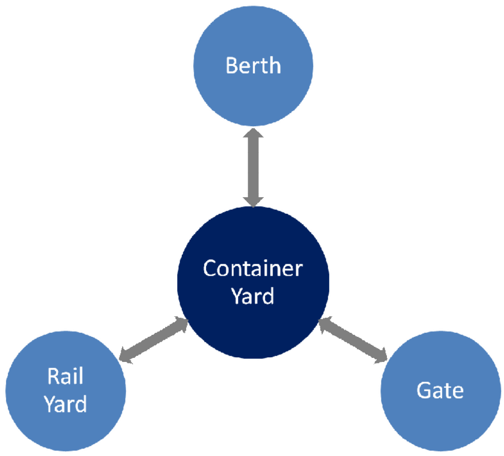


Figure 11.1 Schematic Container Flow Diagram

11.1.2 Container Terminal Operation Strategy

The container terminal will have two container berths with total quay length of 800m, which can cater to a minimum of two container ships at any time. It is proposed to provide 8 Rail Mounted Quay Cranes (RMQCs) on these berths. There would be flexibility of moving the quay cranes to the adjacent berths so that 2 to 5 cranes can be deployed on a ship, depending upon ship size.

As per the best industry practices, it is recommended to provide RMQC: quay crane to RTGC ratio as 1:3. Based on this, it is proposed to provide 24 Rubber Tired Gantry Cranes (RTGCs) for handling in the Container Yard. Two Reach Stackers are provided to handle containers being moved by rails. For handling of Empty Containers, 6 Side Picks are proposed. For movement of containers between quay, container yard and rail yard 55 Internal Transfer Vehicles (ITVs) are provided.

It is to be noted that the actual operation strategy is to be decided by the selected operator who would be operating the terminal. However, the number of equipments is arrived at based on the terminal capacity to cater the projected forecast.

The flow diagram for the container handling system is presented in figures below.

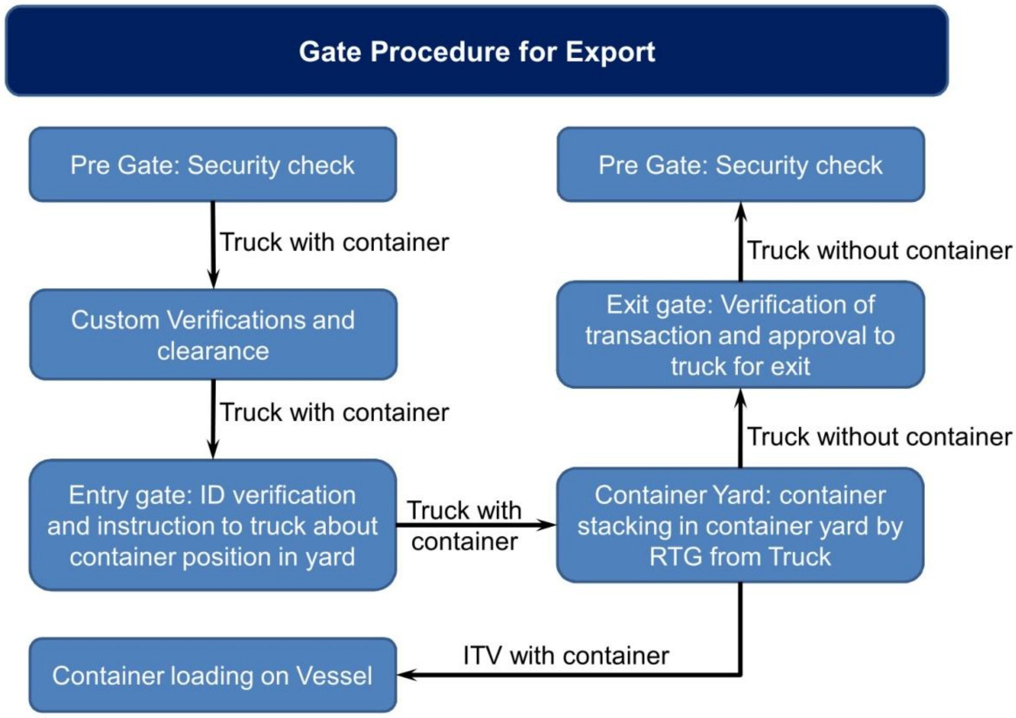


Figure 11.2 Gate Procedure Diagram of Container Export

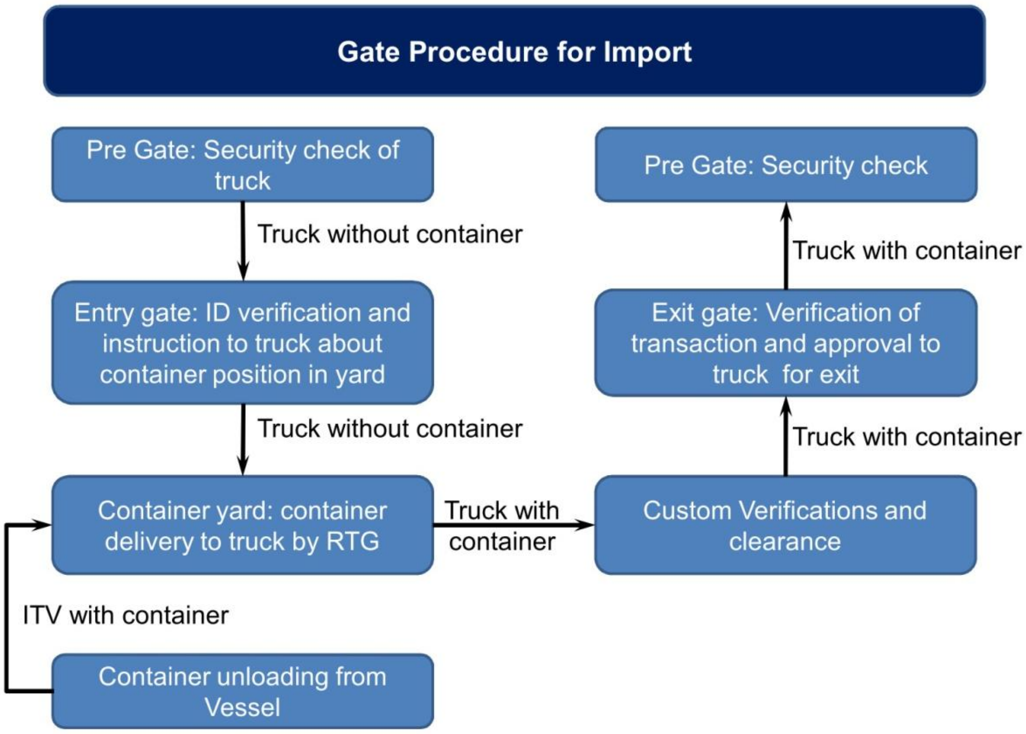


Figure 11.3 Gate Procedure Diagram of Container Export

11.1.3 Storage and Evacuation Strategies for Container Terminal

The container yard is planned based on the transshipment and gateway container forecast, expected dwell time at yard and the storage height of the containers. Considered dwell time for planning perspective is 5 days. As the dwell time decreases, the productivity or container handling capacity of yard increases. The actual dwell time will be based on business strategies of VISL and the Terminal Operator.

The loaded container shall be stored maximum up to four high. The Reefer containers shall have the similar stacking high but stacking arrangement will be different with provision of electricity supply. Empty container storage can go up to seven high depending upon handling equipment. Size, specifications and handling capacity of the equipments will be decided by the operator so the handling patterns may change than the pattern considered in AECOM PRECAP Model for capacity analysis.

11.1.4 Container Yard Operation Strategy

Vizhinjam Port is being developed with a vision of green initiative, it is planned to operate the container yard with (eRTG's) i.e. RTG's run on electric power supply rather than diesel electric power, which are eco-friendly. RTGs can be operated in the yard to handle the containers up to five high and seven wide blocks and it can be moved from one block to other blocks. ITVs would be utilized for transfer of containers between yard, rail yard and the berths.

Separate blocks shall be designated for long standing containers, i.e., containers which are not lifted beyond 60 days should be moved away from the yard for subsequent auction and disposal of the cargo. If necessary these containers can be moved out to another custom bound area where the CFS operations will be undertaken. This will minimize the unproductive moves in the yard.

11.1.5 Handling of Inland Containers Depot (ICD) containers

It is proposed to provide one working rail siding to receive and dispatch ICD containers. Two reach stackers are provided in the rail terminal for loading and unloading the containers from the trains. The containers for dispatch will be planned and pre-stacked to turn around the train faster as per the operators' requirement and also to meet the railway requirement of engine on load concept. To augment the pre-stacking, there will also be a continuous movement of ITVs between container yard and rail yard.

11.1.6 Container Terminal Equipment Planning

11.1.6.1 System Requirements

The majority of container traffic at Vizhinjam port is expected to be transshipment containers with some portion of both import and export traffic. The incoming containers will comprise of:

- Transshipped from mainline mother vessels to feeder line vessels;
- Going to ICDs by rail;
- Going to nearby ICDs or customers' premises by road;
- Going to CFS where they will be de-stuffed and the goods transported by road to consignees' premises.

Similarly outgoing containers will also comprise of units as under:

- Coming from ICDs by rail;
- Coming from nearby ICDs or customers' premises by road;
- Stuffed at the CFS after bringing goods from consignees' premises;
- Transshipped into mainline mother vessels.

The system should be capable of handling all the above types of traffic, including storage and retrieval from storage.

11.1.7 Container Terminal Equipments

11.1.7.1 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 a front 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 11.4.

Figure 11.4 Typical RMQCs Operating at Berth

11.1.7.2 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 11.5 shows an E-RTG in operation.

Figure 11.5 Typical E-RTG for Yard Operation

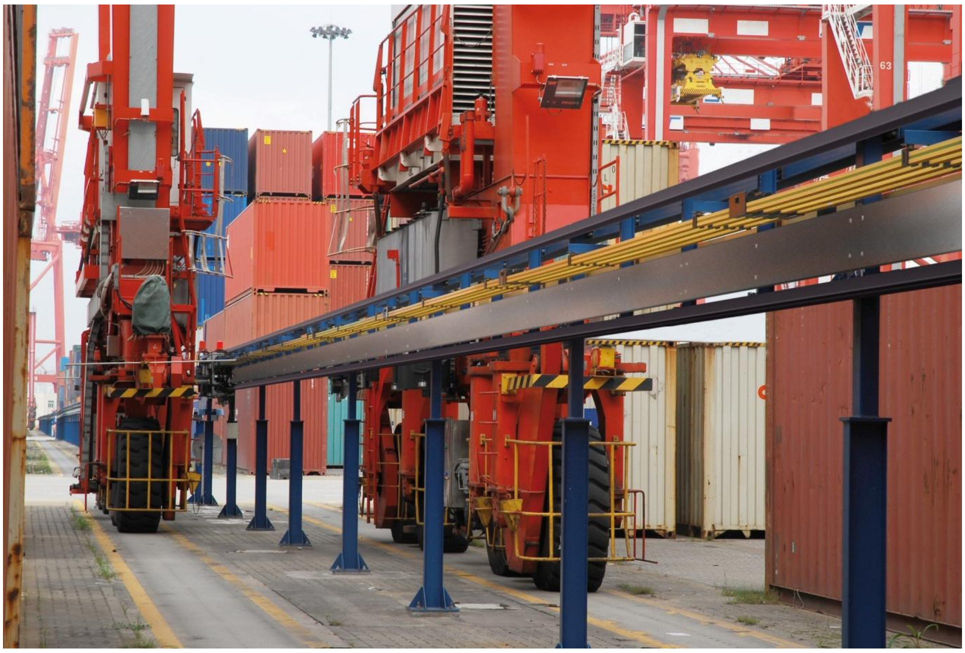


Figure 11.6 Typical Details of Electric Buss Bar Arrangement for E-RTG

11.1.7.3 Reefer Load Container Storage

Refrigerated loaded containers (reefers) are envisioned to be stored at the south end of the middle RTG stack row. 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.

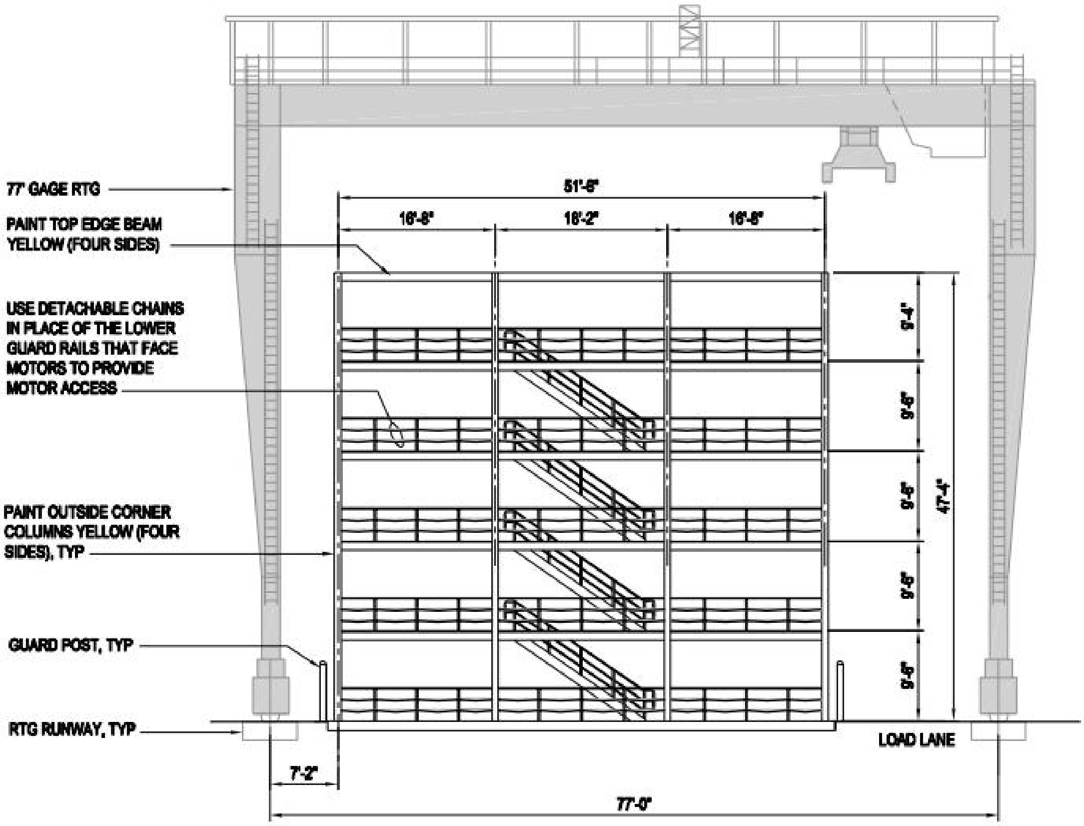


Figure 11.7 Typical Arrangement Details of Reefer Stacks

Figure 11.8 Typical Details of Reefer Stacks

Figure 11.9 Typical Details of Reefer Stacks Operation

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.

Empty reefer containers can be stored in designated areas of the empty storage area and/or the RTG container storage rows.

Empty reefers are plugged in and tested (pre-tripped) to confirm their operating condition. Pre-tripping can be done in the grounded reefer stacks.

11.1.7.4 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.

ECHs may include, at the discretion of the concessionaire:

- Medium-duty forklift trucks;
- Side-pick cranes;
- Top-pick cranes;
- Reach-stacker cranes.

Side-Pick empty container handlers are recommended as the primary equipment for ECH operations. See image below. Should the concessionaire elect to do twin-picking of twenty-foot boxes, a twin-pick reach-stacker can be used in the proposed layout.

Figure 11.10 Snapshot of Typical Side-pick Handling

The dedicated empty storage area is provided at the eastern end of the container terminal between the RTG rows and the container terminal main access road.

ECHs may transport empty containers over short distances to or from the container repair shop or reefer washout area. Containers will be transported between the quay and the empty storage areas by ITVs. Traffic through the ECH storage rows can be either unidirectional or bidirectional based on the preference of the operator.

11.1.7.5 **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 11.11 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.

11.1.7.6 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. The battery operated ITVs are also in practice in place of diesel based ITVs in upcoming terminals developing on green and eco friendly mechanisms.

Figure 11.12 Typical ITV for Handling Containers

ITVs requirement for container handling has been identified as 55 no. for Phase-1 development of Vizhinjam Port. The actual requirement and classification of the ITV procurement will be decided by the awarded terminal operator.

11.1.7.7 Phase-1 Container Terminal Equipment Requirement

Table 11.1 provides a summary of estimated requirements for various container terminal equipments for the Phase-1 associated attributes including quantity and productivity rate. This is just an estimate based on industry practice and general operating procedures. Terminal operator will finally decide on the requirements based on his operational requirements and actual container throughput.

Table 11.1 Estimated Container Terminal Equipment Requirements for Phase-1

S. No	Container Terminal Equipment	Quantity	Productivity
		(no.)	(moves per hour)
1.	Rail Mounted Quay Cranes (RMQC)	8	25
2.	Rubber Tired Gantry Cranes	24	15 to 20
3.	Reach Stackers	2	12
4.	Empty Container Handlers	6	15 to 20
5.	Internal Transfer Vehicles	55	4 to 6

Drawing 12086/DPR/251 shows a cross-section through the container yard.

11.2 Multipurpose Cargo Handling System

The multipurpose cargoes at Vizhinjam port comprise of Fertilizer and FRM, Timber and Raw Cashew. The forecast of these cargoes is not significant that would require a dedicated berth and equipments. These commodities can be handled at container berth using the ship's gears.

The flow diagram for the multipurpose cargo handling system is presented in figure below.

Figure 11.13 Flow Diagram for Multipurpose Cargo Handling System

12 Infrastructure and Port Facilities

12.1 External Rail Connectivity

Vizhinjam Port is situated on the west side of the existing railway line running from Thiruvananthapuram Central Station to Nagercoil junction Station – Kanyakumari of Thiruvananthapuram division of Southern Railway. The Division is having jurisdiction from Thiruvananthapuram to Kanyakumari, Nagercoil and Mallapalayam Halt station in the Southern direction and to Kollam, Kottayam– Ernakulam junction, Vallatol Nagar, Thrissur Guruvayur Kochi Harbour terminus and Kayamkulam junction having a route of 610km.

The main line of broad gauge that passes through Nemom, Neyyatinkara and Balaramapuram railway stations are approximately 10 Km from the Vizhinjam Port location. The broad gauge single rail line is running between Thiruvananthapuram and Kanyakumari. Beyond Thiruvananthapuram towards north, up to Kayamkulam double rail line exists.

Balaramapuram (Flag station) and Neyyatinkara (Block station) are located on the southern side of the proposed rail alignment whereas Nemom (Block station) is on the northern side. These three stations are at a distance of approximately 9km, 13km and 10km respectively from the port boundary. The 'Rail Transport Clearance' (RTC) was granted to Vizhinjam Port by the Ministry of Railways to develop private rail siding from the nearest hauling station to Vizhinjam Port on 'Engine-on-load' (EOL) concept. Subsequently, feasibility study for this rail line was undertaken by VISL for development.

For the development of the sidings for transport of cargos to the port hinterland, couple of alternatives was developed as part of the feasibility study for rail line development and to convert the hauling station to a block station with the necessary upgradation. During the initial stage of the study, RITES suggested the rail through general ground level connecting to Balaramapuram. But the Railway authorities did not approve the alignment citing technical problems for connecting to Balaramapuram.

Later, RVNL was entrusted to study the rail alignment and the probable block station for development. Based on their assessment, rail would be generally running through elevated structures and connecting to Neyyattinkara. Since the route displaces about four temples enroute near Neyyatttinkara, RVNL was advised to study alternate route to Nemom. Accordingly, RVNL in their study proposed that the rail would be running through elevated structures and connecting to Nemom. The proposed alignment of the Rail is shown in **Drawing 12086/DPR/261**.

The rail link to Vizhinjam Port will be a single line with automatic signaling to ensure that the trains can be moved efficiently.

It is estimated that around three trains per day would be calling into the port for the forecasted hinterland traffic for Phase-1 development.

12.1.1 Exchange Yard

Exchange/ Transit yard is the point where trains are exchanged between the main railway line and the port connected line. Facilities for reception and dispatch of trains are arranged here. Block loads of trains or point to point trains are proposed to run to and from the Nemom Station, only a Receipt & Dispatch (R&D) yard is proposed to be provided at the port. Rail line from Nemom to port will be an electrified traction line. Train operation within port boundary will also be of electric traction for arrival and departures.

RVNL has carried out detailed project report for the rail connection from Nemom station to port. Nemom is a block station having 2 main lines. 2 full length siding lines with linkage to the main line at both ends are proposed at Nemom railway station along with a station building to cater to the generated rail traffic by port.

The location and details of exchange yard are as shown in **Drawing 12086/DPR/261**.

12.2 **Internal Rail Links**

12.2.1 **Rail Yard**

In Phase-1, it is proposed to take two electrified loop siding for pull and push operation of rake on a working siding and single working siding for loading/unloading of containers. Train coming to the port will be having locomotive with EOL (Engine on load) and the entire rail operation within port will be carried out by the same locomotive; no separate provision for dedicated locomotive has been considered for rail yard in port.

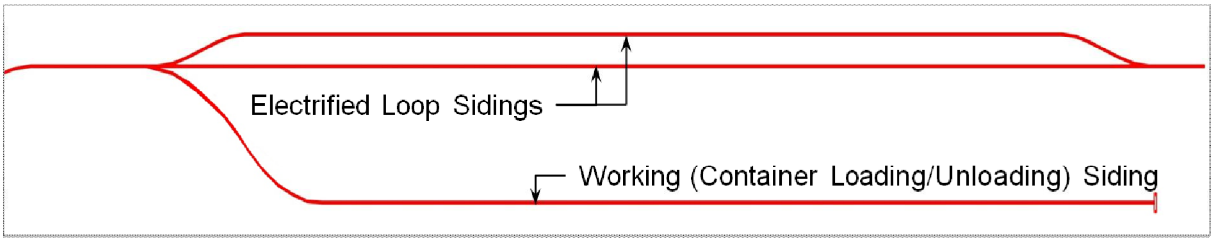


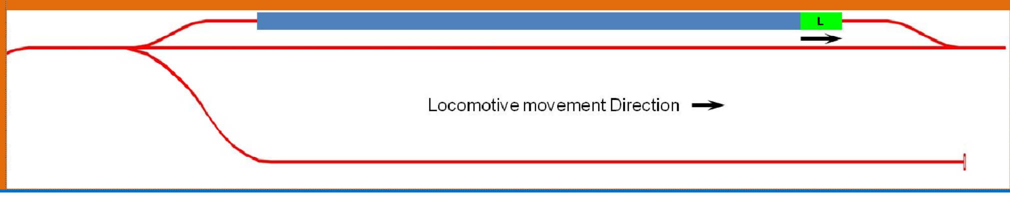
Figure 12.1 Schematic Layout of Rail Yard within Port Boundary

The total length of the internal rail link to the Container Terminal is estimated at 2870m. The rail terminal is planned with 3 sidings (a working siding and two loop sidings) with clear length of 700 m. The track spacing for the Rail Terminal is 6m between two adjacent rail sidings to allow for maintenance access and inspection of containers and wagons. Spacing between working siding and loop siding is planned considering the future deployment of extra rail sidings to cater to the future hinterland traffic. A secondary storage area for containers is provided adjacent to working sidings. The proposed rail lines and the associated rail facilities within the port are shown in **Drawing 12086/DPR/261**.

Railway operation within the port boundary (Port's Rail Yard) is illustrated as under.

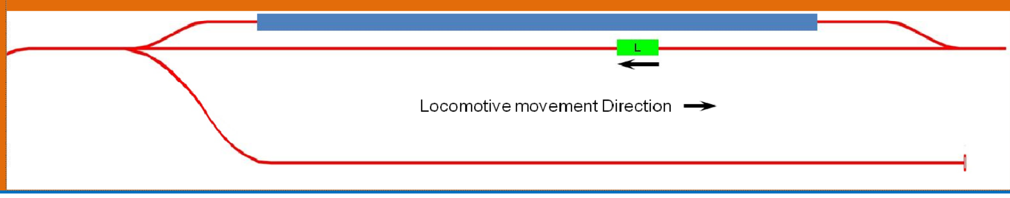
STEP 1

Rake with containers will enter on either of the electrified loop sidings with pulling action of electric locomotive



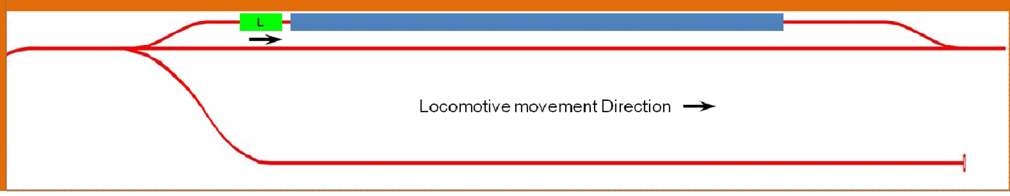
STEP 2

Locomotive get detached and escape out through another loop siding.



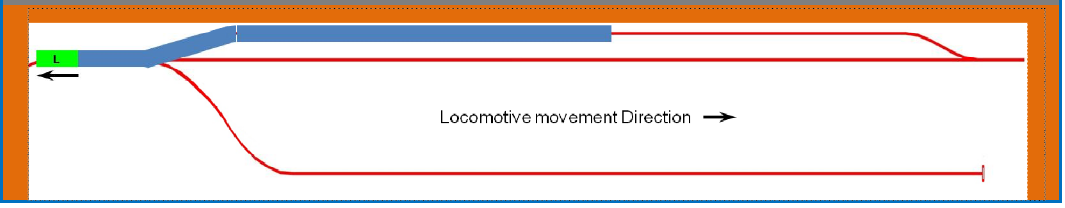
STEP 3

Locomotive then get attached on the other side of the rake



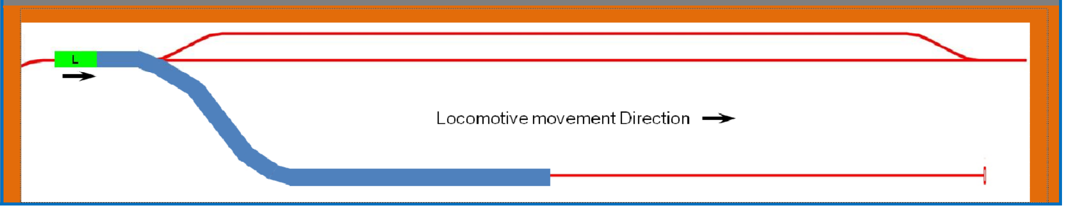
STEP 4

Locomotive pull the rake outside the loop siding.



STEP 5

Locomotive push the rake on the working track.



STEP 6

Working track will be partially electrified up to locomotive reach on track and rest of the siding length is not electrified for convenient container handling operation. After loading/unloading container operation, train directly dispatch from the yard.

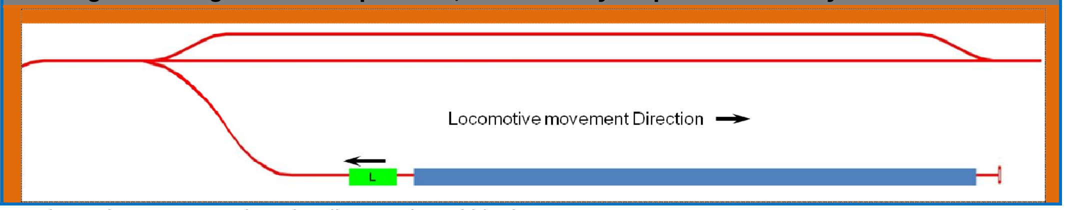


Figure 12.2 Schematic Representation of Rail Operation within the Port

12.3 **External Road Connectivity**

Thiruvananthapuram district is well developed by roads. NH-47 which connects Salem to Kanyakumari passes through Thiruvananthapuram district and at a distance 8 Km approximately from the coast line in the project region and is connected to Cochin port through NH-47A. From Cochin further north is connected by NH-17 to Mumbai. The nearest major urban centres on the NH-47 are Thiruvananthapuram in the North and Nagarcoil-Kanyakumari in the south. NH-47 also connects major towns in Kerala such as Ernakulam, Thrissur, Palakad, Kollam, Alapuzha and in Tamilnadu Salem and Chennai and the rest of the country through NH-7; NH4 etc. Thus NH-47 is well connected to the National Highway network of the country.

It has been proposed to have a road connecting Vizhinjam to NH-47 bypass. The external road connectivity to port is also shown in **Drawing 12086/DPR/261**.

The connectivity of the port can be further divided in three portions,

- Road towards gate and container terminal,
- Road connecting VISL Port Administration Building and
- Road connecting Cruise Terminal/Resort Area.
- Dedicated road for Indian Navy/Coast Guard

All roads will be merging with the road connecting port to the NH-47 bypass and forming rotary junction. Road from rotary junction to custom gate and container terminal will be of four lane wide road and the other roads from rotary junction to VISL Port Administration Building and Cruise Terminal will be of two lane wide roads. The road to the cruise terminal will then bifurcate with two lanes each - one as the dedicated road to Navy/Coast Guard through the +6.0 M level ground around the port boundary and (ii) one as the cruise terminal road proceeding to the cruise service area in the north back up area proposed in the hillock.

12.4 Internal Roads

Internal connectivity of the terminal will be developed by the terminal operator selected by VISL authority. The proposed internal roads for traffic flow within the port are shown in Phase-1 Layout Drawing 12086/DPR/211. Most of the terminal roads will have two-way traffic. The truck lanes under the RTG as well as under the quay crane will have one-way traffic. The quay apron - yard movement will be anti-clockwise whereas the yard – gate/ rail yard movement will be clockwise.

12.5 Container Terminal Infrastructure

12.5.1 Container Yard

12.5.1.1 Container Stack Area

Yard area of approximately 25 Ha for container stack will be designed for stacking 5.5 T/sqm (for upto 5 full container high stacks). After consolidation of reclaimed dredge material, the yard area will be leveled and fill material will be spread and compacted for base layer.

