Marine Infrastructure Developer Private Limited (MIDPL)

DRAFT COMPREHENSIVE EIA/ EMP REPORT
PROPOSED REVISED MASTER PLAN DEVELOPMENT OF KATTUPALLI PORT

Volume I (Part-A)
Draft CEIA Report Chapters

December 2020

PREPARED BY

L&T Infra Engineering

NABET ACCREDITED

Certificate No: NABET/EIA/2023/RA 0175

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RP002, Rev. A

KATTUPALLI PORT
CHENNAI's NEW GATEWAY

Undertaking by the Project Proponent

1 M/s Marine Infrastructure Developer Private Limited (MIDPL) has carried out a Comprehensive Environmental Impact Assessment (CEIA/EMP) study for the Revised Master Plan Development of Kattupalli Port, near Kattupalli village of Ponneri Taluk, Thiruvallur District, Tamil Nadu.

2 As per MoEF&CC Office Memorandum No.J-11013/41/2006-IA.II (I) dated October 05, 2011, MIDPL herewith declares the ownership of contents (information and data) of this CEIA/EMP Report.

For and on behalf of **Marine Infrastructure Developer Private Limited**

Jai Singh Khurana

Managing Director

MARINE INFRASTRUCTURE DEVELOPER PVT. LTD. CHENNAI

Marine Infrastructure Developer Pvt Ltd
(Kattupalli Port)
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Registered Office: Ramcon Fortuna Towers, 4th floor No 1/2, Kodambakkam High Road, Nungambakkam, Chennai 600034

Declaration by Experts contributing to the CEIA Report for Revised Master Plan Development of Kattupalli Port, Thiruvallur District, Tamil Nadu

I, hereby, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

	EIA Coordinator	Associate EIA Coordinator
Name:	B. Ratheesh	Susruta Mamidanna
Signature:		
Date:	December 14, 2020	December 14, 2020

Period of Involvement: 2016-2020

Contact Information:
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Functional Area Experts

S. No	Functional Areas	Name of the Expert/s	Involvement (Period & Task)	Signature & Date
1	**AP**	B. Ratheesh	Period: 2016-Till date Task: Selected monitoring locations, reviewed baseline ambient air and meteorological data. Identified Red category of industrial sectors. Identified probable emissions and suggested suitable control systems.	December 14, 2020
2	**WP**	B. Ratheesh	Period: 2016- Till date Task: Selected sampling locations. Reviewed water requirement and WW generation and water balance. Identified probable impacts of effluent discharge. Suggested appropriate treatment schemes. Framed EMP and calculated the budget.	December 14, 2020
		M. Uma Devi	Period: 2017- Till date Task: Identified probable impacts of effluent discharge. Suggested appropriate treatment schemes.	December 14, 2020
		With Support From: • Injeti Ratan Reddy (TM) • Aruna P (TM)		
3	**SHW**	Susruta Mamidanna	Period: 2016- Till date Task: Identified hazardous and non-hazardous wastes from various industries proposed in the project. Reviewed solid waste management proposed for various type of wastes.	December 14, 2020
		With Support From: • Injeti Ratan Reddy (TM)		

S. No	Functional Areas	Name of the Expert/s	Involvement (Period & Task)	Signature & Date
4	**SE**	Ramu L. Banakar	Period: 2019- Till date Task: Conducted socio-economic surveys and stakeholder consultations. SIA and identified the need of economic and social infrastructure in PIA. Estimated the Corporate Environment Responsibility budget	December 14, 2020
		<u>With Support From</u>: Dr. Subramanyam N. V. R. M.(TM)		
5	**EB**	Hanumantha Rao V Varapu	Period: 2016- Till date Task: Primary survey and analysed the primary surveyed data with available secondary data and suggested species for Green Belt development, Conservation Plan was prepared	December 14, 2020
		<u>With Support From</u>: Dr. Subramanyam N. V. R. M.		
6	**HG**	C.V. Sundara Rajan	Period: 2016- Till date Task: Reviewed the surface hydrological data. Reviewed storm water drainage plan including management of storm water. Identified ground water potential and also identified watershed areas for surface waters	October 20, 2020
		<u>With Support From</u>: • Gorji Navya Tej (TM)		
7	**GEO**	C.V. Sundara Rajan	Period: 2016-2020 Task: Analysis of geology and geomorphology. Review of maps.	October 20, 2020
		<u>With Support From</u>: T. K. S. Sridhar Rajagopalachari (TM)		
8	**SC**	Hanumantha Rao V Varapu	Period: 2019- Till date Task: Identified sampling locations. Assessment of soil fertility by nutrient availability. Analysis of baseline soil quality data.	December 14, 2020
		<u>With Support From</u>: • M. Uma Devi (TM)		
9	**AQ**	Susruta Mamidanna	Period: 2016- Till date Task: Review of secondary data on meteorology. Estimation of various emissions from proposed industries. Air Quality modelling using AERMOD. Representation of GLCS using isopleths for different scenarios.	December 14, 2020
		<u>With Support From</u>: • M. Uma Devi (TM) • Aruna P (TM)		
10	**NV***	Rajasekhar Elangovan	Period: 2016- Till date Task: Reviewed the baseline noise monitoring data. Identified probable noise and vibration impacts of the proposed sectors. Representation of same using	December 14,

<table>
<tr><th>S. No</th><th>Functional Areas</th><th>Name of the Expert/s</th><th>Involvement (Period & Task)</th><th>Signature & Date</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td></td><td>relevant models. Suggested mitigation measures</td><td>2020</td></tr>
<tr><td>Reji Baby Varghese</td><td>Period: 2016- Till date
Task: Selected noise monitoring locations. Identified impacts of noise from proposed industries and suggested control measures.</td><td>December 14, 2020</td></tr>
<tr><td colspan="3"><u>With Support From</u>:
• M. Uma Devi (TM)</td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">LU</td><td>Gorji Navya Tej</td><td>Period: 2018- Till date
Task: Generated data related to land use pattern. Prepared GIS based maps like land use map. Contribution to EIA documentation.</td><td>December 14, 2020</td></tr>
<tr><td colspan="3"><u>With Support From</u>:
• Hanumantha Rao V Varapu (TM)</td></tr>
<tr><td>12</td><td>RH</td><td>Susruta Mamidanna</td><td>Period: 2016- Till date
Task: Identified hazardous processes and risks in proposed sectors. Prepared on-site Emergency preparedness plan & off-site DMP.</td><td>December 14, 2020</td></tr>
</table>

Declaration by the Head of the Accredited Consultant Organization

I, T. K. S. Sridhar Rajagopalachari, hereby, confirm that the above mentioned experts prepared the **CEIA Report for Revised Master Plan Development of Kattupalli Port, Thiruvallur District, Tamil Nadu**. I also confirm that the Consultant Organization shall be fully accountable for any misleading information mentioned in this statement.

Signature:

Name: T. K. S. Sridhar Rajagopalachari
Designation: City Office Manager & Head – Area, Urban Planning and Environment Department
Name of the EIA Consultant Organization: L&T Infrastructure Engineering Limited
NABET Certificate Number & Issue Date: NABET/EIA/2023/RA 0175 Dated July 01, 2020.

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ACRONYMS

AADT	Annual Average Daily Traffic
AAQ	Ambient Air Quality
ADT	Average Daily Traffic
AE	Auxiliary Engine
AMSL	Above Mean Sea Level
BIS	Bureau of Indian Standards
BMW	Bayerische Motoren Werke
BOD	Biochemical Oxygen Demand
BOG	Boil Off Gas
CBFS	Carbon Black Feedstock
CCR	Central Control Room
CD	Chart Datum
CEO	Chief Executive officer
CGWB	Central Ground Water Board
CHWIF	Common/Hazardous Waste Incineration Facility
CHWTSDF	Common Hazardous Waste Treatment Storage & Disposal Facility
CMB	Channel Marker Buoys
CMDI	Component Metadata Infrastructure
CMO	Chief Medical Officer

CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CRT	The cathode-ray tube
CRZ	Coastal Regulation Zone
CSR	Corporate Social Responsibility
CTE	Consent to Establish
CTO	Consent to Operate
CWDP	Chennai Water Desalination Plant
CZMA	Coastal Zone Management Authority
CZMP	Coastal Zone Management Plan
dB(A)	Decibels-A Weighting
DCMA	Double Counterweight Marine Arm
Dd	Drainage density
DEM	Digital Elevation Model
DG	Diesel Generator
DMF	Dual Media Filters
DMP	Disaster Management Plan
DO	Dissolved Oxygen
DPR	Detailed Project Report
DWT	Dead Weight Tonnage
EAC	Expert Appraisal Committee
EC	Electrical Conductivity
EC	Environmental Clearance
ECLO	Escherichia Coli
EDA	Ethylene diamine
EIA	Environmental Impact Assessment
EMC	Environment Management Cell
EMP	Environment Management Plan
ENVIS	Environmental Information Systems
EPZ	Export Processing Zone
ESD	Emergency shutdown system
ESZ	Eco sensitive zone
ETP	Effluent Treatment Plant
FB	Fairway Buoy
FC/ FCLO	Faecal coliforms
FH	Fishing Hamlet
FM	Flexible Mesh
FOIS	Freight Operations Information System
FRP	Fibre Reinforced Plastic
FSRU	Floating Storage and Regasification Unit
GDP	Gross Domestic Product
GIS	Geographic Information System

GLCs	Ground level concentrations
GoI	Government of India
GoTN	Government of Tamil Nadu
GRP	Glass Reinforced Plastic
GW	Groundwater
H_2SO_4	Sulphuric Acid
Ha	Hectares
HCL	Hydrochloric Acid
HDPE	High-density polyethylene
HNO_3	Nitric Acid
HoD	Head Of Department
HoS	Head Of Section
HSD	High Speed Diesel
HTL	High Tide Line
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA, previously known as International Association of Lighthouse Authorities)
IC	Incident Controller
IESNA	Illuminating Engineering Society of North America
IMD	Indian Meteorological Department
IMO	International Maritime Organisation
IOCL	Indian Oil Corporation Limited
IR	Infra-Red
ISPL	International Seaports Private Limited
IUCN	International Union for Conservation Of Nature
IVI	Important Value Index
IWAI	Inland Waterways Authority Of India
JV	Joint Venture
KLD	Kilo Litres per Day
L&T	Larsen & Turbo
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
LNTIEL	L&T Infrastructure Engineering Limited
LPG	Liquefied Petroleum Gas
LSI	Langelier Saturation Index
LTL	Low Tide line
LTSB	L&T Ship Building Limited
MARPOL	The International Convention for the Prevention of Pollution from Ships
MCM	Million Cubic Metres
ME	Main Engine
MFF	Marine Fabrication Facility
MHHW	Mean Higher High Water
MHU	Mobile Health Unit
MIDPL	M/s Marine Infrastructure Developer private Limited
MMTPA	Million Metric Tonnes Per Annum
MoEF& CC	Ministry of Environment, Forest And Climatic Change

MOP	Muriate of Potash
MoU	Memorandum of Understanding
MOV	Motor Operated Valve
MSDS	Material Safety data Sheet
MSL	Mean Sea Level
MT	Mud Transport
MTPA	Million Metric Tonnes Per Annum
MVA	Mega Volt Ampere
NAAQS	National Ambient Air Quality Standards
NABET	National Accreditation Board for Education and Training
NCLT	National Company Law Tribunal
NCTPS	North Chennai Thermal Power Station
NFPA	National Fire Protection Agency
NG	Natural Gas
NGL	Normal Ground Level
NGO	Non-Governmental Organization
NH_3	Ammonia
NO_2	Nitrogen Di Oxide
NO_{2-}	Nitrite
NO_{3-}	Nitrate
NOC	No Objection Certificate
NO_X	Oxides Of Nitrogen
NRSC	National Remote Sensing Centre
NSDP	Net State Domestic Product
NTPC	National Thermal Power Corporation
NTU	Nephelometric Turbidity Unit
NW-4	National Waterway-4
OBE	Operating Basis Earthquake
OCIMF	Ocean Companies International Marine Forum
OES	Occupational Exposure Standard
OHE	Overhead Equipment
OHT	Over Head Tank
OISD	Oil Industry Safety Directorate
ORV	Open Rack vaporiser
OWS	Oil Water Separator
PALO	Pseudomonas aeurginosa
PCI	Per-Capita Income
PERCs	Powered Emergency Release Couplers
PESO	Petroleum and Explosives Safety Organization
PFR	Pre-Feasibility Report
PHC	Petroleum hydrocarbons
PIA	Project Influenced Area
PIANC	Permanent International Association of Navigation Congresses
PIANC	The World Association for Waterborne Transport Infrastructure
PM	Particulate Matter

PMIS	Port Management and Information System
POL	Petroleum Oil Lubricants
PPE	Personal Protective Equipment
PPP	Private Public Partnership
PSF	Pressure Sand Filter
PSU	Practical Salinity Unit
PUC	Pollution Under Control
PVC	Poly Vinyl Chloride
QCI	Quality Council Of India
R&R	Resettlement & Rehabilitation
RA	Risk Analysis
Rb	Effective Basin Width
Rc	Circularity ratio
RCC	Reinforced Cement Concrete
Rf	Form factor
RH	Relative Humidity
RLNG	Re-gasified Liquefied Natural Gas
RMP	Risk Management Plan/ Revised Master Plan
Rn	Ruggedness umber
RO	Reverse Osmosis
ROW	Right of Way
Rs	Shape factor
RTG	Rubber Tyre Gantry
SCNBWL	Standing Committee of the National Board for Wildlife
SCV	Submerged Combustion Vaporizer
SDI	Silt Density Index
SDMRI	Suganthi Devadason Marine Research Institute
SDNP	Sustainable Development Network Partners
SEZ	Special Economic Zone
SHLO	Shigella
SIA	Social Impact Assessment
SLO	Salmonella
SO_2	Sulphur Dioxide
SPM	Single Point Mooring
SPT	Standard Penetration Test
SRTM	Shuttle Radar Topographic Mission's
STD	Standard
STD	Storage Tank Design
STP	Sewage Treatment Plant
STV	Shell & Tube Vaporizer
SW	Spectral Wave
SWRO	Salt Water Reverse Osmosis
TC	Total Coliform
TDS	Total Dissolved Solids
TEU	Twenty foot Equivalent Units
TIDCO	Tamil Nadu Industrial Development Corporation Limited

TLF	Tanker Loading Facility
TNEB	Tamil Nadu Electricity Board
TNPCB	Tamil Nadu Pollution Control Board
TOC	Total Organic Carbon
ToR	Terms of Reference
TPD	Tons Per Day
TPP	Thermal Power Plant
TSDF	Treatment, Storage and Disposal Facility
TSS	Total Suspended Solids
TULF	Tanker unloading facility
TVC	Total Viable Count -Total Heterotrophic Bacteria
UG	Under Ground
UGC	University Grants Commission
UKC	Under-Keel Clearance
UV	Ultraviolet
VCLO	*Vibrio Cholera*
VDF	Vehicle Damage Factor
VLCC	Very Large Crude Carriers
VPLO	*Vibrio Parahaemolyticus*
VTMS	Vessel Traffic Management Systems
VTS	Vessel Traffic Service
WB	World Bank

Chapter 1
Introduction

Chapter 1 Introduction

1.1 Background

Tamil Nadu Industrial Development Corporation Limited (TIDCO), a Government of Tamil Nadu Enterprise, is the nodal agency to identify and promote establishment of large and medium scale industries within State of Tamil Nadu. TIDCO identified the leading technology, engineering and construction conglomerate, Larsen & Turbo (L&T), as partner for developing Shipyard cum Port Complex on a Joint Venture (JV) basis and submitted a proposal to Government of Tamil Nadu (GoTN). GoTN approved TIDCO’s Proposal and allotted about 1200 acres of land at Kattupalli. L&T Shipbuilding Limited, a JV of L&T and TIDICO, was formed and JV agreement was signed between the parties on April 15, 2008 to develop the Shipyard cum Port Complex at Kattupalli.

L&T Ship Building Limited (LTSB) has obtained EC & CRZ clearance for Shipyard cum Port Complex at Kattupalli, Thiruvallur District, Tamil Nadu vide Letter No. 10- 130/2007-IA.III, dated July 03, 2009. Tamil Nadu Pollution Control Board (TNPCB) has accorded Consent to Establish (CTE) vide letter dated August 18, 2009. LTSB obtained amendment for dredging and dumping from MoEF&CC vide Letter No. 10- 130/2007-IA.III, dated May 12, 2010. LTSB commenced the construction in October, 2009. Consent to Operate (CTO) was also obtained from TNPCB vide letter dated November 16, 2012 and regularly renewing the same. LTSB has commissioned its operations on January 30, 2013. LTSB obtained amendment to handle revised cargo traffic at the Kattupalli Port in EC & CRZ clearance along with extension of validity from MoEF&CC vide Letter No. 10- 130/2007-IA.III, dated December 17, 2014.

Considering the divergent nature of business of LTSB and to harness the potential for growth with clear focus on port business, LTSB had approached the Hon’ble National Company Law Tribunal (NCLT), Chennai with a Scheme of arrangement for demerger of port business of LTSB into a separate company Viz., M/s Marine Infrastructure Developer private Limited (MIDPL). The Hon’ble NCLT after careful examination of the scheme had accorded its approval on March 20, 2017. Pursuant to the said NCLT Order, the Port business in Kattupalli Shipyard cum Port Complex on a going concern basis together with the identified port assets, powers, sanctions, approvals, registrations etc., stands transferred and vested with MIDPL. Accordingly LTSB had approached MoEF&CC to bifurcate the existing Environmental and CRZ Clearance in the name of L&T Shipbuilding for Shipyard and MFF related activities and in the name of MIDPL for Port and common infrastructure related activities. Environmental and CRZ Clearance bifurcation completed on mutually acceptable division of responsibilities between LTSB & MIDPL and bifurcated EC was granted to MIDPL vide letter no. F. No.10-130/2007-IA.III dated February 9, 2018. MIDPL obtained CRZ Clearance for development of rail corridor at Kattupalli Port through vide letter no. F. No.11-22/2019-IA.III dated December 02, 2019. The above mentioned clearance letters and certificates are given in **Appendix A.** Latest certified compliance report of Environmental/CRZ Clearance is given as **Appendix B**.

The facilities to be operated by MIDPL in the Kattupalli Complex, post demerger are given in **Table 1-1**.

Table 1-1: Facilities to be operated by MIDPL

Company	Facilities to be Operated
Marine Infrastructure Developer Private	**Port and Common Facilities** • North breakwater, facilities required for Port such as Navigational Channel

Company	Facilities to be Operated
Limited (MIDPL)	(Inner (-)16.7 m CD and Outer (-)17.5 m CD depth), Other Navigational Facilities, • Five Berths and 2 Port Craft Berths, Container Freight Station, • Container Stackyard, Cargo Storage areas and Tank farms, other various necessary supporting infrastructures, utilities and services etc., Dredging of Port area and Navigation channel and Offshore dumping • Area: 336.75 Acres (321.75 Acres of Revenue Land and 15.0 Acres of Coastal land)

The activities to be carried out by MIDPL at Kattupalli port are as given in **Table 1-2**.

Table 1-2: Permitted activities to be carried out by MIDPL

Company	Activities to be Carried out	
Marine Infrastructure Developer Private Limited (MIDPL)	Cargo Handling	
	Containers (Mn TEU's)	1.80
	Ro-Ro –Automobiles (nos)	1,49,899
	Project Cargo (MTPA)	0.44
	Break Bulk/general cargo (Barytes/Gypsum/Limestone/Granite/Steel Cargo) (MTPA)	1.82
	Edible oil, CBFS, Base Oil, Lube Oil and Non- Hazardous Liquid Cargo (MTPA)	0.57
	Total Handling Capacity at Port	24.65 MTPA

For Port development total five berths are approved, out of which first two berths are constructed and operational since January 30, 2013. Third berth is operational since September 2019. Fourth and Fifth berths are not yet constructed. Currently, container berth is being used for container handling and multipurpose berth is being used for handling container, Ro-Ro, project cargo and break bulk/ general cargo and non – hazardous liquid cargo as approved.

Considering the future business potential, MIDPL proposes development of Revised Master Plan of Kattupalli Port.

1.2 Details of Project Proponent

The contact details of authorised person of MIDPL are as below.

Address for correspondence: **Mr. Jai Singh Khurana,**
Managing Director,
Marine Infrastructure Developer Private Limited,
Ramcon Fortuna Towers,
4th Floor No1/2, Kodambakkam High Road,
Nungambakkam,
Chennai 600 034.

1.3 Project Site

The Kattupalli Port is located towards North of Kamarajar (Ennore) Major Port near Kattupalli village of Ponneri Taluk, Thiruvallur District, Tamil Nadu. The geographic location of the Kattupalli port is at Latitude 13^0 18' 50.35" N and Longitude 80^0 20' 45.68" E. The location map showing the project site is given as **Figure FD0101**.

1.3.1 Salient Features of Project Site

The project site is having a flat terrain with varying levels. The salient features of project site are given in **Table 1-3**.

Table 1-3: Salient Features of Project Site[1]

S. No	Details	Description
1.	Location	Kattupalli Village
2.	District	Thiruvallur
3.	State	Tamil Nadu
4.	Topography	Plain with few undulations and sea reclamation
5.	Temperature	34.0^{0}C(Maximum) and 19.1^{0}C(Minimum)
6.	Wind Speed	4.24 m/sec (mean)
7.	Rainfall	1382.9 mm (Annual)
8.	Relative Humidity	69 – 76%
9.	Present Land use	Sea, intertidal area, sandy area/beach, abandon salt pans, and land with/without scrub and sparse vegetation (*Prosopis juliflora* /Casuarina/Eucalyptus).
10.	Seismicity	Seismic zone III
11.	Nearest Road Connectivity	NH-5 (Chennai-Kolkata) is ~ 15.9 km W
12.	Nearest Rail Connectivity	Athipattu railway station is ~ 2.7 km SW
13.	Nearest inland waterway connectivity	Buckingham Canal which has been declared as National Waterway-4 (NW-4) is adjacent.
14.	Nearest Seaport	Kamarajar Port - adjacent
15.	Nearest Airport	Chennai airport - 35.0 km S
16.	Nearest Town/ Village	Kalanji, Kattupalli, Kattur -II, Ebrahampuram, Puzhudivakkam, Voyal

The Surveys No's pertaining to Revised Master Plan is enclosed as **Appendix C**.

Some of the site photographs showing proposed expansion site are given as **Exhibit 1-1**.


Existing Kattupalli Port


North side of Existing Kattupalli Port near Buckingham canal

[1] *Distances mentioned are from project boundary*

Buckingham Canal area in Proposed Development

Kosattalaiyar River and low laying areas in western portion of Proposed development

Development activities in West side boundary

Scrub land in western side of Proposed Development

Propophis in north westren side of Proposed Development

South westren side of Proposed Development

Exhibit 1-1: Site Photographs showing Proposed Expansion Site

1.4 Applicable Legal and Policy Framework

The proposed expansion of the Kattupalli Port project attracts the provisions of Environmental Impact Assessment (EIA) Notification, 2006 (as amended) and Coastal Regulation Zone (CRZ) Notification, 2011 (as amended). The project categorisation as per EIA Notification is provided in **Table 1-4.**

Table 1-4: Project Components and its EIA Study

Project	Activity as per schedule of EIA Notification	Category
Ports and Harbours	7 (e) Port, Harbour, Break water and Dredging	Category A

Project	Activity as per schedule of EIA Notification	Category
	[≥ 5 million TPA of cargo handling capacity (excluding fishing harbours)] of EIA notification, 2006 (as amended)	

The following rules and regulations are applicable to this proposed development is given in **Table 1-5**.

Table 1-5: Applicable Environmental Regulation

Applicable GoI Policies & Regulations	Year	Objective	Reason for Applicability
Environmental (Protection) Act	1986	To protect and improve overall environment.	Environment in general.
Environmental Impact Assessment Notification (as amended)	2006	EIA notification for more effective Environmental clearance process.	Direct
Coastal Regulation Zone Notification (as amended)	2011 & 2019	To protect the Coastal ecological resources and to prevent coastal pollution.	Direct
Air (prevention and control of pollution) Act	1981	To control air pollution by controlling emissions according to prescribed standards.	Control of Air pollution
Noise Pollution (Regulation and Control) (Amendment) rules	2000 & 2010	Noise pollution regulation and controls.	Control of Noise pollution
Water (Prevention and Control of Pollution) Act	1974	To control water pollution by controlling emission & Water pollutants as per the prescribed standards.	Control of Water pollution.
Solid Waste Management Rules (as amended)	2016	Management of Solid Waste.	Appropriate handling of Solid Waste.
Hazardous and other Wastes (Management and Transboundary Movement) Rules and Amendment Rules	2016 & 2019	To store/handle hazardous waste and materials as per the provisions of the manufacturer, storage and import of Hazardous Chemical Rules, Hazardous Wastes (Management and Handling) Rules and Amendments	Appropriate handling of Hazardous and other Waste
E-Waste (Management) Rules and amendment thereof	2016 & 2018	Consumer or bulk consumer of electrical and electronic equipments listed in Schedule I shall ensure that e-waste generated by them is channelized to authorized collection centre (s) or registered dismantler (s) or recycler or is returned back to the pick up or take back services provided by the producers.	Involvement of information technology and telecommunication equipment, electrical and electronics.
Batteries (Management and Handling) Rules (Amended)	2001 & 2010	Consumer to ensure that used batteries are not disposed off in any manner other than depositing with the dealer, manufacturer, importer, assembler, registered recycler, reconditioner or at the designated collection centres.	Appropriate handling of used batteries.
Construction and Demolition Waste Management Rules and amendment thereof	2016	Generator shall prima-facie be responsible for collection, segregation of concrete, soil and others and storage of construction and demolition waste generated, as directed or notified by the concerned local authority in consonance with these rules. The generator shall ensure that other waste (such as solid waste) does not get mixed with this waste and is stored and disposed separately.	Appropriate handling of Construction and Demolition waste.
Bio-medical Wastes (Management and Handling) Rules and amendments thereof	2016	Generator to take all necessary steps to ensure that bio-medical waste is handled without any adverse effect to human health and the environment.	Appropriate handling of Bio-Medical Waste.