Alternative solutions for the paving in the stacks are discussed in this section. The stack area options are discussed below.

12.5.1.1.1 Concrete Block Paving (CBP) in Stack Areas

If hard surfacing is to be adopted for the stack area, it is recommended that this would be formed using Concrete Block Paving. CBP is well known in the marine terminal world. Where ground conditions are good (and limited settlement is expected) the periods between major maintenance are relatively long and hence annual maintenance costs are relatively low. If large settlements are expected, however, maintenance costs can be higher and involve more frequent lifting and re-laying of blocks. This is a time consuming operation and significant coordination of yard activities is required to avoid reduction of yard capacity during maintenance periods.

CBP in direct contact with corner castings can show local deterioration. However, experience has shown this is not usually of operational significance. Capital costs for CBP are relatively high in comparison with other options.

12.5.1.1.2 Gravel Stacking Beds

Gravel beds can offer a cost effective solution where RTGs are used to handle boxes to and from the stacks. This option involves supporting the container stacks directly on to gravel beds, without the use of concrete pads. Construction of beams for the RTGs will still be required.

Plain gravel beds have been successfully used elsewhere for four high stacking. Gravel beds have been used satisfactorily in a number of container terminals world-wide, including Ashdod, Limassol, Rotterdam, Dusseldorf, Penang, Haifa, Nhava Sheva, Vallarapadam, Thamesport and ECT[7]. Singapore also uses gravel but only combined with corner pads. However, five high (or higher) stacks on plain gravel beds are not common.

The use of plain gravel beds requires the use of high quality gravels to accommodate the loads without crushing of the gravel. Sourcing suitable gravel to Vizhinjam could be a significant construction risk.

Use of gravel beds is operationally relatively inflexible because the locations of the stacks cannot be easily moved. However, boxes can be readily moved within the stack area. The gravel beds cannot accommodate frequent access by forklifts or reach stackers. The capital costs for a gravel bed solution are lower than that for a hard pavement solution.

Properly graded crushed rock is free draining. Water can be drained from under the stacking areas and adjacent roads by the provision of porous pipes within the gravel layer, minimizing, avoiding, or delaying installation of expensive slot drains. In areas of high rainfall the gravel beds can also be used to temporarily 'store' peaks in surface water runoff volumes, allowing the drainage system for the yard to be optimized for peak rainfall conditions. One perceived drawback of gravel beds is that there is less opportunity to intercept spillage. However, a number of standard technologies exist that retain or detain runoff for testing or clean up prior to release.

[7] *Europe Container Terminal*

Maintenance of gravel beds is required relatively frequently, particularly during the first few years of operation. It is relatively simple, comprising of re-leveling and refilling of the gravel as and when necessary. For sites with good ground conditions, where only limited settlements are expected, maintenance is generally more expensive than for a hard pavement. Where large ground settlements are expected, however, then gravel beds can offer reduced maintenance costs over a hard pavement options such as CBP.

If necessary, plain gravel beds can be readily upgraded to gravel beds with beams (see below) and there can be some advantages in doing this after the initial settlements at the site have occurred. We understand, however, that the new stacks at Pipavav are likely to be fully utilized relatively soon after construction. It is therefore likely that the stack will be operated as five high stacking from early on, and that the disruption associated with a subsequent ‘upgrade’ would be operationally unacceptable.

While gravel beds can be cost effective, the limitation on stack heights, the need to source very high quality gravel, and the need for the stack to be fully utilized early on mean that this option appears less advantageous than other stack options.

One possible advantage for the use of gravel beds is in situations where significant subsidence of surface profiles is expected. The surface can be re-leveled fairly simply by the addition of gravel on a periodic basis.

12.5.1.1.3 Gravel Beds with Concrete Bearing Beams / Pads for Corner Castings

This involves supporting the corner castings of the containers on concrete beams or pads that are set into the gravel bed. The areas between the beams/ pads are filled with gravel. Five high stacks are well within the scope of this concept. In one configuration Pads/ beams are generally set out to suit 40’ boxes, with special provision being made to accommodate 20’ boxes within certain areas of the stack. This method imposes certain constraints on yard operations with regard to container distribution within the yard. Pads or beams can be installed to accommodate 20’ containers throughout the yard but the configuration is significantly more expensive.

Gravel beds with pads/ beams are operationally inflexible and do not allow movement of the stack or relocation of the box positions within the stack area. Capital costs for beams and pads are likely to be similar - although beams require a greater volume of concrete; this is likely to be largely offset by the reduced work required during forming. Capital costs are likely to fall between the costs of plain gravel beds and hard surfacing.

Maintenance is required less frequently than for plain gravel beds but more frequently than for a hard paved solution. Maintenance involves lifting the pads/ beams and re-packing the gravel. This is simpler for pads than for beams. Beams are likely to require less frequent maintenance than pads albeit, that each maintenance will be likely to be more expensive given the size of the beams. Beams will offer a marginally more flexible solution as they will allow movement of boxes sideways within the stack and are considered to be more stable than pads. We would recommend the use of concrete beams over concrete pads if this solution is adopted.

12.5.1.2 **Proposed Yard Pavement**

It is noted that the reclamation and ground treatments if any will need to be completed within a relatively tight timescale. Some differential settlements are therefore expected in the container stack areas, particularly during the first years of operation and it is likely that some re-leveling of the surface below the container stacks would be required during the early years of operation.

It is therefore proposed that a gravel bed solution be adopted in order to minimize the cost and time. However, it is the choice of the selected operator to adopt the type of yard pavement for the operations.

12.5.1.3 **RTG Runways**

For the movement of RTGCs, reinforced concrete beams of 400mm thick are provided with sub-base layer of CBM. For RTGCs, turning pads with structural plates and inserts will be provided.

In the container yard, electrical conduits and pits are to be provided for cranes, HT electrical, general lighting, communications and reefer arrangements. Also Miscellaneous works like kerbs, foundations for lighting, RTGC tie down are to be provided.

12.5.2 Reefer Gantries

Reefer containers are planned to be stacked up to 4 high. Plug in and plug out the power supply and monitoring the reefer container parameters are the operations carried out in each reefer boxes. To carry out these operations of reefer boxes which are stacked above ground level, an operation platform is required. Hence a Galvanized Iron gantry structure is planned in each slot to accommodate the power plugs as well as carry out operations. Under these platforms the compact substation and the reefer power distribution panels will be installed. From the Reefer distribution panel along the platform structure the power cable will be laid for each reefer power plugs.

300 TGS will hold on an average 700 TEUs. Each Reefer Block will have 28 plug points (7 containers * 4 stack heights) for 42 TEUs. Hence 17 Reefer Blocks are required for supporting 467 (700/TEU Factor 1.5) Reefer Points.

12.5.3 Rail Terminal

The rail yard area is planned with a total outer dimension of 1,110m length and 62m width. This area will also be on reclaimed land. After consolidation of dredged material reclaimed, the yard area will be leveled and fill material (CBR 20) will be spread and compacted for base layer. For the track portion the sub-base will be CBM and infill concrete will be provided in between sleepers and rails.

12.5.4 Gate House

The area can accommodate parking for 50 trucks. The pavement for the gate house area will be provided with a layer of GSB under CBM. 5 no. in-gates lanes and 5 no. out-gates lanes are to be provided for the container gate house area. **Drawing 12086/DPR/262** shows details of the proposed gate complex. The area of Gate house is 64,460m^2 as given below:

Table 12.1 Area of Container Gatehouse

S. No.	Component	Area
		(m^2)
1.	Garden	3,200
2.	Gate staff (Administration) and Custom Building	900
3.	Gate Pavement Area	60,360
	Total Gate House Area	**64,460**

12.5.5 Terminal Fencing

Container terminal fencing will be provided as per ISPS requirements. The fencing is planned along the periphery of the container and the rail yard.

12.6 Power Supply and Distribution

12.6.1 General

The required electrical system for the project will consist of

- The incoming electrical supply at 66 kV level;
- 66/11 kV substations containing transformers, switchboards, control equipment, etc. to supply the electrical power to various parts of the site at the required voltage levels of 11 & 0.415 kV;
- Control and Monitoring systems;
- 11 kV underground cabling system for medium voltage supply like for quay cranes etc.;
- Fibre optic communications from the substation to the quay cranes;
- 0.415 kV cabling system from the 11/0.415 kV substations to the reefer area. The cables should be run in cable trenches;
- Provision of underground power cabling to the buildings and gate complex shall be provided;
- Provision of underground power cabling to terminal light towers.

In additional, consideration of future electrical requirements of the terminal shall also be taken into account, and all necessary provisions shall be made in the design and installation of the electrical system, to take account of future requirements. This applies to switchboards, transformers, underground cabling system etc.

Details of the electrical load and demand requirements are as discussed in the sections below.

12.6.2 Electrical Load and Demand

The handling systems for containers are power intensive. 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. The following energy requirements have been considered when defining the electrical supply requirements.

12.6.2.1 High Voltage Supply

It is understood that the power to the site will be supplied at 66 kV through underground cabling system which would be stepped down at 11kV level through 2 numbers of 66/11kV 17.5 MVA transformers.

It is envisaged that Medium Voltage (MV) supply at 11 kV will be provided for the MV power requirements of container yard and terminal support facilities like:

- Power Supply to Quay cranes.
- Provision for Power Supply to ERTGs for yard operations

12.6.2.2 Low Voltage Supply

It is envisaged that Low Voltage (LV) supply at 415 V will be provided to each installation. LV requirements for the wharf and access include lighting, the operation of the fire pump house and miscellaneous LV power services.

The LV power requirements for the container yard and terminal support facilities include:

- Reefer Points,
- Yard Lighting,
- Miscellaneous LV power Requirements, and
- Power Supply to the Gate Complex and Terminal Buildings.

12.6.2.3 Electrical Demand

The electrical demand for the Phase-1 development for Vizhinjam Port is estimated in Table 12.4. This information should be regarded as provisional, and it shall be a requirement of the detailed design to fully define the items within the terminal that will require electrical power and the corresponding electrical demand and diversity which must be verified / checked from the proposed manufacturer and service provider. If the terminal operator decides to use the electric RTGs, the overall electrical demand will vary and a detail planning/simulation modeling shall be conducted to provision for the electrical infrastructure at the terminal. Similarly, the need for "Cold Ironing" will change the electrical demand and shall be accounted for during the detail design of the project.

Table 12.2 Power Demand for Port Terminal Development

S. No	Equipment Description	Qty	Installed Load		Diversity Factor	Demand
		No.	KW / Equip	Total		KW
1.	RMQC	8	2400	19,200	0.8	15,360
2.	RTG	24	500	12,000	0.8	9,600
3.	Reefer Points	476	3	1,428	0.8	1,142
4.	Lighting Towers - Jetty, Container Yard and Rail Yard	27	15	300	0.8	324
5.	Operation Office, Gate complex, other utilities	1	400	400	0.8	320
	Total Demand of Container Terminal in KW					**26,746**
	Power Factor					0.85
	Demand in KVA					**31,466**

Table 12.3 Power Demand for Utilities and Other Misc.

S. No	Equipment Description	Qty	Installed Load		Diversity Factor	Demand
		No.	KW / Equip	Total		KW
1.	Fire Fighting	1	475	475	0.5	237.5
2.	Sump Pumps	1	40	40	0.5	20
3.	Water Supply	1	400	400	0.5	200
4.	Office Buildings, Port Area Lighting	1	375	375	0.5	187.5
5.	Support Services	1	1000	1000	0.5	500
6.	Illumination of Approach roads/ service roads	1	800	800	0.5	400
	Total load in KW					1,545
	Power Factor					0.85
	Demand in KVA					**1,818**

Table 12.4 Peak Demand for Vizhinjam Port

Power Demand for Container Terminal	MVA	31.5
Power Demand for Utilities and Other Misc	MVA	1.8
Total Demand	MVA	**33.3**

12.6.3 Power Cables/Controls and Power Factor Improvement

Appropriate Power Cables for the voltages of 66kV, 11kV and other service requirements with sufficient current carrying capacity for the power demands of transformers; with due consideration of the effect of position/installation of cables and other ambient de-rating factors will be provided.

The 66kV main receiving station as well as 66/11 kV downstream substation in container yard; will be controlled from the control system through a dedicated large screen Video Display Unit(VDU) in the main receiving station with an additional VDU in the control room.

Suitable rated capacitors or capacitor banks will be provided to improve and maintain the system power factor over and above 0.9 with Automatic Power Factor Correction (APFC) relay system to take care of the basic load as well as to compensate peak loads.

12.6.4 Emergency Power Requirements

The diesel generator in the substation as well as installed at different locations shall have sufficient capacity to provide power for the following functions in the event of an interruption to power from the supply authority:

- The security, fire fighting and communication system.
- 25% of lighting in the Administration Building.
- 25% of lighting in the Workshop Offices.
- Computers of key staff as nominated by the Client.
- Computer system main server and back-up server UPS.
- All gates functions.
- All Operations Team functions.
- The slow operation of 1 or 2 cranes acting simultaneously, for the purpose of installing back the vessel hatch covers.
- 25% of terminal flood lighting.
- Compact Substations (CSS) of Reefer Plug Points.

In addition, appropriate electrical connections shall be provided at the reefer area to allow the RTGs, acting as electrical generators, to supply power to reefers stacked at the terminal when needed.

Standby Diesel Generators planned for Container Terminal are 6 × 3000 KVA. This will support closing operation of vessel during power failure as well as backup to Reefers and power functional requirements.

12.6.5 Terminal Area Lighting

The container terminal area lighting will be provided with suitable 30 or 40 m high light masts with compliance of the required average lighting levels at the different areas as follows:

- Substation/Control Room 300 Lux
- Reefer Platforms 100 Lux
- Wharf/Jetty 50 Lux
- Yard Area 50 Lux
- Gates Area 50 Lux
- Workshop Perimeter 50 Lux
- Car Parking/Road 20 Lux

In the lighting calculations, an allowance shall be made for 20% deterioration in the performance of each luminaire over time. This shall be taken into account when final illumination measurements are taken, with Lux levels on site to be 20% higher than the design levels nominated above.

Each Terminal Yard light tower shall have separate circuits – a Main Lighting Circuit and an Emergency Lighting Circuit.

Each light tower shall have a lightning rod at its top and have a separate lightning conductor connected to an earth pocket.

12.6.6 Source of Power Supply

Kerala State Electricity Board is going to supply power to the port by upgrading the 66 KV line to the existing Vizhinjam substation to 110/220KV, along with a dedicated GIS substation planned to VISL at the land adjoining the truck terminal at Kdarakkuzhy It is required to run a new receiving line to the Port Main Receiving Substation to draw the power load requirement for the port development activities.

12.6.7 System Arrangement

The power will be made available by KSEB to VISL (by constructing a new 220/66 KV substation near truck terminal at Kdarakkuzhy) from their 220 kV overhead transmission lines from the main receiving substation and shall be stepped down to 66 kV in the outdoor switch yard and with necessary metering arrangement to the indoor switch yard through 3x1 run of singles core underground cables.

The power from the 220/66 kV switch yard is drawn through twin 66 kV feeders each of 3 core XLPE cables to the Gas insulated substation SS-1 through the 2 Km dedicated approach road to the Port..

The power is distributed from this substation SS-1 to respective loads. **Drawing 12086/DPR/263** shows the proposed single line distribution system for the port**.** All the low tension loads meant for illumination, office buildings etc. are drawn from SS-1 through a 66 /11 kV transformers. The substation shall be equipped with capacitor banks for automatic power factor correction and for maintaining a PF of not less than 0.9.

The system design is in accordance with rules and regulations of central electricity authority (CEA) / the chief electrical inspectorate of the state government, and as per standards prescribed by BIS / IEC.

The 11 kV cables will rise to the electrical houses of the respective equipment such as RMQC, eRTG, etc. and the electrical houses will have necessary safety systems.

All the LT loads will be drawn from SS-1 through adequately sized UG cables and to feeder pillars of the respective buildings.

The voltage of the different systems is as under.

Main incoming from KSEB	220 kV
Outdoor switch yard	220 kV / 66 kV
One No of GIS switch yard to SS-1	66 kV
Transformers at SS-1 for loads of yard and Quay Equipments	66 kV / 11 kV
Transformer for LT loads at SS-1	11 kV / 415 V
Feeder cables from SS-1 to the Electrical houses of equipment	11 kV or 415 V as per requirement
LT feeders for illumination and of roads, yards, Buildings, etc.,	415 V / 230 V, 3 Ph / 1 Ph

12.6.8 Location of Substation

The location of the substation is proposed in the utility area, west of the main container gate.

12.6.8.1 Sub Station – 1

The twin feeders of 3 core 66 KV XLPE cables coming from the 220/66 KV switchyard feeds to this substation through necessary circuit breakers. In this substation two 66 kV / 11 kV of 17.5 MVA capacity transformers are installed to step down the voltage to 11 kV meant for feeding the HT loads of the quay & gantry cranes. The capacity of transformer allows for additions in future.

In this substation separate 11 kV / 415 V transformers are also planned for taking care of all LT loads & other equipments operating at LT voltage. The substation is also planned with necessary circuit breakers and isolators. The substation is designed with independent feeders to the respective loads and adequate number of spare feeders.

12.7 Water Supply

12.7.1 Water Demand

The water demand for Vizhinjam Port over the Master plan horizon has been worked out in the Table 12.5 below:

Table 12.5 Estimated Water Demand over Master Plan Horizon

	Consumer	Demand (kL /day)	
		Phase-1	Master Plan
A.	**Raw Water**		
	Greenery and Landscape	120	264
	Reefer Wash and Misc	24	93
	Total Raw Water (A)	**144**	**357**
B.	**Potable Water**		
	Port Personnel, Users & Misc.	64	113
	Township	250	500
	Cruise Terminal	40	60
	Ship Supply	-	-
	Total Potable Water (B)	**354**	**673**
	Total (A + B)	**498**	**1,030**

It can be seen from above that daily water demand for the Phase-1 development is estimated to be around 0.5 MLD (million litres per day). Out of this the potable water demand is 0.35 MLD which will accommodate the requirements for the port personnel, township with balance being the raw water. The total water demand over the master plan horizon is expected to go upto 1.0 MLD. This would comprise of 0.7 MLD of potable water with the balance being raw water. Kerala Water Authority has already sanctioned 1.0 MLD of potable water for Vizhinjam Port use. Source of Water Supply

As indicated in section 2.7.4, the source of water shall mainly be from Vellayani Lake. The plan is for drawing 3.30 MLD of water from Vellayani Lake and to treat the same at a treatment plant located at Vizhinjam in the land available with the Harbour Engineering Department (HED). 3.00 MLD of water will be available after treatment with a net availability of 2.49 MLD. As part of the port development a total of 2.49 MLD of potable water have been allotted to cater to the port requirements, of which 1.49 MLD of water from the proposed water supply scheme of Vizhinjam Port shall be distributed to the locality as part of initiation of the implementation of Corporate Social Responsibility (CSR) activities of VISL.

The proposed fresh water mains will mainly serve the purpose of potable water supply to the usage points. Since the raw water quality is a crucial parameter while deciding any treatment process, it is recommended to get the quantity and quality of available water analyzed. The water treatment plant must ensure that it produces water of acceptable quality as per the provisions of IS 10500: 1991.

12.7.2 Storage of Water Supply

The treated water supplied by the Kerala Water Authority will be collected in an underground sump at a point near the proposed cruise terminal area and resort complex development near the eastern boundary of the port. The capacity of the treated water sump will be 1000 cum, which is equivalent to about two days consumption.

It is proposed to provide a supplementary sump for raw water of 300cum capacity (150cum for greenery & landscape and 35cum for reefer wash and other misc. requirements and rest being the provisional storage to suit any additional requirement) adjacent to potable water sump. The potable water is pumped into an overhead tank of 200cum capacity provided near the sump, from where, the water is pumped into port operational area through gravity. Separate individual water tanks are proposed for the port buildings such as Administration, canteen etc. and the details of the same as indicated below.

Table 12.6 Separate Storage for Terminal Operation Buildings

S. No	Area	Tank Capacity
		cum
1.	Administration	3.0
2.	Resource	6.0
3.	Canteen	4.5
4.	Workshop	4.0
5.	RTGC Service Building etc.	4.0
	Total	**19.5**

The schematic diagram showing the proposed water storage and supply arrangement in the port area is presented in **Drawing 12086/DPR/264**.

12.7.3 Distribution System

The treated water from Kerala Water Authority connection will be brought into the underground storage tank of 1200 cum capacity. The treated water from the potable water sump near the proposed resort complex shall be pumped through pumps and pipeline of 200mm diameter supply to the overhead tank of 200 cum capacity located near the storage sump tank. The overhead tank is provided with the pipeline of two separate pipelines of 100mm diameter through which water is supplied to all port usage points and the proposed residential colony area by gravity.

The water from raw water sump shall be pumped to the secondary storage to facilitate reefer wash and other miscellaneous requirements through two separate pumps and a separate pipeline of 150mm diameter line.

12.8 Drainage and Sewerage System

12.8.1 Drainage System

The port land is about 500m wide and about 800m in length along the coastline and a hilly area in the rear of the proposed port. The drainage system needs to be designed to minimize the potential pollution in the port basin. The rainy season persists during the Southwest and the northeast monsoon. May to November is the wettest months of the year with an average rainfall in excess of 220mm per month, with a maximum of 356mm in June. The average annual rainfall is around 1800mm. The average number of rainy days per year is 132 days. The maximum rainfall intensity has been taken as 30mm / hr.

It is proposed to lay the trench drain parallel to the proposed internal road. These drains are connected through various cross drains bringing the water from the different areas of the terminals covering the port operational buildings. All the drains will be of Random Rubble (RR) stone pitched and grouted with cement mortar of 1:4.

A drainage system will be provided below the stacking area, with buried perforated drain lines. An impervious layer will be placed in the ground below these transverse drain lines. The storm water runoff from the yard area and adjacent roads will be collected, via trenches and buried pipelines. Figure 12.3 shows a typical arrangement for drainage system over gravel bed container pavement.

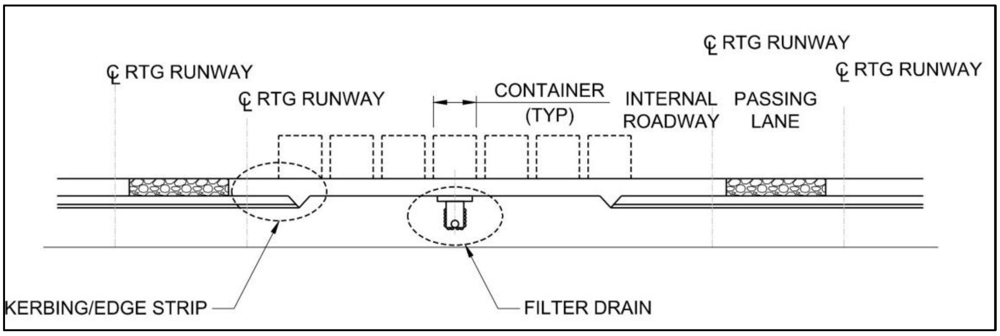


Figure 12.3 Typical Representation of Drainage for Gravel Bed Pavement in Container Yard

The storm water from the administrative offices, transit sheds and all other buildings will also be connected to the storm water drain. The waste water collected from the workshop will be treated in an oil skimmer before disposing off to the storm water drain.

12.8.2 Sewerage System

The sewerage system is limited to the areas wherever office buildings, canteens, and other operational buildings are constructed. 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. The treated sewage shall be discharged to the main drainage network. During monsoon months, the sludge will be stored separately in a storage structure with adequate capacity. The treated water will be discharged into the main drainage system of the port. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

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

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. In the initial phase of development, no STP has been planned in the port complex.

12.8.3 Solid Waste Management

The solid waste generation will be basically from 2 sources – cargo handling and the garbage/ human waste. The cargo envisaged at the port is primarily container cargo. The garbage and human waste generation will be minimal and is proposed to be disposed off using the normal measures. The garbage will be carried through covered trucks and disposed at the designated dumping grounds in the locality. One Incinerator will be required in Vizhinjam Port to dispose the solid waste.

Drawing 12086\DPR\265 shows the various utility arrangements within the Phase-1 terminal development area.

12.9 Terminal Support Systems

12.9.1 Harbour Crafts

12.9.1.1 Tugs

The main activity of harbour tug is providing assistance to vessels entering / leaving the harbour, turning of the vessel in the harbour and the berthing / de-berthing operations.

Phase-1 development of Vizhinjam Port envisages a creation of a 1.2 km long inner channel dredged to 18.4m depth with 2 berths for handling large size container vessels, 1 berth for handling cruise cum multipurpose cargo. The maximum size of the ships to call at this port during initial development is fully loaded 18,000 TEU container vessels. As per the results of the ship navigation simulation studies carried out by BMT CI, for berthing / de-berthing of the design container vessels a minimum of three tugs of 70T and one tug of 40T bollard pull capacity are required.

12.9.1.2 Mooring Launches

The main activities with these small boats are the transfer of mooring ropes between vessel and quay and transfer of mooring crew.

The mooring launches with good maneuverability will be about 10m long with open deck and single screw. The propulsion power shall be delivered by an electrically starting diesel engine of approximate 75-100 kW, driving the propeller shaft via a reverse reduction gearbox. Two mooring launches will be provided at the port.

12.9.1.3 Pilot cum Survey Vessels

Pilot boats transfer pilots to and from the incoming / outgoing vessels.

It is proposed to provide one all weather type pilot launch. The pilot launch should be a twin screw with 15 to 20m overall length and of steel construction. The speed range shall be 15-20 knots. The pilot launches will be provided with survey equipment and it can be used for hydrographic surveys and for buoy lights maintenance.

The summary of the requirements of Harbour Crafts envisaged for the Phase-1 development of Vizhinjam Port development are given in Table 12.7 below based on the Ship Navigation Studies.

Table 12.7 Harbour Craft Requirements for Phase 1 Development

S. No.	Harbour Craft	Phase-1
		No.
1.	Tugs	
	– 70 T bollard pull	3
	– 40 T bollard pull	1
2.	Mooring Launch	2
3.	Pilot cum Survey Vessels	1

12.9.2 Navigational Aids

Navigation aids for the port are required to ensure safe and efficient navigation of ships entering and leaving the port through the approach channel as well as berthing / un-berthing requirements inside the docks. It is envisaged that navigation will be carried out throughout the year, by day and night, except during cyclonic weather. These aids will assist the captains and pilots in determining the position of vessel while transiting the navigational channel and maneuvering inside the port.

The approach channel stretching from the breakwaters head to 21.0m contour has a width of 400m. The channel has a total length of about 2.8km. From the deep water initially the channel is oriented 343°, it takes a turn at a radius of 1200m before approaching straight into the harbour at an orientation of 317° N.

These aids as listed below are proposed to be installed on land or in water for guidance to all vessels for safe and regulated navigation in channels, basin, berths and docks.

- Fairway buoys, Port and Starboard buoys
- Leading / Transit lights
- BEACONS and
- Vessel Traffic Management Information System (VTMIS)

VTMIS will have the requisite communication, Radar system integrated into it.

Drawing 12086/DPR/271 indicates the proposed layout of navigational aids at Vizhinjam Port.

12.9.2.1 Fair Buoys, Port and Starboard Buoys

Fairway buoy (FB) marks the entry to the approach channel and also indicates the location of the pilot boarding area. Hence the vessels calling at port should be able to detect the fairway buoy while approaching the port. As per PIANC guidelines the maximum spacing of paired navigation buoys is 1 nautical mile. However, as per IALA guidelines the ideal spacing of paired buoys should be 3 times the width of the channel in the straight portion and 2.8 times the channel width in the curved portion of the channel. IALA[8] maritime buoyage system as per Region A in which Vizhinjam port falls will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

A total of 14 buoys, which include 11 outer channel buoys i.e. one fairway buoy (3.5m dia.), 5 port side buoys (3m dia.) & 5 starboard buoys (3m dia.) and 3 buoys (2.5m dia.) in the inner channel and harbour basin marking the periphery of the harbour basin area would be required for the navigational purpose.

12.9.2.2 Leading Lights

It is necessary to mark the centre line of the channel with leading lights to ensure safe day and night navigation of vessels visiting the port.

The leading lines may meet the following criteria:

- Useful range: Navigation channel
- Visibility range: 20 nautical miles

The Leading lines and Leading lights are designed in accordance with IALA Guidelines and recommendations and the details are as follows:

Leading Light Requirements	Characteristics
Height of Front Leading light (FLL) above CD	17.2m
Height of Rear Leading light (RLL) above CD	37.3m
Day Mark	As per IALA Guidelines
Light Characteristics	
– Front Light	Fl Y 1s
– Rear Light	Occ. Y 3s

The leading lights will be controlled by a sun-switch to ensure that the lights operate only during darkness or bad visibility. Power supply will be provided by batteries, to be recharged by solar panel systems mounted on the supporting structure, and/ or by power supply from the port distribution system. The battery banks shall be sized to ensure 24 hours continuous operation of the lighting system.

12.9.2.3 BECONS/ Breakwater Lights

Roundhead of the north breakwater will be provided with Beacon. It will also be provided with RACON. The structure would consist of 200mm CHS with an access ladder on mass concrete block foundation to reach light position.

12.10 Security System

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

- Sabotage;
- Pilferage and thefts;
- Encroachments by unauthorized persons;
- Trespassers and antisocial elements.

[8] *International Association of Marine Aids to Navigation and Lighthouse Authorities*

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:

- Port boundary provided with a rubble masonry wall 2.4m high with barbed wire fencing of 1m high;
- Perimeter Fence CCTV System - comprising high sensitivity colour cameras
- A security office and check post at the entrance to the terminal;
- Provision of watch towers at suitable intervals for manual monitoring;
- Adequate Container scanners are provided to scan percentage of boxes as per security plan;
- Radiation Portal Monitors (RPM) for the screening of vehicles and cargo for detection of illicit sources;
- Adequate isolated area would be allocated for storage of dangerous goods;
- The lighting in the port area shall be to the acceptable standards.

For Phase-1 development, it is proposed that the boundary wall needs to be constructed only around the actual operational areas.

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.

12.11 Port Buildings

12.11.1 Administration Building

The Administration Building is located adjacent to the entrance and exit gate. It will be 3-storeyed building with a total floor area of 800sqm. The building is located on the site plan to allow visual access to the gate complex from the Customer Service Department and the second floor Control Room. Office areas on the third floor will have visual access to the container yard, container ship wharf, rail yard, and all gate areas. Building will be located on reclaimed land and will be RCC structures with piled foundations.

12.11.2 Entry/Exit Gate Inspection Canopy

Both entry and exit gate canopy will have five lanes each with five booths on each side. Each clerk booth needs to be able to house two staff and have 360° visibility of the lanes.

12.11.3 Security Guard Booth

Security guard booth will be located at the main entrance of the secured port boundary after crossing the roundabout shown on the layouts. It provides security surveillance at the main gate truck access and exit lanes.

The building is located on the site plan on either side of the road to allow visual access to the gate complex and the public roadway (Port road).

12.11.4 Maintenance and Repair Building

The building needs to be positioned near the perimeter of the container terminal so as not to interfere with terminal traffic circulation. The building has been planned in such a way that it can be easily expanded if needed. Sufficient area has been provided for additional maintenance and repair building for future phases.

The design shall include bridge cranes, floor loadings from tie-down anchors, and access platform loading in the service bays. Structural systems shall adequately support this equipment.

12.11.5 Quay Crane Maintenance and Marine Operations Building

This building is to be positioned and of sufficient height so that marine operations can have visual oversight of the wharves. Visual contact can be augmented by the use of CCTV cameras as required.

Sufficient area has been provided for additional quay crane maintenance buildings for future phases or different private operators along the berth as needed by the users.

The buildings are located on reclaimed land and will be RCC structures with piled foundations.

12.11.6 Railway Master Building

The building will be located in the planned railway yard within the terminal and will be an industrial/maintenance type building. Sufficient area has been provided for expansion for future phases.

12.11.7 Electrical Buildings

The substation and control room having a total area of 400 m^2 will be located in the utility area, west of the gate complex. Smaller satellite substations and electrical rooms will be provided at various locations in the terminal areas as well. These buildings will be of RCC structures with pile or shallow foundations as needed.

12.11.8 Building Requirement Summary

Most of the port buildings are low rise buildings and it is expected that these can be safely founded on shallow foundation comprising of a combination of strip and isolated footing.

The estimated building areas required for the Phase-1 development are provided in Table 12.8.

Table 12.8 Vizhinjam Port Buildings

S. No.	Particulars	Floor Area (m^2)
1.	Administrative Buildings	
	– VISL Administrative Building	800
	– Private Operator Administrative Building	800
2.	Port Marine Operations Building	630
3.	Yard Operations Building	300
4.	Crane Maintenance Building	830
5.	Maintenance & Repair Building	3,400
6.	Trouble Kiosk & Restrooms	60
7.	Longshoremen Restrooms	60
8.	Reefer Shop w/ Genset	330
9.	Canteen	100
10.	Fire station	100
11.	Utility Building	400
12.	Electrical Sub Stations	400
13.	Security Booth - Entry Gate	30
14.	Security Booth - Exit Gate	30
15.	Other Misc. Buildings	200
16.	Rail Administration Building	200

12.12 Information and Technology Systems

12.12.1 General

State-of-the-art information technology is essential if the productivity levels and container handling efficiency of the port are to be maximized. The IT Management System will be designed to encompass port planning, operations, administration, and accounts, in addition to internal and external communications. The following minimum functions should be available:

- Ship-to-shore loading and discharge control;
- Yard planning, gate delivery and receipt control;
- Ship planning and dispatch including a vessel stowage planning module;
- Electronic Data Interchange (EDI) abilities;
- Radio Data Transfer (RDT) abilities;
- Payment status and service billing;
- Management information reports and statistics;
- Linking to shipping lines/agents.

The IT infrastructure will encompass a wide range of port functions, including planning operations and financial processing. This will allow the Licensee to optimize the management functions, respond in a timely manner to events, and readily provide shipping lines with information requested. In addition, these systems will enable the service of electronic data exchange and stowage planning to be offered to the shipping lines.

The Personal Computing (PC) network will include PC workstations for all relevant port employees, communication devices such as RDT, internet links and adequate servers, storage capacity for the operational database, and network management. Provision for data security and uninterrupted power supply will be included in the hardware, network, and communications systems.

A Vessel Traffic Management System (VTMS) will be installed at the new port with the system being built up from a family of advanced maritime information applications and sensors. It will be based on a well proven, concept of software modules and components that will make the system highly flexible and able to be augmented in both functionality and scalability.

The VTMS provided will allow it to be used as an aid to navigation (AtoN), ship reporting, Automatic Identification System (AIS) and voyage management. It will have features such as message and voice communications, multi-media logging and replay. It is intended that the system software will use a programming language that enables the software to be executed on virtually any kind of computer platform to reduce costs and ensuring a maximum system life-length.

A VTMS control centre will be designed and built to suite operational requirements. The console display units for VTS operators' workstations will provide state-of-the-art presentation and control systems. The software to be installed will permit several functions to be combined in a single workstation such as radar, AIS, AtoN management, seamless handling of voyage management information, CCTV, weather information, air situation picture, multi-fuel chart and GIS presentation etc. as applicable.

12.12.2 Information Technology / Computer System

The efficiency of a port container terminal is synonymous with the information systems that practically drive and track the movement of containers as well as acting as an interface between the user, the vessel and the terminal. The container terminal with a huge amount of data being generated would naturally require sophisticated IT infrastructure with connectivity to its users. The system provided is likely to have data base servers, a large number of PCs, printers, Uninterruptible Power Supply (UPS), terminal operation/planning software (supplied by NAVIS, Cosmos or Total Softbank) etc. In particular, the Terminal Operating System should have ship planning, Electronic Data Interchange (EDI), BAPLIE, external tracking and billing modules.

A computer system for port operation takes the form of a central computer processor with hard disc storage on which information files are stored and updated. It is linked to a variety of terminals where operators can access, update or supplement this information at any time.

The operator terminals may have visual display units comprising screens and keyboards, printers for obtaining 'hard' copy or gaining access to printed information, card or tape readers, etc. depending on the specific system requirements.

A system whereby the central computer is connected with computers with Pentium processors through local area network (LAN) is required. The computers would be able to work independently as well as 'in linked' mode with the container terminal's central computer. The capital cost of this would also include developing specialised software, computerization of all operations including the management information system etc.

12.12.3 IT & Terminal Operating System

12.12.3.1 General

This section describes the proposed IT and Terminal Operating System architecture to be utilized for managing and operating the terminal.

A typical IT system Cloud is as shown in Figure 12.4 depicting the complete process and modules involved in the system.

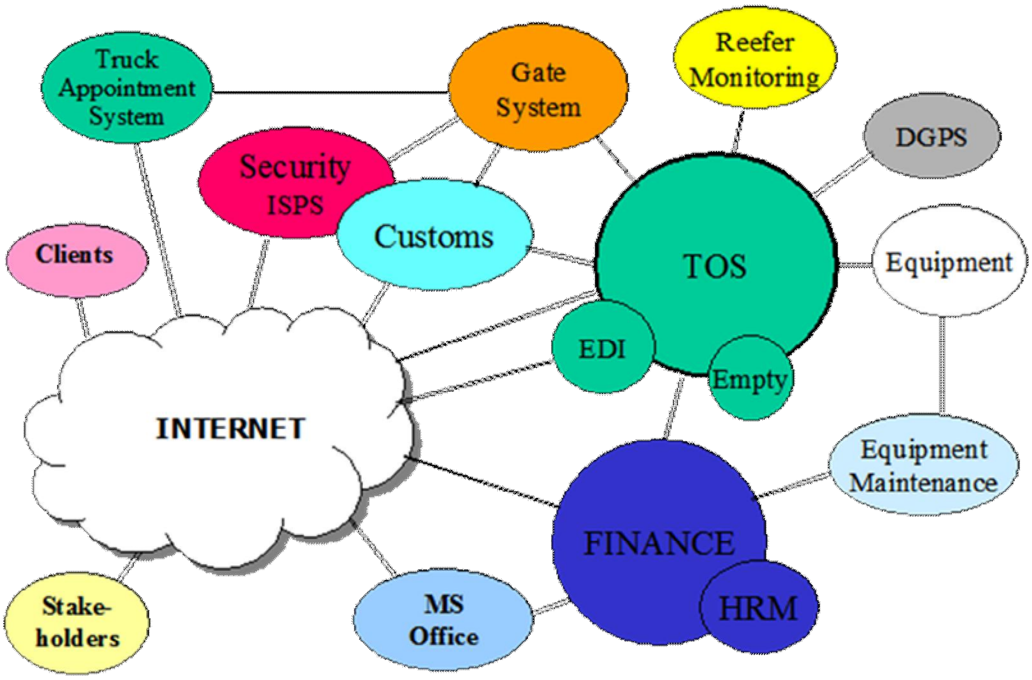


Figure 12.4 Typical Terminal IT System Cloud

12.12.3.2 IT Systems and Logistics

The cargo terminal is an intermodal link in the logistics chain. And since a chain is as strong as its weakest link the cargo terminal must be equipped with modern systems to fully function (cargo tracking and handling, safety, security) in the logistics chain.

Typical systems just range between 5% and 7% of the total capital investment in cargo terminals. These systems are crucial for productivity, serviceability and cost control, and represent the higher risk in the implementation of any terminal development project.

12.12.3.3 Container Terminal Software Modules

A container terminal can be best managed when management and the supporting departments can use an integrated set of software systems.

The operational process is automated by a software system such as the Terminal Operating System (TOS) and its related modules. All of these systems are inter-related and can transfer data between each other. The systems receive data via the Internet and EDI. The systems provide information to the external stakeholders via the Internet.

The software selection process involves the selection of modules in the TOS and the Gate Operating System (GOS) if needed.

Brief descriptions additional subsystems that can be interfaced with the TOS and GOS are provided below.

12.12.3.4 The Finance and Human Resource Management System

These systems cover financial management, terminal labour management, management reporting and control. The systems are connected with the TOS for management reporting, invoicing and labor planning purposes. The equipment maintenance system is connected with the finance system for cost control, management reporting and purchasing. The finance system is connected with the external stakeholders and bank's authorities and clients, via secured Internet.

12.12.3.4.1 Office System

This covers the standard Microsoft Office® software suite. The office systems have access, via well defined protocols, to the TOS and the Finance System for data access (read-only).

12.12.3.4.2 Database System

The terminal operator will need to have a data base license agreement for a system such as Oracle, SAP or other database, including maintenance and support.

12.12.3.4.3 Equipment Maintenance System

All equipment in use at the terminal requires preventive and corrective maintenance. Cost control, spare part management, resource management, quality control and equipment failure analyses are covered by this system. The system reads data from the equipment for error analyses and feeds the finance system for financial control.

12.12.3.4.4 Customs

The Customs system in this overview is not a terminal system. Rather, it is the system to be developed and implemented by Customs at their cost. This system will be connected with the TOS and the GOS. The Custom officers should have special authorized access to the TOS container data base.

12.12.3.4.5 Security ISPS

This system needs to be developed in collaboration with agencies (coast guard etc.) responsible for national security. The Gate Operating System (GOS) and the Terminal Operating System (TOS) include certain interfaces to security and access to the terminal. When such a system is implemented, the interface between the TOS, the GOS and the Port Security System should be evaluated and implemented as needed to support the security procedures developed by the port operator.

The terminal gate confirms authorized access to the terminal based on information obtained from the Port Security System. Access to VISL facilities is controlled for drivers, suppliers, maintenance companies, employees, visitors and the authorities.

The terminal access system checks the card database for access control and can be used as well for the registration of working hours of the employees; a step that requires integration with the terminal's Human Resource Management and Payroll system. A more advanced option could involve integration with Shift Planning Systems.

12.12.3.5 Terminal Operating System

The TOS is the nucleus of the terminal. EDI and empty handling are basic modules of a TOS. It is important to define the integration of all systems in detail. Data Dictionary, Data Base design and Data Management are of utmost importance.

Typically there are dedicated systems for power supplies, uninterrupted power units, power distribution, lights and light monitoring, harbour control system, radar systems and camera surveillance systems. These are separate from the above described architecture.

12.12.3.6 TOS Satellite Systems

The TOS will be surrounded by satellite systems, including the following:

12.12.3.6.1 Gate Systems

A basic gate system is embedded in the TOS. This application can manage the truck visits to the terminal in the Phase-1 development stage of the terminal. A (semi) automated gate system based on OCR technology and equipped with X-ray, gamma ray and RPM scanners and RFID technology can be installed in the future. This type of system is very modular and the detailed configuration is highly dependent on local security rules defined by Port Police and Customs. This advanced functionality is not available in standard TOSs. An automated gate system, hardware and software, is only obtainable from specialized gate suppliers. The GOS is connected with the TOS, the Truck Appointment System, the Port Security Systems and the Customs System.

12.12.3.6.2 Truck Appointment System

Trucks usually arrive at the container terminal as they please. This leads to traffic peaks, congestions and pollution. To manage and control the truck visits to the terminal an Internet-based truck appointment system can also be implemented. The trucker makes an appointment via the Internet to visit the terminal. The system maximizes terminal visits by allowing a maximum number of truck visits per hour. The GOS manages the terminal visits by checking the Truck Appointment System and the Customs Systems.

12.12.3.6.3 Reefer Monitoring

The reefer containers have to be kept under precise conditions. The control can be done manually by the reefer mechanic using a hand held terminal, or managed by a fully automated reefer control system (REFCON). The basic functionality using a handheld terminal is usually available in the TOS.

12.12.3.6.4 Equipment

Driven equipment can also be equipped with screens to give the drivers the ability to query into and receive information from the TOS. The TOS can send instructions to the drivers. The TOS can detect equipment running idle or not running at all. The TOS can measure the equipment performances to monitor the terminal performance and if needed, can reschedule equipment for optimized vessel handling. The screens and communication systems should be part of the equipment specifications and built-in by the equipment suppliers as an integrated part of the equipment controls.

12.12.4 Communications

12.12.4.1 General

An efficient and effective operation of a port terminal requires the provision of reliable and adequate communication facilities. Communication is usually required between the outside world and the port, between and within the terminals as well as other locations where port staff, customs officials etc. are located. To meet these requirements, a communication system comprising telephones, fax machines, wireless sets, computers, etc. and a public address system will have to be provided. These are broadly described below.

12.12.4.2 Telephone System

An electronic (digital) automatic PBX exchange will be provided for the port. Adequate connections will be taken to all required places within the port’s limits. A telephone system in open and in high sound areas will be provided with adequate weather and sound proof arrangements. Telephone connections will also be provided for each berth for use by vessels moored alongside.

12.12.4.3 Radio Communications

The efficiency of port terminal operations depends on a speedy flow of information between the key personnel who are directly involved in the handling of cargo.

A radio communications system will need to be developed in order to handle the flow of information which passes between the personnel engaged in the following operations:

- Ship working duties;
- Quay crane and mobile equipment operations;
- Shore side duties;
- Control office;
- Terminal engineering services;
- Operations management;
- Supervision; and
- Port Security.

In order to ensure an effective radio communication network the port operations have been divided into the following four organizational segments each of which requires a dedicated radio channel(s):

- Ship work;
- Quay and Storage work;
- Control (base station); and
- Port Security/Customs

The system will need to reflect the importance of establishing and maintaining contact between the following areas of operation:

- Ship and crane
- Ship and quay/stacking yard/storage area(s)
- Ship and base station;
- Base station and engineers;
- Engineers and supervisors;
- Supervisors and all foremen, ship and quay/stacking yard/storage area(s);
- Base station and supervisors;
- Management and supervisors; and
- Port security staff and customs officials.

In planning the radio communication system, it is essential that the installations provided in Phase-1 can be readily expanded in response to the future growth of the port.

12.12.4.4 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.

The public address system would provide a comprehensive paging system for oral communication and announcement by loud speakers covering all working areas of the port terminal. The loud speakers would be mounted on purpose built supports provided on permanent structures. The exterior speakers would be weather-proof.

12.13 Fire Fighting System

The fire fighting system is to be designed to be capable of both controlling and extinguishing fires. There will be two types of system i.e. Sea Water and Fresh Water. The sea water system would broadly consist of a fire water intake to draw water from the sea, pump house with pumps, nozzles for water curtains along the front side of operating platform, hydrants and distribution networks. The container and car carrier berths will also be covered under the sea water system.

A centralized fire station will be provided for attending to all calls which will house 2 mobile fire tenders. One fire tender will be provided with snorkel attachment.

Fire Alarm Bells will be located on permanent structures at strategic locations that can be heard by the terminal operators. Buildings where the hazard of fire and the occupancy are high will be provided with alarm bells (e.g. the workshop, administration building etc.). The fire alarm system will be activated by push buttons located at strategic places within the terminal areas and around the port's perimeter.

12.14 Bunkering Facility

As Vizhinjam port is developing as a container trans-shipment port the fuel bunkering facilities will be required for fuelling of vessels. To meet the bunkering requirements of ships (HFO and Marine Diesel), a provision for laying a 350mm dia pipeline will be made in the berths. The bunkering tank farm will also serve fuel to port crafts and port vehicles/equipments.

Fuel bunkering facility is not planned for Phase-1, but it will be a part of the master plan. It is proposed that in Phase-1, vessels are supplied bunker fuel through mobile fuel tankers/ trucks bringing the fuel from outside the terminal and directly feeding the vessels. However, the selected port operator may decide to upgrade to an automated bunkering hydrant system.

For future phases, it is estimated (based on the vessel calls for master plan) that a throughput of 1 MTPA of bunker fuel will be required. This will need space for bunker fuel storage, fuel hydrant system from tanks to berths, and unloading berth. It is estimated that approximately 100,000 tons of static storage capacity will be able to meet the annual throughput needs. These tanks may be supplied by the unloading berth or using rail. Based on various types of tanks, provision for 2 Ha land is provided in the port master plan in the future expansion area east of rail tracks and north of gate complex. It is anticipated that the provision of necessary infrastructure such as tanks, pipelines and pumps would be provided and operated by an interested oil company.

12.15 Pollution Control

12.15.1 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 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.

Containers being low hazardous cargo, no specific pollution control facilities are required for a container terminal. The following steps will be taken for pollution control at the port:

- For containment and cleaning of oil spillage from fuel stations, a special drainage system will be installed for the area which can separate oils from drain water. The reefer wash down area will also be provided with an oil-sediment separator unit as part of the drainage system.
- For containment and cleaning of oil spillage from vessels, a portable inflatable type oil spill containment booms and oil skimmer is proposed.
- High mast lights with shielding arrangements will be used at the terminal to minimize light pollution.

The port is envisaged as a green port and usage of eRTGs and hybrid ITVs is proposed amongst other measures to reduce the environmental impact of the port. In addition, the port is planned as a world-class facility with efficient systems that minimize processing times which reduce fuel consumption and air pollution, thus positively impacting the environment.

13 Cost Estimates

Disclaimer

The capital cost estimates prepared for the Phase-1 development of the project have been arrived at based upon site information, appropriate assumptions, wherever required, and the database available with the AECOM for the similar projects. These site information and assumptions are subject to many factors that are beyond the control of the AECOM; and AECOM thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.

13.1 Introduction

A preliminary CAPEX (**Cap**ital **Ex**penditure) estimate has been prepared for the Phase-1 development. The preliminary development budget estimates are provided for reference only, and represent a professional opinion based on “macro” cost level and available site information. Actual costs may vary significantly from the provided cost estimates, depending on the construction timeline, changed market conditions, availability of materials, change of policy and other unlisted factors. Therefore, these budget cost estimates are not guaranteed figures for financing or carrying out any transactions.

The cost is divided into major components such as Project Preliminaries & Site Development, Dredging & Reclamation, Breakwaters, Berthing Structures, Buildings, Container Yard, Equipments, Utilities, Port Crafts & Aids to Navigation and Gate Complex etc. For each major component, based on its functional requirements, cost has been estimated as per the proposed development. For berthing structures, dredging & reclamation, breakwaters the cost estimation has been done by considering the preliminary engineering as per the Vizhinjam Port site and environmental conditions. The unit rates have been taken based on the past projects carried out by AECOM in India and current market rates obtained from ongoing projects and vendors.

The calculations used to create the estimates reflect current construction costs (2012 base year), as well as estimated allocation of funds for construction contingencies and planning/design costs. Refer to Annexure 2 for the detailed estimates for the master plan development. Refer to Section 10 for various details of the proposed port components which have been used to develop the cost estimates.

The following assumptions were used during the development of these estimates:

- The capital cost estimates are based on the project descriptions and drawings which were prepared after carrying out basic engineering of various components of the project. These will need to be developed, revised, and refined during the detailed design phase, and, therefore, some quantities shown in the cost estimates may undergo revision.
- A 10% planning, design and construction administration contingency has been included.
- A 20% overall contingency has been included.
- All cost estimates are represented in 2012 USD.
- All mobilization costs are included in respective entities.
- A construction methodology has been assumed based on experience of similar structures and utilized for costing provided in this section.
- The costs for components of the port outside the secured boundary that include components that are responsibility of VISL or RVNL (Rail Vikas Nigam Limited) such as VISL Building, Rail Yard and External connectivity, land etc. have been directly provided by VISL. Costs for environmental studies and potential mitigation have been estimated by LTR as part of the EIA studies.

The following exclusions were used during the development of these estimates:

- No taxes such as Service Tax, VAT etc. are included.
- The costs to furnish buildings and operate the facility are not included.
- General administrative supplies are not included.
- Only cruise berth costs are included and no other facilities either behind the berth or in the cruise terminal area are included.

13.2 **Project Preliminaries and Site Development**

This includes the cost involved in site preparation & development for construction activities, pre-operative expenses, initial surveys & project studies.

13.3 **Dredging and Reclamation**

Dredging and reclamation is one of the major cost parameter for any port project. Based on the bathymetry contours provided by VISL and as per the proposed phase wise development plan, the dredging and reclamation quantities have been estimated.

It is estimated that reclamation quantity required for Phase-1 development will be met by dredging needs as explained in Section 10.4. The initial reclamation bund and shore protection revetment costs have also been included. The ground improvement costs are estimated over the complete gross reclaimed area of the port.

13.4 **Breakwaters**

As per the site specific near shore wave climate studies carried out by LTR, basic engineering has been done for the breakwaters considering the recommended design wave height. The breakwater is considered to have a single layer concrete armor (ACCROPODE) unit and crest elevations designed as per Section 10.2.3. The cost estimation has been done for the breakwater based on estimated Bill of Quantities (BOQ) of armor units, crown wall, rubble requirements for secondary layer, bedding and toe protection. The Schedule of rates (2012) from Govt. of Kerala Public Works Department has been used to arrive at average cost of quarry material based on the options identified in Section 10.2.7.

13.5 **Berthing Structures**

Cost estimated for the berthing structures includes container terminal berths, Coast Guard and Port craft berths (20m apron width), Navy berths (20m and 27m width for 200m and 300m berth respectively); and Fishery berths (12m apron width). The cost estimates are done considering the basic design of an open pile berthing structure with stone pitching underneath the berth. These include costs for piles, crane rails where applicable, fenders, bollards, in-situ and pre-cast concrete works.

13.6 **Container Yard**

Major items included in the cost estimate for container yard development are site grading, pavement and RTG beams.

13.7 **Equipments**

Costs for required equipments as discussed in Section 11 have been considered for Phase-1 development. Major equipments are Rail Mounted Quay Cranes (RMQC), Rubber Tire Gantry (RTG for container yard), Reach Stackers, Empty Handlers and Internal Transfer Vehicles (ITV).

13.8 Buildings

Major buildings included in the cost estimate include

- Administrative Building including Port Users
- Port Marine Operations Building
- Yard Operations Building
- Crane Maintenance Building
- Maintenance & Repair Building
- Trouble Kiosk & Restrooms
- Quay Workers Restrooms
- Railway Master Building
- Reefer Shop & Genset
- Gate Canopy
- Canteen
- Fire Station
- Utilities Building
- Electric Substation
- Guard booth (Entry & Exit Gate)
- Fuel Station
- Fish Landing Center Buildings
    - Auction Hall
    - Management Office
    - Net Mending Shed
    - Fuel Station
- Other Miscellaneous Buildings

13.9 Utilities

The following within the terminal utilities have been included in the cost estimate:

- Electric supply & distribution including high mast lighting for container yard
- Fire fighting
- Lighting & Earthing
- Water supply
- Drainage & Sewerage
- Communication & IT (including Terminal Operating System)
- Compound wall for land side port area
- Workshop equipments
- Security infrastructure.

13.10 Port Craft & Aids to Navigation

The terminal will need tug boats for berthing, stopping & turning maneuvers for the container & other vessels. The other port crafts include mooring launch and pilot cum survey launch. Aids to Navigation requirements have been assessed as per the IALA guidelines with details provided in Section12.9.

13.11 Gate Complex & Terminal Road

The gate complex, customs processing area and main terminal road (4 lane road along the container yard) costs have been included.

13.12 Block Cost Estimation Summary

The cost estimates have been summarized in Table 13.1. The Phase-1 development is estimated to cost USD 674 million or INR 3,840 Crores. An exchange rate of 1USD=54 INR is used for block cost estimates. Please refer to Annexure 2 for detailed breakup of the quantities.

Table 13.1 Phase-1 Port Block Cost Estimate Summary

S. No.	Item	Capital Cost	
		(in Mil. USD)	(in Crore INR)
1.	Project Preliminaries and Site Development	2	13
2.	Dredging and Reclamation	70	379
3.	Breakwaters	142	767
4.	Berths	100	541
5.	Buildings	5	25
6.	Container Yard	22	119
7.	Equipments	117	632
8.	Utilities and Others	30	160
9.	Port Crafts and Aids to Navigation	21	114
10.	Gates Complex & Road Development	9	50
	Total	**518**	**2,800**
	Contingencies @ 20%	104	560
	Engineering and Project Management @ 10%	52	280
	GRAND TOTAL	**674**	**3,640**

Based on the “landlord” port model, Table 13.2 lists out the estimated capital cost split between VISL and private terminal operator(s) on the basis of discussions with VISL and AECOM’s understanding of the market. It is assumed that VISL will provide all civil costs associated with the project including breakwaters, dredging and reclamation, berths, port crafts and navigation aids. Some buildings such as VISL Admin, security guard booth, fish landing center will be provided by VISL. Private operator will provide all container terminal and gate complex development costs as well as equipment costs. It is also assumed that VISL will provide utilities to an agreed upon “hand-shake” point and the private terminal operator will be providing the utilities for the rest of the container terminal.

For Phase-1 development, it is estimated that VISL will incur USD 432 million or INR 2,333 crores whereas the private operator will incur around USD 242 million or INR 1,307 crores. These cost numbers are in 2012 base year and may vary depending on actual contractual agreements between VISL and the potential terminal operator.

Table 13.2 Phase-1 Port Block Cost Estimates Split between VISL and Private Port Operator

S. No.	Item	Capital Cost			
		VISL		Private Operator	
		(in Mil. USD)	(in Crore INR)	(in Mil. USD)	(in Crore INR)
1.	Project Preliminaries and Site Development	2	13	0	0
2.	Dredging and Reclamation	70	379	0	0
3.	Breakwaters	142	767	0	0
4.	Berths	100	541	0	0
5.	Buildings	1	6	4	19
6.	Container Yard	0	2	22	117
7.	Equipments	0	0	117	632
8.	Utilities and Others	16	87	14	73
9.	Port Crafts and Aids to Navigation	0	0	21	114
10.	Gates Complex & Road Development	0	0	9	50
	Total	**332**	**1,795**	**186**	**1,006**
	Contingencies @ 20%	66	359	37	201
	Engineering and Project Management @ 10%	33	179	19	100
	GRAND TOTAL	**432**	**2,333**	**242**	**1,307**

13.13 External Infrastructure Cost Summary

The external infrastructure cost including land purchase, external connectivity, utilities and costs for costs for environmental management & corporate social responsibility activities etc. has been provided by VISL and is summarized in this section:

Table 13.3 Total Phase-1 Project Costs (as provided by VISL)

S. No.	Item	Capital Cost	
		in INR Crores	in Million USD
1	External Infrastructure	470	87
1.1	Road	60	11
1.2	Rail	350	65
1.3	Power	50	9
1.4	Water	10	2
2	Phase-1 Port Costs	**3,640**	**674**
3	Total (1+2)	4,110	761
4	CSR & EMP Costs (5% of 1 plus 5% of VISL portion of Phase-1 port costs)	140	26
5	Land Cost (140.42 Ha)	937	174
6	**Grand Total (3+4+5)**	**5,187**	**961**

14 Project Implementation Schedule

14.1 General

The following sections describe significant construction elements in the development of port at Vizhinjam. Construction timeframes are described further based on BOQs and construction schedule for Phase-1 development is provided in this section.

It should be noted that the timeframes have been estimated based on an assumed construction methodology. The EPC contractor may choose a different construction methodology depending on their capability and understanding and this may change the calculations presented below.

It should also be noted that delays in project implementation due to environmental or other statutory approvals, financial closure, construction delays etc., that are beyond AECOM's control and cannot be estimated, have not been factored in the implementation schedule

14.2 Breakwater

14.2 Breakwater

The breakwater construction is proposed to be the foremost activity as it is needed to provide shelter for other activities such as reclamation and berth construction to commence. It is intended to construct the rubble mound breakwaters using plant based on land and at sea. Due to the size of the North Breakwater and a tight completion timeframe for Phase-1 development, it is believed it would be economical to incorporate both methods and work on two fronts or more. The typical sequence of construction is as follows:

- Bed preparation
- Core placing
- Toe construction
- Under-layer
- Armour- seaward and leeward sides and
- Crest structure.

It is estimated that about 7 million tons of rock is required for the construction of breakwaters and shore protection bund. The stones from the quarry sites would be brought and stacked at site in the plots earmarked for the different size of stones. The rock quarries are located at a distance of 50 km from site. There would need to be some improvements carried out in the approach road to the quarries to enable free movement of dumpers carrying rock to the barge loading site.