Applicable GoI Policies & Regulations	Year	Objective	Reason for Applicability
The Manufacture, Storage and Import of Hazardous Chemical Rules (as amended)	1989, 1990, 1994 & 2000	To prevent major chemical accidents arising from industrial activities; and to Limit the effects of chemical (industrial) accidents.	MIDPL Revised Master Plan envisages handling and storage of LNG, Propane, Butane, LPG, CNG, NG and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals and other Liquid cargos. Appropriate handling and storage of these cargos.
Chemical Accidents (Emergency Planning, Preparedness and Response) Rules	1996		
Merchant Shipping Act,	1958	To prevent the waste arising out of the operation from ships and to Limit the effects	MIDPL Revised Master Plan envisages that no all Merchant ships will be allowed for berthing without satisfying the MARPOL regulations

1.5 Need for Revision of Master Plan

1.5.1 National Scenario

India is strategically located on the world’s shipping routes with a coastline of approximately 7,517 km. According to the Ministry of Shipping, around 95% of India's trading by volume and 70% by value is done through maritime transport. The government has introduced various fiscal and non-fiscal incentives for enterprises that develop, maintain and operate ports, inland waterways and shipbuilding in India.

The Government launched the ambitious Sagarmala Programme in March 2017, with the vision of port-led development and growth of logistics-intensive industries. Under Sagarmala Programme, $123 bn would be invested across 415 projects across the following identified components: Port Modernization and New Port Development; Port Connectivity Enhancement; Port-Linked Industrialization and Coastal Community Development[2].

By Financial Year 2018-19, 34 PPP projects with an investment of $3.05 bn involving capacity addition of 300 MTPA is under operation. Another, 13 PPP projects with an investment of $978.3 mn involving capacity addition of 140 MTPA is under implementation. Further, there are 20 captive projects with an investment of $713.8 mn involving capacity addition of 142.45 MTPA under operation and 7 captive projects with an investment of $930.5 mn involving capacity addition of 55 MTPA is under implementation.

India has 12 major and 200 non-major/intermediate ports (under state government administration). Jawaharlal Nehru Port Trust is the largest major port in India, while Mudra is the largest private port. Cargo traffic in the country is expected to rise to 2,500 MT by 2024-25 from 1,072.23 MT in 2015-16. The major ports in India collectively handled 679.4 MT of cargo during 2017-18 compared to 648.4 MT a year ago; thereby registering a growth of 4.8%. During 2018-19, major and non-major ports in India handled a total cargo throughput

[2] *https://www.investindia.gov.in/*

of around 1,282 MT. The traffic grew by 6.13% over the corresponding period of the previous year.

In FY20, major ports in India handled 704.82 million tonnes (MT) of cargo traffic, implying a CAGR of 2.74% during FY16–FY20. Cargo traffic at non-major ports reached 447.21 MT in FY20 (till December 2019).

1.5.2 State (Tamil Nadu) Scenario and Kattupalli Port

With a length spanning 1,076 km, Tamil Nadu has the second longest coastline among Indian states. The coastline is dotted with 3 Major Ports (at Chennai, Ennore and Tuticorin) and 23 Minor Ports. The Major ports have been developed under the Major Port Trust Act of 1963 and function under the control of Government of India while the Minor Ports are developed based on Indian Ports Act of 1908 by Government of Tamil Nadu.

The minor ports facilitate the establishment of port based industries such as Thermal Power Plants, Refineries, Fertilizer plants, etc., by providing exclusive port facilities. Given the rapid industrialization and economic development of the State, a port policy was formulated to provide investment opportunities for the development of minor ports in Tamil Nadu through Public Private Participation.

The minor ports are proposed to be developed with multi user facilities capable of handling all types of cargo like bulk, break bulk, containers, liquid bulk petroleum products, chemicals, etc. Private companies making substantial investment in coastal areas will be allotted sites for construction of captive jetties. The development of all the infrastructure facilities in these captive ports is the responsibility of the private developer.

Port Traffic in TN stood at 100 million tonnes vis-à-vis All India traffic of 930 million tonnes. Port traffic growth in TN (CAGR of 2%) has trailed All India traffic growth (6%). As a result, share of traffic of Ports in TN has come down from 12.6% in 2008 to 10.8% in 2012. Though traffic growth at Minor ports has matched national average of 16% CAGR in the last five years, traffic at Minor Ports in Tamil Nadu contributed a miniscule 1.6% of total port traffic vis-à-vis 40% nationally. Container cargo (in million tonnes) in TN grew at 14%, nearly twice the national average growth of 7% during the corresponding period. The share of container cargo (in million tonnes) out of the total traffic in TN increased from 26% in 2008 to 39% in 2012. This is different from rest of India where there was no appreciable change in share of container cargo emerging from all-India trends (12.7% in 2008 to 12.9% in 2012). Container traffic (in TEU terms) in TN grew only at 7%, reflecting an increase in average cargo per TEU from 15 Tonnes to 19.3 Tonnes during 2008-12[3].

Considering the potential for container traffic in the vicinity of Chennai as well as from the proposed Ennore SEZ adjacent to the site, expansion of the Kattupalli Port is proposed. Thermal power stations of NTPC, NCTPS and major refineries are located in the northern suburbs of Chennai leading to huge potential for coal, crude and POL products. Apart from these, Car Manufacturing Plants such as Ford, Hyundai, BMW and Daimler are situated in the vicinity of the port in Chennai which makes huge prospects for Car export requirement. Tamil Nadu contributes 17% of the total number of factories and 11% to the industrial output of the country which requires infrastructure for speedy cargo evacuation for trade.

Buckingham Canal is passing through the proposed Revised Master Plan development, which has also been declared as prestigious National Waterway-4 project by GoI. NW-4 has a vast coverage having a length of more than 1000 km connecting the coastal areas from

[3] *Vision Tamil nadu 2023-Strategic plan for Iinfrastructure Development in Tmail Nadu (February 2014)*

Pondicherry to Kakinada. It also connects inland area via Krishna & Godavari Rivers. In NW-4 barges of capacity 300 Tons (40m X 9m) will be navigating, which requires 1.5m draft.

The Buckingham canal stretching from Peddaganjam lock to Chennai and further down south up to Marakkanam is a tidal influenced canal. The stretch of the canal from Peddaganjam lock to Chennai for a length of 316 km (196 mi) is called "North Buckingham canal" and the canal path from Chennai to Marakkanam for a total length of 110 kilometres (68 mi) is called "South Buckingham canal". Considering the above development of NW-4, there is enormous potential of movement of cargo.

1.5.3 Traffic Projections

Based on the available hinterland the revised traffic forecast for the Kattupalli port has been worked out as given below:

- Multi-Purpose (including Liquid) – 320 MMTPA (including 24.65 MTPA Existing cargo handling)

The indicative list (But Not Limited to) of cargo mix proposed to be handled in Revised Master Plan is given in **Table 1-6**.

Table 1-6: Cargo Mix for Revised Master Plan

S. No.	Cargo Type	Cargo Mix
1.	Multipurpose (Including Liquid)	Coal / Iron ore / limestone / Mines & Minerals & other dry bulk/Fertilizers and raw materials for manufacture of fertilizer / food grains / sugar / clinker / cement / Project cargo / timber & wood / machines/ Iron steel products / Break Bulk etc./Container, Ro – Ro & Automobiles and any other non-hazardous cargo All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos Tentative list of hazardous liqud cargo but not limited to are as follows: Ethylene, Propylene (Propene), Butadiene, Pentane, Ethyl Mercaptan Motor Spirit, Propylene Oxide, Hexane, Naphtha, Acetone, Methyl Chloride / Chloro Methane, Cyclohexane, Benzene, Ethyl Acetate, Acrylonitrile Acetonitrile, Methyl Methacrylate, Methacrylonitrile, Methanol (Methyl Alcohol),Isopropyl Alcohol, Ethyl Alcohol (Ethanol), Ethylene di chloride, Methyl Isobutyl Ketone, Ethyl Benzene, N-Butyl Acetate, Isobutyl Alcohol (Iso Butanol), N-Butyl Alcohol (N-Butanol), Epichlorohydrine, Styrene, O-Xylene, High Speed Diesel, Cumene, Crude Oil, Aviation Fuel, Kerosene, Acetic Acid, Acetic Anhydride, Non-edible/Mentha Oil Low Sulphur Heavy Stock/ Furnace oil, Carbon Black Feedstock (CBFS), Aniline, Methyl Ethyl Ketone Peroxide, Ethyl Hexanol-2, Vinyl Chloride, Phenol, Naphthalene, Ethylene Glycol, Mono Ethylene Glycol, Toluene 2.4 -di isocyanate, Diphenyl Methane Di-Isocynate, Edible oil/Palm Oil, Paraffin, Bitumen, Sulphur, Lube oil, Asphalt, Coal, CNG, NG, Ammonia (NH_3), Diammonium Phosphate, Muriate of Potash (MOP), Soda Ash (Sodium Carbonate), Urea, Limestone, Caustic Soda, Sulphuric acid, Phosphoric acid, Piperine/ Piperdine, Chloroform, Hydrochloric Acid (HCL), Ethylene diamine (EDA), CMDI etc.
2.	Gas / Cryogenics/Liquid	LNG, Propane, Butane, LPG, CNG, NG and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos.

1.6 Revised Master Plan Development

Considering the future business potential MIDPL is now proposing Revised Master Plan of Kattupalli Port. Type of berth and type of cargo is based on commercial and business requirement. Hence revised master plan is proposed with flexibilities to accommodate all berths (existing as well as proposed) as multipurpose.

Along with berths, transloading facilities, backup facilities and independent port craft facilities, waste reception facilities, conveyor systems, drainage, water supply, electrical works, internal roads, railway works and other utilities, amenities and bunkering will be developed to accommodate all multipurpose cargo provided in **Table 1-6**.

The salient features of Proposed Kattupalli port have been tabulated in **Table 1-7**.

Table 1-7: Salient Features of Kattupalli Port Existing and Proposed Development

Features/Description	Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
Handling Capacity	MTPA[4]	**24.65**	**320** (Including Existing Approve Capacity)
Cargo Mix	-	Container MTEUs), Break Bulk / General (MTPA), Project Cargo, Ro-Ro (No's), Non-Hazardous Liquid Cargo (MTPA)	Revised Master Plan Development of Kattupalli Port involves handling and storage of Multipurpose Cargoes including liquid, Coal, Iron Ore, Bulk, Break Bulk, Project Cargo, General Cargo, Dry Cargo Container, Fertilizer and FRM, Ro – Ro & Automobiles and any other non-hazardous cargo and Liquid/ Gas / Cryogenics (Upto -162 degree Celsius) cargoes including All Class A, B, C petroleum products, excluded petroleum products, Non - Classified Chemicals & Petroleum products Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos Including LNG/CNG/LPG etc., etc. Apart from port backup area, external road, rail (double line), utility corridors and 30 MLD capacity of desalination plant etc. Port backup Industries & Industrial development area and its infrastructure
Length of North Western Breakwater	m	1775	Apart from existing breakwaters, two new breakwater of about total 12.1 km length is proposed, out of which new Northern Breakwaters will be about 9.02 & 1.22 km and new Southern Breakwater will be about 1.86 km
Length of South Breakwater	m	1665	
Total Area	Ha	~136.28	Revised Master Plan Development of Kattupalli Port will be carried out in total area of 2472.85 ha which includes which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 hectares including basin and all developable area.
Dredging Quantity	MCM	8.0 out of 24 approved	Dredging will be carried out at proposed berthing areas and for widening and deepening of existing approach channel, as per the revised master plan development requirements. It is estimated that ~ 85 Mm^3 (MCM) of dredged material will be generated.
Reclamation	MCM	6.0	

[4] *MTPA: Million tons per annum*

Features/Description	Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
			Entire dredged material will be used for reclamation. Additional material for reclamation will be borrowed from identified borrows area (onshore/offshore). Total proposed quantity for Reclamation including landfilling is estimated about 138 Mm^3 (MCM) which will be used for reclaiming 1145 Ha area.
Offshore Disposal	MCM	2.0	1.25-3.2 of maintenance dredging quantity
Maintenance Dredging	MCM/Annum	~0.4	1.25 (Avg.) -3.2 (Max.)
Diameter of Turning Circle	m	580	One 650 m & two new 700 m
Depth at Turning Circle (Manoeuvring Areas)	below CD m	(-) 14.0	(-) 20.5 & (-) 25.0
Quay Length	m	1900 and 2 Port Craft Berths. Only 3 out of 5 berths are existing	11467 (Cumulative) in addition to 1250 m long barge berths and 12 Port Craft Berths + Trans loading Facility & 2 SPMs
Approach Channel – Outer Channel – Width	-	180 m	500 m
Approach Channel – Outer Channel – Depth		(-) 14.0 m	(-) 27.0 m
Approach Channel – Outer Channel – Length		2325 m	5000 m
Approach Channel – Inner Channel – Width		215 m	500
Approach Channel – Inner Channel – Depth		(-) 14.0 m	(-) 25.0 m
Water (Potable) Source	m^3/day	60/CWSSB Desalination Plant	30000 (Proposed Captive Desalination Plant Cumulative)
Seawater Intake for Desalination Plant	MLD	-	~75
Reject from Desalination Plant	MLD	-	~45
Seawater intake for Regasification/Process if any	MLD	-	2910
Power	MVA	6.5	100
Greenbelt and other areas	Acres	~7.0	241
New Road/Rail	-	Road access developed	The rail connectivity to existing Kattupalli port is also proposed from the existing nearby railway line and is termed as southern link. However in parallel to Revised Master Plan Development, to cater immediate cargo evacuation requirement, connecting to southern rail link is being taken up and separate CRZ clearances for the same has already obtained by MIDPL. In future the existing facility of southern connectivity of the Kattupalli Port, will not be sufficient to cater the projected

Features/Description	Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
			increase in traffic of the port as well as operationally there will be need of another railway link to the Kattupalli port which is proposed from Minjur station, situated on the north side of existing railway link and is termed as northern link. However, feasibility of alignment of proposed corridor will be checked during detailed study. Apart from port backup area, external road, rail and utility corridor is proposed in an area of around 30 ha to provide connectivity
Employment	Nos.	250	1500 Direct & 4500 Indirect
Project Cost	Crores	4675 As per EIA	53031
Navigational Aids	-	Channel marker buoys, Fairway buoy and Turning circle buoys, Front and rear leading light, Berth corner lights, Maritime Buoyage Systems (Lateral marks, Cardinal marks, Isolated danger marks, Safe water marks, Special marks) and Other Marks (Lighthouse, Beacons, Sector lights, Leading lines, Port or Harbour marks), VTMS, Tugs, etc.,	
Environmental Aspects	-	Stacks for DG, Oil Water Separator (5KLD), STP (45 KLD), Organic Waster Convertor, Hazardous waste to Authorized Vendor/TSDF, PPEs, Approved Oil Spill Contingency Plan and Green Belt	Covered Coal Storages; Wind Barrier; Covered Conveyor; Dust Suppression System; Use of Specialised Unloaders; Proper housekeeping; Trucks & railway wagons covered with tarpaulin; Washing of Trucks Tyres and areas susceptible for coal; Green Belt, Stacks for DG, ETP (1500 KLD), STP (240 KLD), Settling Pond at Coal Stockyard; Storm Water Drainage System, Organic Waster Convertor, Hazardous waste to Authorized Vendor/TSDF, PPEs, Updated Oil Spill Contingency Plan and Green Belt

With a view to optimize the waterfront area, utilize the maximum marine development potential, increasing the backup area usage to accommodate future cargo projections and business requirement, MIDPL has proposed to revise the Master Plan.

1.6.1 Proposed Rail/Road Corridor

For easy evacuation of cargo, a new rail, road and utility corridor is also proposed within existing Port boundary. However, feasibility of alignment of proposed corridor will be checked during detailed study.

The Kattupalli Port has good network of roads and railways. NH-5 (Chennai-Kolkata) is about 15.9 km from project site.

A 100 m wide ROW for Road Corridor is also proposed by TNRDC as Northern Port Access Road (NPAR) to connect both Ennore and Kattupalli Port to NH-5. Proposed Port Access will be connected to the NPAR once it is executed which will become backbone of the road evacuation.

Land identification and marking has been done on the site, while Land Acquisition is under process.

A Four (4) lane TPP road is also existing which also improves the road connectivity to the Kattupalli Port. The North Port Access Road mentioned above in its first phase links to this TPP Road at Vallur Junction.

Presently there is no railway sliding inside the Kattupalli port. Ennore Port is connected to broad gauge Southern Railway Main Line through a siding from Athipattu railway station. Athipattu is at a distance of about 2.7 km from Ennore Port.

For the rail connectivity of Kattupalli port, the nearest IR network is Chennai-Howrah trunk route of double line electrified section with the provision of automatic signalling. This rail line will connect Kattupalli port with nearby southern rail link at Ennore Rail-yard and proposed Northern Rail Link at L&T Spur location.

1.6.2 Proposed Utilization of Inland Waterway Connectivity

To augment the efficacy of NW-4 and treating it as great opportunity, evacuation by waterways is also proposed just like railways and roadways in our Revised Master Plan development.

Waterway Evacuation is considered approximately 5% of total projected traffic. Two 'weirs' at both end of berthing area are proposed which will maintain same water level as that of Buckingham Canal all around the year and will also not obstruct water flow during heavy monsoon season.

1.7 Comprehensive Environmental Impact Assessment (CEIA) Study

The CEIA study for the revised master plan development of Kattupalli Port covers both terrestrial and marine environmental assessment.

MIDPL has submitted the proposal (Form-1, Draft ToR and Prefeasibility Report) for consideration by the Expert Appraisal Committee (EAC, Infra 2) for obtaining Terms of Reference (ToR) for Environmental/CRZ Clearance in accordance with the provisions of the EIA Notification, 2006 (as amended) and CRZ Notification, 2011/2019 (as amended).

The EAC (Infra-2), MoEF&CC has considered and deliberated the project proposal in its 38th meeting held during 6-8 February, 2019, 39th meeting held during 26-28 March, 2019 and 42nd meeting held on 10-12 July, 2019 at New Delhi to determine the ToR and granted the ToR vide MoEF&CC letter No: F.No.10-7/2019-IA.III, dated October 15, 2019 for Revised Master Plan Development of Kattupalli port. A copy of the ToR letter is enclosed as **Appendix D**.

The EIA study has been carried out comprehensively based on the approved ToR covering both terrestrial and marine environments including the Standard ToR provided at Annexure - 1 of ToR letter dated October 15, 2019. The compliance to ToR and replies to representations/complaints received as a part of ToR is enclosed as **Appendix E**.

1.7.1 Project Influence Area (PIA)/Study Area

As per the Ports and Harbour EIA guidance manual issued by MoEF&CC, an area within 5 km radius from project boundary for primary data generation and 15 km radius as the general study area for secondary data generation is considered. A map showing the study area is given as **Figure FD0102**.

1.7.2 Study Period

The EIA study has been carried out as per MoEF&CC approved ToR for both terrestrial and marine environment. The baseline terrestrial and marine environmental surveys were carried out covering the following seasons:

- Winter season (January 2018 – February 2018)
- Summer season (March 2018 – May 2018)
- Post monsoon season (June 2018 – September 2018)

In line to comply the ToR conditions MIDPL has also assessed Biodiversity of the area, viz, estuary and coastal region, collected three season's data in the coastal region as well as estuarine region at proposed site covering northern end of project and saltpans present in the western Kosattalaiyar including survey during monsoon season along with the other places.

1.8 Structure of EIA Report

This CEIA report is prepared in two volumes pertaining to all components of the project. The first volume is CEIA report itself and the second volume is the Mathematical Modelling studies & Marine Biodiversity Plan studied in line to the granted Terms of Reference. Kattupali Port has completed all required studies comprehensively to address all issues and impacts concerning the project.

- **Volume I: Draft Comprehensive EIA/ EMP Report**
- **Volume II: Mathematical Modelling studies & Marine Biodiversity Plan**

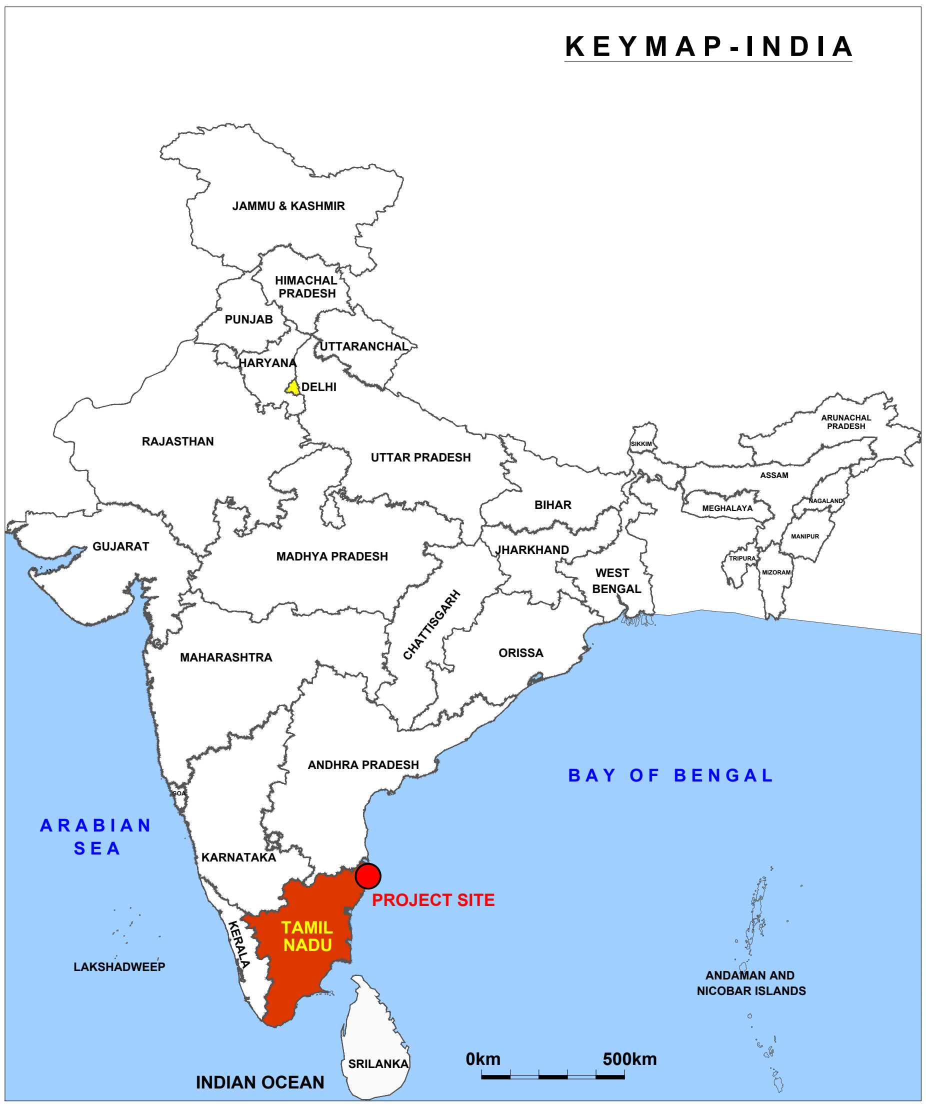
The report is structured as per Appendix III of EIA Notification, 2006 and also EIA Guidance Manual for Ports and Harbours, 2010 released by MoEF&CC.

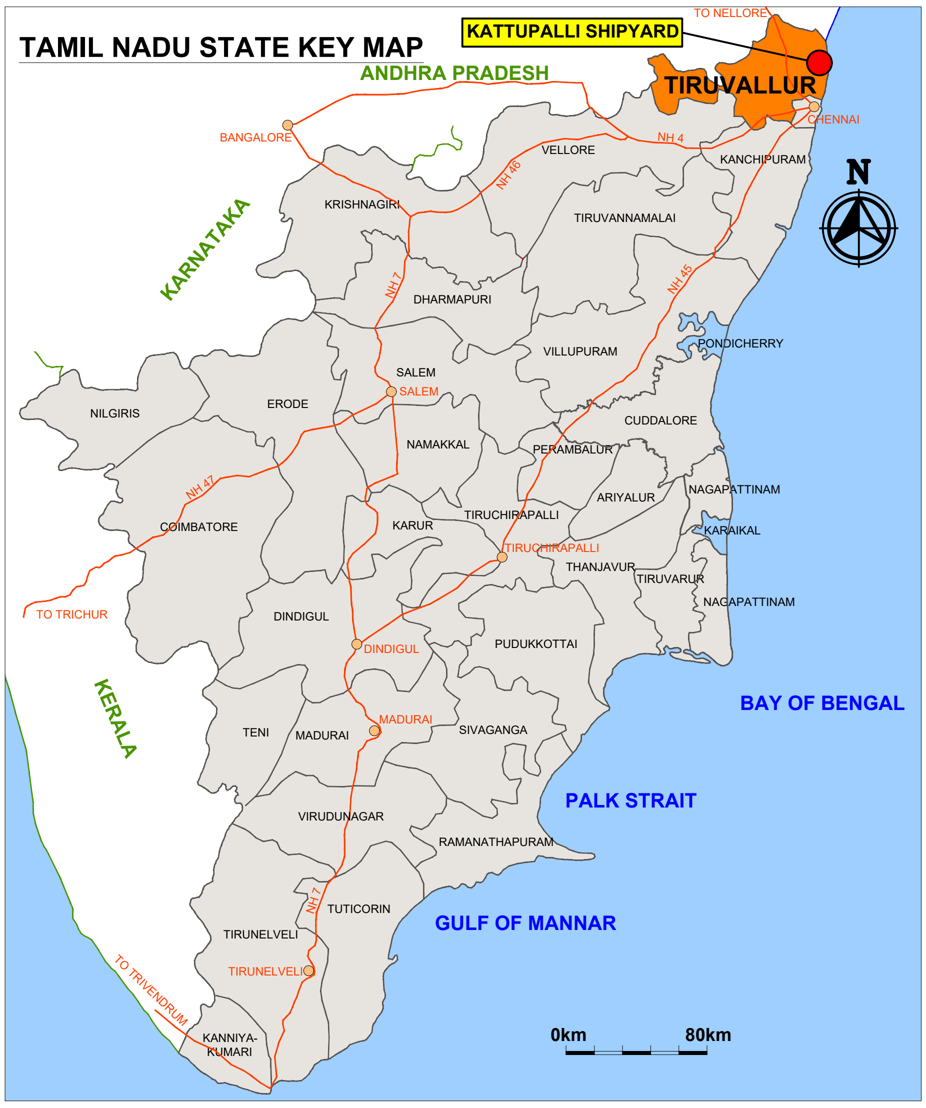
Volume I: Draft Comprehensive EIA/ EMP Report

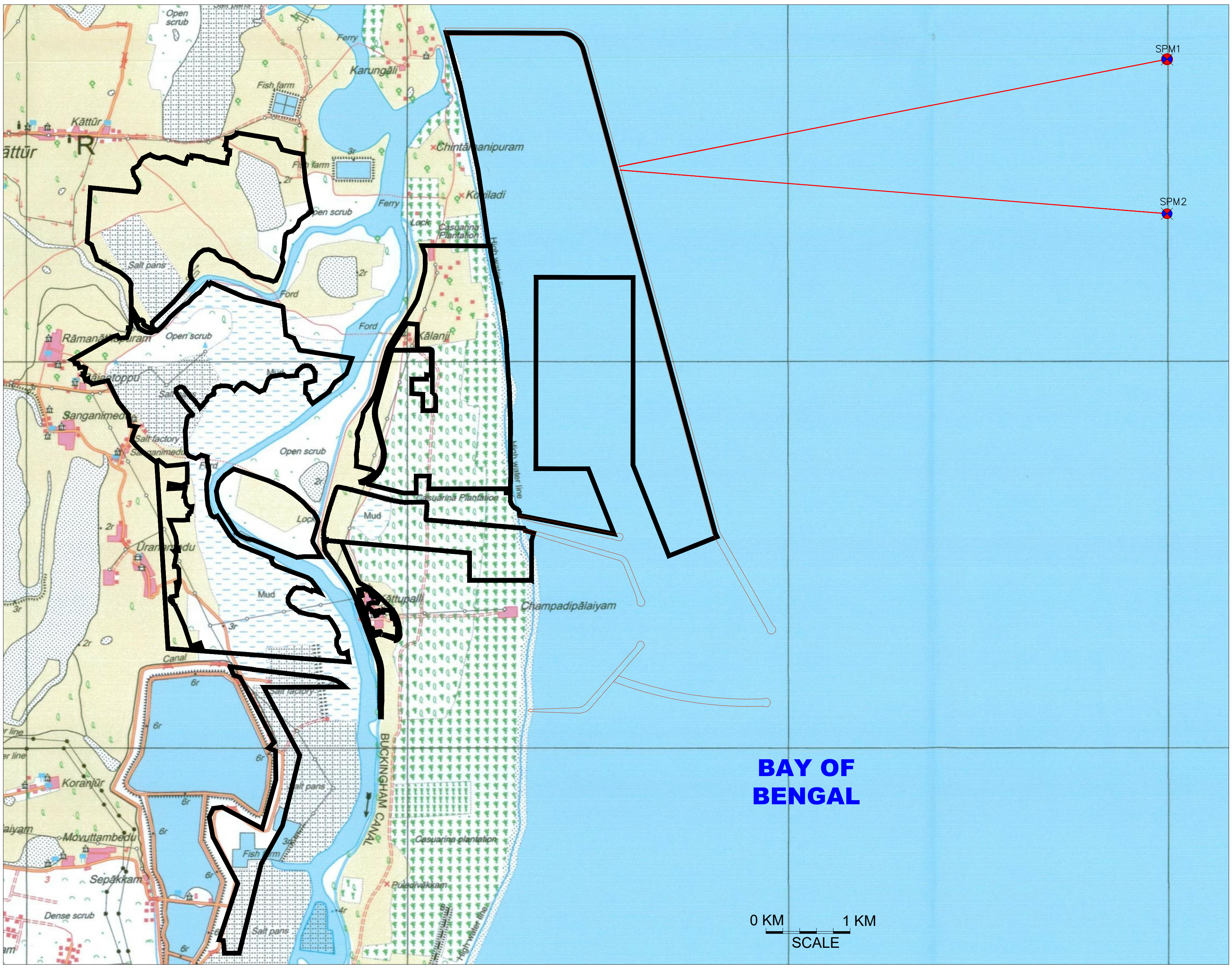
- Chapter 1 : Introduction
- Chapter 2 : Project Description
- Chapter 3 : Analysis of Alternatives
- Chapter 4 : Description of Environment
- Chapter 5 : Anticipated Environmental Impacts and Mitigation Measures
- Chapter 6 : Environmental Monitoring Programme
- Chapter 7 : Additional Studies
- Chapter 8 : Project Benefits
- Chapter 9 : Environment Management Plan (EMP)
- Chapter 10: Summary and Conclusion
- Chapter 11: Disclosure of Consultants Engaged

Volume II: Mathematical Modelling studies & Marine Biodiversity Plan

Figures







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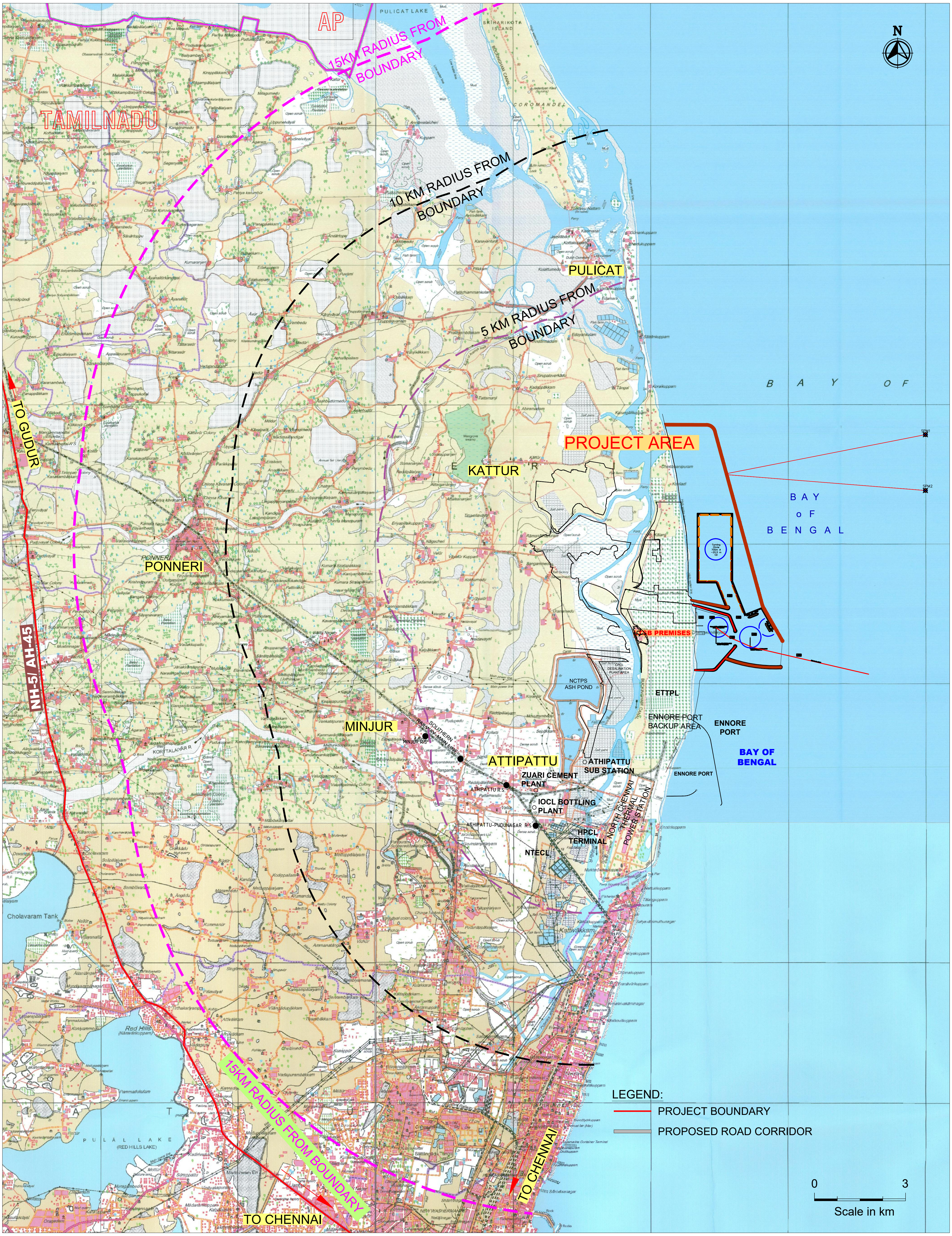

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Chapter 2
Project Description

Chapter 2 Project Description

2.1 General

In this chapter, Existing Kattupalli Minor Port facilities (EC approved, developed and proposed), revised master plan development (RMP) is presented summarising the details of location, land, traffic potential, field surveys carried out for the RMP, layouts, Dredging and Reclamation, cargo handling, utilities and services, estimated cost for the development of project, environmental protection works, project implementation schedule and the proposed activity with respect to CRZ compatibility.

Port location is described in **Section 1.3** of **Chapter 1**.

Being one of the industrialized states of India, Tamil Nadu is an south-eastern gateway of India to the world. The state capital, Chennai is the base to several international car makers namely Ford India Co, Hyundai Motors, Toyota, Nissan Motors Co, Renault S.A, Daimler AG, BMW AG, Mahindra and Mahindra. Also Ro-Ro, Liquid, Bulk and Break Bulk movement through Chennai and Kamarajar Ports (Ennore port) are expected to double in next decade, but factors such as the restrictions on the land availability, Congested road connectivity to the ports, time restrictions on cargo evacuation, exposure to dust & saline environment shooting up the maintenance expenses and higher tariffs & handling charges levied from the operators are influencing exporters look for alternate ports in the vicinity for their exports. Hence there is a need for expansion of the existing facilities of Kattupalli Port.

2.2 Kattupalli Port Existing Facilities

In line to approved EC's, facilities to be operated and permitted activities to be carried out by MIDPL are presented in **Table 1-1** and **Table 1-2**. The facilities developed and yet to be developed at Kattupalli Port are presented in **Table 2-1**.

Table 2-1: Existing/Approved MIDPL Port Facilities

Facilities Developed as per EC/CRZ Clearance	Facilities Yet to be Developed under approved EC/CRZ Clearance
• Navigational Channel o Outer Channel: Length: 2325m; Width: 180 m; Depth: (-) 14 CD o Inner Channel: Length:910 m; Width:225 m; Depth: (-) 14 CD • Other Navigational Facilities • North breakwater: 1775 m • Offshore dredge spoil disposal site • three berths o Berth-1: Length: 353 m; Width: 35 m; Depth: (-) 14 CD o Berth-2: Length: 350 m; Width: 65 m; Depth: (-) 14 CD o Berth-3: Length: 294.5 m; Width: 39.3 m; Depth: (-) 14 CD • Container stackyard/storage area • Liquid Terminal - Tank Farms, ETP, etc., • Container Freight Station • Control Tower • TNMB/Custom	• Development of 2 berths and associated backup facilities & Utilities • Extension of Container Storage area • Development of Cargo Storage areas as per cargos amended • Extension of Navigation facilities • Dredging of 6.0 MCM for Port areas from (-)14.0 m to (-)16.7 m and Navigation Channel from (-)14.0 m to (-)17.5 m • Augmentation of Necessary Cargo Handling equipment • Augmentation of STP/Oil Water Separators if required • Augmentation of Raw Water storage and supply Facilities

Facilities Developed as per EC/CRZ Clearance	Facilities Yet to be Developed under approved EC/CRZ Clearance
• Admin and Immigration Buildings • Security and parking • Toilet Block/STP/Oil Water Separator • Canteen/Raw Water UG Sump/OHT/Pump House • Integrated Waste Management Shed • Substations/Switchyard/DG Building/Workshops • Fire Station/Fire water UG Sump/Fire Water Pump House • Port Operational Buildings • Green Belt areas & Port Nursery	

Currently, Container Berth is being used for container handling and Multipurpose berth is being used for handling Container, Ro-Ro, Project cargo and Break bulk/ General Cargo and Non – Hazardous Liquid cargo as approved. The MIDPL Existing / facilities are shown as **Figure FD0201**.

Some of the existing development salient features pictorial representations are shown in **Exhibit 2-1 to Exhibit 2-4**.

Exhibit 2-1: Berthing Facilities

Exhibit 2-2: Substation at Port Site

Exhibit 2-3: Container storage facility

Exhibit 2-4: Dedicated Road Connectivity for MIDPL

2.2.1 Traffic Forecast

Based on the available hinterland, traffic forecast for the Kattupalli port has been worked out and same has been summarized in **Table 2-2**.

Table 2-2: Cargo Projections for RMP development

Sr. no	Cargo mix	Estimated Cargo Projection (MMTPA)
1	Multi-Purpose (including Liquid)	300
2	Liquid/ Gas / Cryogenics	20
	Grand total	**320**

The indicative list (but not limited to this list) of cargo mix proposed to be handled in RMP is presented in **Table 1-6**.

2.3 Field Surveys and Investigations

2.3.1 Bathymetry

The bathymetry is obtained from echosounder survey and C-map source. Seabed information from Ennore to Pulicat creek was mapped using single beam echosounder. The data was collected from 1m below low water level up to a water depth of 35m with respect to Chart Datum. The spacing between the main lines is 100m and the corresponding cross lines is considered as 500m.

The data indicates that coastal environment show more variation in the cross-shore direction than the alongshore direction. Also, the seabed at Katupalli Port is complex with varied slope between Ennore Creek and Pulicat Creek. The slope at the south of Ennore port is relatively steep (1 in 300) at Ennore Creek, while the slope on the north of Katupalli port is flat (1 in 500) with submerged shoals extending in north-easterly direction.

The measured bathymetry and C-Map data for the open coast area are shown in **Figure 2-1**. The measured bathymetry at Pullicat lake and Ennore creek are shown in **Figure 2-2**.

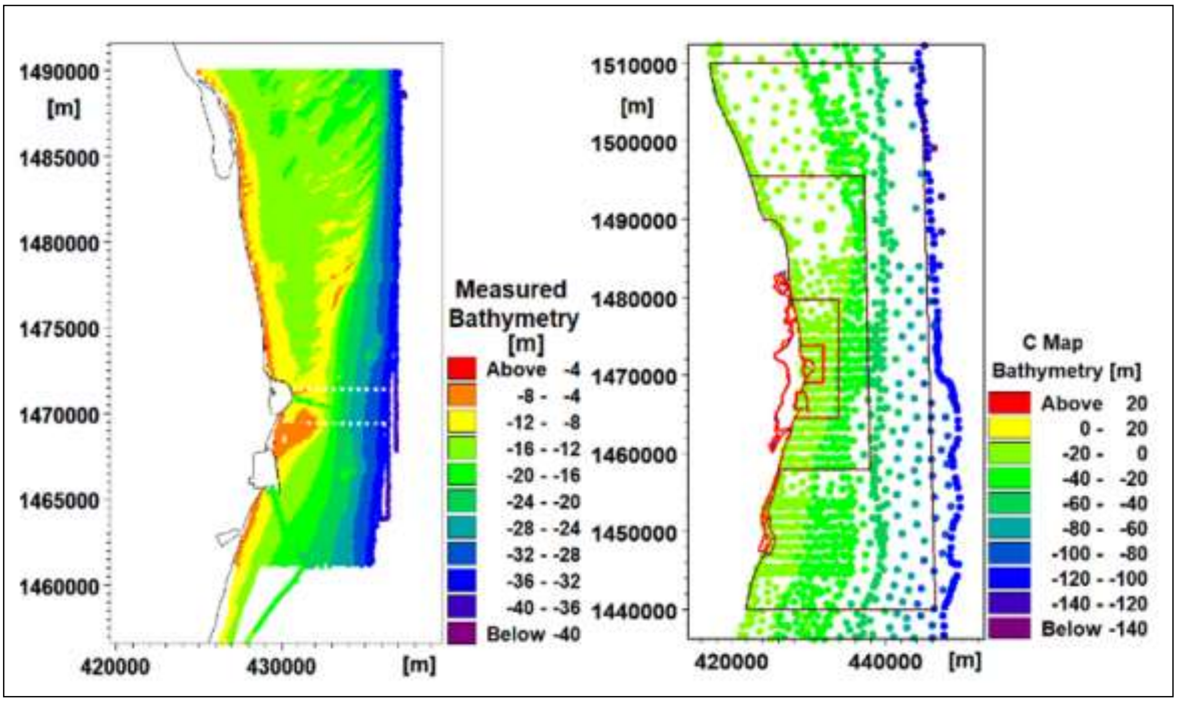


Figure 2-1: Measured nearshore bathymetry and C-Map bathymetry along the coast

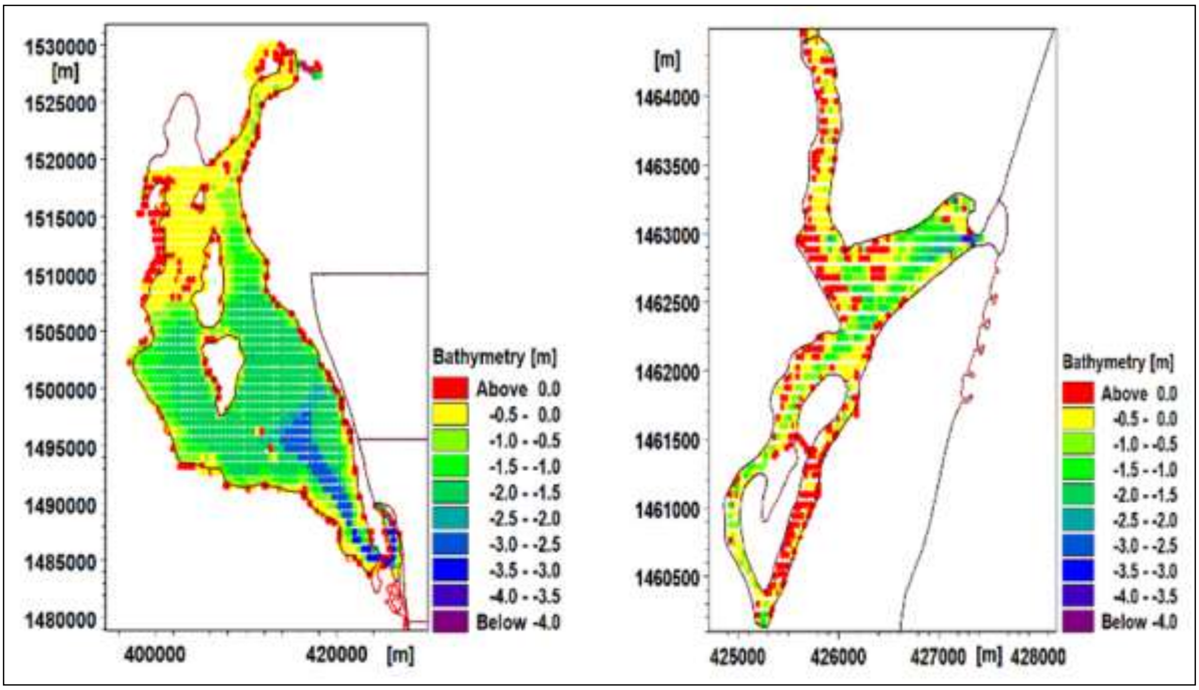


Figure 2-2: Measured bathymetry of Pulicat lake and Ennore Creek

2.3.2 Geotechnical Investigations

Rotary boring was performed at eleven boreholes at one location in accordance with IS: 1892 done up to hard strata to explore the subsurface stratigraphy and obtain soil samples for laboratory testing. Based on the sub-soil information from available geotechnical investigation reports of the boreholes explored in the area, it is observed that the top soil in entire area is comprised of non- plastic soft to very dance

Description of Soil with varying depths and their characteristics

- 0 to 7.5m depth have Grey fine sand with shells to Brown medium to fine sand with Relative density /Consistency of Very Loose to very stiff having N-Value in the range of 02 to 94.
- 7.5 to 10.5 m depth have Brownish grey silty medium to Brownish grey medium to fine sand with clay binder with Relative density /Consistency of medium having N-Value in the range of 03 to 26.
- 12.0 to 18.0 m depth have Brownish grey silty medium to fine sand to Brown fine to medium sand with Relative density /Consistency of medium to very dense having N-Value in the range of 12 to 75.
- 19.5 to 40.0 m depth have Yellowish brown silty medium to Greyish brown silty fine to medium sand with Relative density /Consistency of medium to very dense having N-Value in the range of 12 to >100.

2.3.3 Oceanography Investigations

The site specific oceanographic conditions such as tide, wave, current etc., are discussed in detail in **Section 3.7.1**.

2.3.4 Study on Ennore Shoals

Ennore shoals are naturally formed shore parallel shoals extend up to a length of about 14 km with widths varying between 500 m and 1500 m and depths varying between 3 m and 6 m. In the study area, Ennore Shoal (**Figure 2-3**) plays a significant role in dissipating wave energy and reducing the erosion rate on the northern side of the northern Ennore breakwater. Model studies for assessment of Impacts on Ennore shoals are discussed in detail in **Section 4.9.2.4**.

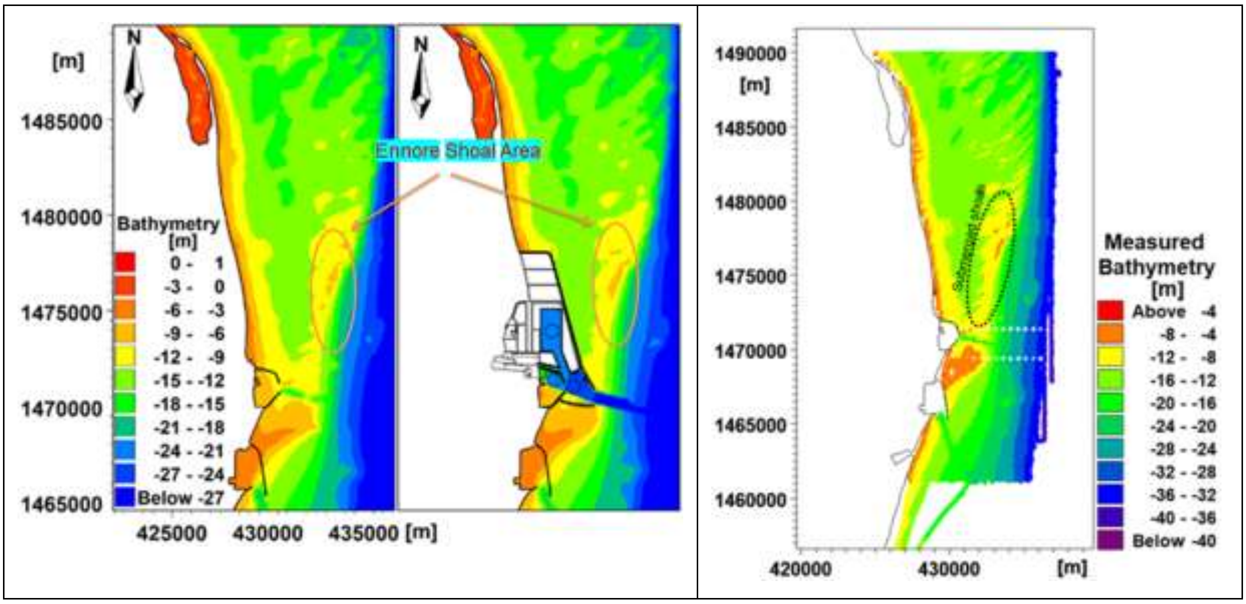


Figure 2-3: Ennore Shoal Area

Ennore shoal and at Pulicat mouth area

The modelling simulation explicitly shows that the circulation pattern remains the same at the Ennore shoal and at Pulicat mouth area, and there are minor variations in the direction of current flow in front of the proposed masterplan configuration and there is no impact to the Ennore shoal area. Pulicat lake is situated at a distance of 10 km from the proposed masterplan, found that there is no effect to Pulicat lake circulation after implementing the layout in the hydrodynamic model. The model simulation shows that, in both the baseline and layout conditions, the position of the barrier island in the Pulicat lake mouth is unchanged. Depth averaged current speed and direction during spring and neap tides with baseline and layout condition are shown in **Figure 2-4** and **Figure 2-5**.