It is estimated that majority of the material will be supplied through barges from identified quarry sites (details in Section 10). It is proposed that core of the breakwater be formed up to say -5.0m CD by end on dumping method as well as using the marine equipment viz. self propelled side dumping and/or bottom opening barges.

It is envisaged that using the end on dumping and the floating equipment, about 12,000 T stones can be placed per day. The placement rates would also depend upon the adequate supply of stone to site from the quarry sites. The rest of the breakwater profile can be constructed by dump trucks from land. The building of breakwaters section shall be initially progressed by end on dumping, supplemented by barge dumping. Upon completion of the Accropode armour / stone armour to full length, the mass concrete capping shall be commenced from the root.

Both marine and land plants could be used for placement of under-layer and armour layers. It is expected that breakwater construction through marine plant will be halted for around 4 months during the monsoon season whereas construction through land plant will experience considerable downtimes. It is also acknowledged that some rock will be lost in the monsoon.

An allowance has been made in the development of the preliminary schedule covering the construction phase for downtime due to adverse weather. There will be a need to perform a detailed assessment of the potential for downtime during construction planning in order to derive the optimum solution in terms of working fronts, equipment selection and so on for the likely conditions at the site. It is expected that breakwater construction will be very crucial for completion of the project in time. This will involve careful analysis of the logistics chain. Table 14.1 shows a calculation to assess breakwater construction schedule. The contractor may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 14.1 Breakwater Construction Timeframe Calculation

Breakwater Construction		
Characteristics		
Length	3,180	m
Core	5,629,384	T
Stone	1,265,822	T
ACCROPODE	33,113	No.
Supply Needed	**Quantity**	**Unit**
Rock/Core (Total)	6,895,206	Tons
ACCROPODE (Total)	33,113	No.
Construction Time		
Rock/Core	**Quantity**	**Unit**
Transport by barge	12,000	Tons per day
For 7 day week, expected duration of core/rock placing	**18**	**Months**
ACCROPODE	**Quantity**	**Unit**
Placing rate	8	Min. each
No. placed per day	67	Per 9 hour day
For 7 day week, expected duration of armour placing	**18**	**Months**

14.3 Dredging

The dredging methodology has been explained in Section 10.4.3 .

As discussed earlier in Section 10, it is recommended to deploy CSD for undertaking capital dredging works for the harbour. If the contractor wishes to operate in rougher weather conditions than permissible with CSD dredges, TSHD can also be deployed in the outer approach channel. This enables dredging operation to start before the construction of breakwater. It is recommended that CSD be used for dredging within the basin including the turning circle and berth pockets.

Table 14.2 shows calculation for calculating dredging completion time for Phase-1 capital dredging. The dredging work for outer harbour dredging is estimated to take 21 months whereas dredging inside the harbour is estimated to take 11 months. The contractor may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 14.2 Dredging Works Timeframe Calculation

Dredging Calculations	Unit	Quantity
Average Production Rate (per Hr)	Cum	800
Number of Dredgers	no.	1
Hours Per Day	Hr/day	20
Working Days per Month	no.	25
Outer Channel Dredging		
Efficiency	%	80
Production per Day	Cum	13,600
Production per Month	Cum	340,000
Approach Channel Dredging Qty.	Cum	4,779,873
Working Months Needed	Months	18
Monsoon delay	Months	3
Total Time	**Months**	**21**
Inner Channel & Basin Dredging		
Efficiency	%	85
Production per Day	Cum	13,600
Production per Month	Cum	340,000
Turning Circle Dredging Qty	Cum	1,976,700
Harbour Basin+ Berth Pockets Dredging Qty	Cum	883,320
Working Months Needed	Months	9
Monsoon delay	Months	2
Total Time	**Months**	**11**

14.4 Reclamation Bund and Shore Protection

The reclaimed ground will be protected by providing rubble mound bund on all sides supported by sand fill from dredge spoils. This reclamation bund will be designed for a design life of 50 years. The methodology provided in the Construction Industry Research and Information Association (CIRIA) manual (manual on use of rock in coastal and shoreline engineering) has been followed.

The reclamation bund will comprise of quarried rock / stones from quarry sites and sand fill from dredge spoils. It will include a geotextile membrane on the rear face to enhance its fill retention properties. The outer face will be protected against wave action with suitable protection. The stones required for the construction of bund will be supplied by local quarry through barges and road trucks similar to breakwater construction.

The rock bund and revetment capital works are proposed to be performed in advance of the reclamation work in order to provide the containment necessary for the reclamation material. Assuming similar supply and placement rates as for the breakwater construction, it is estimated that reclamation bund be in parallel with initial dredging works and precede the reclamation works. It is approximated that reclamation bund and shore protection work will last for approximately 16 months. The contractor may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

14.5 Reclamation

During Phase-1 the fill is needed from a depth varying between -13m and -5m up to 3.5m to 5.3m CD. It is estimated that all fill material for reclamation for Phase-1 development will come from dredging of the basin and the channel. It is assumed that reclamation can start after one month delay from construction of reclamation bund and continues for the duration of dredging activities.

14.6 Berths

The container berths will be formed from concrete piles socketed into rock beneath the seabed supporting a suspended concrete slab for the quay apron. For the container berths, behind the concrete quay apron will be L section retailing wall on the reclamation bund that will contain the fill material for container yard.

To provide adequate protection from waves during monsoons the piling activity will have to be synchronized with the construction of breakwater. It is proposed to first reclaim the site using the suitable dredged spoil upto a level of +3.5m CD. The bored piles supporting the quay deck are then constructed using the land based equipment. The longitudinal and transverse beams connecting the berth piles are also constructed using land based construction.

Table 14.3 provides a calculation for estimating timeframe of completion for Phase-1 berth construction. It is estimated that container berths will be completed within 20 months, cruise/ multipurpose berth can be built in about 13 months and the fishery berths will take around 12 months for construction. The construction activity for the coast guard and navy would be around 14 months. It is assumed that construction activity will be impacted during monsoon and 50% of the time will be lost. It is important to note that breakwater will provide significant sheltering for the marine works. The contractor may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 14.3 Marine Works Construction Timeframe Calculation

S. No	Description	Unit	Container Berths	Cruise/ Multipurpose Berth	Fishery Berths
			Quantity	Quantity	Quantity
1.	Total Length	m	800	300	500
2.	Spacing of piles	m	7.5	7.5	6
3.	Bends/Piles per Week	no.	1.5	3	3
4.	Number of Working Weeks Reqd.	no.	76	13	28
5.	No. of Simultaneous Operation	no.	2	1	2
6.	Efficiency of Operation	%	80	85	85
7.	Effective Schedule with 80% Efficiency	Weeks	48	17	17
8.	Pre-Cast Works Lag	Weeks	12	12	8
9.	In-Situ Works Lag	Weeks	12	12	12
10.	Monsoon Delay	Months	2	2	2
	Total Work Completion	**Months**	**20**	**12**	**12**

14.7 Equipments and Onshore Developments

The container terminal operating equipment and other equipment will need to be procured in such a manner that they are ready for commissioning in time of finish of construction. Due consideration should be given to longer lead time equipment such as quay cranes and items such as terminal operating system requiring significant training times.

Open spaces/storage areas will be paved with a variety of surfacing as follows:

- Container terminal areas: block paving;
- Fish Landing Center (FLC) buildings and infrastructure;
- Access roads: asphalt paving;
- Gate complex and parking areas: asphalt concrete; and
- Truck parking: Portland cement concrete pavement.

These works can be carried out to suit the commissioning of the facilities by the selected operator. However, construction of the access road to tip of breakwater will need to be taken up on priority basis. It is planned for the pavements of open/storage areas to commence after soil stabilization within reclamation areas has been completed. Provisions of required utilities such as electric, power, potable water, water main and communication etc. will also commence after the soil stabilization works.

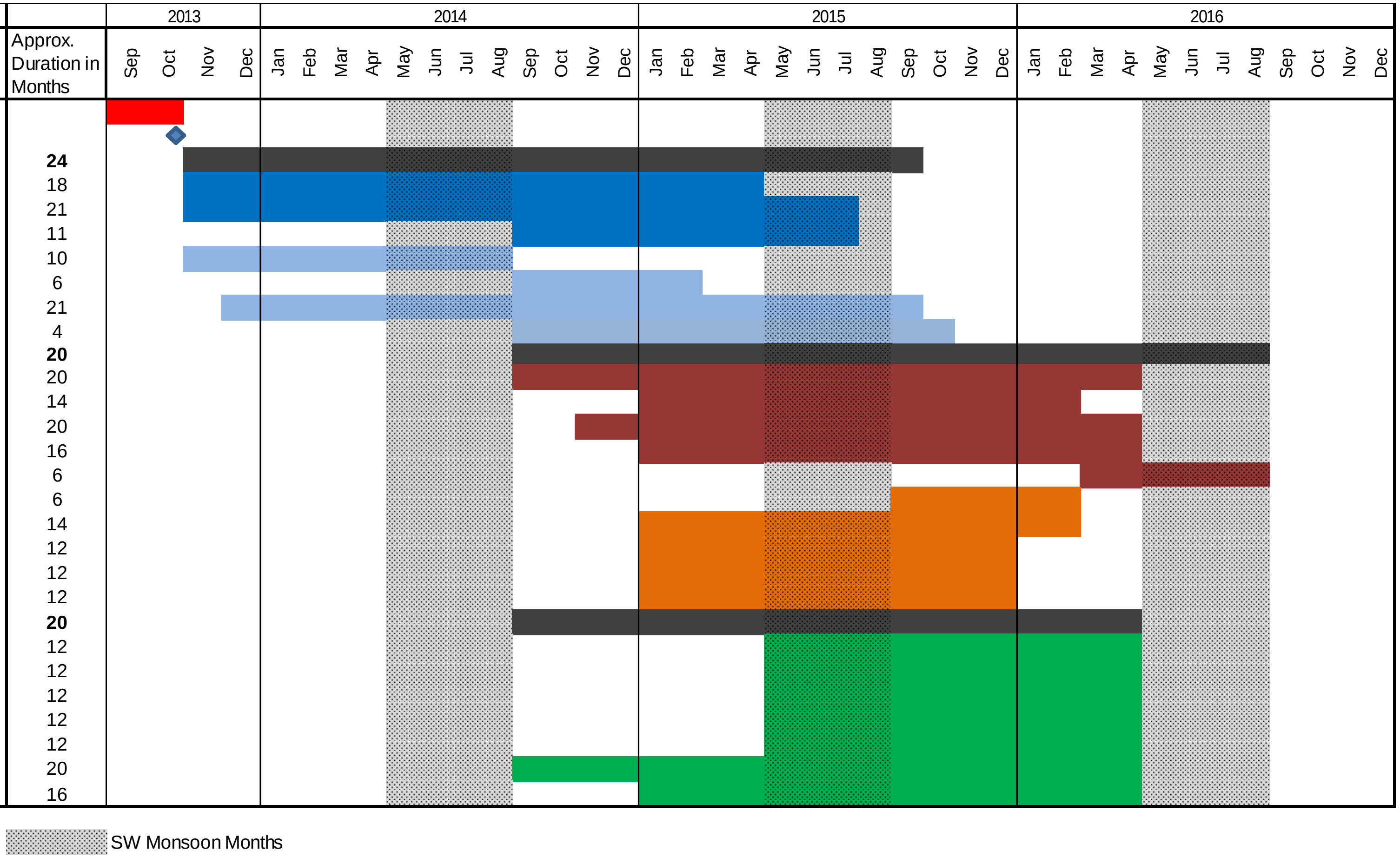
All the buildings shall have RCC framed structure. Structures on the reclaimed land shall be provided with pile foundations or shallow foundations depending on expected settlements. All other structures can be founded on isolated footings. The buildings will start construction after the reclamation areas are stabilized. It is expected that works on pavement, utilities and buildings will be done concurrently with the berth and other site works.

14.8 **Summary**

Table 14.4 shows the implementation schedule and timeframes for various construction elements for Phase-1. According to our calculations, Phase-1 construction is supposed to commence in November 2013 and will take approximately two and a half years. Commissioning of port is expected to take around 4 additional months. This would enable the port to be operational in the fourth quarter of 2016.

Table 14.4 Vizhinjam Port Implementation Schedule

Vizhinjam Port Implementation Schedule	Approx. Duration in Months
EPC Activities & Mobilization	
Start of Construction	
Harbour Construction	**24**
Breakwater Construction	18
Dredging - Approach Channel	21
Dredging - Harbour Basin	11
Reclamation Bund	10
Shore Protection Revetment	6
Reclamation	21
Ground Improvement	4
Container Terminal	**20**
Container Berth	20
Container Yard & Paving	14
Equipment Acquisition	20
Buildings & Other Infrastructure	16
Commissioning	6
Port Craft Berth	6
Coast Guard & Navy Berths	14
Cruise cum Multipurpose Berth	12
Fishery Berths	12
FLC Buildings & Infrastructure	12
Ancillary Infrastructure	**20**
Container Freight Station (CFS)	12
Warehousing/Distribution Center	12
Truck and Rail Terminal	12
Commercial Facilities	12
Residential Facilities	12
Road/Rail Access Within Port	20
Utilities	16



AECOM

15 Economic Impact Assessment

15.1 Introduction

VISL has tasked Deloitte with the responsibility to analyze the economic costs and benefits of the port project and estimate the economic internal rate of return. The port is to be primarily used as a container trans-shipment hub. Along with the main container port, there are also plans to invest in a fish landing centre, cruise terminal, a Coast Guard berth, Navy berth as well as other CSR projects. This section has been extracted from the Deloitte report on “Estimation of Economic Internal Rate of Return of the Vizhinjam Port project – Second Draft”. This will be finalized after the Public Hearing, so as to have a comprehensive assessment. It is to be noted that due to inherent complexity, all indirect and induced benefits have not been currently included in the economic impact assessment. In addition, the economic effect of ancillary activities such as warehousing, truck terminal has also not been currently assessed.

A review of traffic estimates by Deloitte of the forecast made by Drewry Shipping Consultants confirms the fact that there is potential for substantial container trans-shipment traffic to flow to Vizhinjam. Gateway and Coastal traffic is likely to remain low on account of low industrial development in Kerala and strong competition from the ports of Cochin and Tuticorin. Total traffic is expected to be around 1.33 million TEUs at the end of Phase-1 (2022-23), 1.99 million TEUs at the end of Phase-2 (2033-34) and 2.78mn TEUs at the end of the forecast period (2049-50). A summary of the traffic forecast is given in the table below.

Table 15.1 Container Traffic Forecast for Vizhinjam Port

Traffic forecast (‘000 TEUs)	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2027-28**	**2037-38**	**2047-48**	**2049-50**
Year #	1	2	3	4	5	15	25	35	37
Transhipment traffic	-	-	-	75	250	1,472	1,796	1,957	2,002
Gateway Traffic	71	76	81	86	91	171	321	602	682
Coastal Traffic	10	11	12	12	13	26	48	88	99
Total	**81**	**86**	**92**	**173**	**355**	**1,670**	**2,165**	**2,647**	**2,783**

[Source: Estimation of Economic Internal Rate of Return of the Vizhinjam Port project, Deloitte 2013]

15.2 Economic Analysis

The economic cost-benefit analysis is based on the financial analysis of the port project. After the new Master Plan was prepared by AECOM, no financial feasibility study was carried out which could be used as a reference point. Hence, a high-level basic financial model was prepared to determine the financial cash flows of the project. This financial analysis reveals that the project is not financially very attractive. In-spite of high traffic giving substantial capacity utilization, the project is not able to generate sufficient cash flows to generate a surplus. This is because the capital investment is relatively high.

The financial analysis was subjected to four principal adjustments to arrive at the economic cash flows:

- Revaluation of financial cash flows based on shadow exchange rates and standard conversion factors
- Estimating consumer surplus/deficit
- Determining additional economic (non-financial) benefits and costs that will accrue
- Determining effects of environmental externalities

The project creates consumer surplus by reducing costs of transporting containers. The port is nearer the main East-West shipping route as compared to some of the other trans-shipment hubs resulting in savings in ship bunker costs. Additionally, inland logistics cost for gateway traffic and coastal traffic from / to the nearby hinterlands of Trivandrum and Kollam are also saved. Other economic benefits expected are savings in fuel costs for the Coast Guard and Navy, increase in number of tourists in the region, savings in water tanker costs due to the water supply project, employment generation and reduction in carbon emissions. The project will also have costs for the economy such as loss due to relocation of resorts located in the port area, job loss for employees at those resorts, and impact on the environment near the port site. Economic analysis also involved estimating the shadow currency exchange rate, estimating standard conversion factors to arrive at economic values of CAPEX and OPEX, valuing the cash flows at constant prices (ignoring inflation) and removing the effect of taxes and subsidies. The extract of overall economic cash flow forecasts are given in the Table 15.2.

Table 15.2 Overall Economic Cash Flows for Vizhinjam Port

Project economic cash flows (INR crores)	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2027-28**	**2037-38**	**2047-48**	**2049-50**
Year #	1	2	3	4	5	15	25	35	37
Revenues	-	-	-	4	23	163	220	283	301
Operating expenses	-	-	-	(21)	(40)	(76)	(100)	(112)	(115)
Capital Investments	(1,322)	(497)	(531)	(83)	-	-	-	-	-
Economic benefits/costs	(14)	(9)	(9)	112	205	462	631	860	925
Terminal value of cash flows	-	-	-	-	-	-	-	-	11,119
Net cash flows	**(1,336)**	**(506)**	**(540)**	**13**	**188**	**549**	**751**	**1,031**	**12,231**
Cumulative cash flows	**(1,336)**	**(1,842)**	**(2,382)**	**(2,369)**	**(2,182)**	**1,510**	**6,415**	**15,182**	**28,485**

[Source: Estimation of Economic Internal Rate of Return of the Vizhinjam Port project, Deloitte 2013]

This gives an economic internal rate of return on 12.93% and a Net Present Value of INR 303 crores. Hence, it can be concluded that the project is economically viable. A break-up of the economic costs and benefits is shown in Table 15.3 below.

Table 15.3 Economic Costs and Benefits Forecast for Vizhinjam Port

Economic benefits & costs (INR crores)	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2027-28**	**2037-38**	**2047-48**	**2049-50**
Year #	1	2	3	4	5	15	25	35	37
Consumer surplus - Transhipment - Mainline	-	-	-	(0.26)	(0.86)	(5.30)	(9.08)	(12.0)	(12.8)
Consumer surplus - Transhipment - Feeder	-	-	-	0.49	3.58	20.37	21.92	22.32	22.41
Consumer surplus - Gateway - foreign	-	-	-	0.50	2.28	18.28	36.52	68.43	77.58
Consumer surplus - Gateway - coastal	-	-	-	0.07	0.32	2.76	5.30	9.36	10.49
Coast Guard - Savings in fuel costs	-	-	-	3.19	5.47	5.47	5.47	5.47	5.47
Navy - Savings in fuel costs	-	-	-	3.90	6.68	6.68	6.68	6.68	6.68
Tourism - Increased tourist spend	-	-	-	-	-	85.95	114.60	114.60	114.60
Tourism - Loss to resorts	(6.78)	(6.78)	(6.78)	-	-	-	-	-	-
Tourism - Loss to jobs due to displacement/relocation of resorts	(6.07)	(6.07)	(6.07)	-	-	-	-	-	-
Increase in fish exports	-	-	-	71.08	126.80	173.22	197.49	218.15	222.54

Savings in transportation costs of fish exports	-	-	-	1.12	2.31	3.16	3.60	3.98	4.06
Cost of water tankers saved	-	-	-	9.46	16.22	16.22	16.22	16.22	16.22
Additional employment generation	3.85	3.85	3.85	0.97	0.97	1.44	2.41	2.41	2.41
Environment management costs - capital costs	(4.73)	-	-	-	-	-	-	-	-
Environment management costs - operating costs	-	-	-	(0.32)	(0.55)	(0.55)	(0.55)	(0.55)	(0.55)
Reduction in number of trucks required to handle traffic in area	-	-	-	5.68	4.60	3.80	6.80	12.00	13.80
Reduction in road accidents	-	-	-	0.69	1.44	2.04	2.40	2.78	2.88
Reduction in carbon emissions	-	-	-	15.52	35.51	128.9	221.0	390.3	439.3
Net economic costs / benefits	**(13.7)**	**(9.0)**	**(9.0)**	**112.1**	**204.8**	**462.5**	**630.8**	**860.2**	**925.1**

[Source: Estimation of Economic Internal Rate of Return of the Vizhinjam Port project, Deloitte 2013]

Annexure 1

DPR Drawings for Port of Vizhinjam

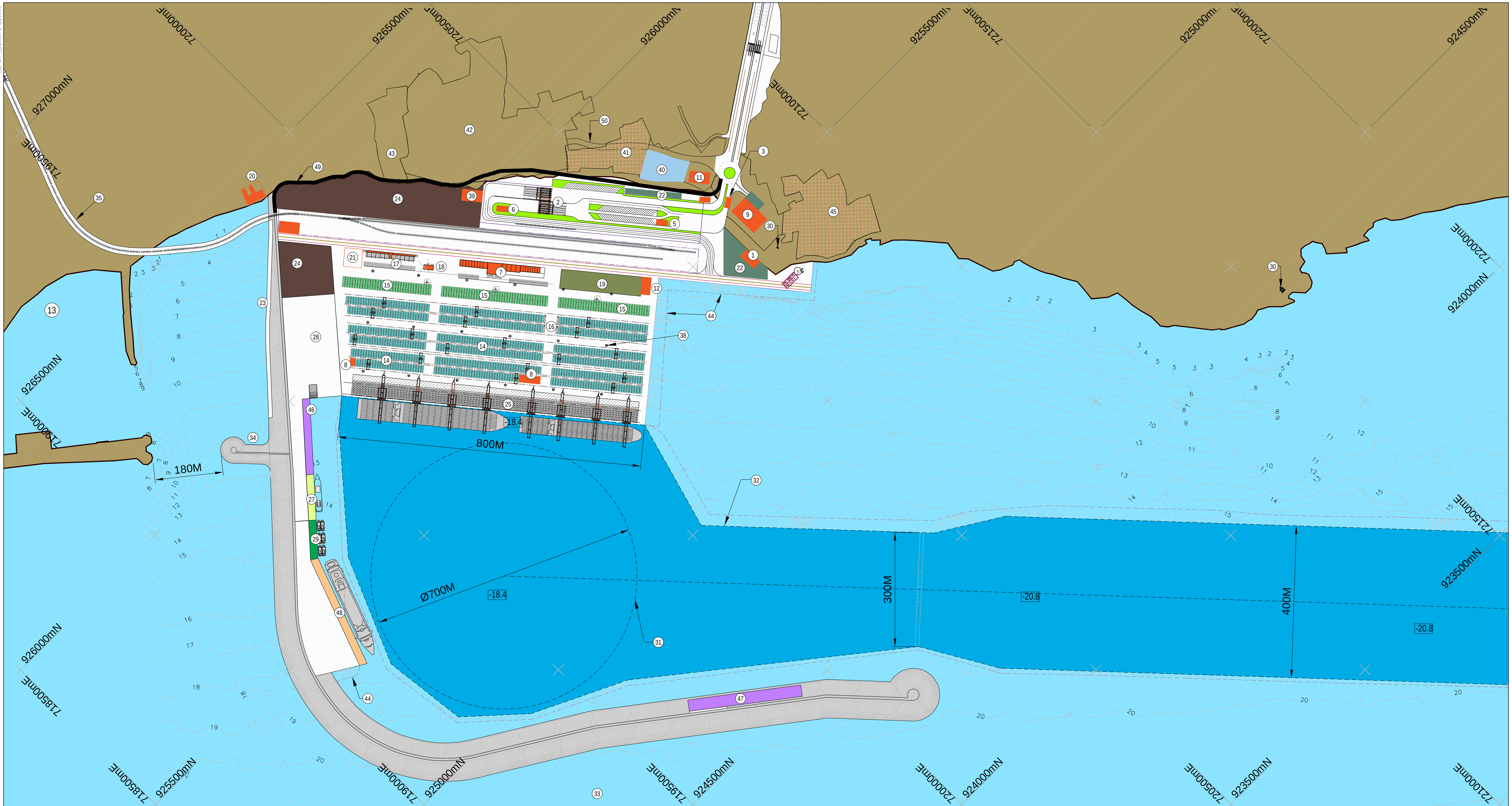
Prepared for

Vizhinjam International Seaport Limited (VISL)

Prepared by

AECOM India Private Limited

May 2013



KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REEFER STORAGE
17. REEFER WASH AREA
18. REEFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE AREA
20. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
21. HAZARDOUS CARGO AREA
22. POV PARKING AREA
23. FISH LANDING BERTHS 500M LONG
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS 800M LONG
26. MAIN PORT ACCESS ROAD
27. COAST GUARD BERTH 120M LONG
28. INDIAN NAVY OPERATIONAL AREA
29. PORT CRAFT BERTHS 100M LONG
30. EXISTING TEMPLE
31. TURNING CIRCLE 700M DIA
32. APPROACH CHANNEL
33. NORTH BREAKWATER (3040M LONG)
34. FISHERY BERTH BREAKWATER (140M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. 12500 TEU CONTAINER VESSELS
37. 9000 TEU CONTAINER VESSELS
38. HIGH MAST LIGHTING POLE (TYP.)
39. FIRE STATION
40. RAIN WATER HARVESTING AREA
41. OPERATOR UTILITY AREA (PHASE - 1 & 2)
42. CRUISE TERMINAL AREA
43. COAST GUARD OPERATIONAL AREA
44. BUND
45. OPERATOR UTILITY AREA (MASTER PLAN)
46. INDIAN NAVY BERTH WITH LOADING RAMP 200M LONG
47. INDIAN NAVY BERTH 300M
48. CRUISE BERTH 300M
49. INDICATIVE ACCESS ROAD FOR NAVY & COAST GUARD
50. CRUISE SERVICE AREA ACCESS ROAD

LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

TRUE NORTH
REF. N

PRELIMINARY

Revision	By	Approved	Date
REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	21 - 05 - 13
REV 3	VB	VA	24 - 05 - 13

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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Approved By: VA
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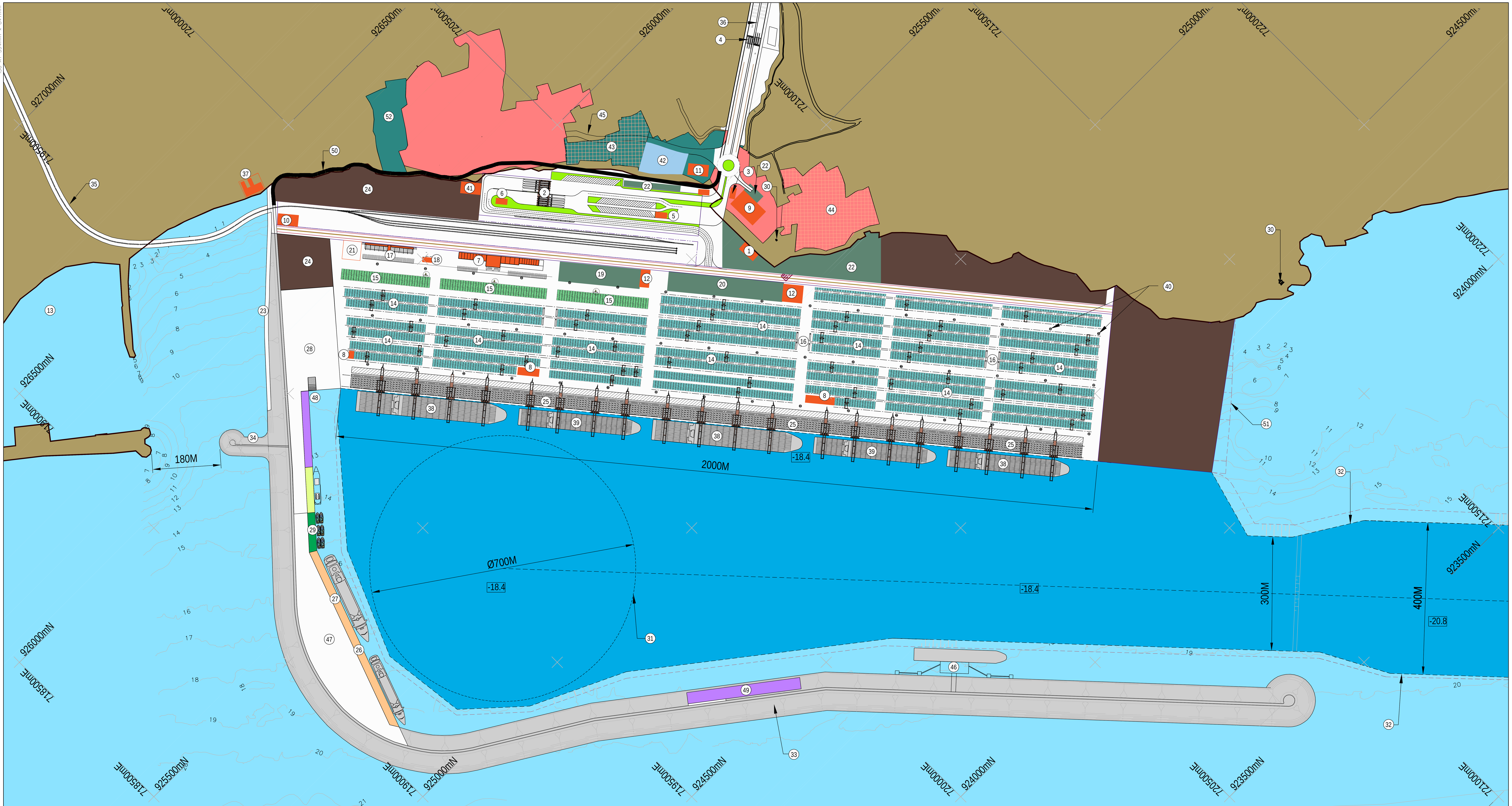
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: RECOMMENDED MARINE LAYOUT OF PHASE-1 PORT DEVELOPMENT