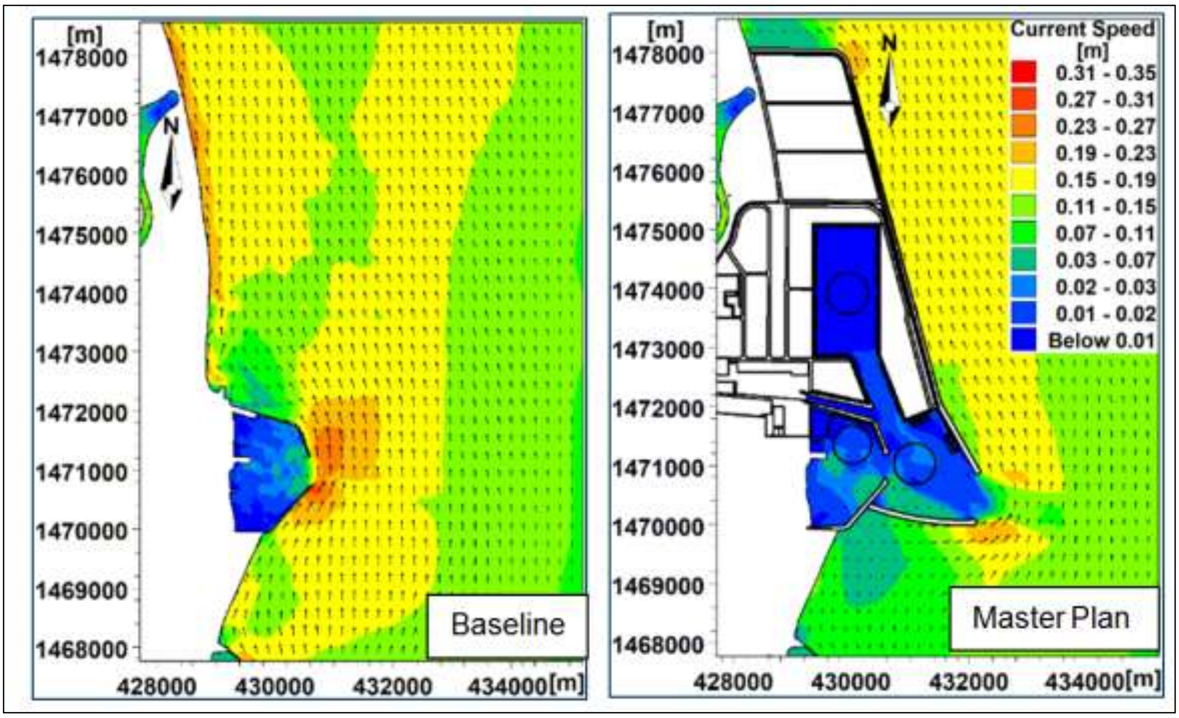


Figure 2-4: Depth averaged current for spring period (Left) with baseline (Right) with layout

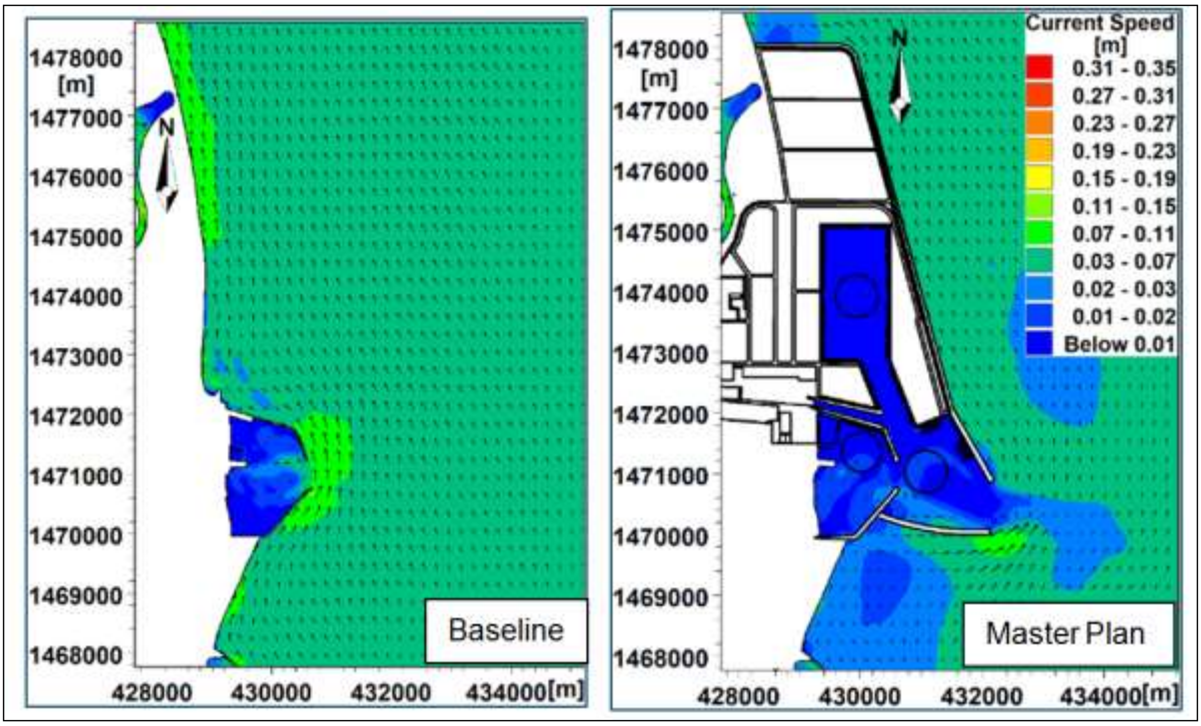


Figure 2-5: Depth averaged current for Neap period (Left) with baseline condition (Right) with layout

The coast north of Katupalli port experiences less energy due to presence of shoals. The waves travel over the shoals, they lose their energy and in turn the wave heights reduce. About 0.2 to 0.4 m difference in wave height has been observed between the eastern and western side of Ennore shoals. From the model, it is clear that the significant wave height (Hs) has considerably reduced up to 0.4 m after the wave crossed the shoals while travelling east to west towards the shore. The overall analysis of offshore wave data at Ennore and

Pulicat also indicates a similar trend in wave height distribution whereas the comparison between offshore and nearshore region indicates changes in wave distribution due to wave transformation from deepwater to shallow water.

2.3.5 Study on Drainage Pattern

The drainage pattern of Ennore Creek, Pulicat lake and Buckingham Canal were studied.

Ennore Creek

The total area of the creek is 2.25 km^2 which lies 20 km away from Chennai in Northward direction. The creek is nearly 400 m wide and is elongated in northeast-southwest direction. Its north-south channels connecting it to the Pulicat Lake to the north and to the Kosasthalaiyar River in the south.

Contribution of total flow to Ennore Creek is from Kosasthalaiyar river (surplus from Poondi reservoir), surplus water from Redhills, industries effluent, outflow from Pulicat lake through Kosasthalaiyar backwater channel), few canal outflows (such as Kuruvimedu Kalvai) on the west, discharge from North Buckingham canal and inflow from the sea during tides.

Pulicat Lake

Pulicat lake is the second largest brackish water body in India. It acts as a barrier to retain flood water during riverine and coastal floods. The seasonal rivers that flow into Pulicat lake are Araniyar at the southern tip, Gummidipoondi in the middle, the Kalangi River at the northwest, and few smaller streams. There are two openings in the Pulicat lake which exchange water to the sea, mouth opening zone at south near Pulicat and the another smaller one which remains often closed at north of Sriharikota boundary. The southern mouth opens during northeast monsoon (November- January) when the freshwater flow into the lake is large and one outlet at the south which drains water to the Kosasthalaiyar backwater channel. The North Buckingham canal passes through Pulicat Lake and it reaches the creek. **Figure 2-6** inflow details of the Ennore creek and Pulicat Lake.

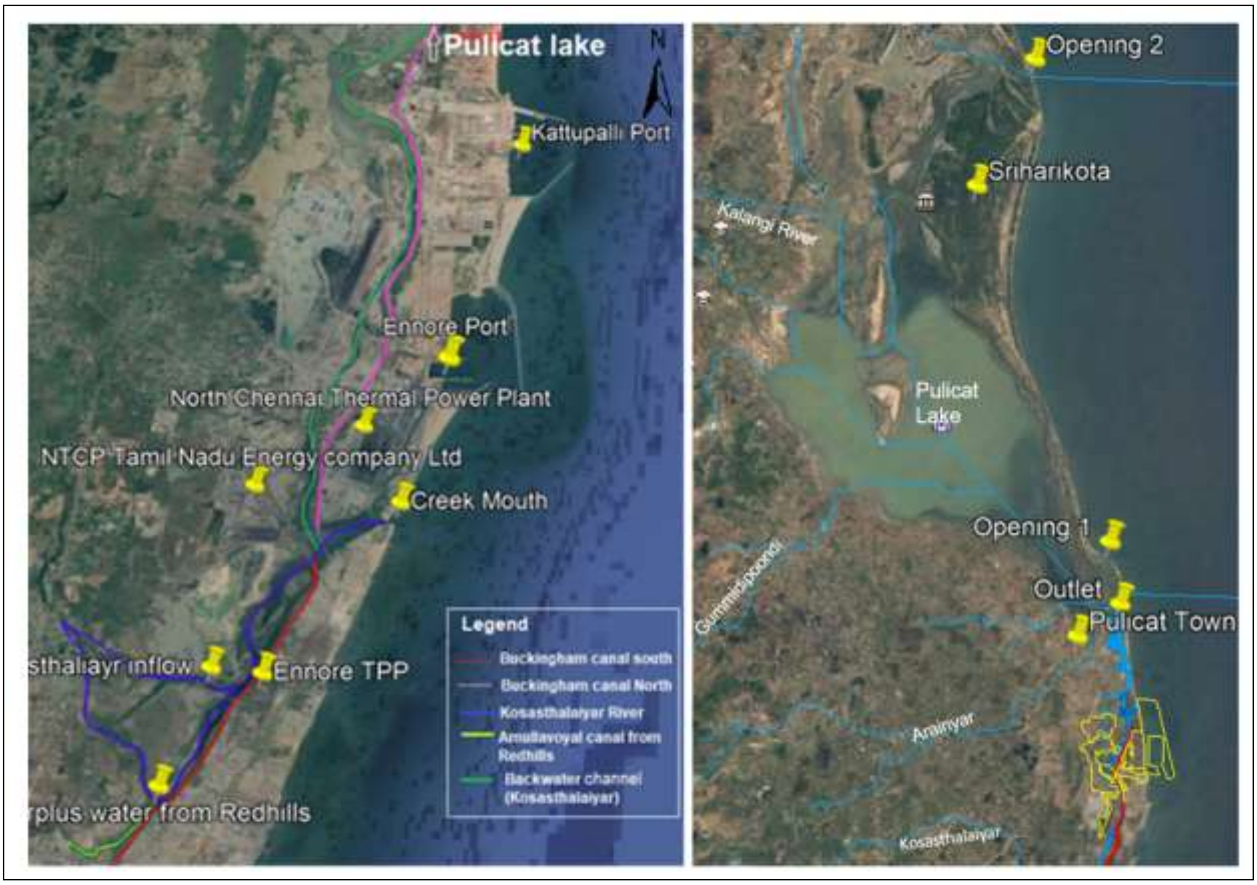


Figure 2-6: Flow into Ennore Creek, and Pulicat Lake

Drainage morphometry provides quantitative description of the drainage system. Linear, areal and relief aspects of morphometric parameters are analysed and given in **Table 2-3**.

Table 2-3: Morphological Parameters of River Basins

Parameters of different aspects	Reference	Araniyar (Ends at Kosasthalaiyar backwater)	Kosasthalaiyar (ends at Creek)	Pulicat lake
Area (km2)		1610.70	3832.70	3287.70
Perimeter (km)		360.54	498.16	371.47
Basin length (km)		91.76	117.88	76.23
Longest flow length (km)		136.17	175.74	125.21
Total Length L (km)		1717.55	3841.65	4025.70
Effective Basin width, Rb		11.83	21.81	26.26
Stream order		6	7	6
Form factor, Rf	Horton (1945)	0.09	0.12	0.21
Shape factor Rs		11.51	8.06	4.77
Circularity ratio Rc	Strahler (1964)	0.16	0.19	0.30
Elongation ratio Re	Schumn (1956)	0.33	0.40	0.52
Drainage Density (1/km)	Horton (1945)	1.07	1.00	1.22
Relief		365.00	438.00	259.00
Relief ratio (%)	Schumm 1963)	2.68	2.49	2.07
Ruggedness umber, Rn		342.29	436.98	211.52

Shuttle Radar Topographic Mission's (SRTM) Digital Elevation Model (DEM) of 30 m resolution is obtained for the three river basin areas and CARTOSAT DEM of 10 m is acquired from Ennore creek to Pulicat creek. These two datasets are processed using ArcGIS. The processed 30 m DEM is used for the evaluation of linear, areal and relief aspects of morphometric parameter. Strahler method of stream ordering is a method for classifying the types of streams based on their numbers of tributaries. The smallest tributaries are referred to as first-order streams, while the largest river is referred to as higher order. Drainage density (Dd) is the expression of the closeness of spacing of channel within a basin as per Horton (1945). Dd is measured as the ratio of the total length of streams irrespective of stream order to the per unit area of the basin.

Drainage density and stream order, of the Kosasthalaiyar basin, Araniyar basis and Pulicat lake basin are shown in **Figure 2-7** and **Figure 2-8**.

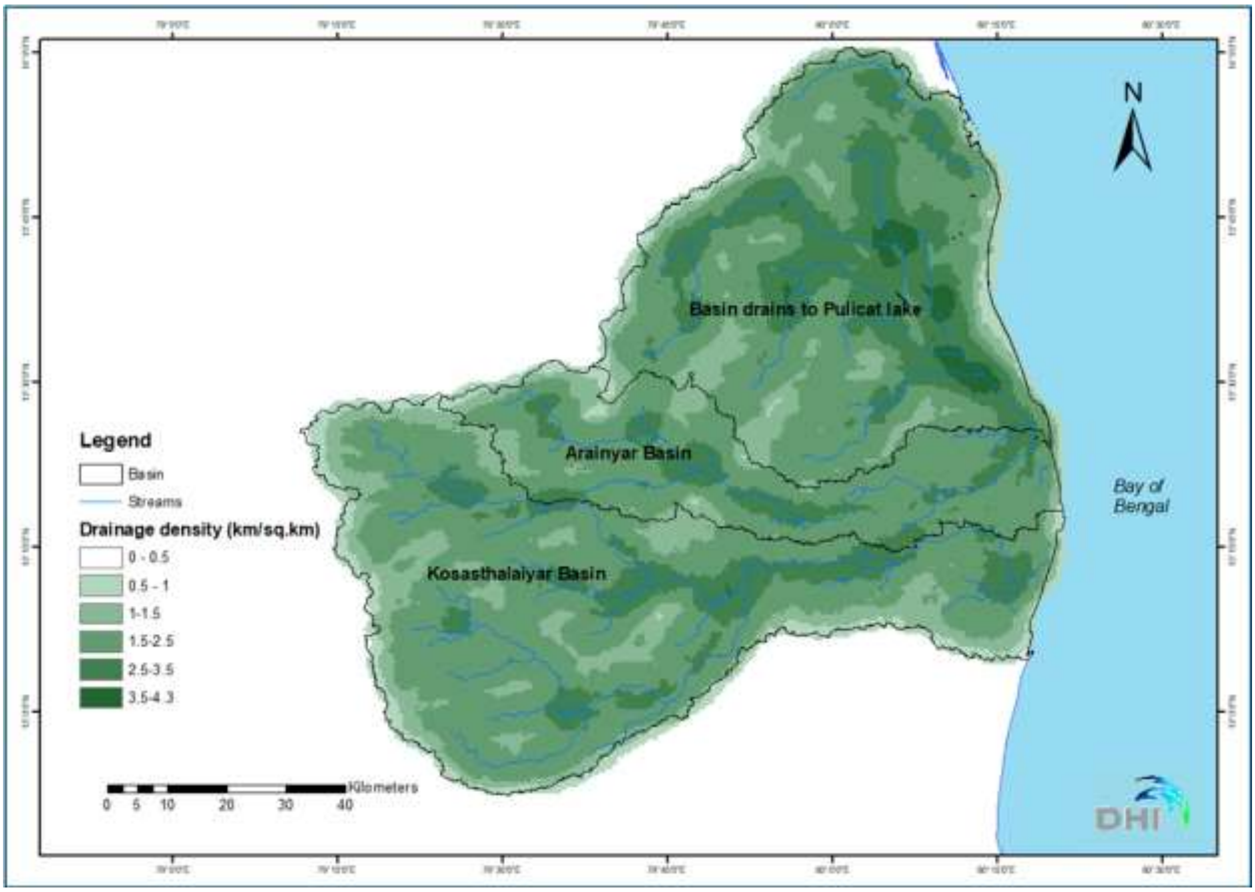


Figure 2-7: Drainage density map of the study area

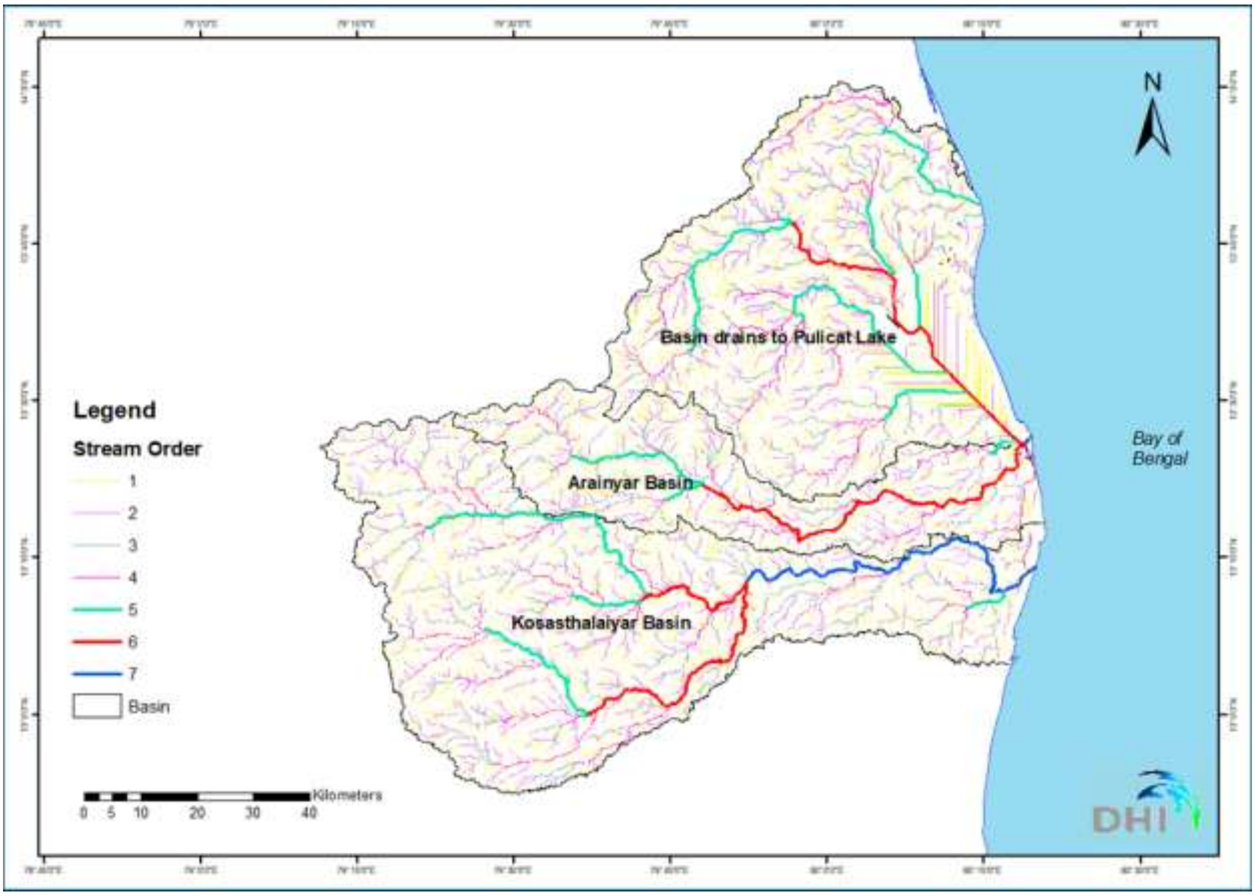


Figure 2-8: Stream order of the study area

The surface elevation of the entire basin varies from 0 to 1035 m (with respect to MSL) which is shown in **Figure 2-9** and the highest elevation within the Kattupalli port boundary is 16m (**Figure 2-10**).

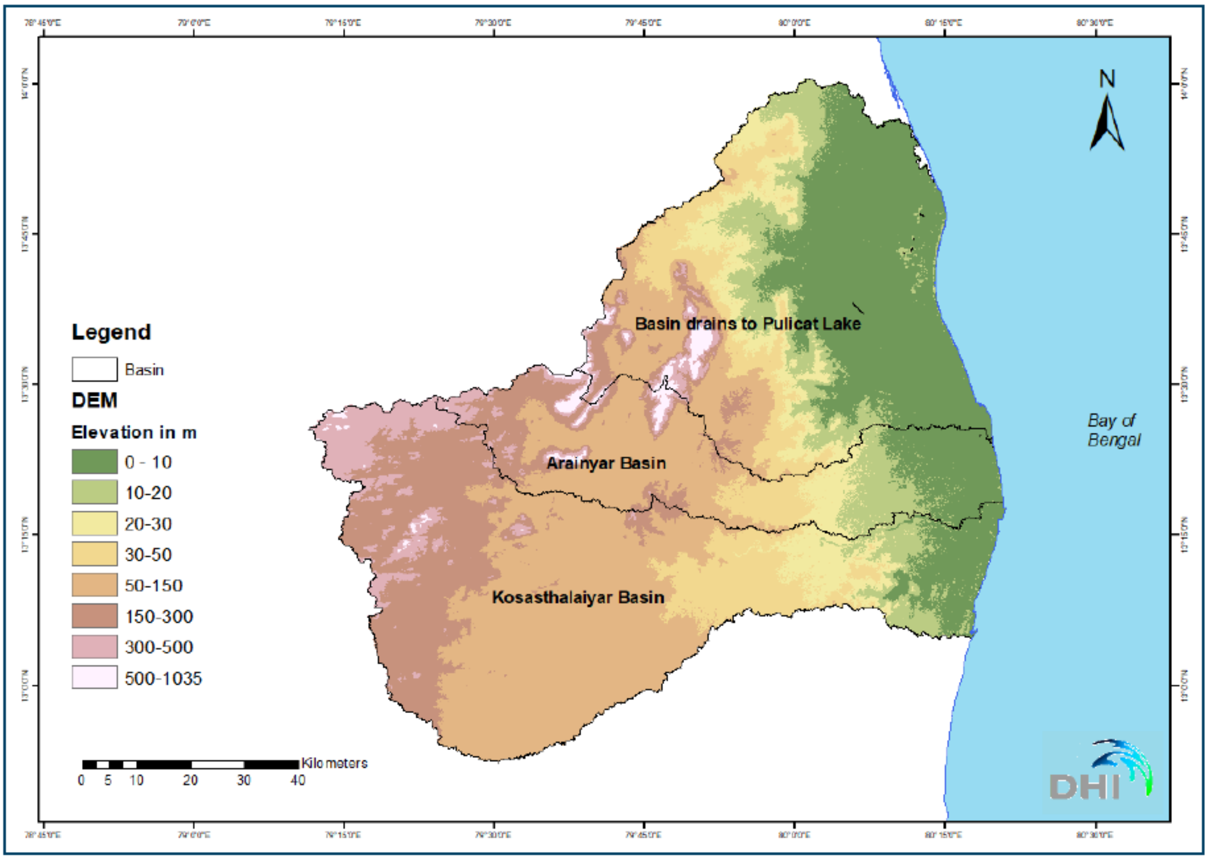


Figure 2-9: Topography of Kosasthalaiyar basin, Araniyar basin and Pulicat Lake basin

Inference

Kosasthalaiyar basin is designated as the seventh stream order; Araniyar and Pulicat basin (basin contributing to Pulicat) as sixth order. Small stream orders such as first and second are predominate in the vicinity of the Kattupalli port area. The study reveals that the Kosasthalaiyar and Araniyar basin exhibits dendritic pattern of drainage.

Strahler states that elongation ratio runs between 0.6 and 1.0 over a wide variety of climatic and geologic types. The varying slopes of watershed can be classified with the help of the index of elongation ratio, i.e. circular (0.9~0.10), oval (0.8~0.9), less elongated (0.7~0.8), elongated (0.5~0.7), and more elongated (less than 0.5).

The smaller value of form factor in Araniyar and Kosasthalaiyar basin indicates that it is more elongated watershed and have flow for longer duration. As the runoff is more for the one with the smallest circulatory ratio, Pulicat basin has quick runoff.

The drainage density is estimated to be nearer to 1 for all basins, which indicate the existence of permeable rock and soil, and vegetation. The calculated value indicates Pulicat basin might have some erosion compared to others. The basin relief indicates runoff, sediment transport and overall steepness of the drainage basin. The relief ratio of the river basin indicates that the discharge capability of watershed is high.

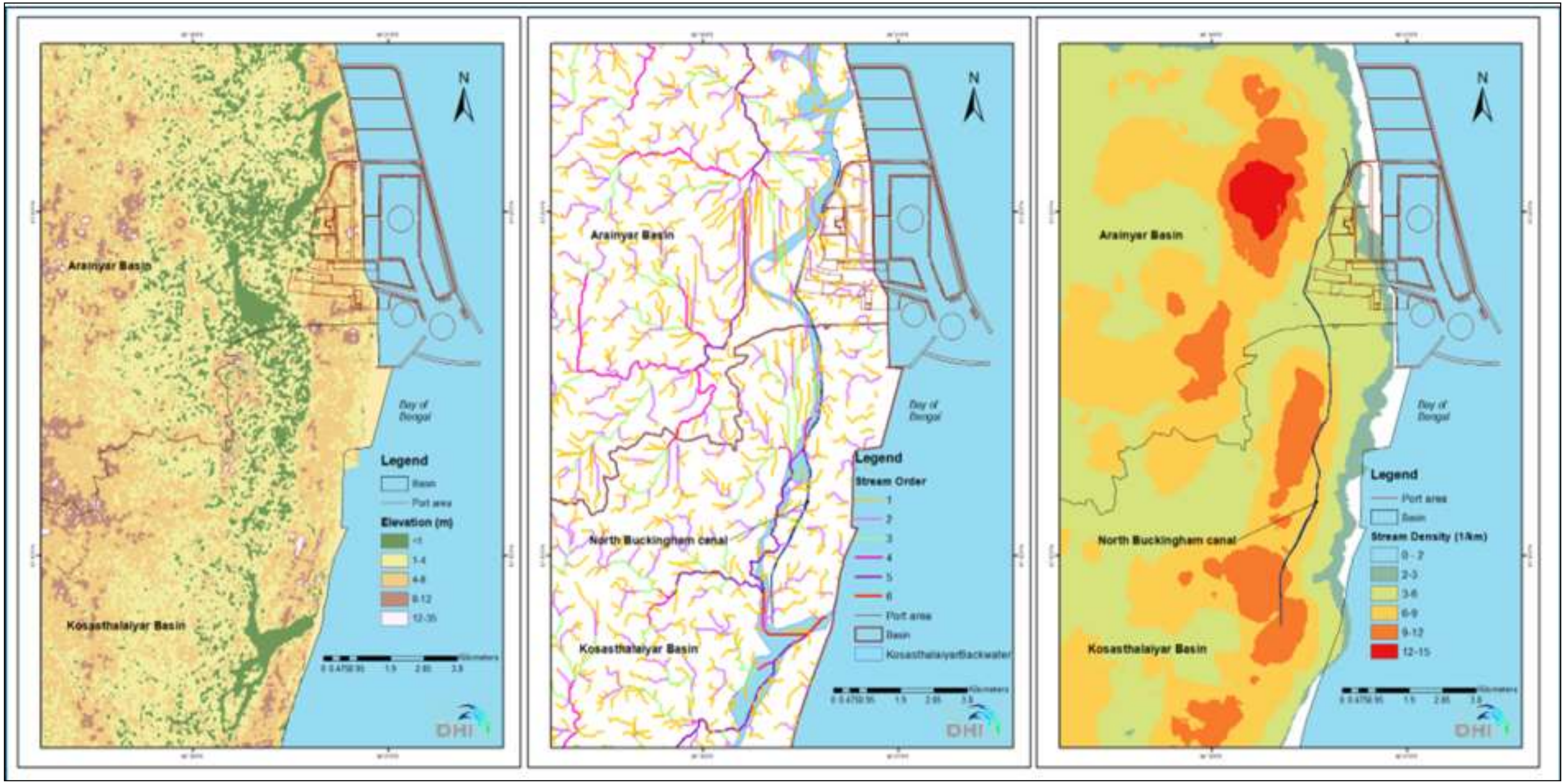


Figure 2-10: CARTOSAT Digital Elevation Model, stream order and drainage density of the port area

2.4 Mathematical Model Studies

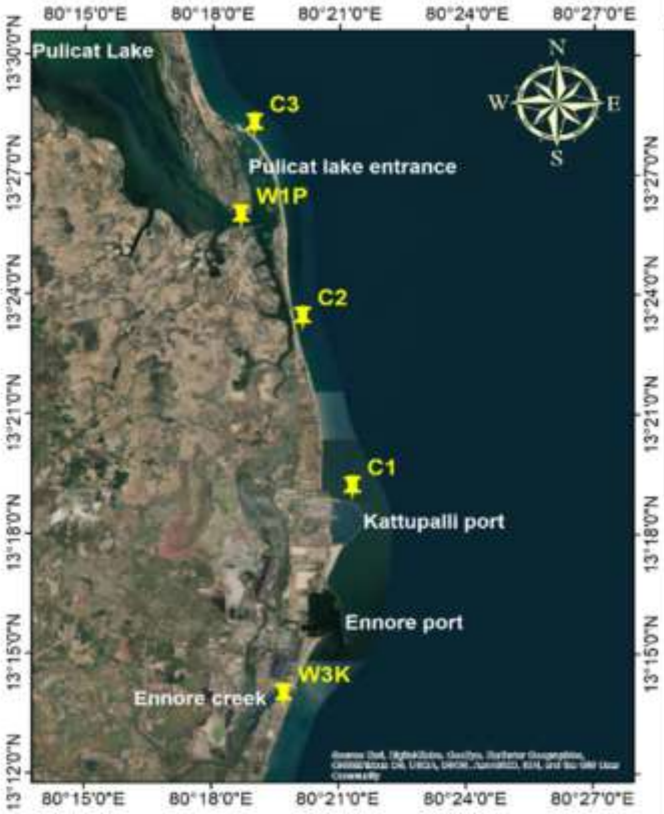
This section provides details of Mathematical Model Studies and exclusive model study reports will be submitted as Volume 2 along with Draft EIA report.

MIDPL has appointed following consultants for conducting model studies:

- DHI (The experts in water environment) for hydrodynamic, wave transformation, shoreline changes, dredge spoil disposal, tsunami, cyclone and flood modelling, intake/outfall for Desalination Plant, Cold water dispersion for LNG/LPG, sedimentation and drainage study.
- BMT Consultants (India) Pvt. Ltd for navigation simulation study

2.4.1 Met Ocean Data Analysis

Coastal processes responsible for shoreline changes were reviewed during pre-monsoon period (February-March 2020). Filed measurements on tides, currents, bathymetry etc. were analysed at selected locations between Pulicat and Ennore creek. Pre-monsoon water levels were monitored at two locations inside the Pulicat Lake (W1P) and Ennore Creek (W3K) for a period of 30 days. Data collection locations area shown in **Figure 2-11**.



Station ID	WGS84 & UTM-43		Measured Parameters
	Easting (m)	Northing (m)	
C1	430195	1472484	Current speed Current direction
C2	428077	1480306	Current speed Current direction
C3	426032	1489244	Current speed Current direction
W1P	425465	1485014	Water level Current speed Current direction
W3K	427256	1462917	Water level Current speed Current direction

Figure 2-11: Measured Data locations

Maximum tidal range at W1P and W3K are 0.44m and 0.94m respectively. Maximum current speed at C1, C2, and C3, are 0.17m/s, 0.25m/s, 0.27m/s respectively. The mean current speeds are 0.04m/s, 0.07m/s, and 0.09m/s. Similarly, the maximum current speed at W1P and W3K are 0.24m/s and 0.91m/s respectively and the mean current speeds are 0.05m/s and 0.33m/s respectively.

Keeping in view of processes identified from field investigations, model investigations on hydro dynamical aspects, nearshore wave transformation processes, sediment transport pattern and shoreline changes have been carried out. The models are calibrated with the field data collected during the pre-monsoon season. By integrating the results of field and model investigations, the sediment budget for Ennore-Pulicat creek was estimated. The existing sediment transport rates of the coast were determined. Also, the proposed Master Plan layout of Kattupalli Port is investigated to assess the sediment transport and shoreline changes. The areas prone to erosion and deposition have been identified.

The following models are being used to generate impact model

- Hydrodynamic model to simulate flow pattern
- Spectral wave models for deriving the wave climate
- LITPACK model for prediction of shoreline changes.

The preliminary results of the model investigations are summarised and presented below:

2.4.1.1 Hydrodynamic Study

2-dimensional hydrodynamic model (MIKE 21 HD FM) was set-up and calibrated for the baseline conditions in order to simulate the water levels and current pattern from Ennore to Pulicat creek. The model account for bottom friction, wind effect, wave radiation stresses. The open boundaries were provided with water levels. The simulation was carried out with tide and pre monsoon wind conditions for a period of 15 days, which covers spring and neap tidal cycles. The simulated water levels and currents are having a good agreement with the measured water level and current data. The two major forcing functions, i.e., tide and wind, influence the circulation pattern, latter being a dominant forcing function, which controls the direction of current. The flow field south of Kattupalli Port is complex and circulation north of port is influenced by the presence of shoals.

2.4.1.2 Spectral Wave Study

Spectral Wave model (MIKE 21 SW) is to predict the annual wave climate for Ennore- Pulicat coast. The basic requirement for the model i) wave boundary data, which was obtained from NIOT Wave model and ii) the bathymetry, which is obtained from echo sounder survey and C-map source.

The annual distribution of wave data indicates that during November-December the waves were observed to be 60°-70° in other months from 120°-140°. Thus the annual wave climate along Kattupalli Port leads to a net northward littoral sediment transport pattern over a year. Wave periods were observed between 3 to 9 sec and heights from 0.5 to 2.0m. Most percentage of waves occurs in the height range 1.0 to 1.5 m and in the periods of 4-10 sec.

Simulations were conducted for predominant wave directions prevailing at Kattupalli. The coast north of Kattupalli experiences concentrations of wave energy at some places due to convergence of wave rays resulting from complex bathymetry (shoals).

The spatial variation of significant wave height was 1.3m (Maximum) and peak wave period was 16 Sec (Maximum) for baseline and layout conditions. Significant wave heights at five locations are extracted from layout and the values varies from 1.36m to 0.03m.

2.4.1.3 Historical Shoreline Changes

GIS techniques used to estimate historical shoreline changes and Littoral Process FM model used for 20 years shoreline prediction. Satellite images were downloaded for years from 2000-2020 to estimate the historical shoreline changes. The shorelines from each image are digitised using GIS techniques to estimate the changes. Coastline from the entire study area are divided in to Six zones (Zone-A to Zone-F). The north side area of Kattupalli Port (Zone-C), where erosion is more predominant, and it is active after the construction of Kattupalli Port, and it is increasing. These changes started during the construction stages of the port affecting the area within the port as well as on south and north sides of the port.

2.4.1.4 Shoreline Change Prediction

To simulate shoreline evolution along Ennore-Pulicat coast, the one dimensional model LITPACK system was used. The model has the capacity to simulate the influence of structures like groin, breakwater, jetties etc on shoreline evolution and has the facility to include sediment source and sinks. The model predicts variations in shoreline position within a stipulated period of time under the combined action of waves and currents.

Three different profiles are considered for the present studies. Wave at 30 m water depth also used. The littoral drift along the Ennore coast is calculated as 3000 m3/year/m for a shoreline orientation of 170-degree N.

The following results have noticed from the shoreline change prediction:

- Northward movement of sand in the order of 213484.3m^3 and southward movement of sand in the order of 31668.9 m^3 is noticed with the baseline conditions for 1 year.
- Northward movement of sand in the order of 213178.7 m^3 and southward movement of sand in the order of 31422.0 m^3 is noticed with proposed port facilities for 1 year.
- Northward movement of sand in the order of 1358018.5 m^3 and southward movement of sand in the order of 60221.8 m^3 is noticed with proposed port facilities for 5 years.
- Northward movement of sand in the order of 3063603.2 m^3 and southward movement of sand in the order of 131301.0 m^3 is noticed with proposed port facilities for 10 years.
- Northward movement of sand in the order of 5102208.0 m^3 and southward movement of sand in the order of 170769.3 m^3 is noticed with proposed port facilities for 15 years.

2.4.1.5 Shoreline Management Plan

In order to prevent the erosion along north coast two types of interventions and the consequent impacts on shoreline management along the coast was studied. Both soft (sand bypassing) and hard measures (groynes) were tested with appropriate model simulations.

Option -1: One km of the coastline immediate north of the proposed port was nourished with dredged material and predicted its movement during the prevailing longshore currents. The shoreline is stable up to 12 years and started eroding thereafter.

Option-2: One km of the coastline immediate north of the port is nourished with dredged material and protected by groin field after 3 km from proposed breakwater. The results indicate that the shoreline is protected in the nourished area and behind the groin field. The erosion is further shifting to north of the groin field.

2.4.1.6 Tsunami Modelling

MIKE 21 HD model was used for tsunami generation and propagation of fault parameters for 1881, 1941 and 2004 Earthquakes in the Bay of Bengal. The maximum water level predicted at Kattupalli Port entrance is about 2.18 m due to 2004 Sumatra tsunami. The corresponding current speed at Kattupalli Port entrance is estimated about 2.8 m/s.

2.4.1.7 Cyclone Modelling

Nine (09) cyclonic events were selected for cyclone study and the cyclone data are collected from IMD. From the 9 cyclones, December 2016 Vardah cyclone made severe impact at the study area. At Kattupalli Port location, the Vardah cyclone has caused a maximum surge height of 0.78 m and a maximum current speed of 2.74 m/s. Similarly, the maximum significant wave height estimated at Kattupalli port due to 2016 Vardah cyclone is 5.15m.

2.4.1.8 Ship Tranquillity Study

The simulated result of the model has provided keen insight into the performance of the harbour layout in the wave agitation point of view. From the results it could be seen that the tranquillity inside the harbour is very good.

Across all modelled scenarios the breakwater provides a large reduction of wave height for the modelled combination of wave periods and direction.

2.4.1.9 Sedimentation Study

The calibrated hydrodynamic model is further extended by sediment transport process calculations using DHI's MIKE 21 FM Mud Transport (MT) model to assess the sedimentation (maintenance dredging quantity) in the proposed dredging area.

From the study the following broad conclusions can be drawn:

- To maintain a water depth of 27 m w.r,t CD in the approach channel (Section-A) of the proposed Master Plan, the predicted average and maximum dredging quantities are 8,54,045 m^3/year and 1,56,5750 m^3/year respectively.
- To maintain a water depth of 25 m w.r,t CD in the basin area (Section-B) of the proposed Master Plan, the predicted average and maximum dredging quantities are 2,23,363 m^3/year and 1,21,2543 m^3/year respectively.
- To maintain a water depth of 20.5 m w.r,t CD in the basin area (Section-C) of the proposed Master Plan, the predicted average and maximum dredging quantities are 1,80,342 m^3/year and 4,50,856 m^3/year respectively.
- To maintain a water depth of 16 m w.r,t CD in the basin area (Section-D) of the proposed Master Plan, the predicted average and maximum dredging quantities are 3119 m^3/year and 3119 m^3/year respectively.

For the given Master Plan consisting of approach channel, turning circle and berthing area, the total predicted average and maximum dredging quantities are 12,60,869 m^3/year and 32,32,267 m^3/year respectively.

2.4.1.10 Recirculation study

The recirculation study of 30 MLD Seawater Desalination Plant showed that in all the simulations the excess salinity does not influence at the intake locations. It is concluded that the 30 MLD outlets result in excess salinity below 1.5 PSU at the point of discharge and 0.1 PSU at the farthest point from the outlet. For 30MLD outlet the excess temperature is comparatively less, and the value is 0.07°C respectively.

Two intake and outfall options were considered for 20 MMTPA LNG/LPG processing facility. The results indicates that, there will not be any recirculation and there will be no impact on water quality at the intake as well as at the shore due to the disposal taking place at the proposed outfall discharge location option-1. Based on Modelling Study output intake and outfall locations are different and there is minimal chance of mixing the intake and outfall waters.

2.4.1.11 Oil Spill Risk Assessment

Eight oil spill scenarios have been modelled, each spill event involve simulation of 6000 (200 particles per 10 minutes for 5 hours) discrete oil spill particles whose advection, dispersion and weathering has been computed over a maximum two-week (14 days) period.

- Scenario 1 to 4: Collision at the turning circle with Gas oil and Heavy oil for NE and SW monsoon.
- Scenario 5 to 8: Collison at SPM location with possible rupture from hale.

Some key observations include:

Spillage occurrence at turning circle is not having any shoreline impact. This is due to the shelter effect of the proposed breakwater and predominant wind direction is from southeast direction. The oil slick is concentrated within the berth area and does not travel far away.

For some combination of tide and wind conditions, the oil slick tends to get trapped within the port.

Spillage occurrence at SPM location is having shoreline impact on the northern side of the proposed development. During the southwest monsoon (June to August), winds from south-easterly is making oil slick moving very far to the east.

2.4.2 Hydrodynamic Modelling

In order to simulate water levels and current pattern along Ennore to Pulicat creek with the baseline and proposed Master plan, the hydrodynamic modelling is carried out using MIKE21 FM (Flexible Mesh) HD model. The model simulates 2D free-surface flows by solving the depth-averaged Navier-Stokes equations and is applicable to simulate hydrodynamic processes in lakes, estuaries, bays, coastal areas and seas. The FM module of MIKE 21 is based on Flexible Mesh approach using triangular and quadrangular elements for addressing geometrical flexibility to complex coastlines, like an archipelago, lagoons, estuaries etc. Inputs include bathymetry, bed resistance, wind velocities and hydrographic boundary conditions (e.g., tides and inflows). Calibration parameters include Manning’s n and eddy viscosity coefficients.

The model domain used for 2D hydrodynamic modelling covers the region 80°16.748'E–13°1.298'N and 80°30.837'E–13°39.367'N, Pulicat lake on the northwest and Bay of Bengal on the East. About 32751 elements with various mesh resolutions have been produced. It features higher resolution in areas where the kinetic power density is high, and lower resolution in areas where the currents are weaker. The unstructured mesh triangles in coarse areas have a maximum element area of 500 km^2 and in the shallow areas 800m2. The coastline was defined throughout as an impermeable, zero normal velocity boundary, while the bottom is a non-slip, impermeable boundary with bed resistance specified by a quadratic drag coefficient of 0.01. Model domain showing overall bathymetry is shown in **Figure 2-12**.

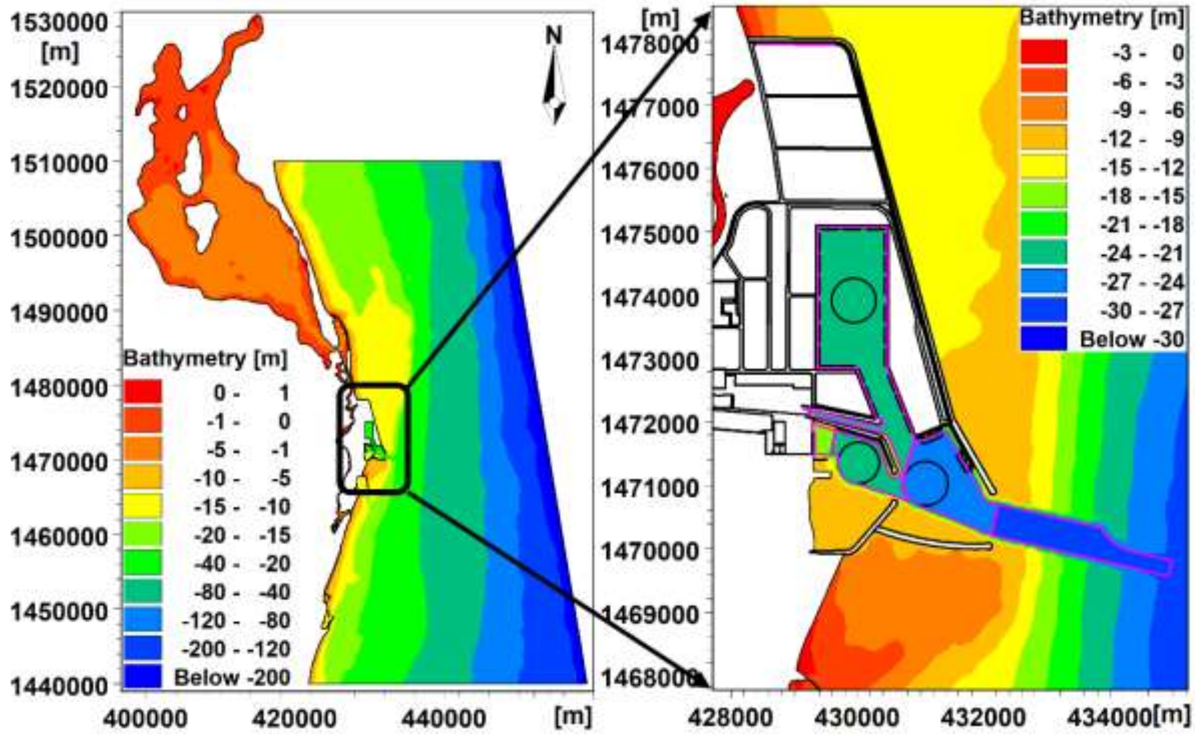


Figure 2-12: Model domain showing overall bathymetry

Model Calibration

The model was calibrated against measured water level and currents collected for pre-monsoon season Feb-Mar 2020. Bed resistance and eddy viscosity were adjusted to achieve the best match between prediction and measurements.

The comparison of measured and modelled water levels at W3K is shown in **Figure 2-13**. simulated water levels are having a good agreement with the measured data in terms of amplitude and phase. The comparison of the simulated and measured water levels is in the acceptable range with Index of agreement as 0.93.

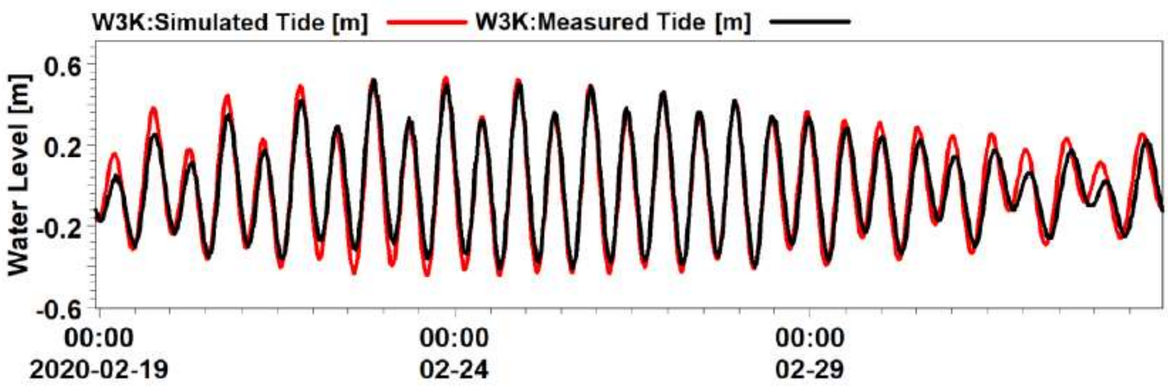


Figure 2-13: Comparison of measured and simulated water level at W3K

Current Speed

The depth averaged current speed and direction obtained from the model are compared with measured current speeds at C1, C2 and C3 (**Figure 2-14 to** to **Figure 2-16**). While the current speed and direction agrees comparatively well throughout the time period, there is a minor phase and amplitude difference between measurements and model at ADCP-1. This difference could be due to the boundary conditions and the changes in the bathymetry.

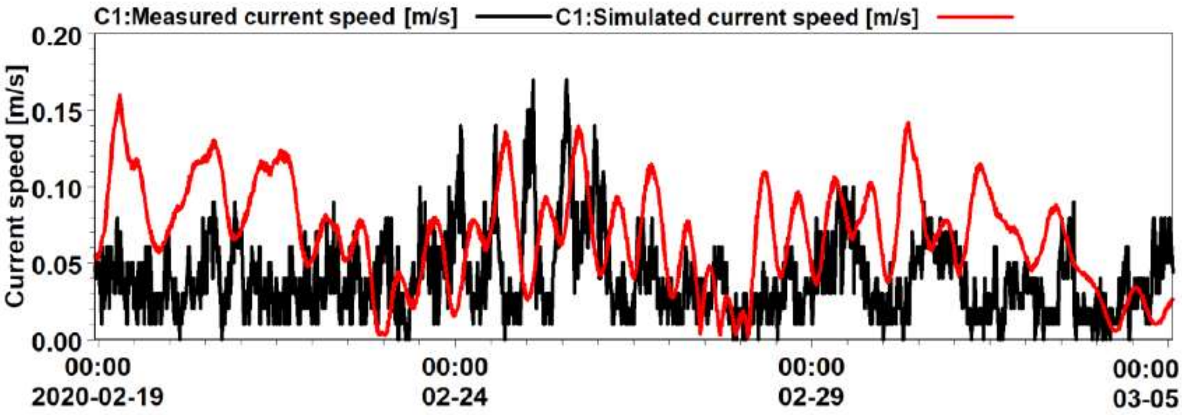


Figure 2-14: Comparison of measured and simulated current speed at C1 location

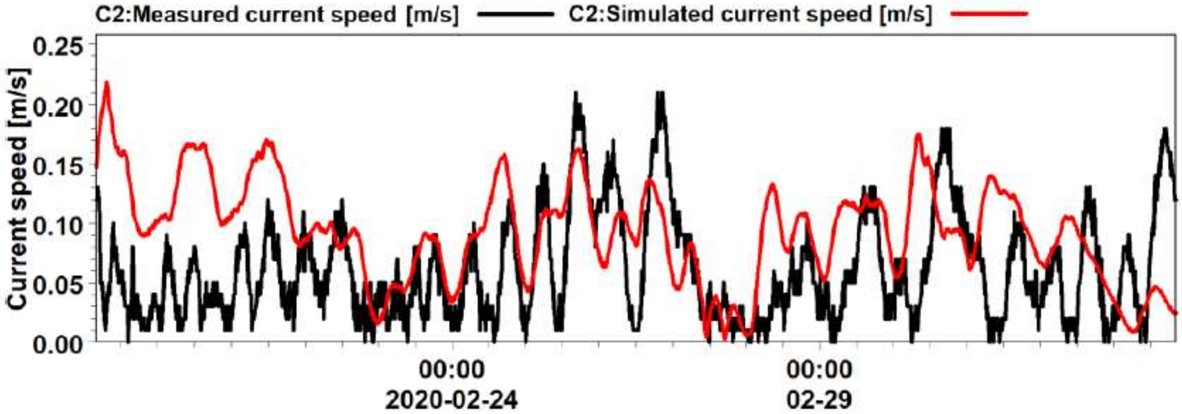


Figure 2-15: Comparison of measured and simulated current speed at C2 location

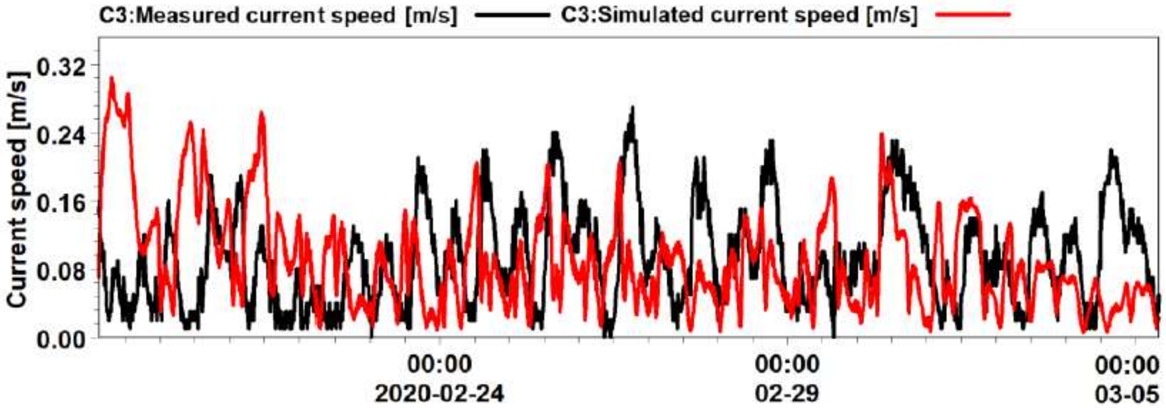


Figure 2-16: Comparison of measured and simulated current speed at C3 location

Model Results

Depth averaged current speed and direction during spring and neap tides with baseline and layout condition are shown in **Figure 2-17** and **Figure 2-18**. Maximum current speed during spring and neap period at study area is 0.28m/s and 0.10m/s respectively. Two major forcing functions, i.e. tide and wind, influence the direction of current. The circulation around Katupalli Port is influenced by the north and south breakwaters and presence of the shoals at offshore. Further, the current magnitudes inside the Katupalli port area are insignificant with the baseline and proposed Master Plan layout.