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 211
REV 3

ISO A1 594mm x 841mm



KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REEFER STORAGE
17. REEFER WASH AREA
18. REEFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE AREA
20. ITV STORAGE / TERMINAL BUILDINGS
21. HAZARDOUS CARGO AREA
22. POV PARKING / TERMINAL BUILDINGS
23. FISH LANDING BERTHS
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS 2000M LONG
26. CRUISE BERTHS 500M LONG
27. COAST GUARD BERTH 120M LONG
28. INDIAN NAVY OPERATIONAL AREA
29. PORT CRAFT BERTH 100M LONG
30. EXISTING TEMPLE
31. TURNING CIRCLE 700M DIA
32. APPROACH CHANNEL
33. NORTH BREAKWATER (3960M LONG)
34. FISHERY BERTH BREAKWATER (140M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. MAIN PORT ACCESS ROAD
37. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
38. 12500 TEU CONTAINER VESSEL (TYP.)
39. 9000 TEU CONTAINER VESSELS (TYP.)
40. HIGH MAST LIGHTING POLE (TYP.)
41. FIRE STATION
42. RAIN WATER HARVESTING AREA
43. OPERATOR UTILITY AREA (PHASE - 1 & 2)
44. OPERATOR UTILITY AREA (PHASE - 3)
45. CRUISE SERVICE AREA ACCESS ROAD
46. LIQUID BERTH
47. CRUISE TERMINAL AREA
48. INDIAN NAVY BERTH WITH LOADING RAMP 200M LONG
49. INDIAN NAVY BERTH 300M
50. INDICATIVE ACCESS ROAD FOR NAVY & COAST GUARD
51. BUND
52. COAST GUARD OPERATIONAL AREA

LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

TRUE NORTH
REF. N

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REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	21 - 05 - 13
REV 3	VB	VA	24 - 05 - 13

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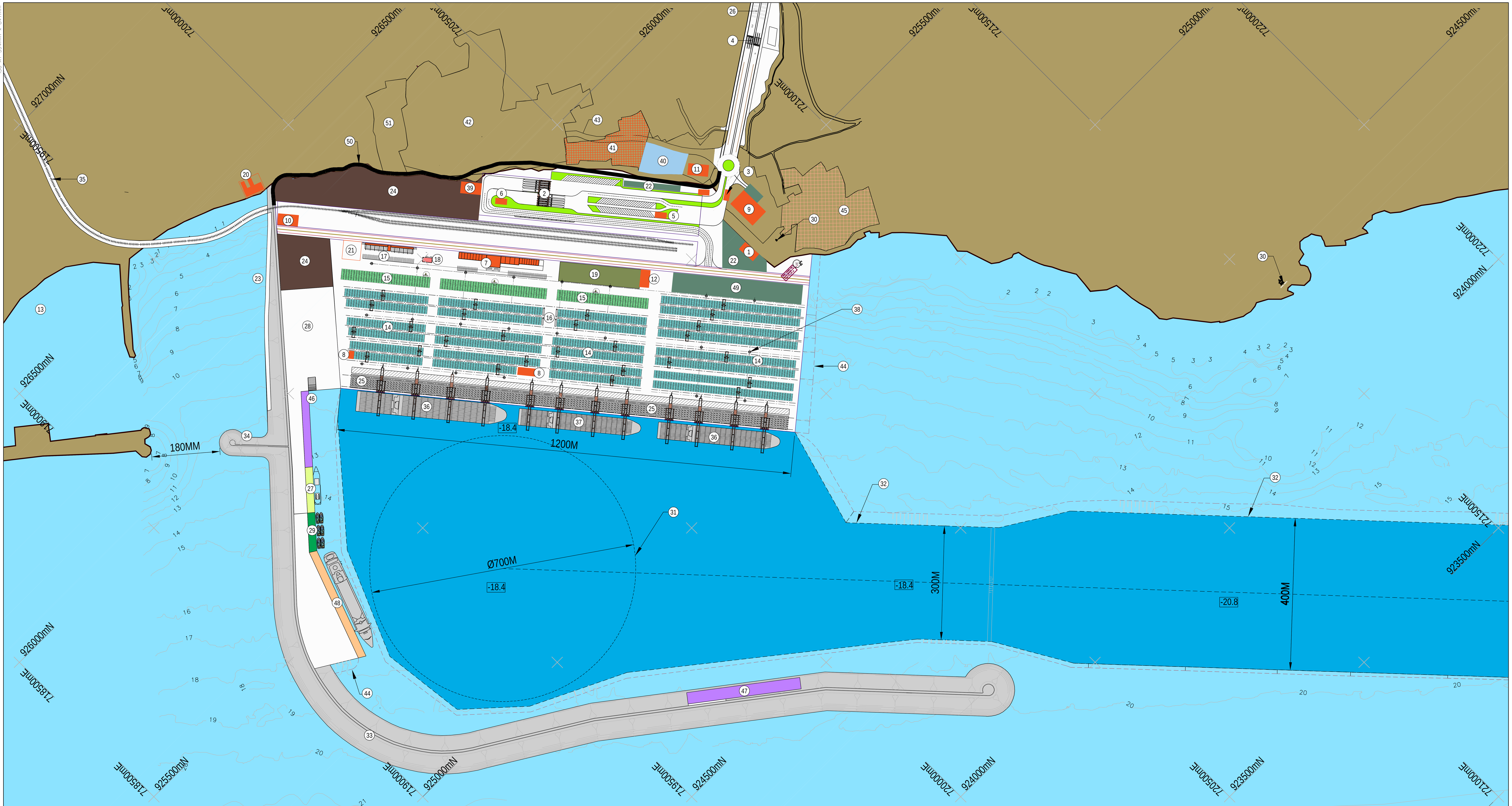
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: RECOMMENDED PORT MASTER PLAN LAYOUT
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 212
REV 3

ISO A1 594mm x 841mm



KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATIVE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REEFER STORAGE
17. REEFER WASH AREA
18. REEFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE AREA
20. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
21. HAZARDOUS CARGO AREA
22. POV PARKING AREA
23. FISH LANDING BERTHS 500M LONG
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS 1200M LONG
26. MAIN PORT ACCESS ROAD
27. COAST GUARD BERTH 120M LONG
28. INDIAN NAVY OPERATIONAL AREA
29. PORT CRAFT BERTHS 100M LONG
30. EXISTING TEMPLE
31. TURNING CIRCLE 700M DIA
32. APPROACH CHANNEL
33. NORTH BREAKWATER (3240M LONG)
34. FISHERY BERTH BREAKWATER (140M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. 12500 TEU CONTAINER VESSELS
37. 9000 TEU CONTAINER VESSELS
38. HIGH MAST LIGHTING POLE (TYP.)
39. FIRE STATION
40. RAIN WATER HARVESTING AREA
41. OPERATOR UTILITY AREA (PHASE - 1 & 2)
42. CRUISE TERMINAL AREA
43. CRUISE SERVICE AREA ACCESS ROAD
44. BUND
45. OPERATOR UTILITY AREA (MASTER PLAN)
46. INDIAN NAVY BERTH WITH LOADING RAMP 200M LONG
47. INDIAN NAVY BERTH 300M
48. CRUISE BERTH 300M
49. ITV STORAGE / TERMINAL BUILDING
50. INDICATIVE ACCESS ROAD FOR NAVY & COAST GUARD
51. COAST GUARD OPERATIONAL AREA

LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

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Revision	By	Approved	Date
REV 1	VB	VA	21 - 05 - 13
REV 2	VB	VA	24 - 05 - 13

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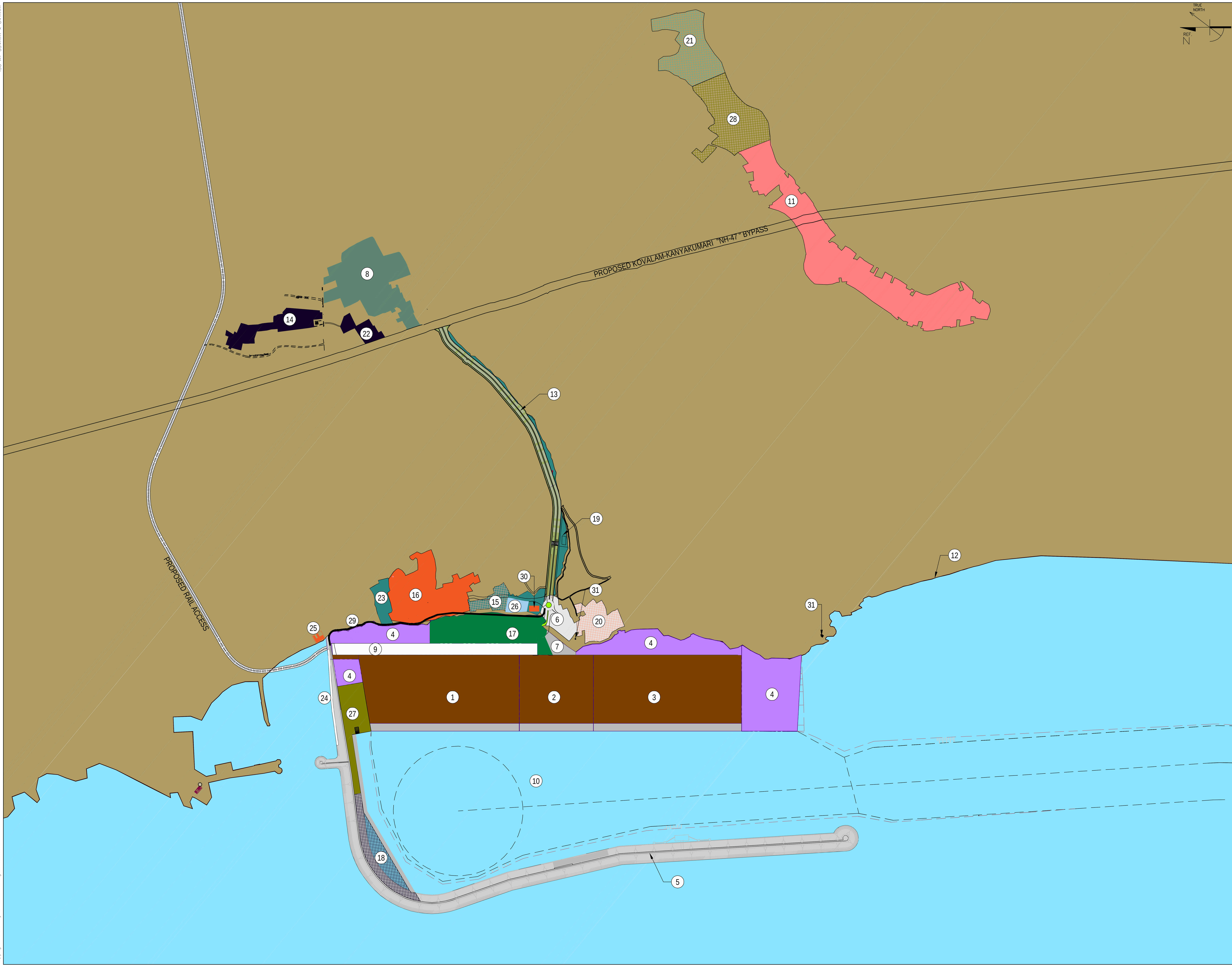
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: RECOMMENDED PORT PHASE-II PLAN
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 213
REV 2

ISO A1 594mm x 841mm



KEYNOTES

1	CONTAINER YARD PHASE 1	31.3HA
2	CONTAINER YARD PHASE 2	14.8HA
3	CONTAINER YARD PHASE 3	29.6HA
4	FUTURE EXPANSION AREA	28.6HA
5	BREAKWATER ROAD	3.3HA
6	AREA RESERVED FOR VISL PORT BUILDING & CONSTRUCTION STAGING AREA	2.1HA
7	TERMINAL ADMIN AREA	1HA
8	TRUCK TERMINAL / FUEL FILLING & OTHER UTILITIES	13.5HA
9	RAIL TERMINAL	6.8HA
10	HARBOUR AREA WITHIN BREAKWATER	167HA
11	PORT BASED SEZ, ADDITIONAL WARE HOUSING & COMMERCIAL FACILITIES	28.7HA
12	SHORE LINE	
13	ROAD ACCESS CORRIDOR	11.7HA
14	PORT OPERATOR'S COLONY AREA	4.9HA
15	AREA TO BE PROCURED FOR PORT OPERATOR UTILITY FOR PHASE 1 & 2	6.1HA
16	CRUISE SERVICE / RESORT AREA	7.5HA
17	TERMINAL GATE AREA	10HA
18	CRUISE BERTHING AREA	5.2HA
19	PREGATE AREA	1.3HA
20	PORT OPERATOR UTILITY AREA FOR PHASE 3 / CONSTRUCTION STAGING AREA	4HA
21	VISL COLONY AREA	9HA
22	VISL 220/66KV MAIN RECEIVING SUBSTATION	1.2HA
23	COAST GUARD OPERATIONAL AREA	1.8HA
24	FISHING BERTHS	0.05HA
25	AUCTION HALL, MENDING HALL, FACILITY FOR FISHING LANDING BERTHS	0.14HA
26	RAIN WATER HARVESTING AREA	0.8HA
27	INDIAN NAVY OPERATIONAL AREA	4.5HA
28	NAVY / COAST GUARD COLONY AREA	10HA
29	INDICATIVE ACCESS ROAD FOR NAVY & COAST GUARD	
30	66/11 KV SUBSTATION FOR PORT	0.02HA
31	EXISTING TEMPLE	

LEGEND

- CONTAINER YARD
- CRUISE BERTING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA
- PORT BASED SEZ / COMMERCIAL FACILITIES
- ROAD ACCESS
- TRUCK TERMINAL
- PORT OPERATOR COLONY AREA
- CRUISE SERVICE AREA
- TERMINAL GATE AREA
- INDIAN NAVY AREA
- VISL COLONY AREA
- INDIAN NAVY / COAST GUARD COLONY AREA

Revision	By	Approved	Date
REV 1	VB	VA	24-05-13

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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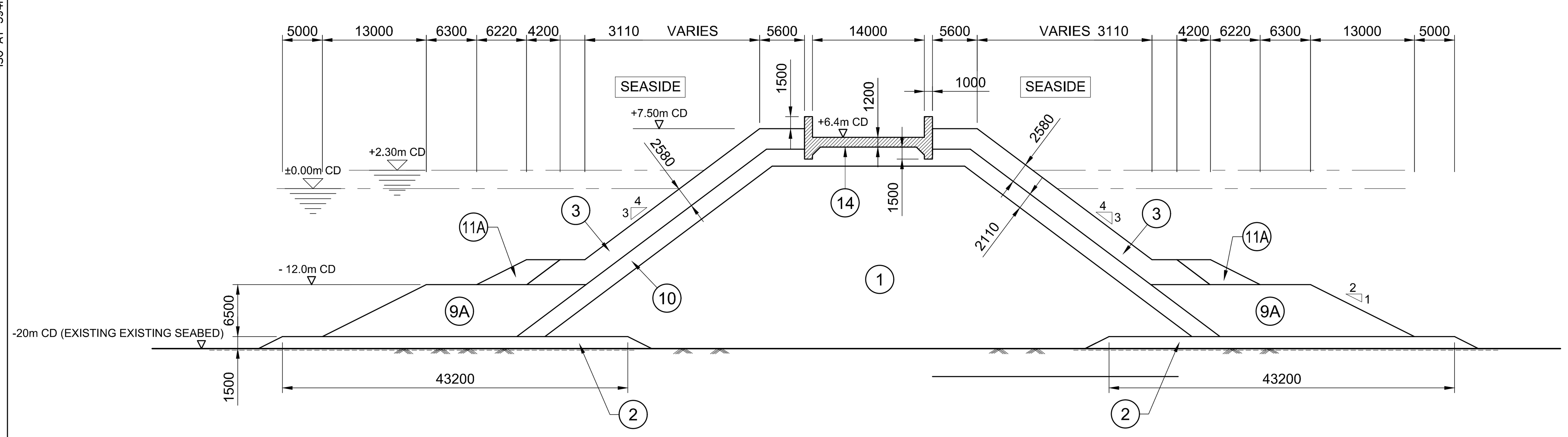
Approved By: VA
Date: 21/05/2013
Meeting: DETAILED PROJECT REPORT

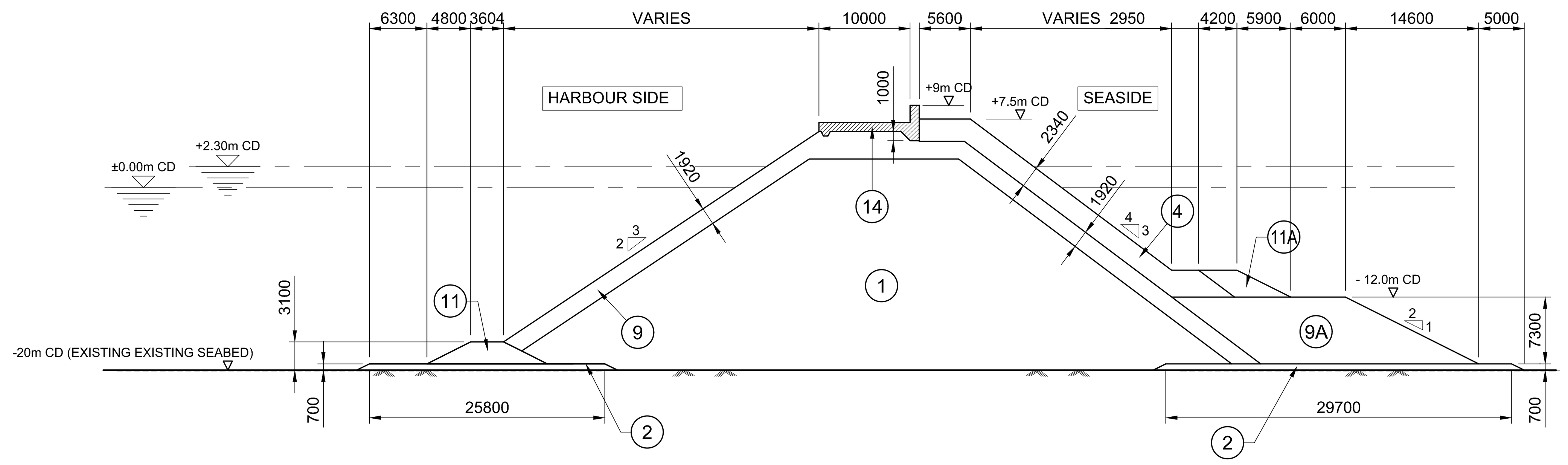
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

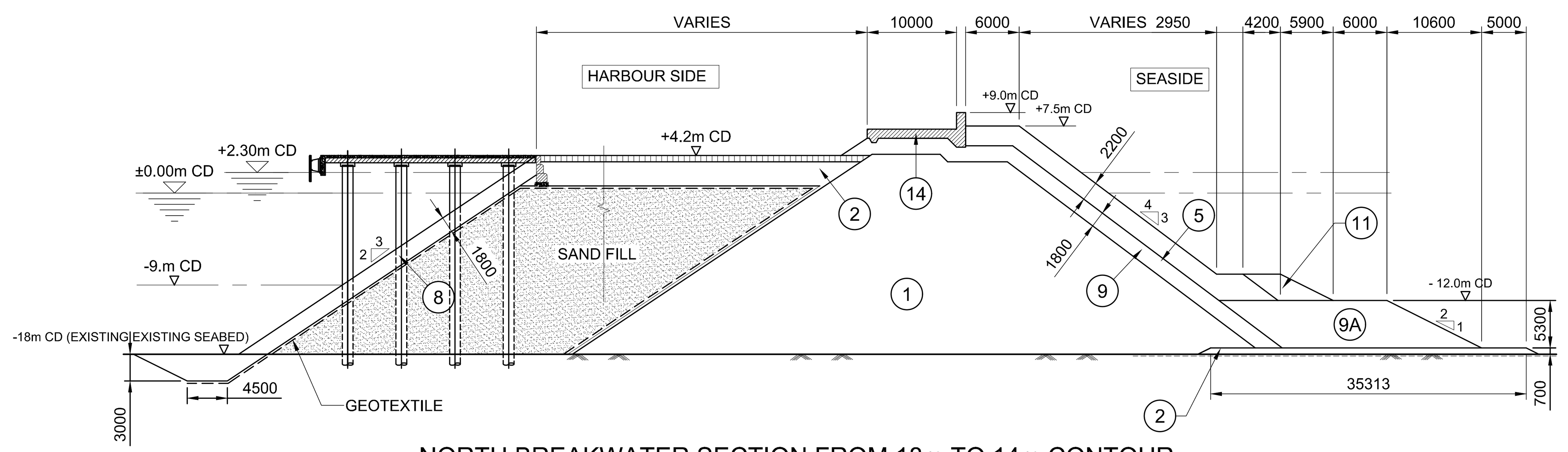
Sheet Title: LAND USE PLAN
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 214
REV 1



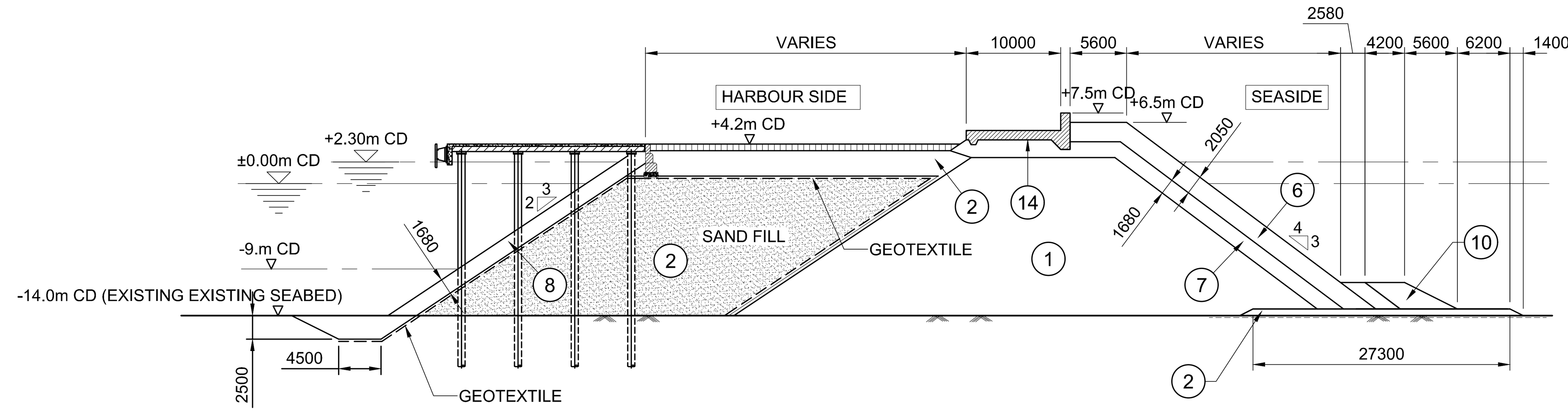
NORTH BREAKWATER HEAD SECTION AT 20m CONTOUR
SCALE 1:500 (A1)



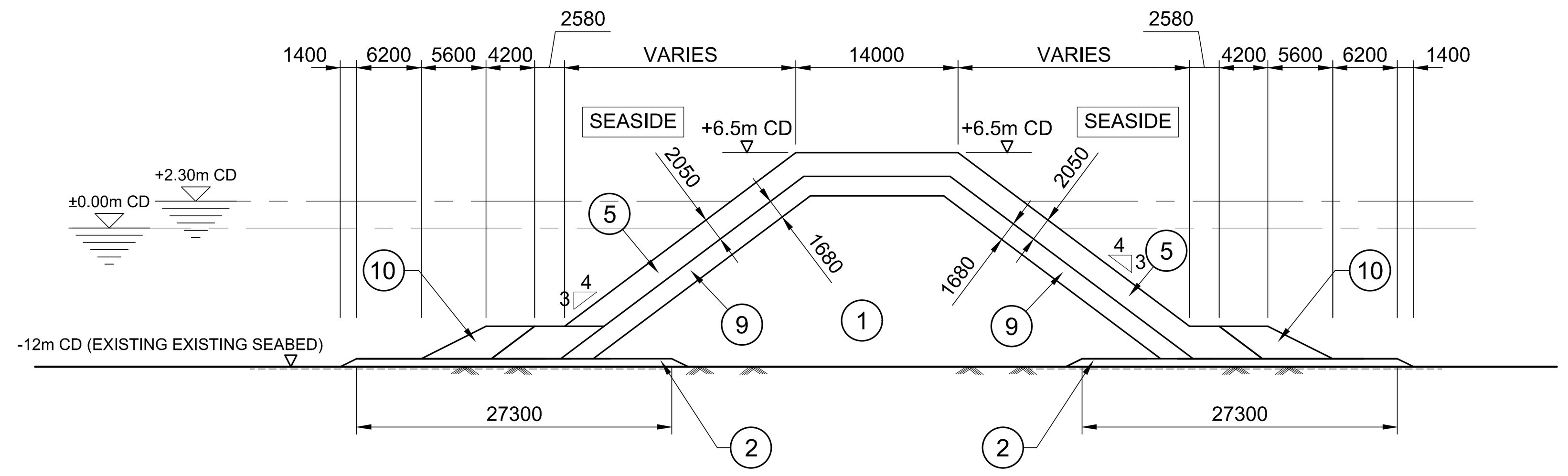
NORTH BREAKWATER SECTION FROM 20m TO 18m CONTOUR
SCALE 1:500 (A1)



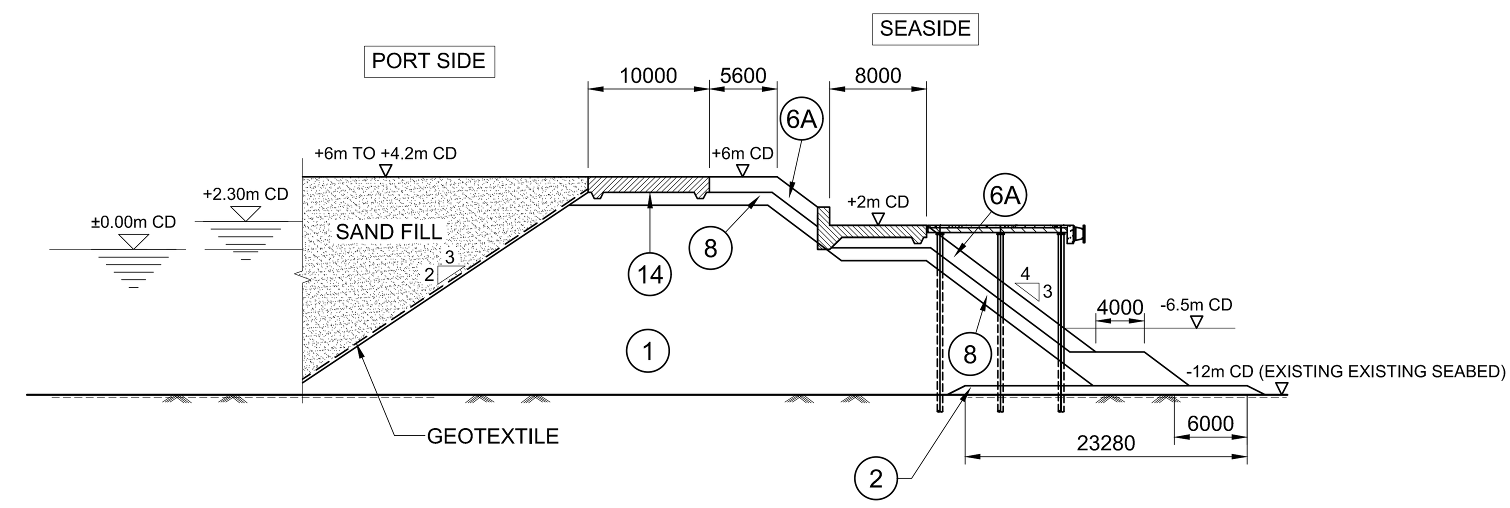
NORTH BREAKWATER SECTION FROM 18m TO 14m CONTOUR
SCALE 1:500 (A1)



NORTH BREAKWATER SECTION FROM 14m TO 12m CONTOUR
SCALE 1:500 (A1)



NORTH BREAKWATER HEAD SECTION AT 12m CONTOUR
SCALE 1:500 (A1)



NORTH BREAKWATER SECTION FROM 12m CONTOUR TO SHORE
SCALE 1:500 (A1)

LEGEND:

1	CORE 10KG TO 0.5T
2	BEDDING LAYER 0.1T TO 0.3T
3	ACCROPODE 8m³
4	ACCROPODE 6m³
5	ACCROPODE 5m³
6	ACCROPODE 4m³
6A	ACCROPODE 1m³
7	ROCK 0.6T TO 1.4T
8	ROCK 0.2T TO 0.4T
9	ROCK 1.0T TO 2.0T
9A	ROCK 2.0T TO 4.0T
10	ROCK 1.4T TO 2.7T
11	TOE PROTECTION ROCK 2.0T TO 4.0T
11A	TOE PROTECTION ROCK 2.5T TO 5.0T
12	TOE PROTECTION ROCK 3.0T TO 6.0T
13	TOE PROTECTION ROCK 1.0T TO 2.0T
14	CROWN WALL

NOT FOR CONSTRUCTION

NOTES:

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

Revision	By	Approved	Date
REV 1	VKM	VA	10-05-13

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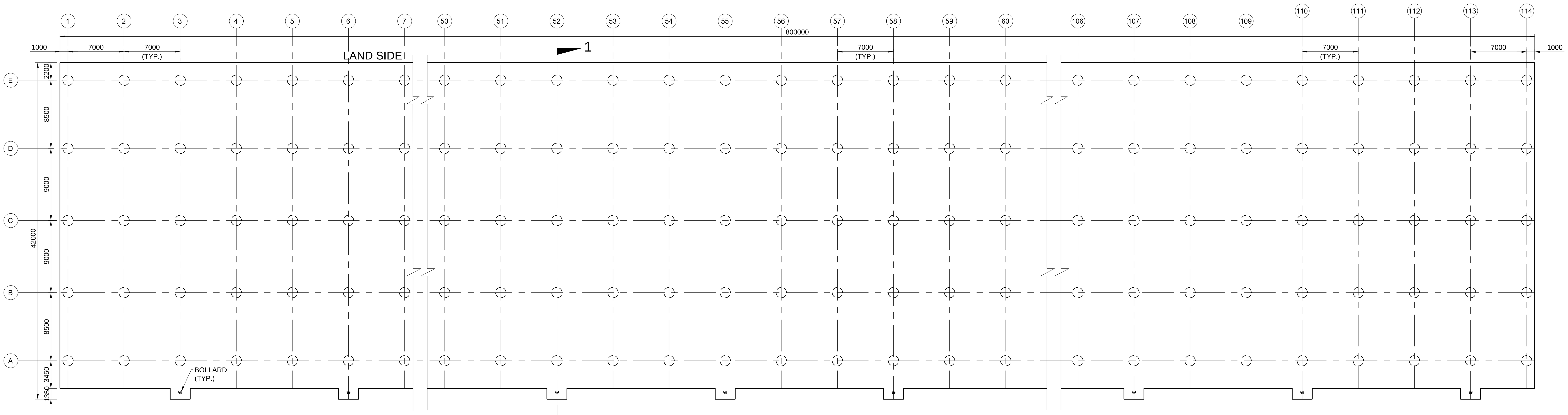
Drawn By: DK
Approved By: AM
Date: 09-01-13
Meeting: DETAILED PROJECT REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

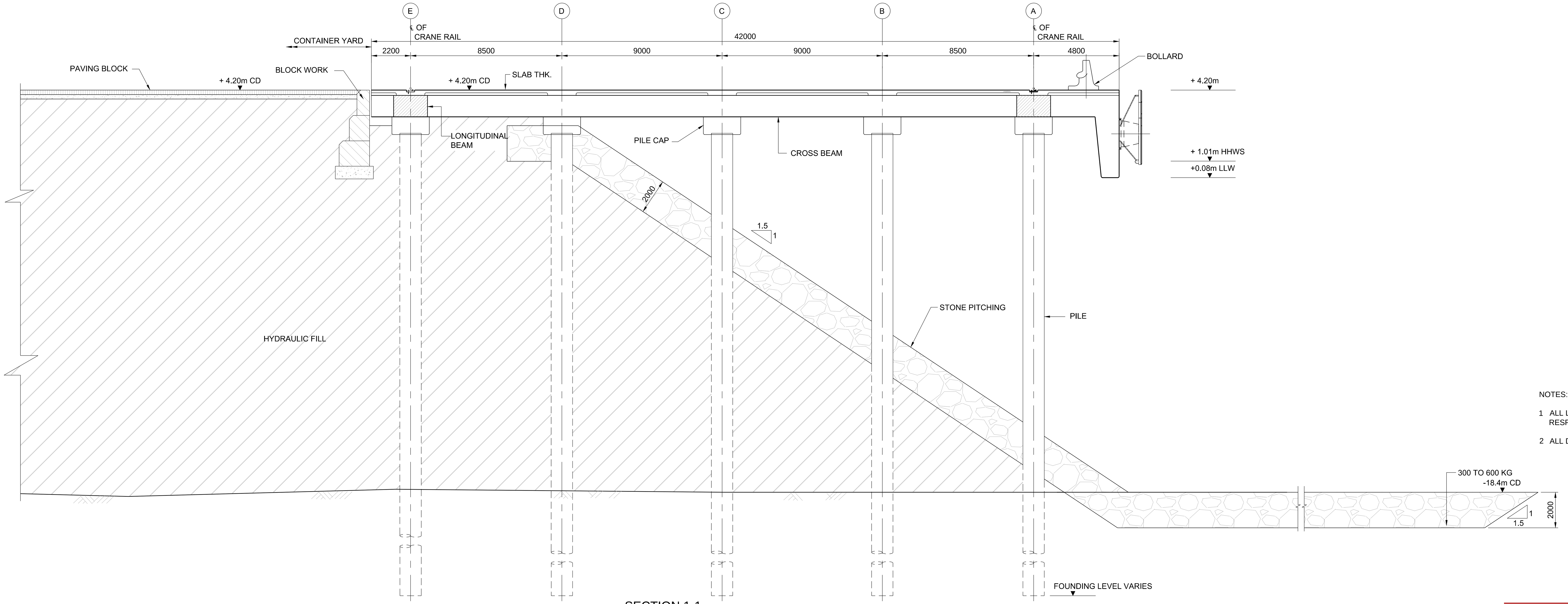
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CROSS SECTIONS OF THE NORTH BREAKWATER
Project Number: DELD12086
Sheet Number: 1 of 2
Drawing No.: DELD12086/DPR/ 221
REV 1

Xref's:



PLAN
SCALE 1:250



SECTION 1-1
SCALE 1:125

NOTES:

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

2 ALL DIMENSIONS ARE IN MILLIMETERS.

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REV 1	VB	VA	10-05-13

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Drawn By: DK
Approved By: AM
Date: 09-01-13
Meeting: DETAILED PROJECT REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

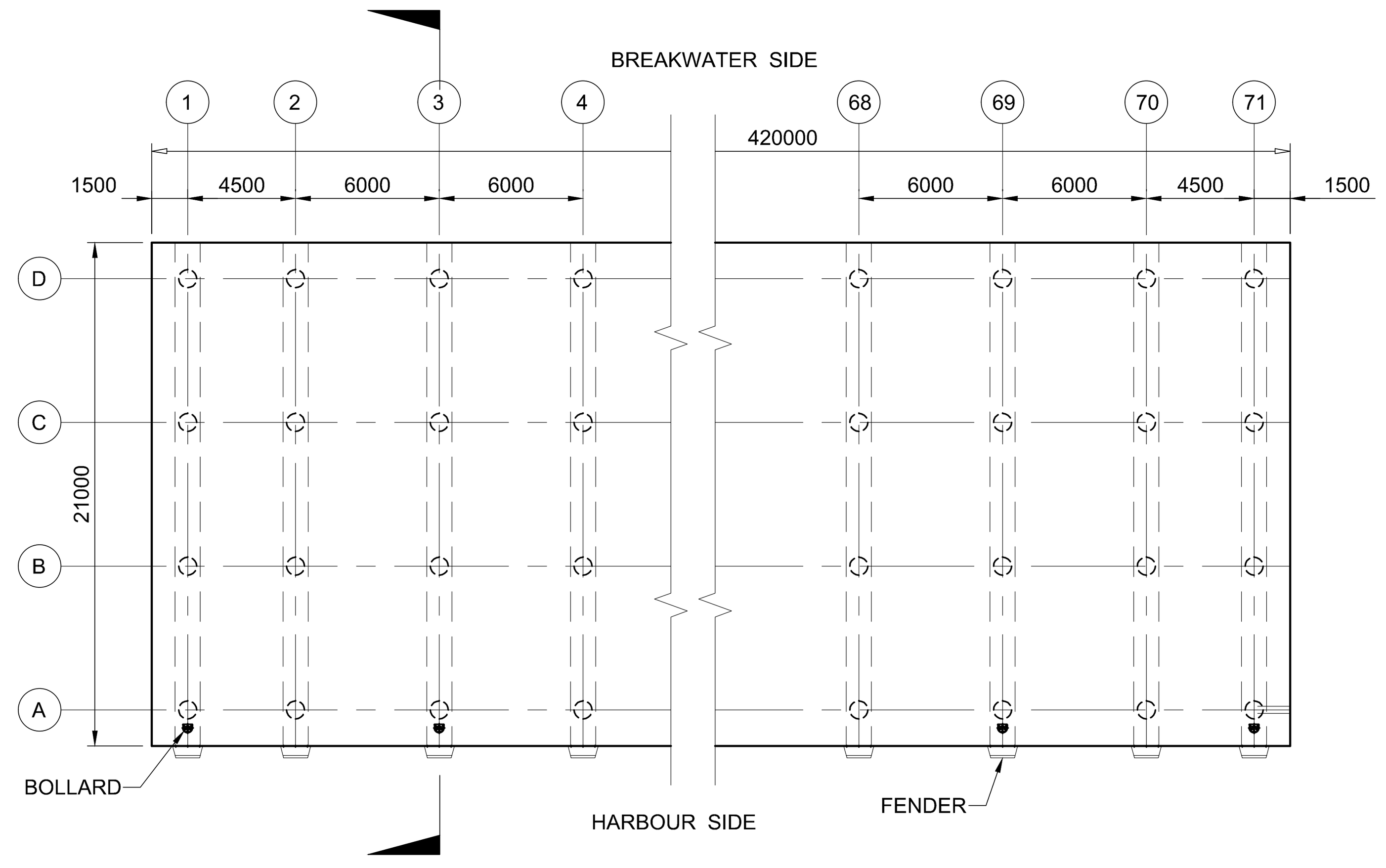
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: STRUCTURAL ARRANGMENT AND CROSS SECTION OF THE CONTAINER BERTHS

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No. DELD12086/DPR/231
REV 1

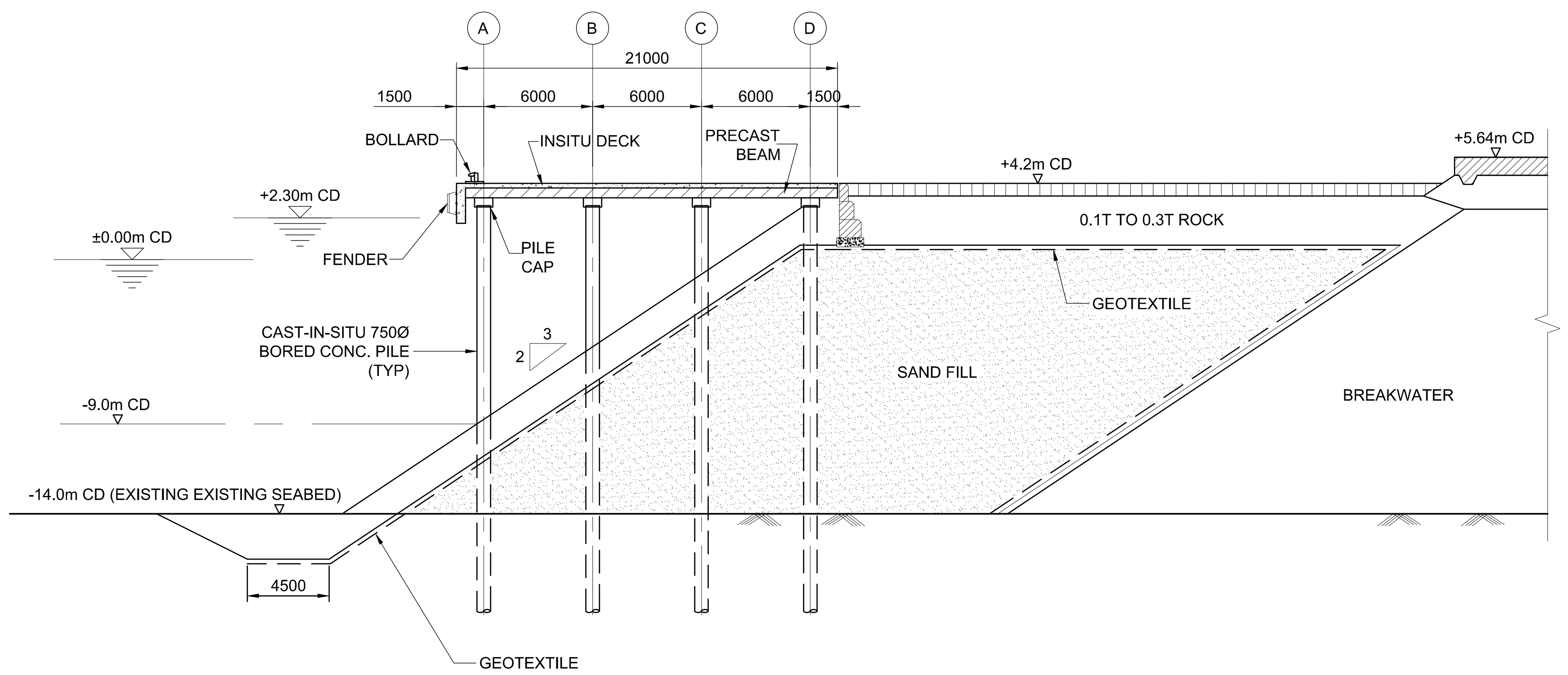
Xref's:

ISO A1 594mm x 841mm



TYPICAL PLAN FOR COAST GUARD / NAVY / PORT CRAFT BERTHS

SCALE 1:250 (A1)



TYPICAL CROSS-SECTION FOR COAST GUARD / NAVY / PORT CRAFT BERTHS

SCALE 1:250 (A1)

NOT FOR CONSTRUCTION

NOTES:

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

Revision	By	Approved	Date
REV 1	VKM	VA	10-05-13

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Approved By: AM
Date: 09-01-13
Meeting: DETAILED PROJECT REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CROSS-SECTION OF THE COAST GUARD/NAVY/PORT CRAFT BERTHS

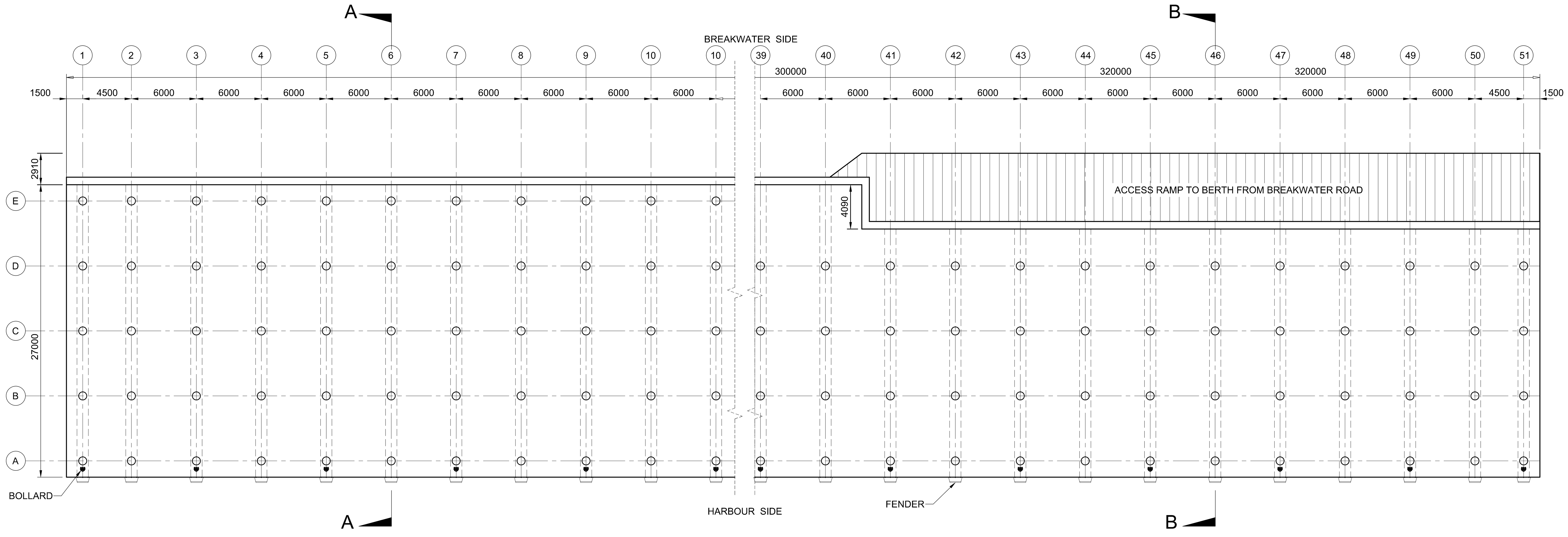
Project Number: DELD12086

Sheet Number: 1 of 1

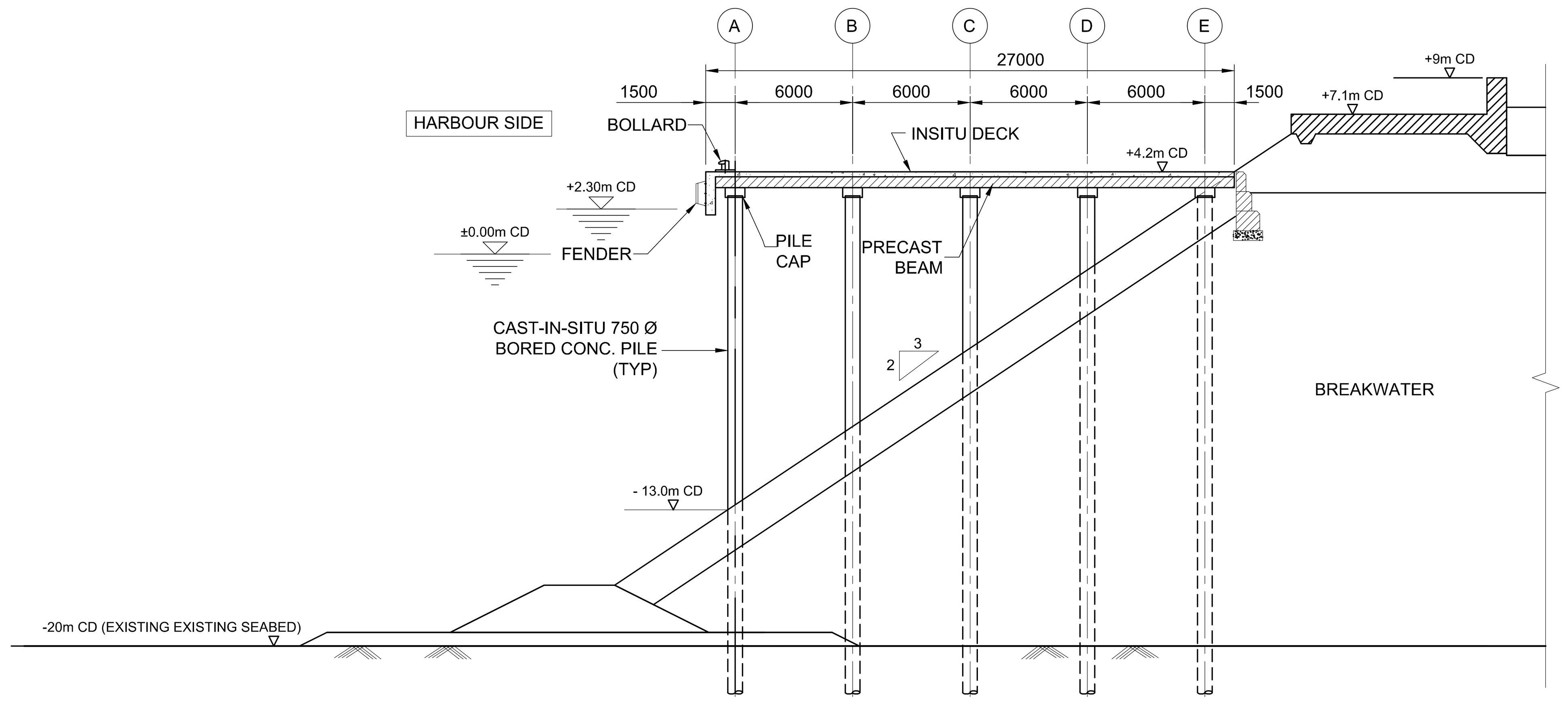
Drawing No.: DELD12086/DPR/ 233

REV 1

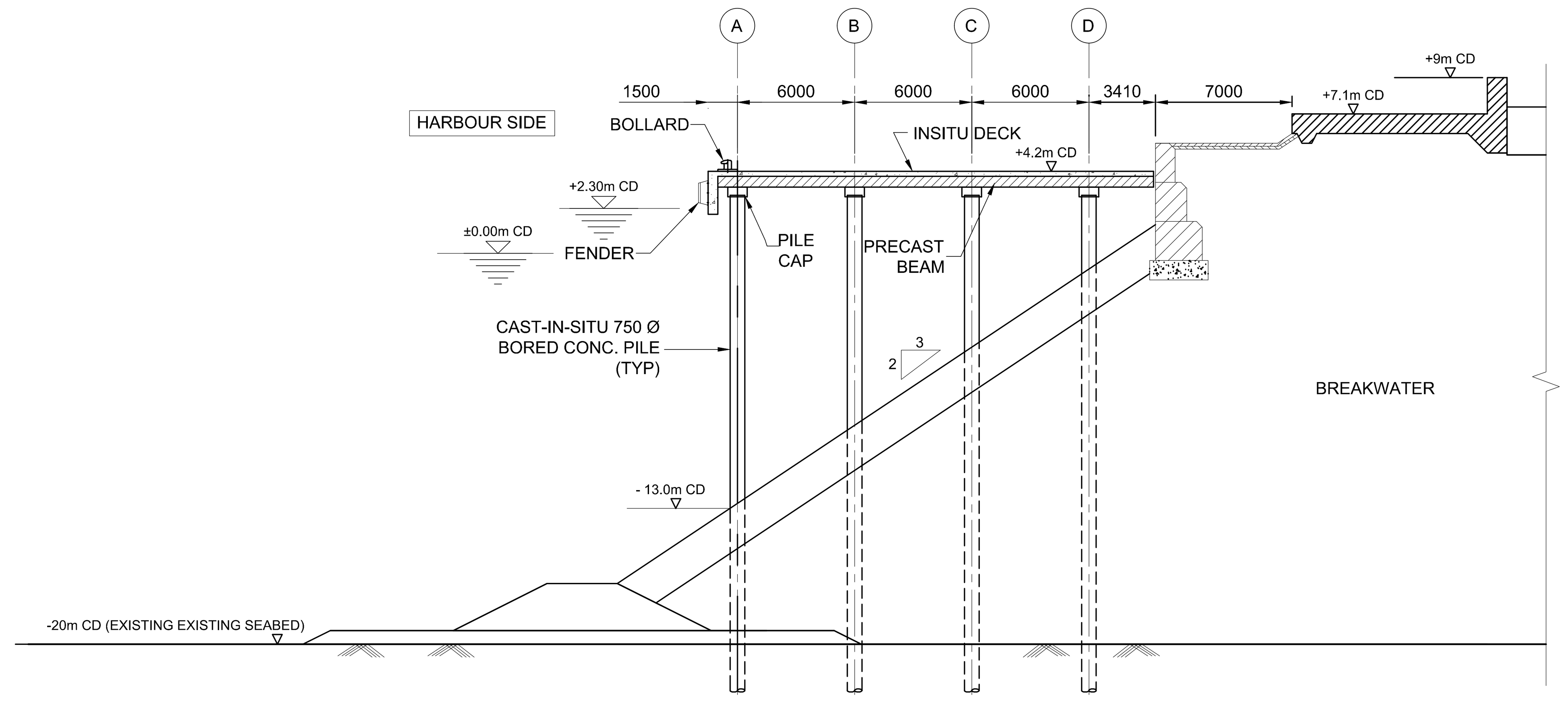
Xref's:



TYPICAL PLAN OF 300m NAVY BERTH
SCALE 1:250 (A1)



SECTION A-A
SCALE 1:250 (A1)



SECTION B-B
SCALE 1:250 (A1)

NOT FOR CONSTRUCTION

NOTES:

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

Revision	By	Approved	Date
REV 1	VKM	VA	03-05-13
REV 2	VKM	VA	10-05-13

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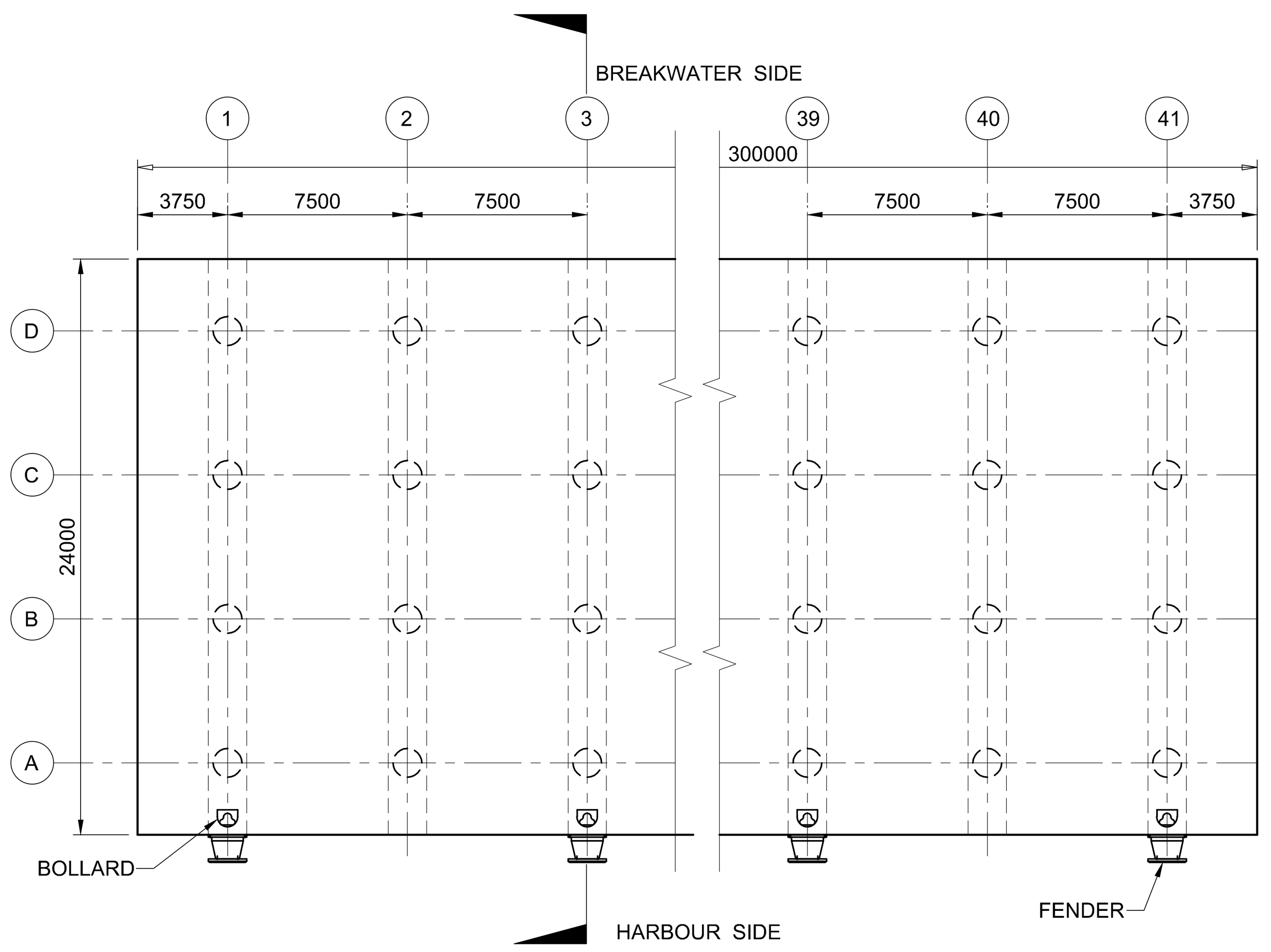
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

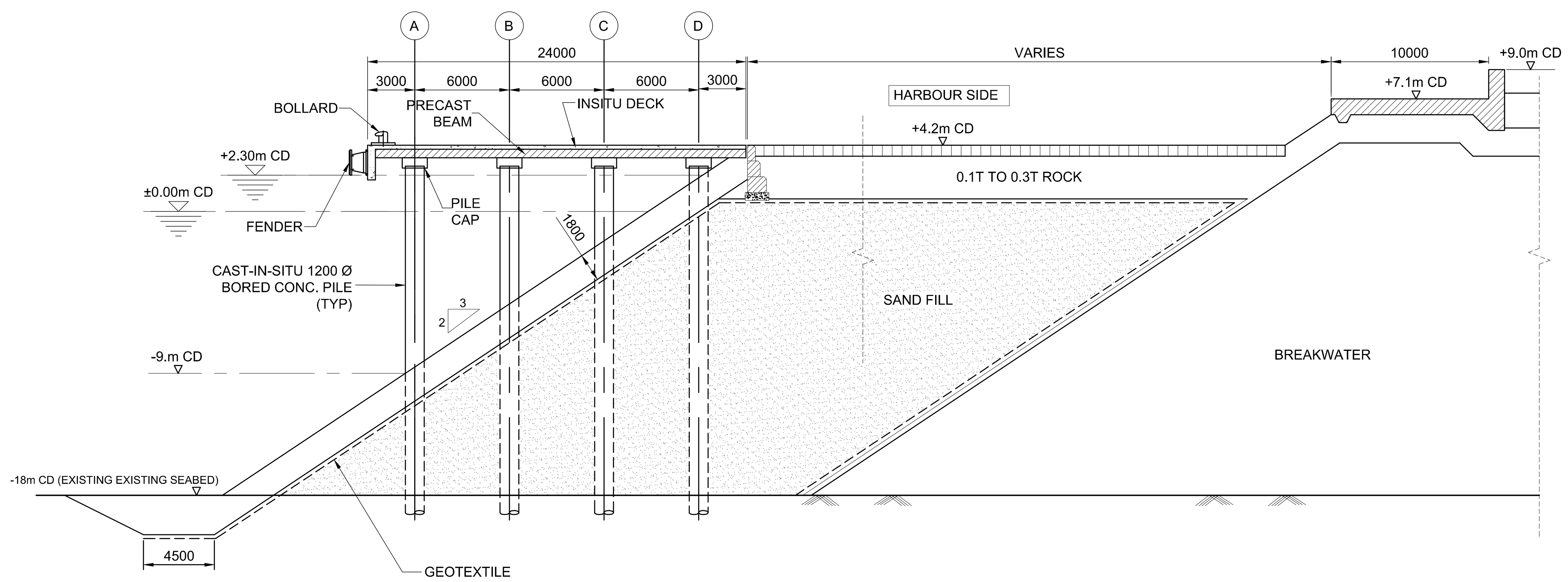
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: TYPICAL CROSS-SECTION OF THE 300m NAVY BERTH
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 234
REV 2

Xref's:



TYPICAL PLAN OF CRUISE BERTH
SCALE 1:250 (A1)



TYPICAL CROSS SECTION OF CRUISE BERTH
SCALE 1:250 (A1)