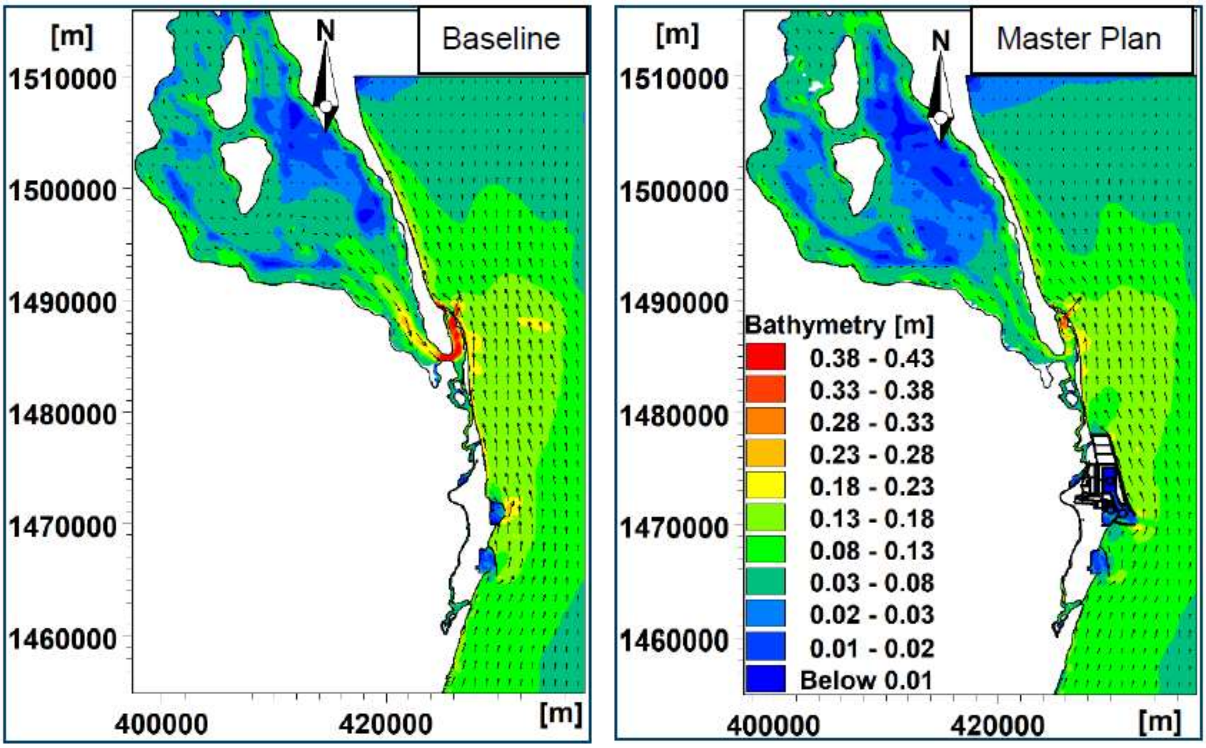


Figure 2-17: Depth averaged current for spring period

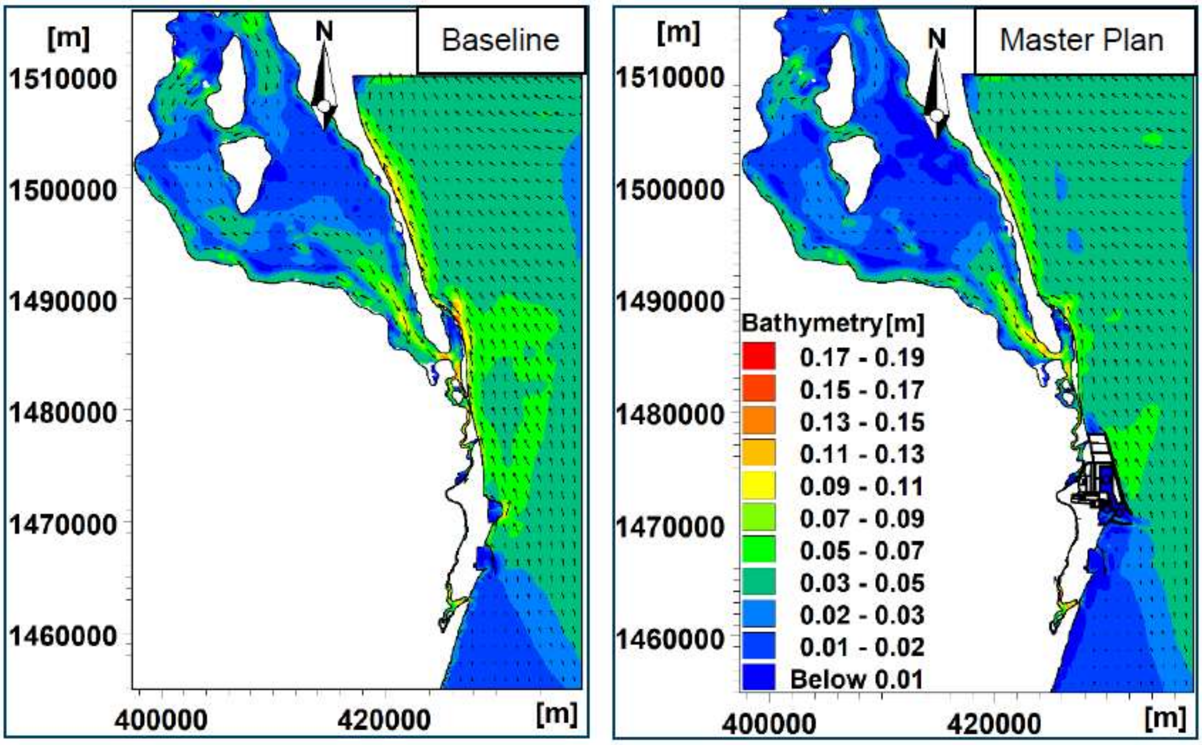


Figure 2-18: Depth averaged current for Neap period

2.4.3 Wave Transformation Modelling

MIKE 21 Spectral Wave (SW) FM model is used in order to predict the annual wave climate along Ennore to Pulicat creek. The spectral wave model is based on an unstructured, cell centred finite volume method and uses an unstructured mesh in geographical space. This approach, which has been available from DHI now for more than a decade and which is thus fully matured, gives the maximum degree of flexibility and allows the model resolution to be varied and optimised according to requirements in various parts of the model domain.

The model domain for wave propagation and transformation is chosen accordingly to transform the offshore wave fields at 30m depth based on field observations. The model extent and bathymetry used for baseline and layout wave modelling is provided in **Figure 2-19**.

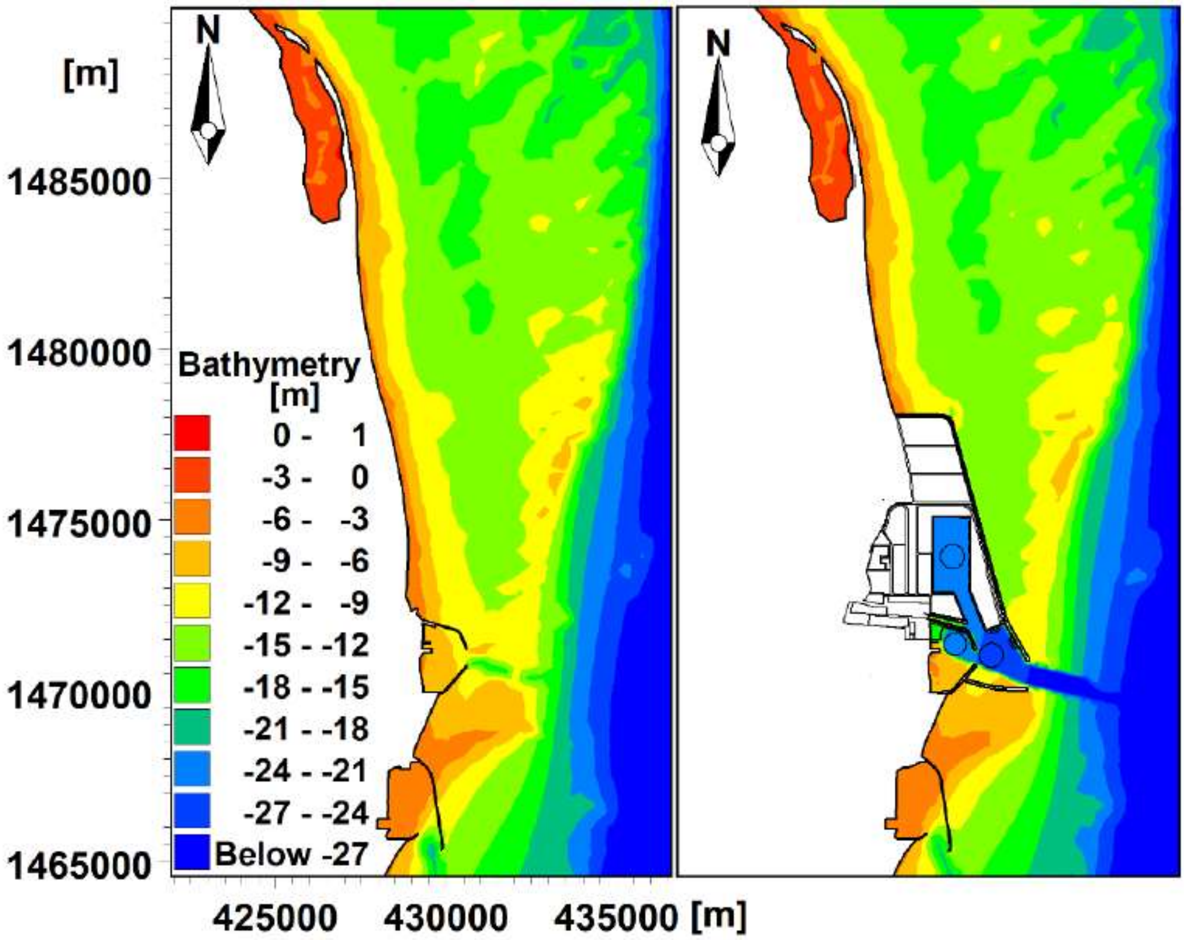


Figure 2-19: Bathymetry used for SW Modelling

Boundary Conditions

Wave boundary conditions were obtained at 30m water depth (13°17'40.57"N 80°24'18.39"E). The parameters include significant wave height, peak wave period, mean wave direction at every 6-hr interval. Time series of significant wave height, peak wave period and mean wave direction used for the model simulation is depicted in **Figure 2-20**.

The annual distribution of wave hindcast indicates that during Nov-Dec the waves are mostly from northeast (300 -900) in other months 1500 – 1800. Percentage distribution of wave directions indicates that almost 80% of waves are coming from E-SE direction and the remaining 20% are from NE-ENE. Most percentage of waves occurs in the height range 0.5 to 1.5m and in the period of 4-10 sec.

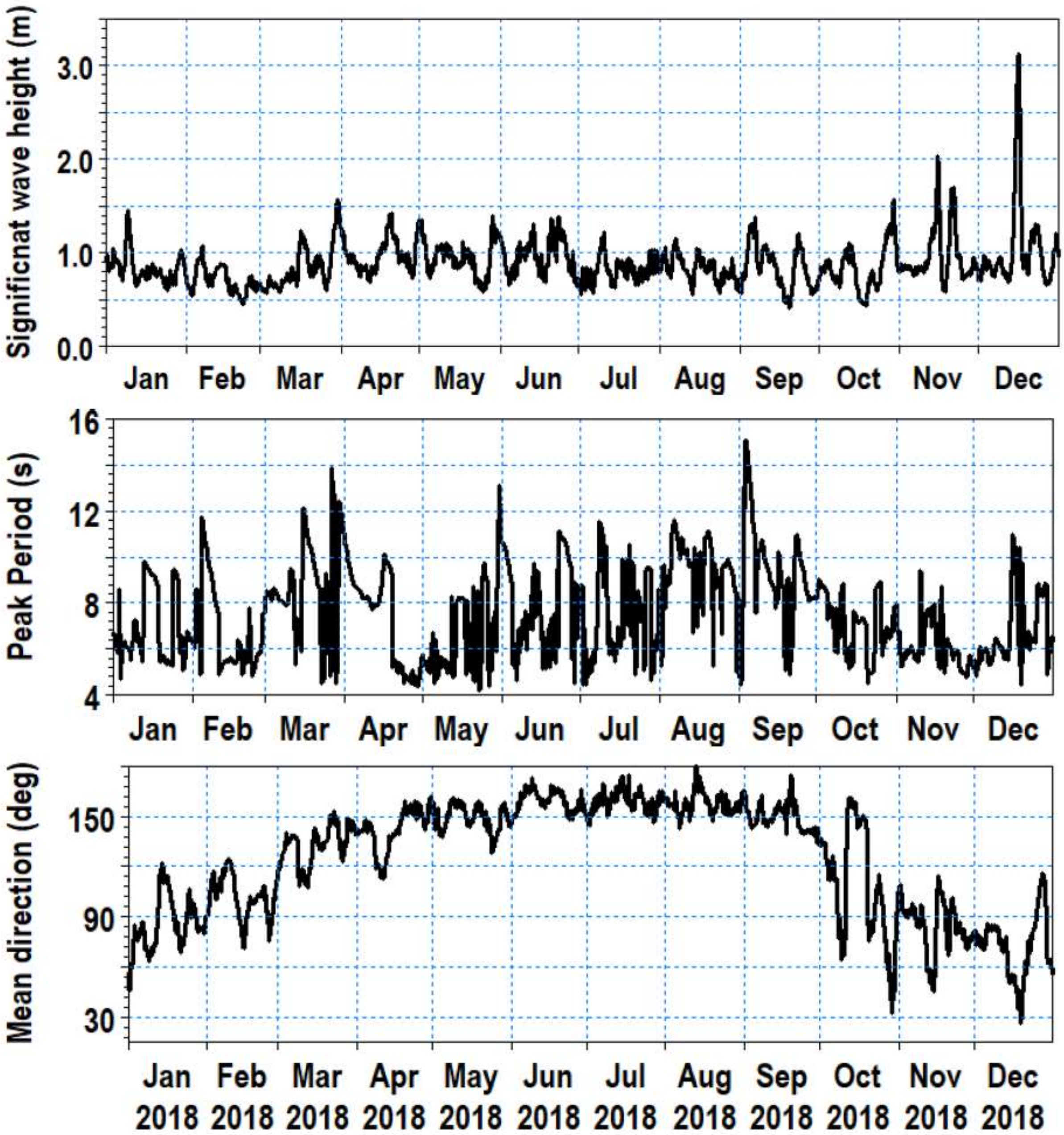


Figure 2-20: Hindcast wave climate at 30m water depth for the period Jan-Dec 2018

Model Results

Figure 2-21 and **Figure 2-22** shows the spatial variation of significant wave height (1.3m) and peak wave period (16 Sec) for baseline and layout conditions. The colour indicates the magnitude and vectors indicate the direction of wave coming from. High concentration of wave energy is noticed at south of the Kattupalli port during SW monsoon. The coast north of port experiences less energy due to presence of shoals.

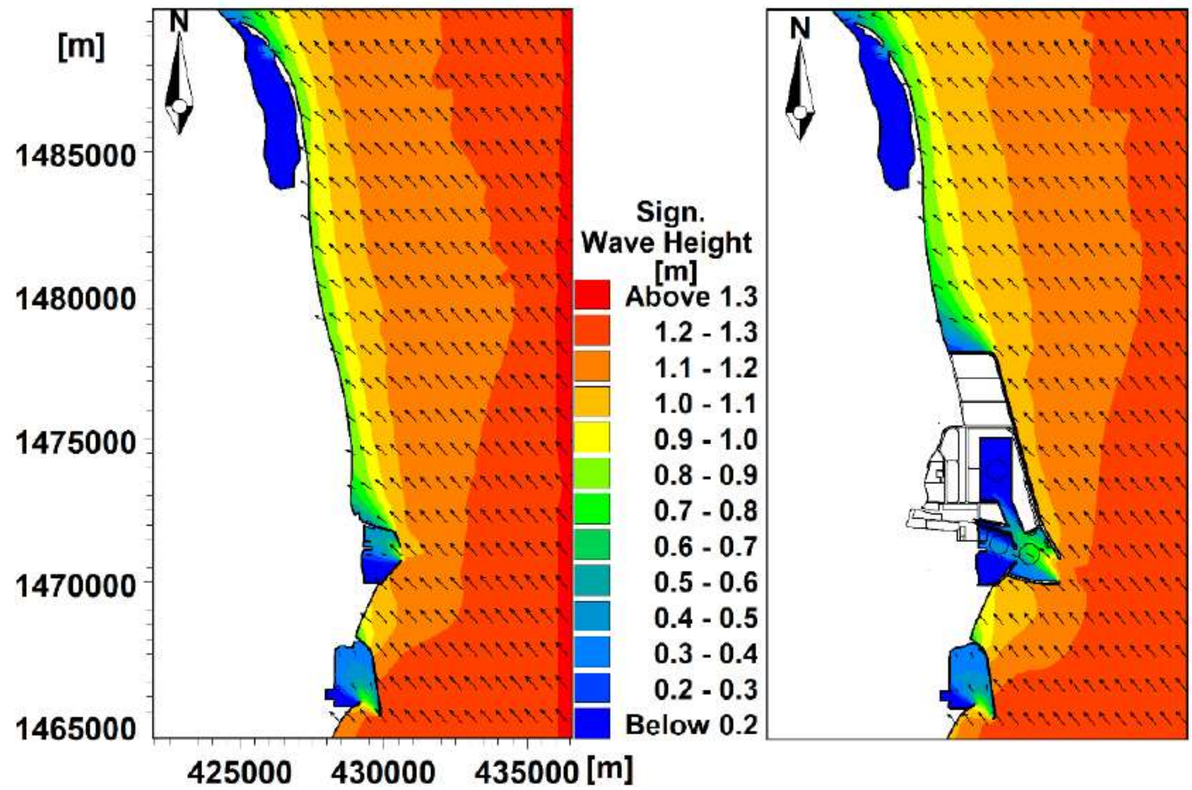


Figure 2-21: Significant wave height for pre monsoon

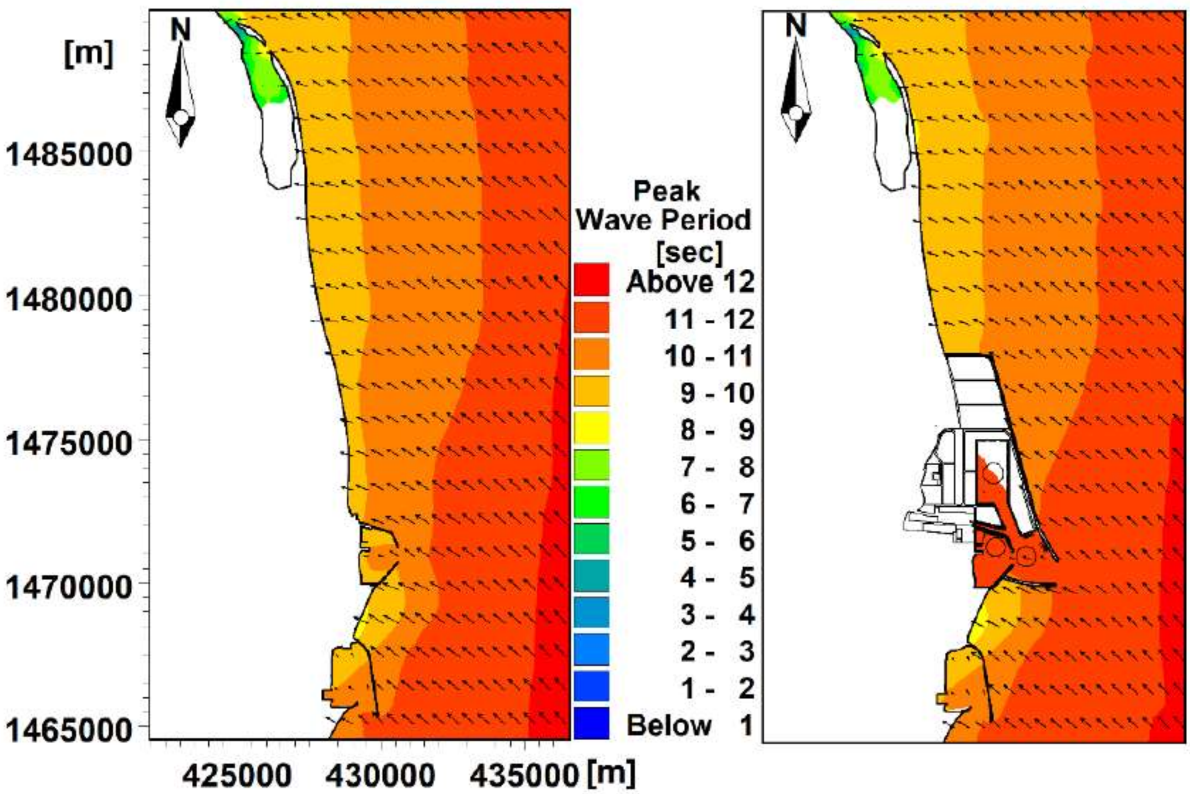


Figure 2-22: Peak wave period for pre monsoon

2.4.4 Ship Tranquillity Study

The present section assess the wave disturbance in the basin and berthing area of the proposed Kattupalli Port Master Plan using DHI's Boussinesq Wave model. BW is phase resolving, two dimensional Boussinesq-type wave models for calculation and analysis of short- and long-period wave disturbance in ports and harbours. MIKE 21 BW can also be used for modelling of surf zone dynamics and swash zone oscillations.

The present model is based on the numerical solution of the enhanced Boussinesq equations formulated by (Madsen & Sørensen, 1992).The model has been extended into the surf zone by inclusion of wave breaking and moving shoreline. This module is capable of reproducing the combined effects of most wave phenomena of interest in port, harbour and coastal engineering. These include:

- Shoaling
- Refraction
- Diffraction
- Partial reflection and transmission
- Non-linear wave-wave interaction
- Frequency spreading
- Directional spreading

Phenomena such as wave grouping, generation of bound sub-harmonics and superharmonics and near-resonant triad interactions are implicitly captured using MIKE 21 BW.

In this study the MIKE 21 BW models applies the wave spectral input from spectral wave model and carry out a highly detailed time-domain wave transformation analysis into the entire port accounting for both sea and swell wave energy.

Model Setup

The numerical parameters and model parameters used for the modelling can be seen in **Table 2-4**. The numerical scheme for the discretization of the convective terms used is 'Central differencing with side-feeding'. A time extrapolation factor of 1 is used in the entire domain to reduce the numerical instabilities that occur when wave breaking is included. One-hour simulation period was considered for the present study.

Table 2-4: Model Parameters used in the Boussinesq Wave model

Parameter	Value
Spatial Resolution – $\Delta x = \Delta y$	5m
Time step – Δt	0.25sec
Courant Number	0.80
Bottom Friction – Manning Number	32
Eddy Viscosity – Smagorinsky	Constant, Velocity based
Wave Breaking	Included
Type of roller celerity	3 - Directional
Half-time for cut-off roller	2.4sec
Slot friction coefficient	0.1

Bathymetry Data

The entire computational domain was discretized with a Cartesian grid with an extent of 8450m by 14500m. Bathymetry data for the entire domain was used from the survey data based on field observations.

A depth cut-off was used at a depth of 32m in the entire domain. This is required for the internal wave generation boundary that can only be applied correctly along a constant depth. It was also done to reduce the computational time from resolving large water depths, where the non-linear wave transformation will be minimal.

Figure 2-23 show the bathymetry considered for the BW model and the extraction locations for the wave disturbance coefficient.

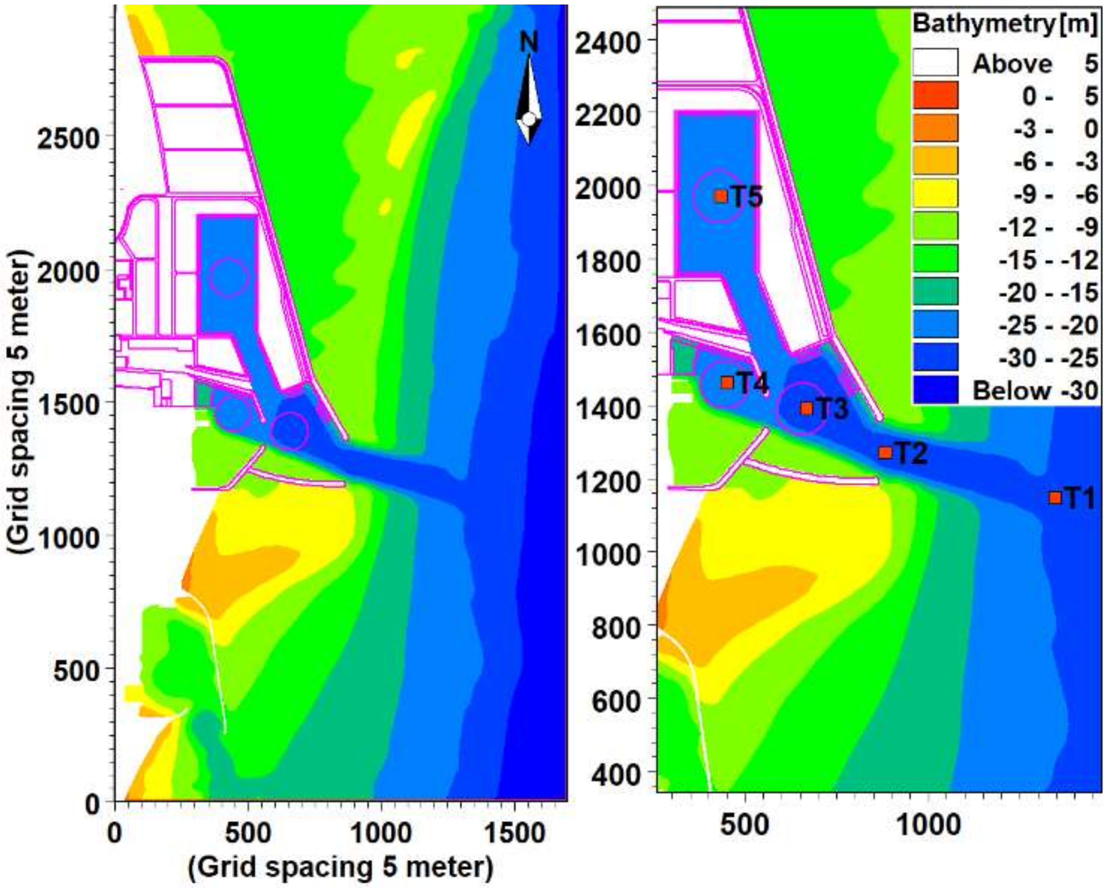


Figure 2-23: Left: Bathymetry used for Harbour Tranquillity Study Right: Zoomed bathymetry with extraction locations

2.4.4.1 Wave Reflection: Porosity and Sponge Layer Maps

All model boundaries were made wave absorbing, meaning that all wave energy reaching these model boundaries (offshore and coast) were absorbed to avoid waves being reflected back into the model domain.

Along the breakwater and revetments, partial wave reflection was applied. For the structures being important for the wave disturbance in the harbour, the reflection properties were estimated and modelled based on the actual structure type and the wave conditions. The variation in reflection is mainly due to variation in wave height/steepness. The Porosity and sponge layers considered for the wave tranquillity study was illustrated in **Figure 2-24**.