NOT FOR CONSTRUCTION

NOTES:

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

2. ALL DIMENSIONS ARE IN MILLIMETERS.

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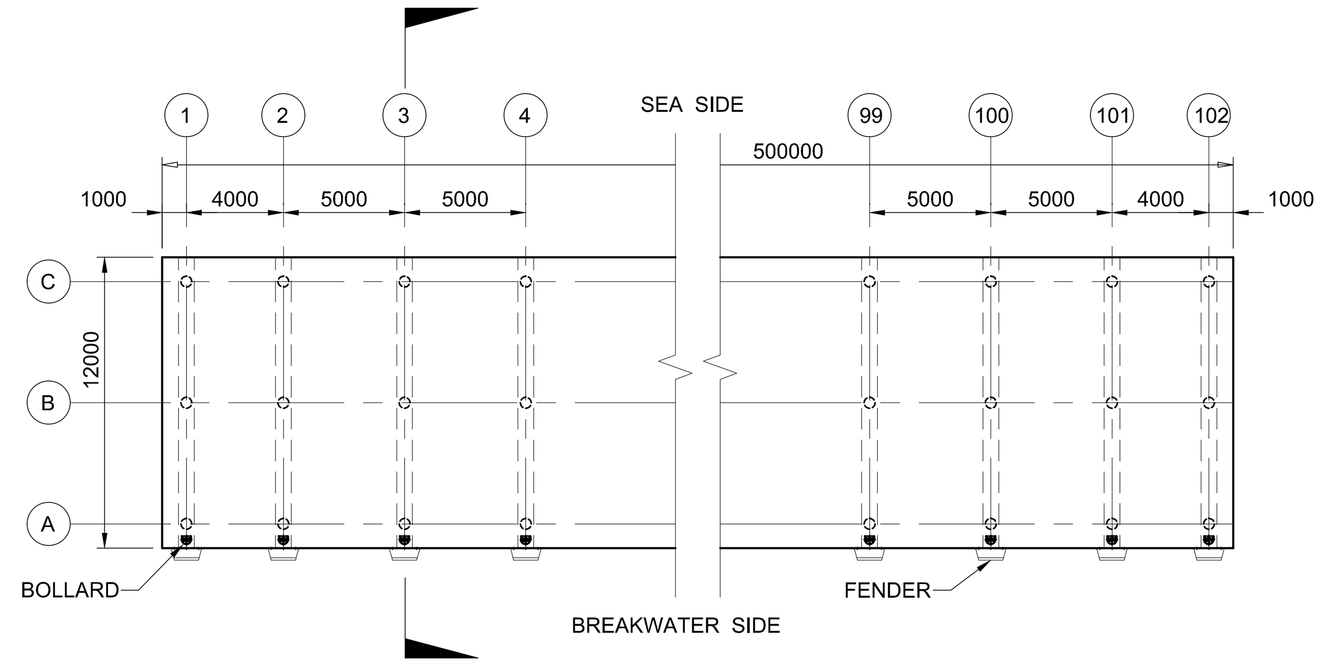
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

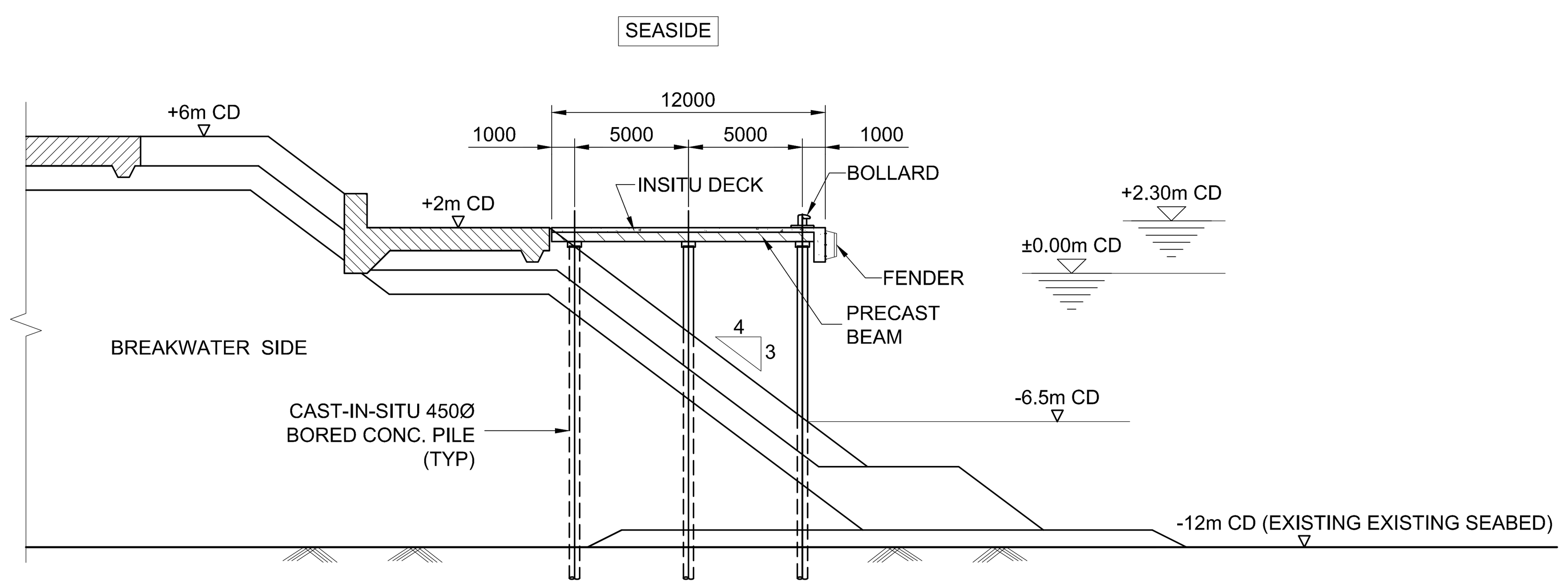
Sheet Title: TYPICAL CROSS SECTION OF CRUISE BERTH
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 235
REV 1

Xref's:

ISO A1 594mm x 841mm



TYPICAL PLAN FOR FISH LANDING BERTH
SCALE 1:250 (A1)



TYPICAL CROSS SECTION FOR FISH LANDING BERTH
SCALE 1:250 (A1)

NOT FOR CONSTRUCTION

NOTES:

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

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REV 1	VKM	VA	10-05-13

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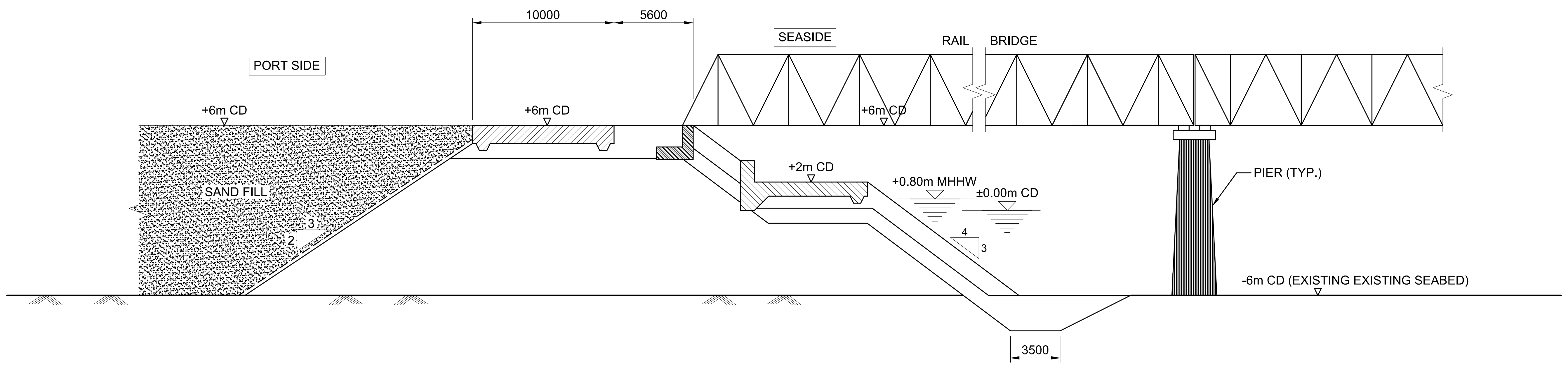
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: TYPICAL CROSS SECTION FOR FISH LANDING BERTH
Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 236
REV 1

Xref's:



TYPICAL CROSS SECTION FOR RAIL BRIDGE OVER BREAKWATER

SCALE 1:250 (A1)

NOT FOR CONSTRUCTION

NOTES:

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

Revision	By	Approved	Date
REV 1	VKM	VA	10-05-13

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DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: TYPICAL CROSS-SECTION FOR RAIL BRIDGE OVER BREAKWATER

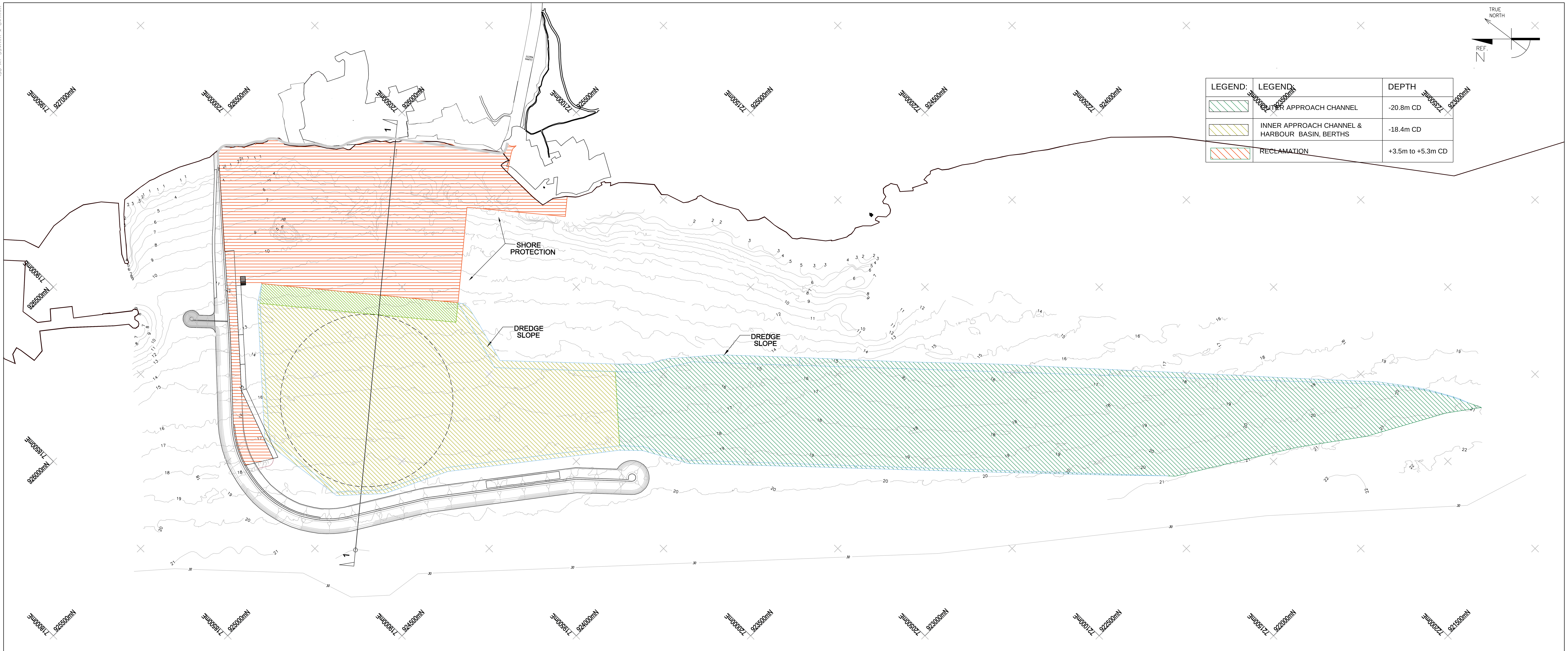
Project Number: DELD12086

Sheet Number: 1 of 1

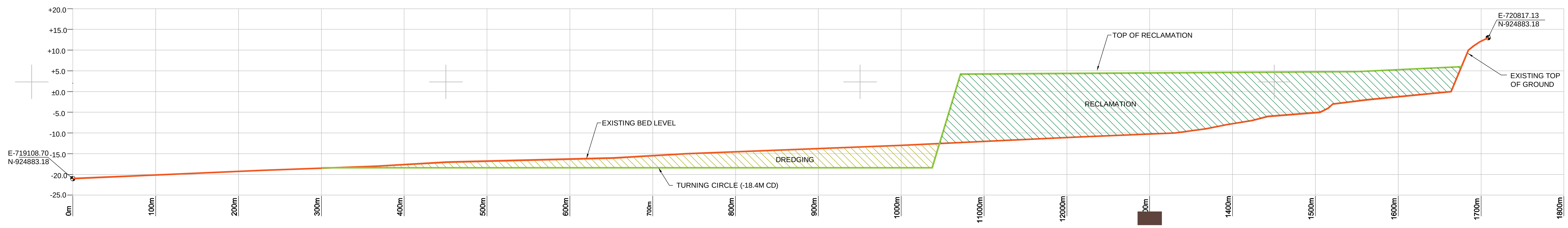
Drawing No.: DELD12086/DPR/ 237

REV 1

Xref's:



LEGEND:	LEGEND:	DEPTH
	OUTER APPROACH CHANNEL	-20.8m CD
	INNER APPROACH CHANNEL & HARBOUR BASIN, BERTHS	-18.4m CD
	RECLAMATION	+3.5m to +5.3m CD



SECTION 1-1

SCALE AS SHOWN

PRELIMINARY

Revision	By	Approved	Date
REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	24 - 05 - 13

0m 100 200 300 400

SCALE 1:5000 FULL SIZE (A1)

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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

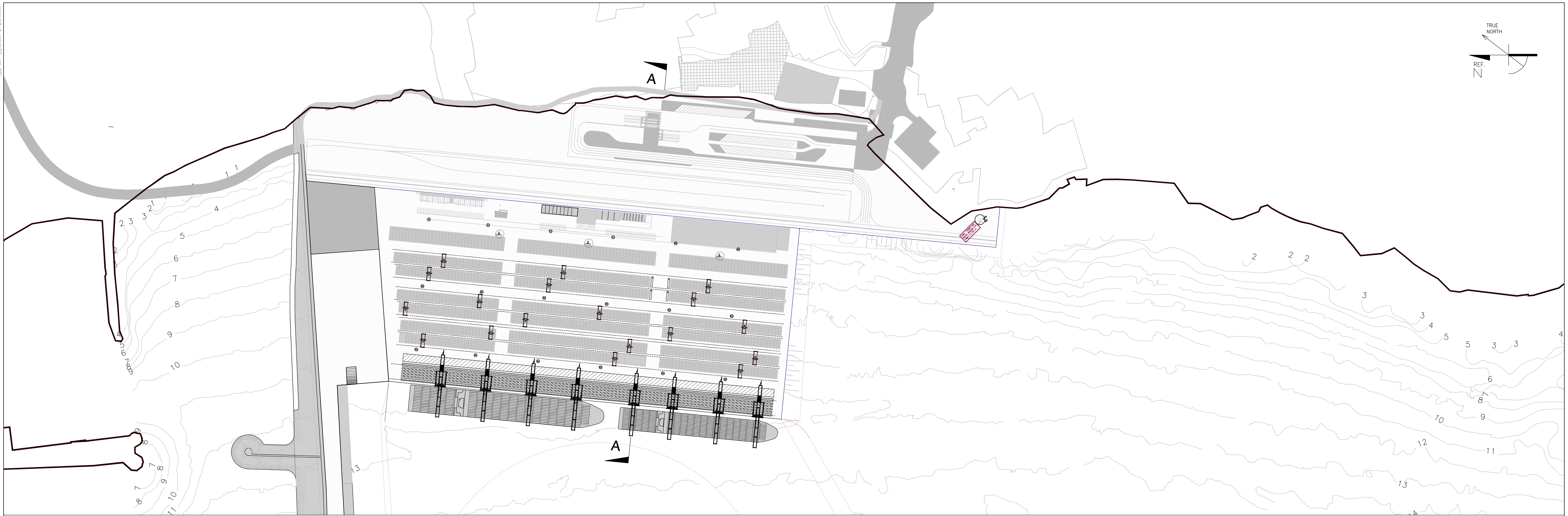
Sheet Title: DREDGING AND RECLAMATION PLAN FOR PROPOSED VIZHINJAM PORT

Project Number: DELD12086

Sheet Number: 1 of 1

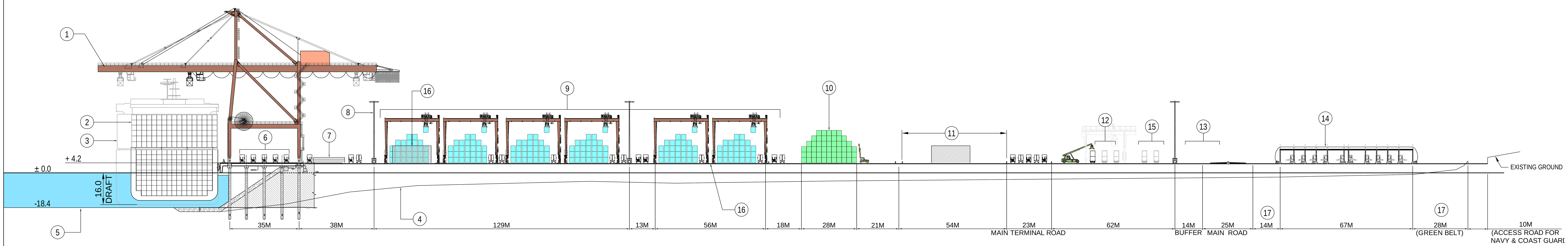
Drawing No.: DELD12086/DPR/ 241

REV 2



PHASE 1 SITE PLAN

1:4000



SECTION

1:1000

A

KEYNOTES

1. 35.00M GAUGE QUAY CRANE
2. 9,000 TEU CONTAINER SHIP
3. 12,500 TEU CONTAINER SHIP
4. EXISTING CONTOUR
5. DREDGE DEPTH
6. 5 LOAD LANES
7. HATCH COVER LAYDOWN AREA
8. HIGH MAST LIGHT POLE, TYP
9. RTG OPERATION
10. EMPTY CONTAINER STACKS
11. MAINTENANCE AND REPAIR AREAS
12. INTERMODAL WORKING TRACKS W/ REACH STACKER
13. INTERNAL ROAD
14. GATE COMPLEX AREA
15. RAIL LOOP LINES
16. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
17. GREEN BELT AREA

NOTES:

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2. ALL DIMENSIONS ARE IN MILLIMETERS.

Revision	By	Approved	Date
REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	24 - 05 - 13

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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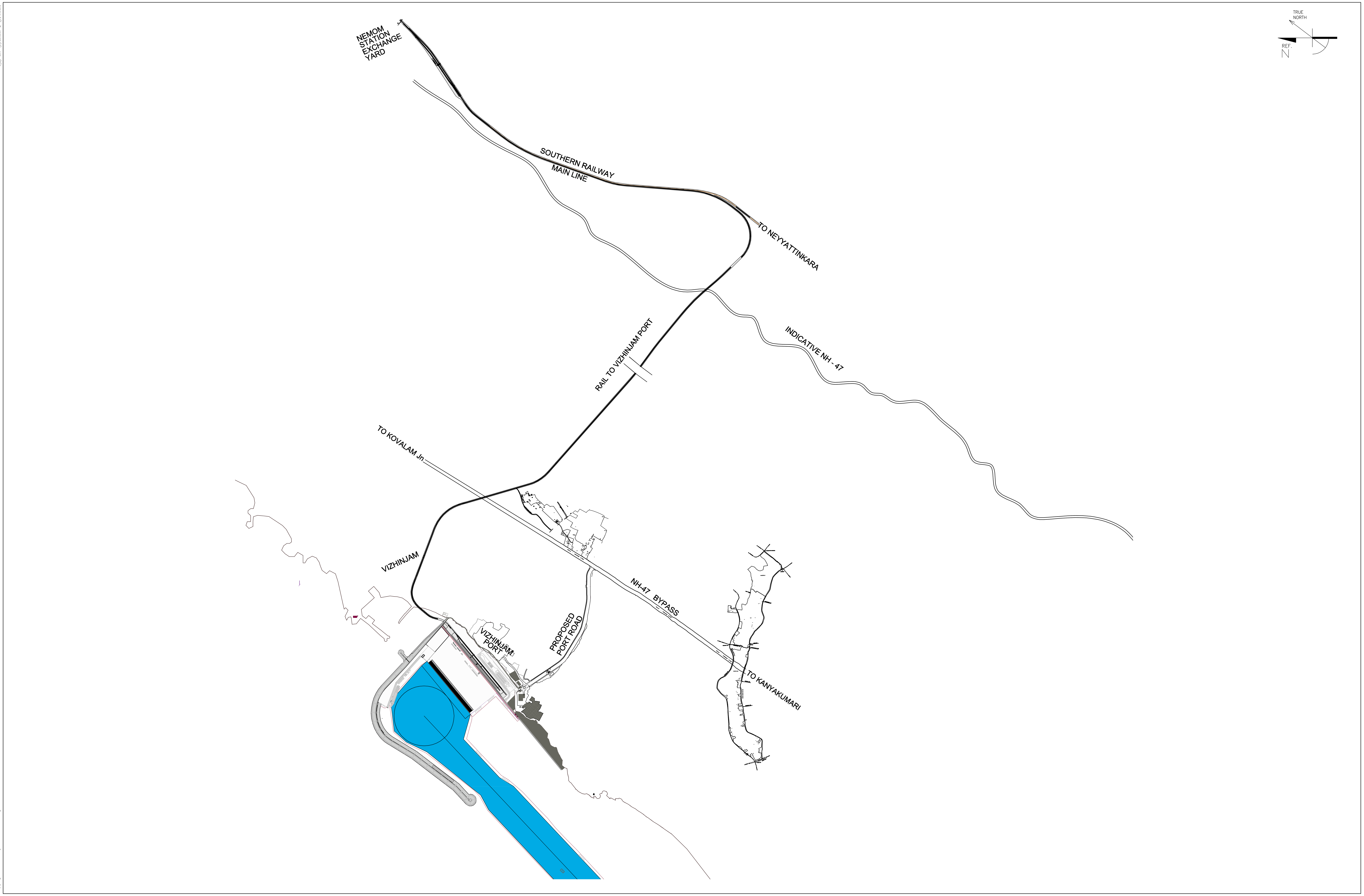
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CROSS SECTION THROUGH CONTAINER YARD

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 251
REV 2



Revision	By	Approved	Date
REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	24 - 05 - 13

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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Drawn By: VKM
Approved By: VA
Date: 09/01/13
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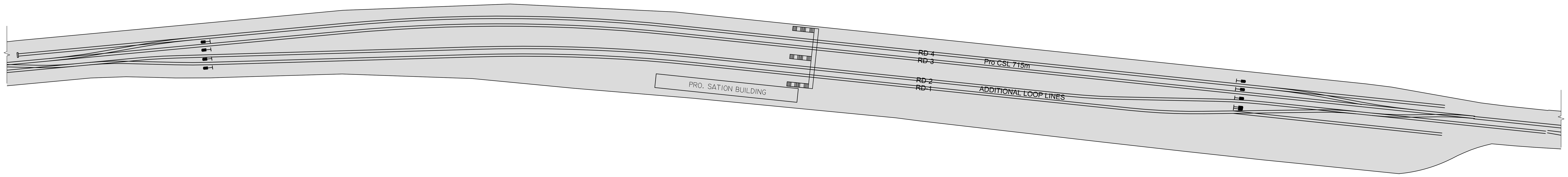
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

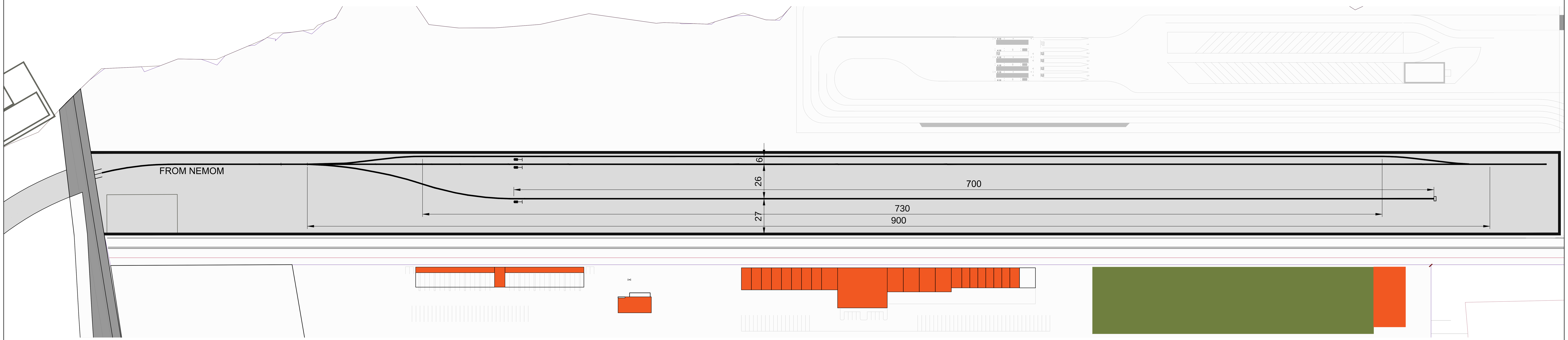
Sheet Title: PROPOSED ROAD AND RAIL CONNECTIVITY FOR VIZHINJAM PORT

Project Number: DELD12086
Sheet Number: 1 of 2
Drawing No.: DELD12086/DPR/ 261
REV 2

ISO A1 594mm x 841mm



NEMOM STATION EXCHANGE YARD
SCALE 2:3000



RAIL YARD WITHIN PORT AREA
SCALE 2:3000

Revision	By	Approved	Date

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Date: 09/01/13
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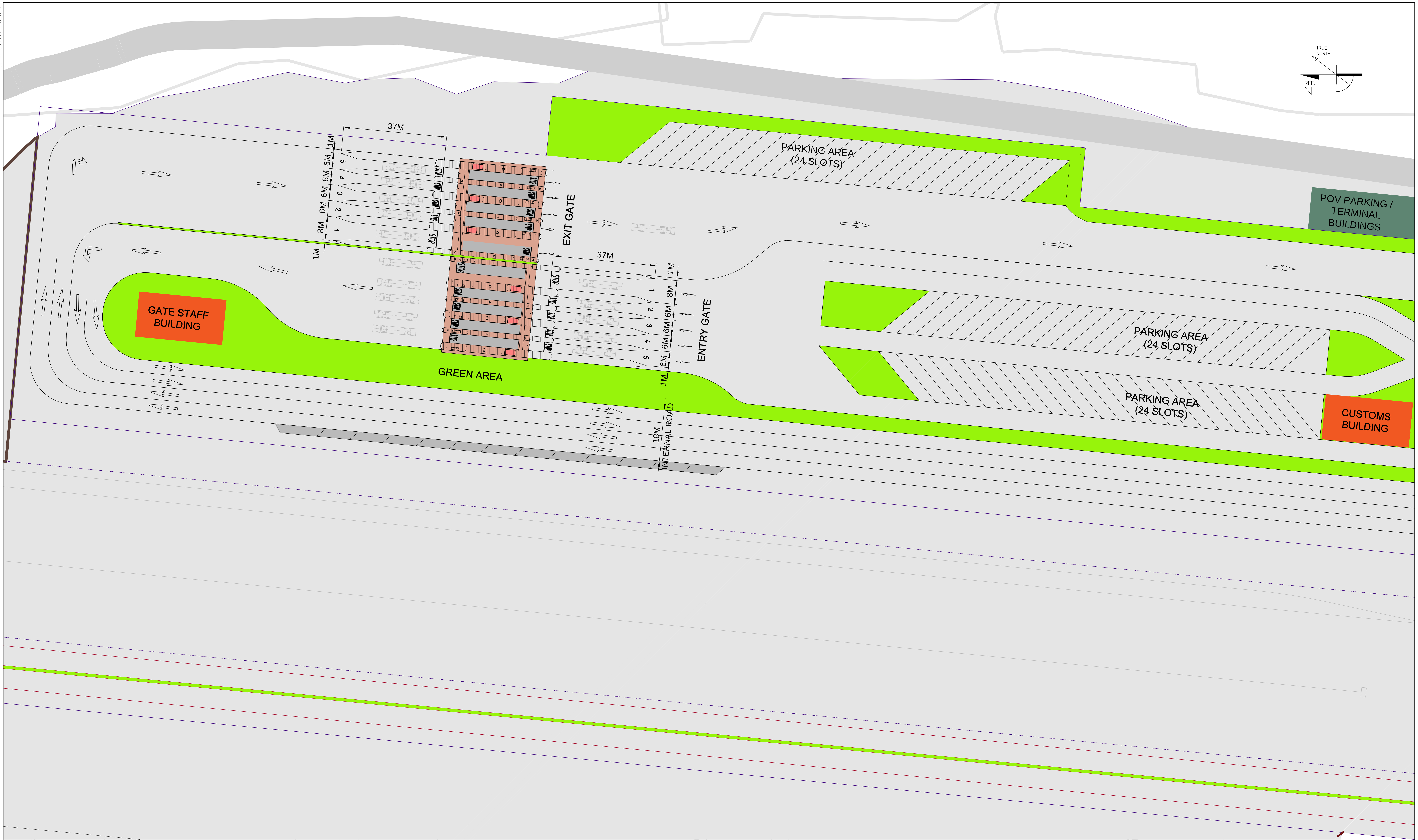
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: PROPOSED ROAD AND RAIL CONNECTIVITY FOR VIZHINJAM PORT
Project Number: DELD12086
Sheet Number: 2 of 2
Drawing No.: DELD12086/DPR/ 261