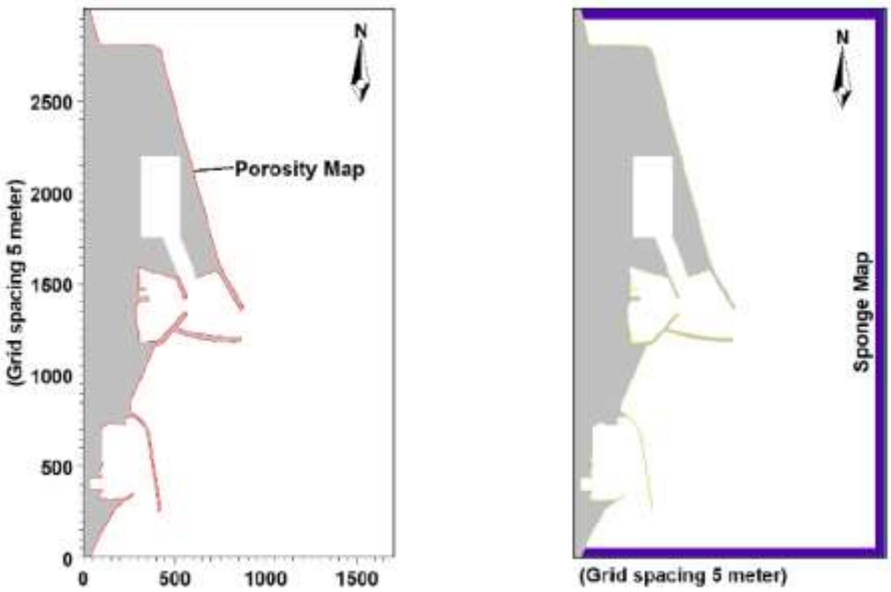


Figure 2-24: Porosity and sponge layer for the wave tranquillity study

Boundary conditions

Based on the one year (2018) hindcast wave transformation result, scatter analysis has been carried out on the modelled offshore wave conditions at -30 m CD. The scatter tables are presented in **Table 2-5** to **Table 2-6**.

Based on the analysis, the following wave periods and wave directions were included in the scope of wave disturbance simulations to cover the relevant operational wave conditions:

- Sig wave height: 1 m and 2.5 m
- Peak wave periods: 8 s and 12 s
- Mean wave directions: 45°N, 90°N, and 135°N

Directional irregular waves with a significant wave height of 1 m and 2.5 m, peak wave period and mean wave direction were applied for defining the incident wave conditions.

The waves were defined using a standard JONSWAP spectrum and directional spreading of 30° has been used in defining the wave spectrum.

Offshore Wave Condition

The wind-wave climate at offshore condition, as evident in **Figure 2-25** shows that the largest monsoon waves reaching the 30 m CD water depth range between 1.0 and 3.0 m during the northeast monsoon, when the site is exposed to the prevailing wind and wave directions. During the southwest monsoon the wave conditions are more benign, with the significant wave height dropping to below 2 m.

The wave rose for the offshore wave conditions at -30 m CD is presented in **Figure 2-26**. It can be observed that the offshore waves are almost entirely coming from the NE to SE sectors.

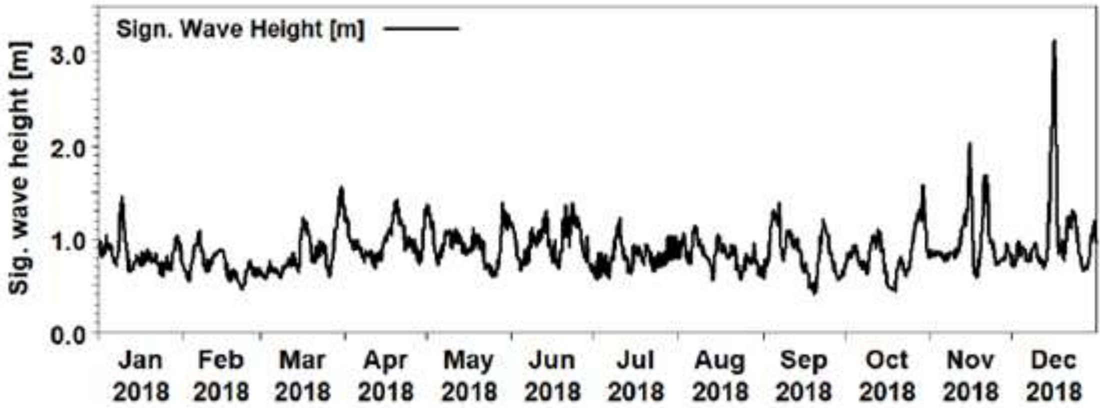


Figure 2-25: Timeseries of 1 year (2018) hindcast wave conditions at -30 m CD

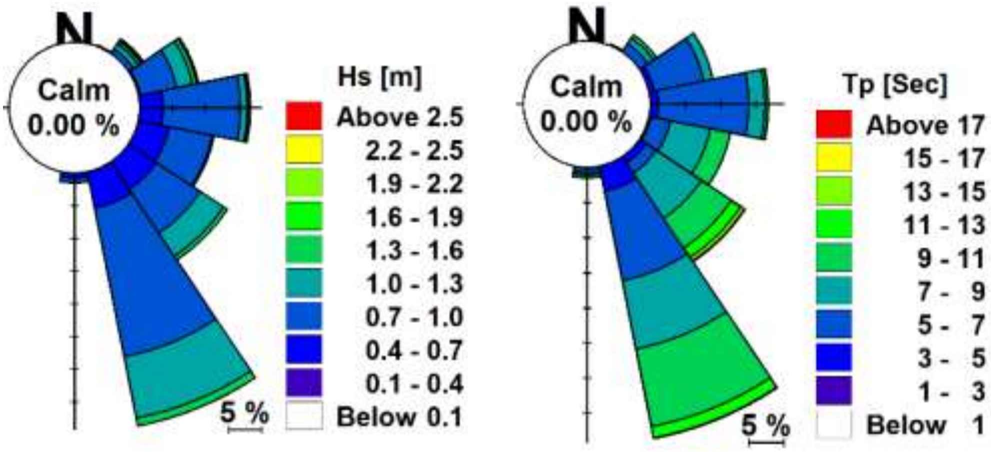


Figure 2-26: One-year (2018) wave rose for offshore wave conditions at -30 m CD

Table 2-5: Scatter table of significant wave height and mean wave direction at -30 m CD

Hs (m)	MWD [° N]								Total [%]
	22.5	45	67.5	90	112.5	135	157.5	180	
0.1	-	-	-	-	-	-	-	-	0
0.4	-	-	-	-	-	-	-	-	0
0.7	-	-	1.44	5.27	3.36	6.78	2.88	0.07	19.79
1	**0.55**	**0.96**	**13.15**	**6.58**	**5.89**	**19.04**	**11.03**	-	**57.19**
1.3	0.14	2.19	1.85	0.34	0.82	9.73	3.49	-	18.56
1.6	0.21	0.62	0.41	0.14	-	1.37	0.55	-	3.29
1.9	-	0.21	0.07	0.14	-	-	-	-	0.41
2.2	-	0.14	0.14	-	-	-	-	-	0.27
2.5	-	**0.14**	-	-	-	-	-	-	0.14
2.8	-	0.14	-	-	-	-	-	-	0.14
3	-	0.21	-	-	-	-	-	-	0.21
Total [%]	**0.9**	**4.61**	**15.62**	**7.2**	**6.71**	**30.14**	**15.07**	-	100

Table 2-6: Scatter table of significant wave height and peak wave period at -30 m CD

Hs (m)	Peak wave period [Sec]							Total [%]
	0-3	3-6	6-9	9-12	12-15	15-18	18-21	
0.1	-	-	-	-	-	-	-	-
0.4	-	-	-	-	-	-	-	-
0.7	-	5.1	12.3	2.3	0.1	-	-	19.8
1	-	**19.8**	**23.8**	**12.8**	**0.7**	**0.1**	-	57.2
1.3	-	4.9	6.0	6.8	0.8	0.1	-	18.6
1.6	-	0.9	1.4	0.7	0.3	-	-	3.3
1.9	-	-	0.3	0.1	-		-	0.4
2.2	-	-	0.3	-	-	-	-	0.3
2.5	-	-	0.1	-	-	-	-	0.1
2.8	-	-	0.1	-	-	-	-	0.1
3	-	-	-	0.2	0.0	-	-	0.2
Total	-	**30.8**	**44.3**	**23.0**	**1.9**	**0.1**	-	100

Table 2-7 shows the run matrix of BW model for the present study. These data arrived based on scatter data analysis. Model with 1m wave height considered as case-1 and 2.5 is case-2 respectively.

Table 2-7: BW simulation matrix

Run ID	Case	Peak Wave Period (sec)	Wave Direction (degrees from, North)	Significant Wave Height (m)
BW01	Case-1	8	45	1
BW02		8	90	1
BW03		8	135	1
BW04		12	45	1
BW05		12	90	1
BW06		12	135	1
BW07	Case-2	8	45	2.5
BW08		8	90	2.5
BW09		8	135	2.5
BW10		12	45	2.5
BW11		12	90	2.5
BW12		12	135	2.5

Results

The solutions to the flux-based equations in the BW model give various types of output results such as wave disturbance and deterministic parameters corresponding to three predominant directions.

Wave Disturbance Coefficients

The key output from the wave penetration modelling is the significant wave height in the model basin with the given Master plan layout. As the incident wave height at the offshore model boundary was 1 m, the values can also be regarded as the wave disturbance coefficients, defined as the wave height relative to incident wave height (i.e. model boundary wave height).

The model results with the Master plan is presented in the following section as wave disturbance coefficient, which is defined as the ratio of wave height at a given location to the incident wave height or the wave height at the model boundary. For instance, a predicted wave disturbance coefficient of 0.5 would indicate a reduction of the incident wave height by 50%.

Wave disturbance coefficient at five (05) extraction locations with all modelled wave conditions are provided in **Table 2-8** and **Table 2-9**. Similarly Contour plots of the wave disturbance coefficients for all modelled wave conditions are depicted in **Figure 2-27** to **Figure 2-30**.

Generally, it is observed that the wave disturbance coefficients near the breakwater and at the berths are less than 30% of the incident significant wave heights of offshore waves coming from all direction.

Table 2-8: Wave disturbance coefficients for operational condition (Case-1) at study area

No	Easting	Northing	Wave Disturbance Coefficients					
			BW01	BW02	BW03	BW04	BW05	BW06
T1	434537	1469818	0.69	0.83	0.61	0.88	1.00	0.91
T2	432214	1470434	0.55	0.67	0.42	0.64	0.70	0.47
T3	431140	1471032	0.20	0.31	0.30	0.44	0.31	0.33
T4	430049	1471384	0.10	0.17	0.14	0.18	0.17	0.15
T5	429961	1473936	0.12	0.13	0.20	0.25	0.20	0.22

Table 2-9: Wave disturbance coefficients for extreme condition (Case-2) at study area

No	Easting	Northing	Wave Disturbance Coefficients					
			BW07	BW08	BW09	BW10	BW11	BW12
1	434537	1469818	0.69	0.80	0.60	0.87	1.00	0.89
2	432214	1470434	0.50	0.63	0.40	0.65	0.67	0.44
3	431140	1471032	0.17	0.29	0.28	0.40	0.29	0.29
4	430049	1471384	0.07	0.14	0.11	0.15	0.14	0.12
5	429961	1473936	0.03	0.03	0.04	0.05	0.05	0.04

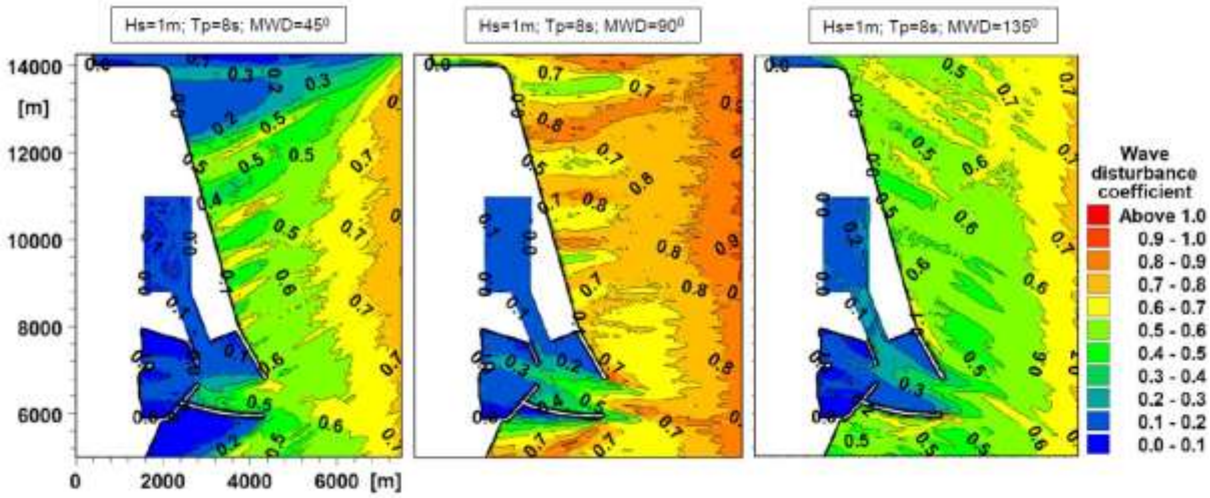


Figure 2-27: Contour plot of wave disturbance coefficient for operational condition (Case-1)

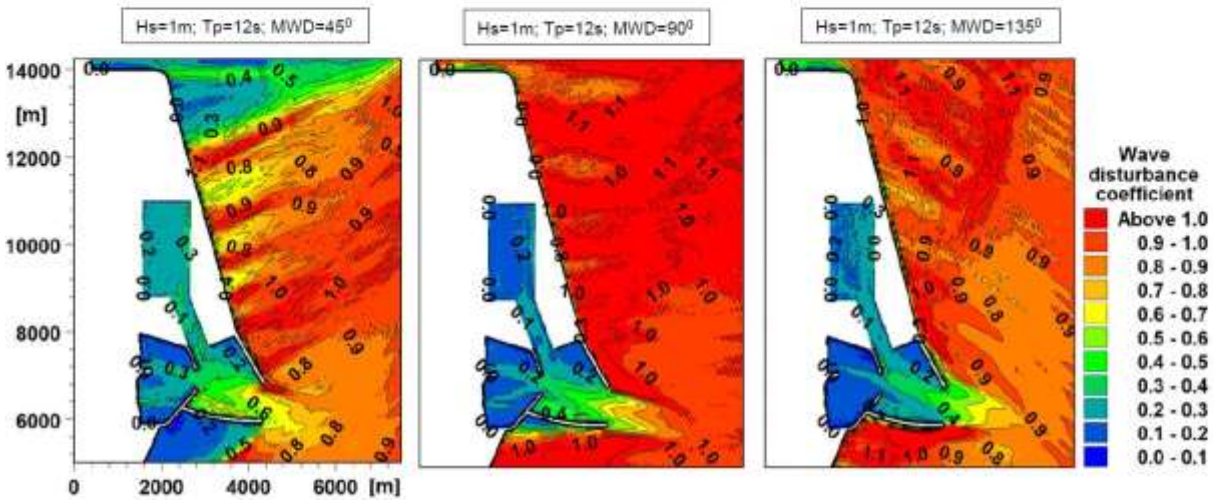


Figure 2-28: Contour plot of wave disturbance coefficient for operational condition (Ccase-1)

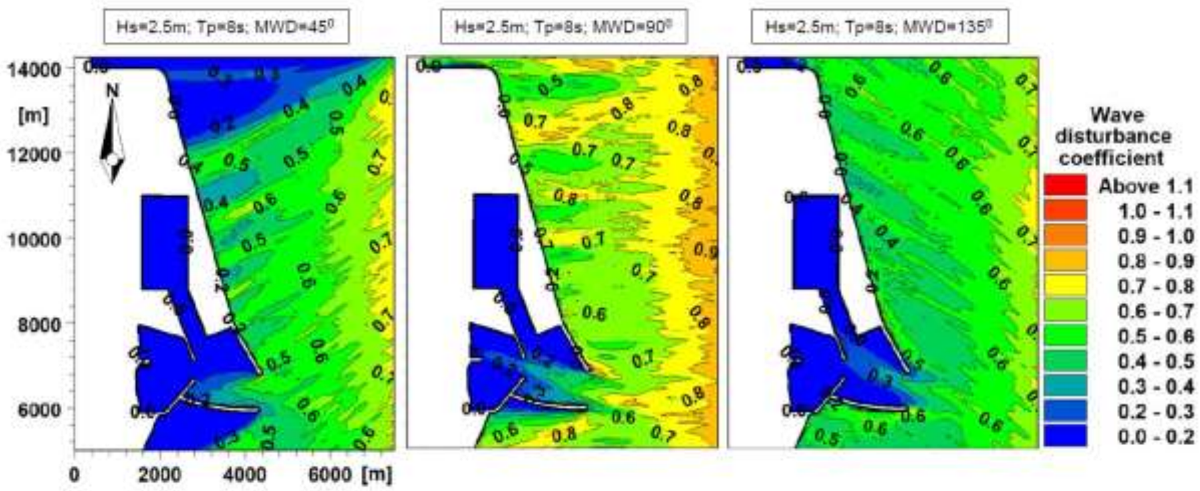


Figure 2-29: Contour plot of wave disturbance coefficient for operational condition (Case-2)

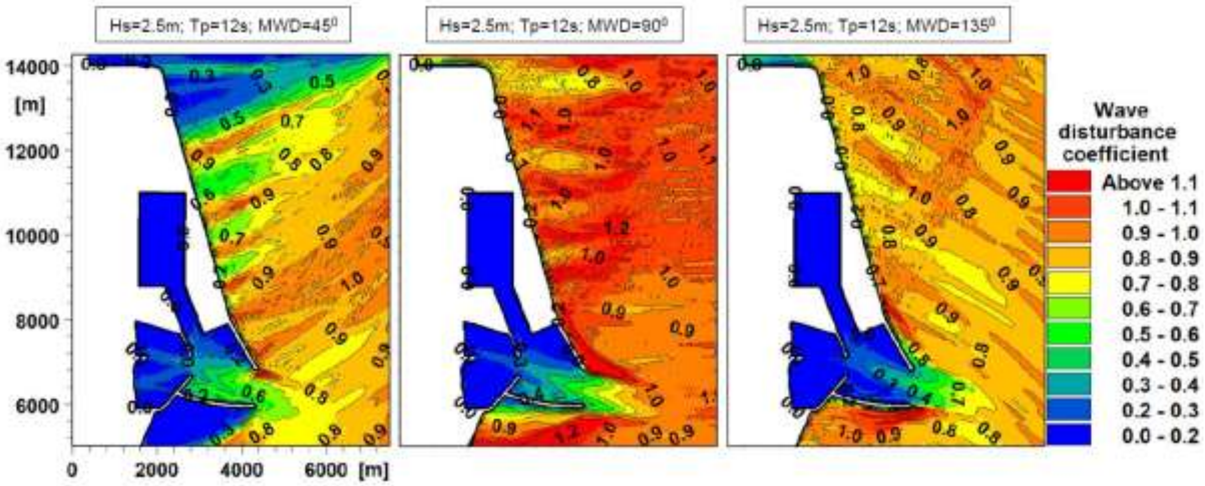


Figure 2-30: Contour plot of wave disturbance coefficient for operational condition (Case-2)

Water level

An example of a three-dimensional (3D) perspective view of the surface elevation is shown in **Figure 2-31** to **Figure 2-32**. The wave crest pattern shows its direction of approach and the diffraction processes behind breakwaters at a different angle than the original wave train.

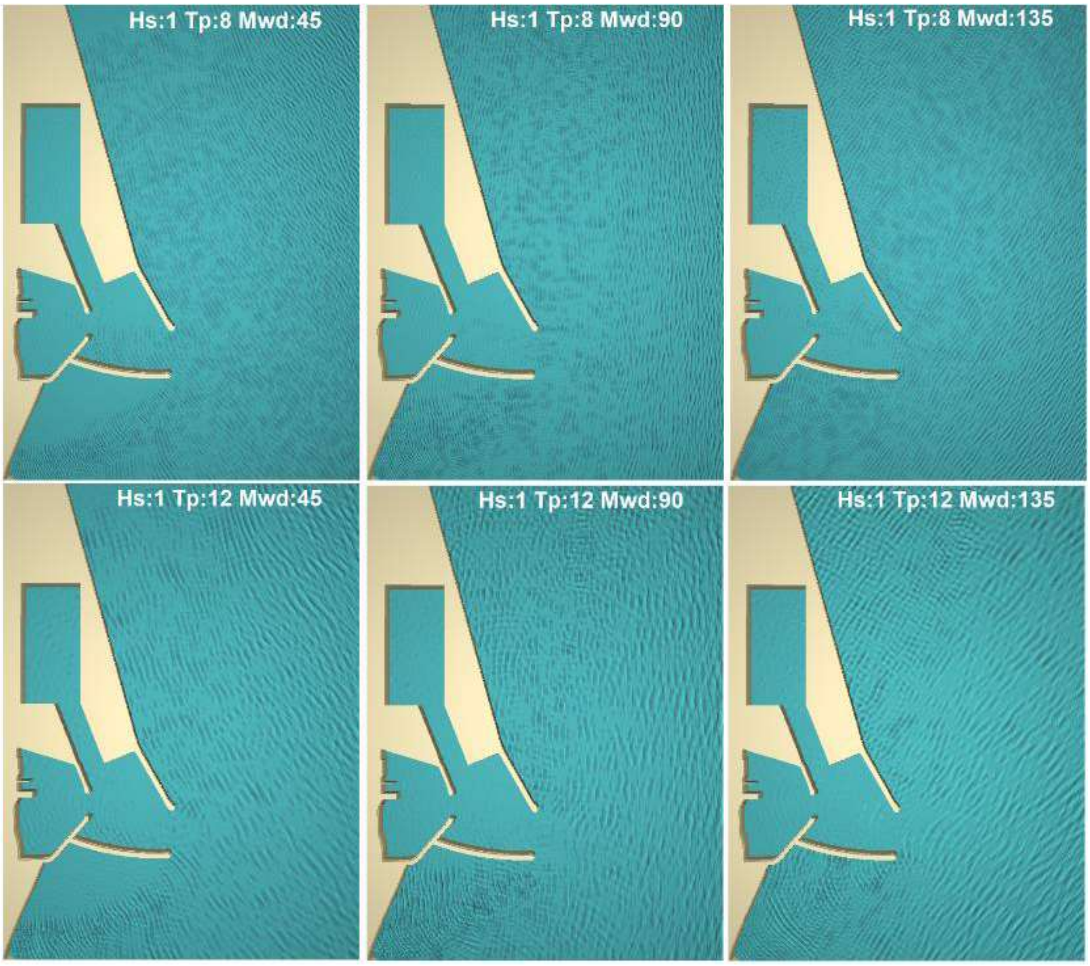


Figure 2-31: 3D perspective view of instantaneous surface elevation for different peak wave period and mean wave directions (Case-1)

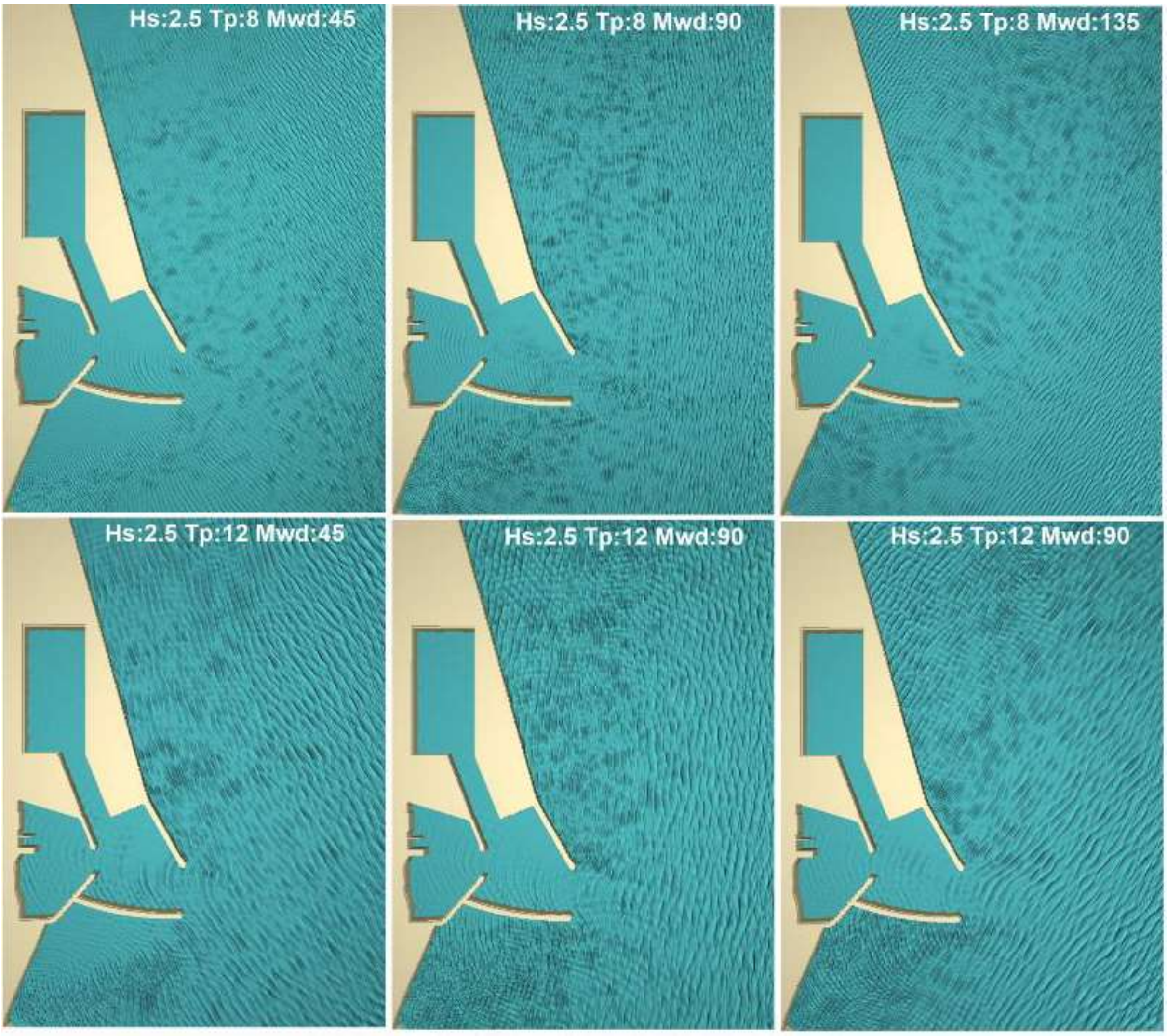


Figure 2-32: 3D perspective view of instantaneous surface elevation for different peak wave period and mean wave directions (Case-2)

Conclusions

The key output from the wave tranquility modelling is the significant wave height in the basin area. As the incident wave height at the offshore boundary was 1m, the values can also be regarded as the wave disturbance coefficients, defined as the wave height relative to incident wave height.