ISO A1 594mm x 841mm

Revision	By	Approved	Date
REV 1	VB	VA	24-05-13

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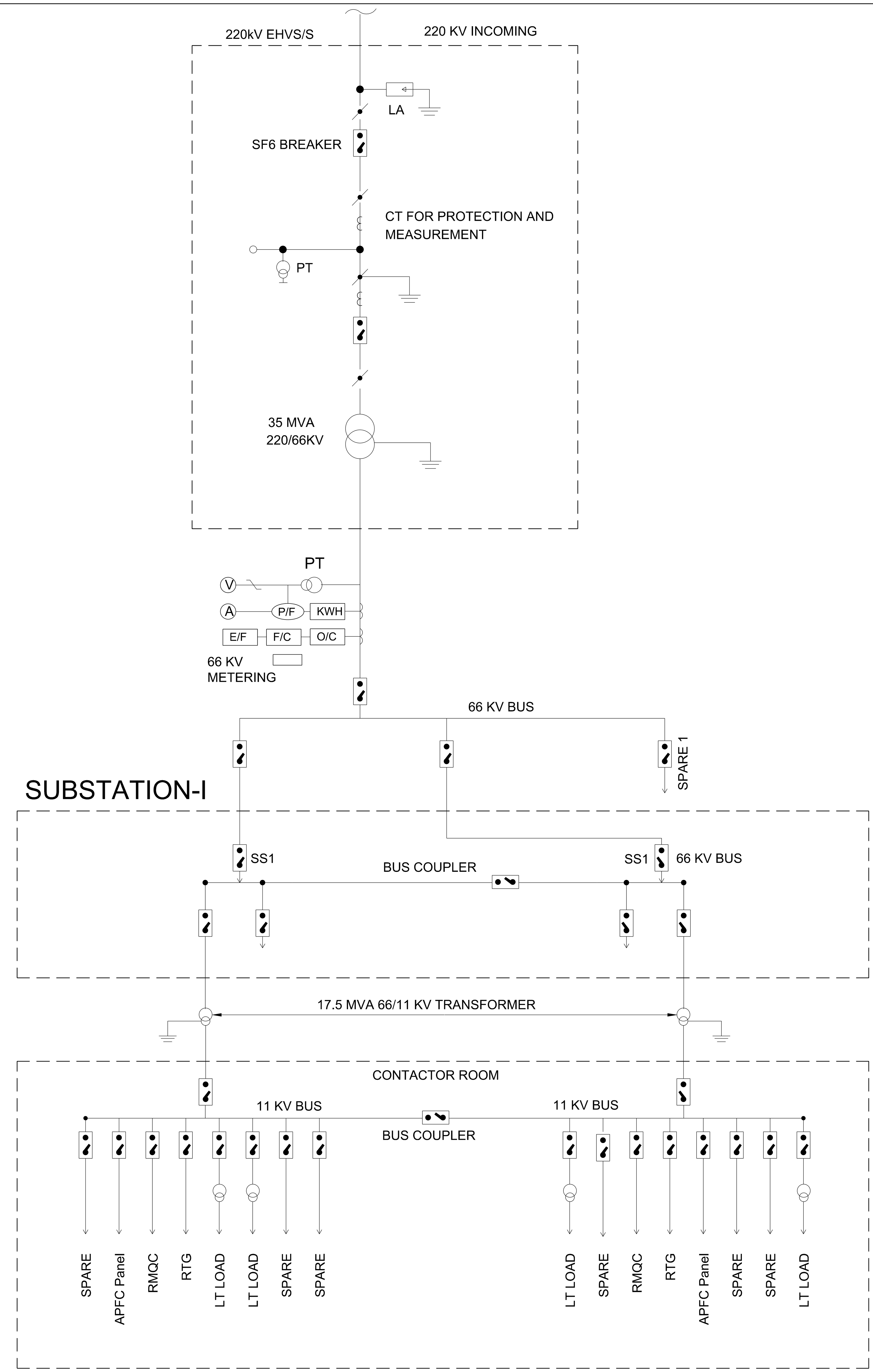
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

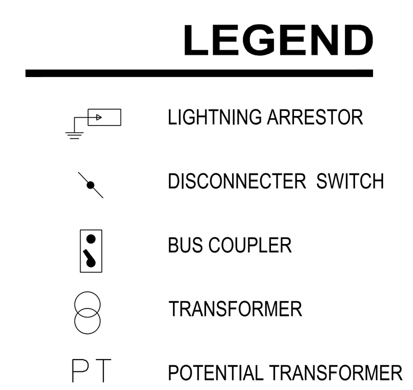
DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: DETAILS OF THE GATE COMPLEX

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 262
REV 1

ISO A1 594mm x 841mm





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Date: 09-01-13
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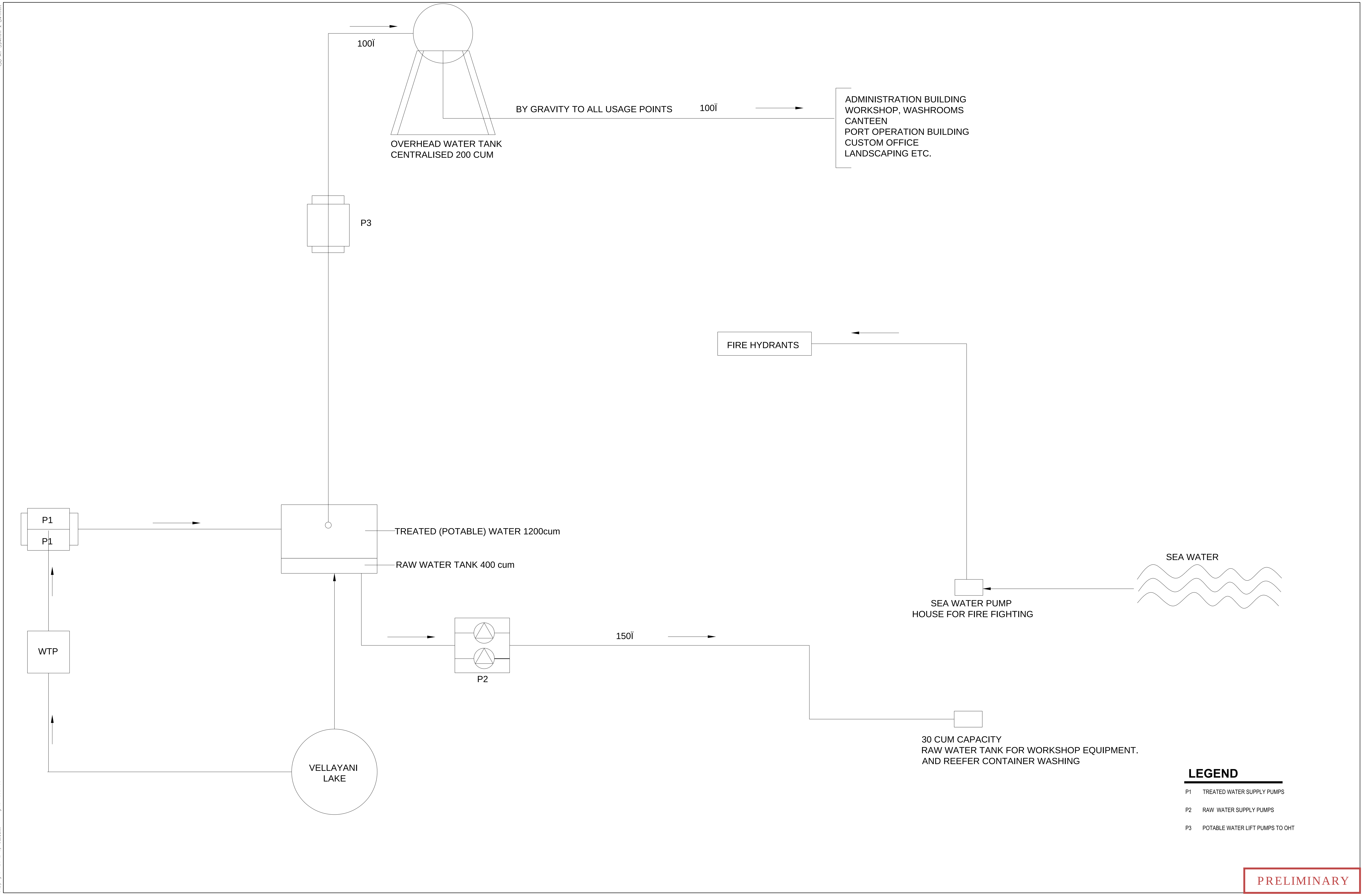
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
SINGLE LINE DIAGRAM FOR ELECTRICAL DISTRIBUTION

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 263



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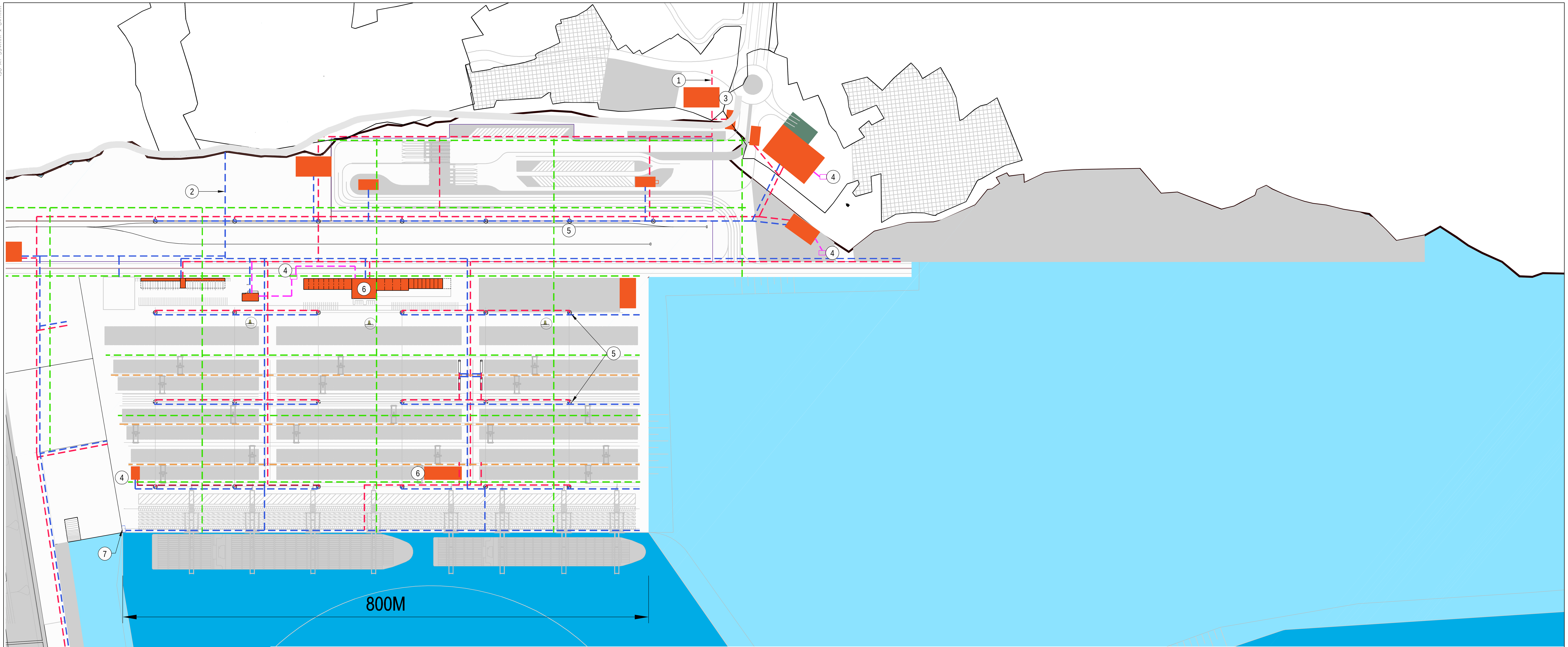
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
SCHEMATIC DIAGRAM FOR WATER SUPPLY AND STORAGE

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 264



UTILITY PLAN SCHEMATIC

1:3000

KEYNOTES

1. MAIN POWER FEED FROM 220KV SUB STATION
2. MAIN WATER FEED FROM CENTRALIZED OH WATER TANK
3. MAIN PORT SUBSTATION
4. UNDERGROUND SEPTIC TANK
5. HIGH MAST LIGHT POLES W/ FIRE HYDRANTS
6. MAINTENANCE BUILDINGS
7. SEA WATER PUMP HOUSE

LEGEND

ELECTRICAL SERVICE
- ALL TERMINAL LIGHTING
- GATE COMPLEX
  ENTRY / EXIT GATE POWER AND LIGHTING
- MAINTENANCE AREA
  SERVICE BUILDINGS POWER AND LIGHTING
- CONTAINER AREA
  REEFER STACK SUBSTATIONS
  REEFER STACK SERVICE PLATFORMS
- QUAY AREA
- QUAY MAINTAINANCE BUIDINGS
- ALL TUG BERTH AND CRUISE BERTH SERVICES

ELECTRICAL SERVICE FOR POTENTIAL ERTG BUS BAR SYSTEM

WATER SERVICE
- MAINTENANCE AREA
  SERVICE BUILDINGS OPERATIONS AND ACCOMMODATIONS
- FIRE FIGHTING
  HYDRANTS AT HIGH MAST LIGHT POLES
  CONNECTIONS AT SERVICE BUILDINGS
  CONNECTIONS AT QUAY
- CONTAINER SHIP SERVICE CONNECTIONS AT QUAY
- ALL TUG BERTH AND CRUISE BERTH SERVICES

SANITARY SYSTEM
- MAINTENANCE AREA
- SERVICE BUILDINGS RESTROOMS

TRENCH DRAINS

TRUE NORTH

REF. N

Revision	By	Approved	Date
REV 1	VB	VA	10-05-13
REV 2	VB	VA	24-05-13

0m 60 120 180 240

SCALE 1:3000 FULL SIZE
1:6000 HALF SIZE

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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

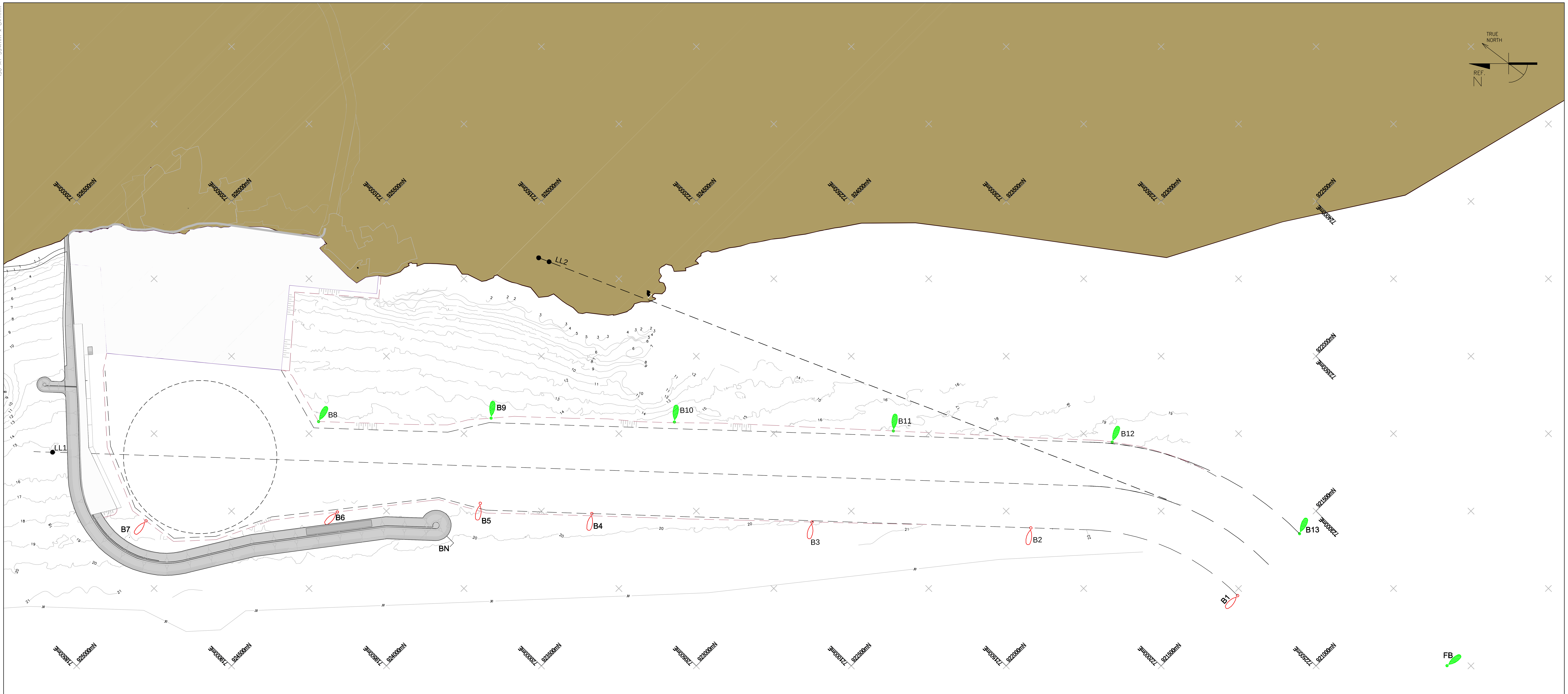
Sheet Title: CONCEPTUAL UTILITY ARRANGEMENTS WITHIN PORT AREA

Project Number: DELD12086

Sheet Number: 1 of 1

Drawing No.: DELD12086/DPR/ 265

REV 2



KEYNOTES

B1.....	CHANNEL MARKING BUOY
FB	FAIRWAY BUOY
BN	BEACON
LL	LEADING LIGHT

LEGEND

- PORT SIDE BUOY
- STAR BOARD SIDE / BUOY
- BEACON
- LEADING LIGHT

Revision	By	Approved	Date
REV 1	VB	VA	10 - 05 - 13
REV 2	VB	VA	24 - 05 - 13

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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

DETAILED PROJECT REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: LAYOUT OF AIDS TO NAVIGATION FOR VIZHINJAM PORT

Project Number: DELD12086
Sheet Number: 1 of 1
Drawing No.: DELD12086/DPR/ 271
REV 2

Annexure 2

Detailed Capital Expenditures (CAPEX) for Vizhinjam Port DPR

Prepared for

Vizhinjam International Seaports Limited (VISL)

Prepared by

AECOM India Private Limited

May 2013

Annexure 2: Detailed Capital Cost Estimates - Detailed Project Report (2012 Price Level)

Exchange rate used 1 USD= 54 INR

S. No.		ITEM	QUANTITY PHASE 1	UNIT	RATE (USD)	AMOUNT (USD) PHASE 1
1.	**PROJECT PRELIMINARIES AND SITE DEVELOPMENT**					
	1.1	Project Studies and Surveys		LS		925,926
	1.2	Preliminary and Preoperative Expenses		LS		925,926
	1.3	Site Clearing		LS		370,370
	1.4	Temporary Construction Fencing		LS		185,185
	Total (1)					**2,407,407**
2.	**DREDGING AND RECLAMATION**					
	2.1	Dredging & Reclmation of Sand	7,639,893	Cum	7.8	59,421,386
	2.2	Reclamation bund (Sand Fill - Dredge Spoils)	535,000	Cum	3.9	2,080,556
	2.3	Shore Protection Revetment	105,375	Cum	69.4	7,317,708
	2.4	Ground Improvement (Gross Reclaimed Area)	62	Ha.	18,519	1,148,148
	2.5	Geo-textile Heavy Duty	89,102	Sqm	3	247,507
	Total (2)					**70,215,305**
3.	**BREAKWATERS (Mob-Demob Cost included in material cost)**					
	3.1	North Breakwater (Length in meters)	3,180			
		a. ACCROPODE (m^3 units)				
		8	707	No.	1,630	1,152,833
		6	10,807	No.	1,222	13,208,239
		5	5,662	No.	1,019	5,767,312
		4	5,604	No.	815	4,565,901
		1	10,333	No.	204	2,104,884
		b. Rock				
		2.5 to 5 T	14,033	Cum	93	1,299,353
		2.0 to 4.0 T	199,403	Cum	74	14,770,594
		1.4 to 2.7 T	10,479	Cum	65	679,194
		1 to 2 T	188,988	Cum	56	10,499,330
		0.6 to 1.4 T	17,305	Cum	56	961,400
		0.2 to 0.4 T	47,461	Cum	44	2,109,361
		c. Core and Bedding	-			
		0.1 to 0.5 T stones (core)	1,960,570	Cum	33	65,352,339
		0.1 to 0.3 T stones (bedding)	163,726	Cum	33	5,457,520
		d. Crown Wall	54,167	Cum	259	14,043,254
	Total (3)					**141,971,514**
4.	**BERTHS**					
	4.1	Container Berths (Quay Length in meters)	800			
		a. Piled Foundation				
		Concrete In-Situ Piles	575	No.	39,137	22,503,552
		b. RCC in Superstructure	33,440	Sqm	402	13,433,722
		c. Fixtures and Accessories				
		Fenders	39	No.	46,296	1,805,556
		Bollards	39	No.	13,889	541,667
		Others	1	LS.	13,17,204	1,317,204
		d. Block Work behind the berth	1	LS.	26,66,667	2,666,667
		e. Stone pitching underside the berth	1	LS.	1,28,68,289	12,868,289
		f. Mob-Demob Cost	1	LS.	22,50,355	2,250,355
	4.2	Port Craft Berths (Quay Length in meters)	100			
		a. Piled Foundation				
		Concrete In-Situ Piles	72	No.	13,128	945,212
		b. RCC in Superstructure	2,000	Sqm	446	892,884
		c. Fixtures and Accessories				

S. No.		ITEM	QUANTITY PHASE 1	UNIT	RATE (USD)	AMOUNT (USD) PHASE 1
		Fenders	9	No.	2,778	25,000
		Bollards	18	No.	926	16,667
		Others	1	LS.	4,90,278	490,278
		d. Stone pitching underside the berth	1	LS.	0	-
		e. Mob-Demob Cost	1	LS.	94,521	94,521
	4.3	Cruise Berth (Quay Length in meters)	300			
		a. Piled Foundation				
		Concrete In-Situ Piles	164	No.	27,318	4,480,149
		b. RCC in Superstructure	7,200	Sqm	320	2,305,796
		c. Retaining Wall		LS.		2,125,000
		d. Fixtures and Accessories				
		Fenders	21	No.	37,037	777,778
		Bollards	21	No.	3,704	77,778
		Others	1	LS.	5,20,648	520,648
		e. Mob-Demob Cost	1	LS.	4,48,015	448,015
	4.4	Fishery Berth (Quay Length in meters)	500			
		a. Piled Foundation				
		Concrete In-Situ Piles	285	No.	4,864	1,386,113
		b. RCC in Superstructure	1,800	Cum	356	641,667
		c. Fixtures and Accessories				
		Rubber Fenders	84	No.	148	12,494
		Bollard	84	No.	93	7,809
		Ladder, Handrails etc.		LS		17,241
		i. Mob-Demob Cost	10%	1		206,532
	4.5	Coast Gaurd Berth (120 lengthX20m width)	2,400	Sqm	1,481	3,555,556
	4.6	Navy Berths				
		a. Berth-1 (200m lengthX20m width)	4,000	Sqm	1,481	5,925,926
		b. Ramp (40m lengthX20m width)	800	Sqm	1,481	1,185,185
		c. Berth-2 (300m lengthX30m width)	9,000	Sqm	1,852	16,666,667
	Total (4)					**100,191,925**
5.	**BUILDINGS**					
	5.1	Administrative Buildings				-
		a. Port Users Administrative Building	800	Sqm	556	444,444
		b. Private Operator Administrative Building	800	Sqm	556	444,444
	5.2	Port Marine Operations Building	630	Sqm	556	350,000
	5.3	Yard Operations Building	300	Sqm	556	166,667
	5.4	Crane Maintenance Building	830	Sqm	463	384,259
	5.5	Maintenance & Repair Building	3,400	Sqm	463	1,574,074
	5.6	Trouble Kiosk & Restrooms	60	Sqm	278	16,667
	5.7	Quay Workers Restrooms	60	Sqm	278	16,667
	5.8	Railway Master Building	200	Sqm	278	55,556
	5.9	Reefer Shop w/ Genset	330	Sqm	648	213,889
	5.10	Canteen	100	Sqm	278	27,778
	5.11	Fire station	100	Sqm	463	46,296
	5.12	Utility Building	400	Sqm	463	185,185
	5.13	Electrical Sub Stations	400	Sqm	556	222,222
	5.14	Security Booth - Entry Gate	30	Sqm	370	11,111
	5.15	Security Booth - Exit Gate	30	Sqm	370	11,111
	5.16	Other Misc. Buildings	200	Sqm	370	74,074
	5.17	Fuel Station	100	Sqm	556	55,556
	5.18	Fish Landing Center Buildings		Sqm		
		a Auction Hall	300	Sqm	333	100,000

S. No.	ITEM			QUANTITY PHASE 1	UNIT	RATE (USD)	AMOUNT (USD) PHASE 1
		b.	Fishery Administrative Office	200	Sqm	333	66,667
		c	Net Mending Shed	250	Sqm	222	55,556
		d	Fuel Station	300	Sqm	370	111,111
		e	Toilet Block	45	Sqm	222	10,000
	Total (5)						**4,643,333**
6.	**CONTAINER YARD**						
	6.1	Yard Pavement					
			Precast paving blocks on 25mm sand bed	272,720	Sqm	14	3,787,778
			Grade M45 in-situ concrete	109,088	Cum	102	11,110,815
			Granular sub-base for road	109,088	Cum	19	2,020,148
	6.2	RTGS Beams					
			HYSD Reinforcement for Structures above 16mm dia	1,728	T	1,389	2,400,000
			Grade M30 in-situ concrete	17,280	Cum	102	1,760,000
			Pavement Type-1 (PCC)	160	Cum	28	4,444
			Granular sub-base for RTGC Runway	480	Cum	19	8,889
			Striping & Signage	20,000	m	4	74,074
	6.3	Miscellaneous items			LS.		370,370
	6.4	Terminal Fencing wall		1,600	m	222	355,556
	6.5	Excavation & Disposal		17,280	Cum	6	96,000
	Total (5)						**21,988,074**
7.	**EQUIPMENTS**						
	7.1	Container Terminal					
		a.	RMQC	8	No.	92,59,259	74,074,074
		b.	Reach Stackers	2	No.	9,25,926	1,851,852
		c.	RTG (Yard)	24	No.	11,11,111	26,666,667
		d.	Empty Container Handler	6	No.	5,55,556	3,333,333
		e.	ITVs	55	m	81,481	4,481,481
		f.	Diesel Locomotive	-	No.	25,92,593	-
		g.	Maintenance Vehicles	2	No.	27,778	55,556
		h.	Workshop Equipments		LS		925,926
	7.2	Multi-purpose Terminal					
		a.	Dumpers	2	No.	55,556	111,111
	7.2	Spares @ 5%					5,569,444
	Total (7)						**117,069,444**
8.	**UTILITIES AND OTHERS**						
	8.1	Electric Supply and Distribution lines			LS		6,481,481
	8.2	Lighting & Earthing			LS		185,185
	8.3	Fire Fighting			LS		740,741
	8.4	Water Supply & Distribution System			LS		1,111,111
	8.5	Drainage and Sewerage			LS		925,926
	8.6	Communication and IT			LS		925,926
	8.7	Workshop equipment			LS		277,778
	8.8	High mast lighting		27	No.	37,037	1,000,000
	8.9	Rail line within port boundary		2,870	m	648	1,860,185
	8.10	Terminal Security			LS		277,778
	8.11	Pavement for Navy/Coast Guard		11	Ha	5,00,000	5,500,000
	8.12	Utilities for Navy/Coast Guard			LS		7,236,111
	8.13	Dedicated Road for Navy/Coast Guard			LS		3,000,000
	8.14	Utilities for Fish Landing Center (Electric, Water & Drainage)			LS		100,000
	Total (8)						**29,622,222**
9.	**PORT CRAFTS AND AIDS TO NAVIGATION**						
	9.1	Port Crafts					
		a.	Tug Boats	4	No.	46,29,630	18,518,519
		b.	Pilot-cum-Survey Launches	1	No.	9,25,926	925,926

S. No.		ITEM	QUANTITY PHASE 1	UNIT	RATE (USD)	AMOUNT (USD) PHASE 1
		c. Mooring Launch	2	No.	3,70,370	740,741
	9.2	Aids to Navigation				
		a. Channel Marking Buoy	10	No.	14,815	148,148
		b. Fairway Buoy	1	No.	37,037	37,037
		c. Manoeuvring Area buoys	3	No.	14,815	44,444
		d. Leading and Transit Lights	2	sets	1,48,148	296,296
		e. Breakwater Lights	2	No.	18,519	37,037
		f. Racon	1	No.	1,01,852	101,852
		g. VTMS	1	Unit	2,40,741	240,741
		h. Fish Landing channel buoys	2	Unit	1,852	3,704
	Total (9)					**21,094,444**
10.	**GATES COMPLEX & ROAD DEVELOPMENT**					
	10.1	Road (Customs + Terminal Area 4 Lane road)	63,000	Sqm	52	3,266,667
	10.2	Inspection/Canopy (Entry + Exit Gate)	2,400	Sqm	370	888,889
	10.3	Gate Staff & Customs Building	900	Sqm	370	333,333
	10.4	Weigh Bridge (Entry + Exit Gate) for Trains	1	No.	20,370	20,370
	10.5	Weigh Bridge (Entry + Exit Gate) for Trucks	6	No.	12,963	77,778
	10.6	Fish Landing Center approach road	3,000	m	1,550	4,650,000
	Total (10)					**9,237,037**
	Total (1+2+3+4+5+6+7+8+9+10)					**518,440,706**
	Contingencies @ 20%					103,688,141
	Engineering and Project Management @ 10%					51,844,071
	GRAND TOTAL					**673,972,918**
		Exchange Rate USD to INR used	**54**			

Disclaimer

The capital cost estimates prepared for the present assignment has been arrived at based upon site information, appropriate assumptions, wherever required, and the database available with the AECOM for the similar projects. These site information and assumptions are subject to many factors that are beyond the control of the AECOM and AECOM thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.