The model output is presented as wave disturbance coefficient, which is defined as the ration of wave height at given location to the incident wave height (or the wave height at the model boundary). For instance, a predicted wave disturbance of 0.5 would indicate a reduction of the incident wave height by 50%. Contour plots of the wave disturbance coefficients for all modelled wave conditions are presented.

The simulated results of the model has provided keen insight into the performance of the harbour layout in the wave agitation point of view. Although the tranquillity of a harbour cannot be completely characterized by means of wave height alone, this is an essence of harbour planning. From the results it could be seen that the tranquillity inside the harbour is very good.

Across all modelled scenarios the breakwater provides a large reduction of wave height for the modelled combination of wave periods and direction. Maximum wave disturbance coefficient from case-1 and case-2 are provided below.

No	Easting	Northing	Wave Disturbance Coefficients	
			Case-1	Case-2
1	434537	1469818	1.00	1.00
2	432214	1470434	0.70	0.67
3	431140	1471032	0.44	0.40
4	430049	1471384	0.18	0.15
5	429961	1473936	0.25	0.05

2.4.5 Cyclonic Modelling

2.4.5.1 Tropical Cyclone Tracks

The number of cyclones that have occurred within the vicinity of 100 km of the proposed project location for the period of 1970 to 2018 from (Cyclone eAtlas) India Meteorological Department (IMD, India) are shown in **Figure 2-33**.

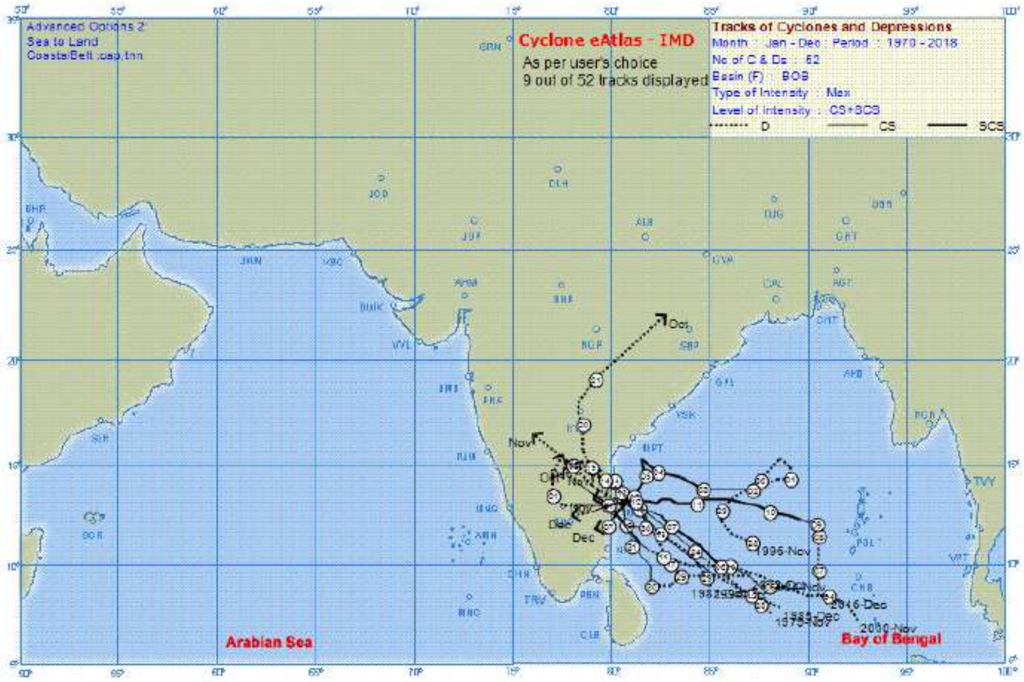


Figure 2-33: Tracks of the cyclones in the vicinity 100 to the study area from 1970 to 2018

For model simulations, nine (09) cyclonic events were selected for simulation. The year of cyclone crossing and maximum wind speed of selected cyclones are given in **Figure 2-34**. From the IMD storm track data, cyclonic stages, maximum wind speed of the system, pressure drop, radius to maximum wind are retrieved and estimated.

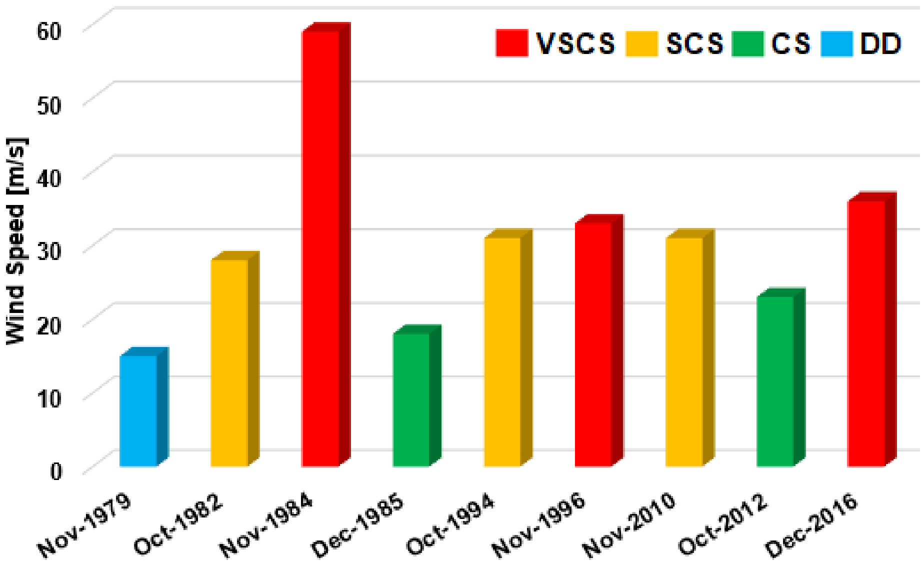


Figure 2-34: Storms crossed within 100 km radius of Kattupalli Port during the period (1970–2018)

2.4.6 Storm Surge Modelling

2.4.6.1 Wind and Pressure fields

The snapshot of wind field and pressure field of 2016 Vardah cyclone generated using MIKE 21 Cyclone wind field generation tool are represented in **Figure 2-35**. The maximum wind speed is 71m/s.

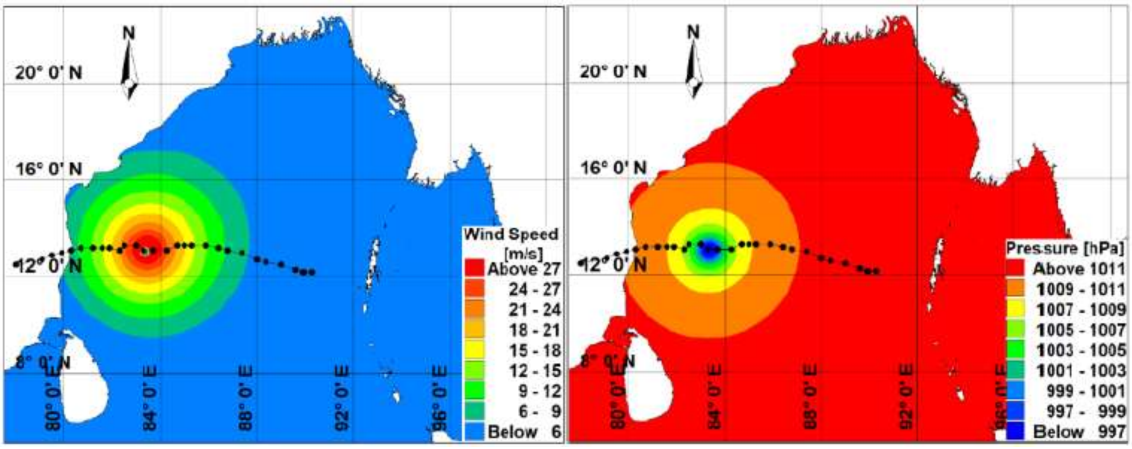


Figure 2-35: Wind and Pressure field map for 2016 Vardah Cyclone

Model results

The snapshot of results obtained from MIKE 21 HD storm surge simulation for 2016 vardah cyclone are presented in **Figure 2-36**. The same is presented in **Figure 2-37** and **Figure 2-38** for Vardah cyclone. The storm surge and current speed for the 09 cyclones at the study area extracted and presented in **Table 2-10**.

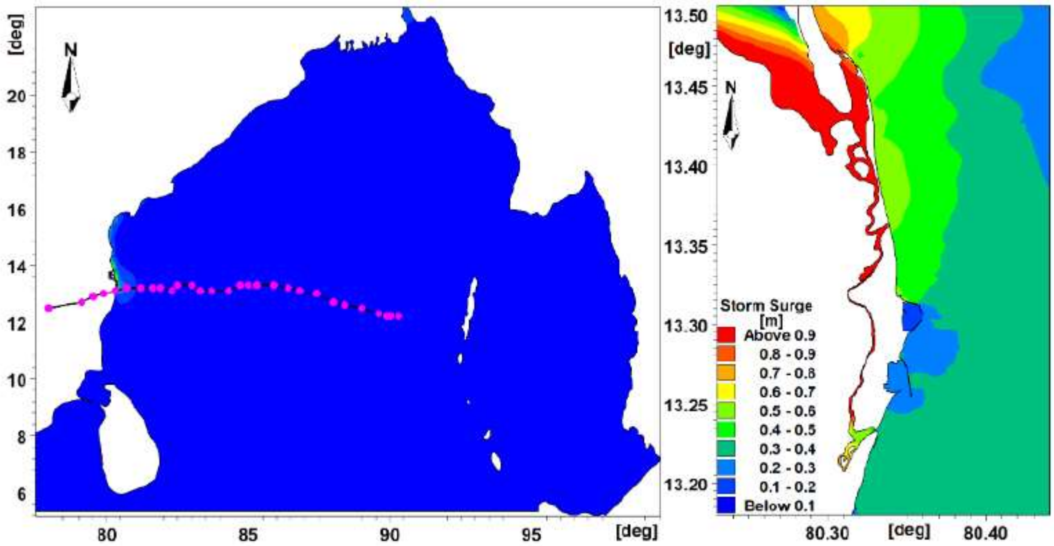


Figure 2-36: Snapshot of simulated storm surge during 2016 Vardah cyclone

At Kattupalli Port location, the December 2016 Vardah cyclone has caused a maximum surge height of 0.78m and a maximum current speed of 2.74 m/s.

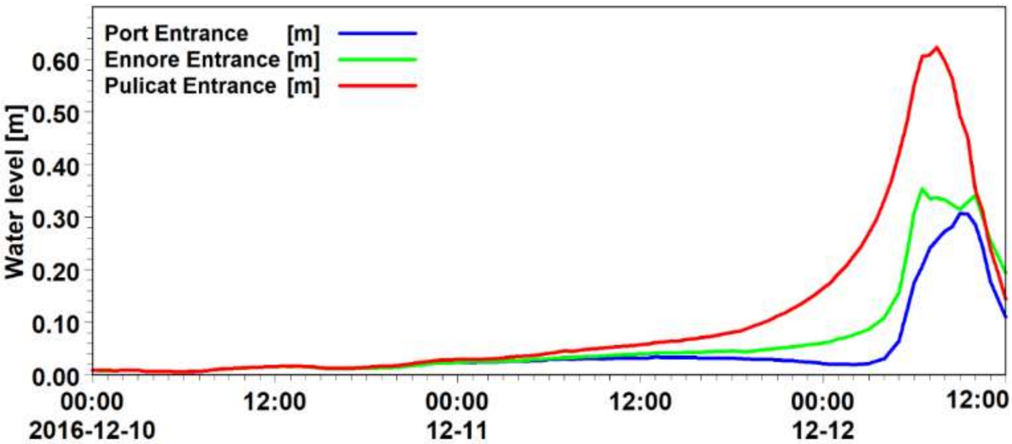


Figure 2-37: Time series of simulated storm surge at study area during 2016 Vardah cyclone

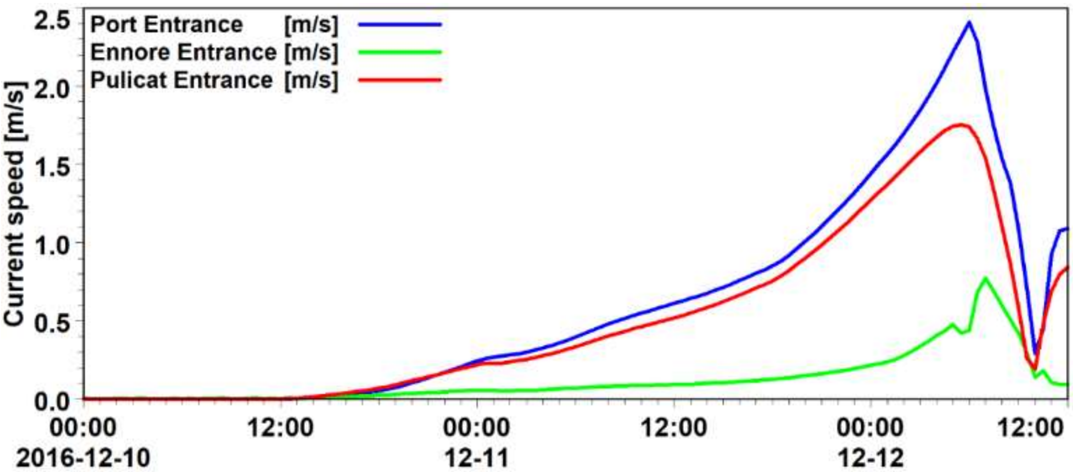


Figure 2-38: Time series of simulated current speed at study area during 2016 Vardah cyclone

Table 2-10: Maximum storm surge at project location due to nine cyclones

S. No	Month & year	V max m/s	Nature of the cyclone	At the study area	
				Storm Surge [m]	Current Speed[m/s]
1	November-1979	15	DD	0.03	0.35
2	October-1982	28	SCS	0.18	1.35
3	November-1984	59	VSCS	0.73	2.63
4	December-1985	18	CS	0.13	1.07
5	October-1994	31	SCS	0.47	1.38
6	November-1996	33	VSCS	0.39	1.83
7	November-2010	31	SCS	0.18	0.89
8	October-2012	23	CS	0.15	0.62
9	December-2016	36	VSCS	0.78	2.74

Storm Wave Model Results

The snapshot of results obtained from MIKE 21 SW Storm Wave simulations for 2016 Vardah cyclone was presented in **Figure 2-39**. The time series of storm wave at the entrance of the existing port is presented in **Figure 2-40** for Vardah cyclone. The storm wave at existing port entrance from the selected cyclones are presented in **Table 2-11**.The maximum wave height estimated at Kattupalli port due to 2016 Vardah cyclone is 5.15m. At Kattupalli Port location, the December 2016 Vardah cyclone has caused a maximum surge height of 0.78m and a maximum current speed of 2.74 m/s.

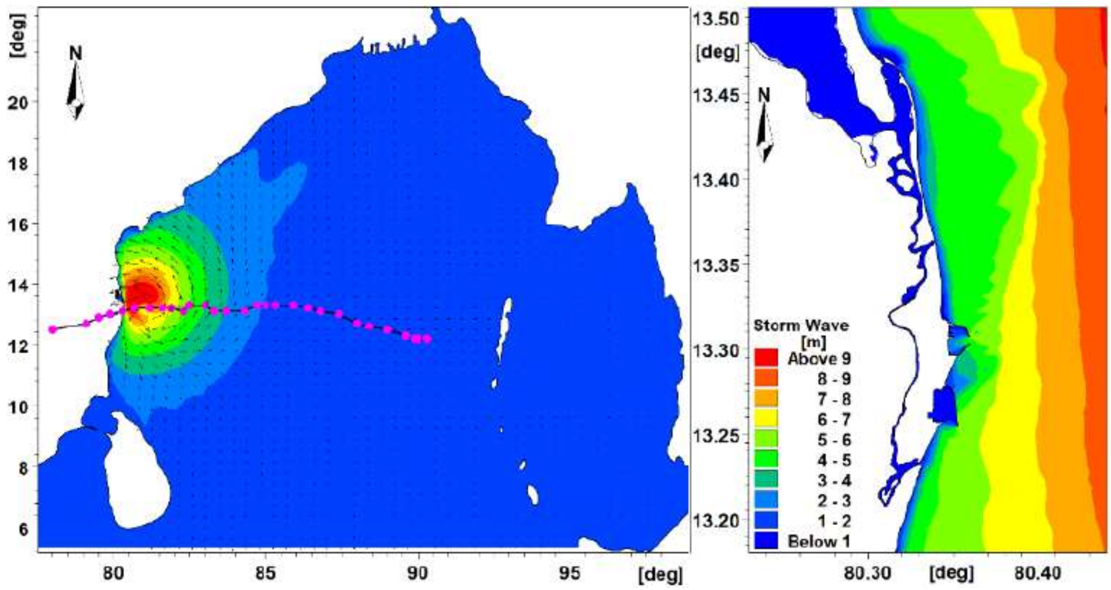


Figure 2-39: Snapshot of simulated storm wave during 2016 Vardah cyclone

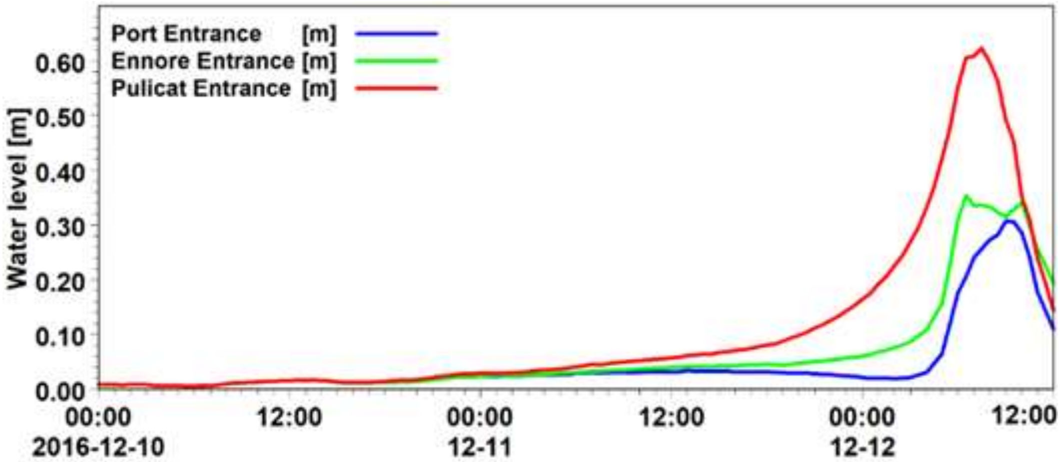


Figure 2-40: Time series of simulated storm surge at study area during 2016 Vardah cyclone

Table 2-11: Maximum storm wave at existing port entrance due to nice cyclones

S. No	Month & year	V max m/s	Nature of the cyclone	Storm wave at port entrance [m]
1	November-1979	15	DD	0.72
2	October-1982	28	SCS	2.25
3	November-1984	59	VSCS	4.40
4	December-1985	18	CS	1.74
5	October-1994	31	SCS	3.76
6	November-1996	33	VSCS	2.84
7	November-2010	31	SCS	2.52
8	October-2012	23	CS	2.48
9	December-2016	36	VSCS	5.15

2.4.7 Dredge Spoil Disposal study

The dispersion of dredge soil at the existing and proposed spoil ground was simulated for 60 days during the pre-monsoon period. A constant sediment disposal/spill rate of 1347m3/hour was specified (assuming that the 1.2 Million Cu. m of the annual maintenance dredged soil is to be disposed within this time window). The maximum bed level change incurred due to dumping is around 0.18m at both the dumping grounds after 60 days simulation period.

2.5 Planning Concepts

Based on the future cargo projections and business requirement of the hinterland, MIDPL proposed RMP for the Kattupalli port expansion. Marine structures of the port will be developed with the flexibility to handle various cargos. RMP will be developed with those flexibilities to accommodate berths as multi-purpose based on commercial and business requirement. The RMP will consist of number of berths, berths locations, material handling area, cargo handling facilities, cargo storage area, operational and utility area, navigation parameters, internal connectivity, drainage, greenbelt and various utilities, amenities, Desalination Plant, facilities for LNG & LPG and bunkering facilities, operational parameters, etc.

The basic navigational needs for servicing the vessels are as given below.

- Sufficient water depths and widths in approach channel

- Basin and jetty for the cargo handling operation
- Tranquillity conditions
- Adequate stopping distance for vessels of largest size
- Sufficient water area for easy Manoeuvrability of vessels throughout the year
- Efficient fenders and mooring systems, etc.

2.5.1 Revised Master Plan (RMP) Development

The proposed RMP shall be with flexibilities to accommodate all berths (existing as well as proposed) as Multipurpose. The salient features of proposed Kattupalli port expansion have been tabulated in **Table 1-7**.

Details of evacuation of cargo are discussed in **Section 1.6.1**. To cater immediate cargo evacuation requirement, connecting to southern rail link is being taken up and separate CRZ clearances for the same has been obtained.

Due to proposed RMP development, relocation of intake and outfall facilities/ structures of Chennai Water Desalination Plant (CWDP) will be explored in consultation with CMWSSB.

Total cargo handling capacity will be approximately 320 MMTPA. Average dredge depth at berths will be (-) 20.5 m CD to (-) 25 m CD. The layout map showing RMP is presented as **FD0202**.

2.5.2 Protection Against Waves

Necessary protection in the form of breakwaters against predominant wave directions needs to be provided. Alignment and the length of breakwaters will be governed by following factors;

- Predominant wave and current direction Water area requirement
- Number of berths requiring protection
- Limiting wave heights of vessels for unloading operations

Kattupalli port is an established all weather port, it has a fully protected basin with two breakwaters protecting the harbour basin. As the existing breakwaters were constructed by considering all the above factors and necessary tranquillity is being ensured for the present operation and same will be extended for proposed berths and cargo handling within existing basin.

For the proposed berths which are not within existing harbour basin, new breakwaters will be constructed considering all the above parameters and the necessary tranquillity will be ensured for the future operation.

Apart from existing breakwater, two new breakwater of about total 12.10 km length has been proposed, out of which new northern breakwaters will be about 9.02 km and & 1.22 km and new southern breakwater will be about 1.86 km. However suitable options will be worked out while carrying the detailed engineering for appropriate execution of breakwater to minimize its impact in the surrounding environment.

Different types of breakwaters are being explored and during detailed engineering appropriate breakwater type will be chosen. Different types of breakwaters (not limited to) under consideration for analysis are slope type rubble mound breakwater, Vertical type breakwater, etc. Breakwaters will be developed either through rocks/slag or any other suitable materials which will also be explored for using in combination while carrying out detailed engineering.

2.5.3 Topographic Features

The general topography of the area is plain with few undulations. The existing Kattupalli port back-up area was reclaimed to a height of (+) 4.5 - (+) 5.0 m CD which serves as the cargo storage yards. Area proposed for expansion is flat, sea (to be reclaimed) area and low-level area towards west of existing port which is varying between (+) 0.1 m to (+) 5.0 m CD will also be raised to (+) 5.0 m CD.

The drainage facilities will suitably be provided for draining rain water from the port back- up area.

2.5.4 Existing Land Use Pattern of Kattupalli Port area

Land area of about 486 Ha has been allotted by TIDCO for the development of Kattupalli shipyard cum port area. The same was used for the development of Kattupalli Shipyard Cum Port. Land area allocated for the port is about 136.28 Ha and on the same land present port was developed.

2.5.5 Proposed Land Use

Total 2472.85 Ha of area will be required for the proposed RMP for material handling area, cargo storage / backup area, operational and utility area, internal connectivity, drainage, greenbelt, buildings etc. Further due to strategic location of the port and resultant logistics advantages, substantial traffic may be attracted to the terminal. Present land use is sea, intertidal area, sandy area/beach, abandon salt pans, and land with/without scrub and sparse vegetation (*Prosopis juliflora* /Casuarina/Eucalyptus).

Revised Master Plan development of Kattupalli Port will be carried out in total area of 2472.85 ha which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 hectares including basin and all developable area.

However, to calculate the area of the storage yard and transit go-downs following factors plays vital role.

- Dwell time
- Storage factor
- Density of the cargo materials or stowage factor
- Aisle space
- Peaking Factor
- Methods of cargo handling
- Utilization factor of storage area
- Higher of 1.5 times parcel size and 5% of cargo throughput

Apart from port backup area, external road, rail and utility corridor are proposed in an area of around 30 ha to provide connectivity.

The proposed development will consist of material handling area, cargo storage/backup area, operational and utility area, desalination plant, internal connectivity, drainage, greenbelt and buildings etc. The proposed land use of Kattupalli port is given in **Table 2-12**.

Table 2-12: Land use Breakup

S. No.	Description	Area (in Ha.)	Area (in Acres)
1	Multipurpose Cargo Backup Area, liquid and Gas, Port backup Industries, Industrial Development Area	1602.35	3959
2	Gate Complex & Parking	105.00	259
3	Greenbelt and other Areas	97.50	241
4	Internal Rail and Road Approaches and Corridors	460.83	1139
5	Utility	151.60	375
6	Buildings + Workshops	34.80	86
7	Mangrove area including Buffer	20.77	51
	Total	**2472.85**	**6111**

2.5.6 Cargo Handling

2.5.6.1 Capacity

The following are the Cargos handling capacity and cargo type mentioned while obtaining ToR is given in **Table 2-13**.

Table 2-13: Cargo Handling Capacity as mentioned in ToR

Facility/ Component		Revised Master Plan
Capacity **(Cumulative)**		320 MMTPA
Cargo Handling Capacity	Bulk Cargo	85 MMTPA
	LNG/ LPG/PoL/Crude Oil	65 MMTPA
	Container	95 MMTPA
	Multipurpose	60 MMTPA
	Barge	12 MMTPA
	Transloading	3 MMTPA

2.5.6.2 Cargo Handling Rates

The proposed cargo handling rates at the port are given in **Table 2-14**.

Table 2-14: Proposed Cargo Handling Rates at the Port

S. No.	Cargo Type	Handling Rate/berth
1	Coal Import (Bulk Cargo)	40,000 – 95,250 TPD
2	Coal Export (Bulk Cargo)	20,000 – 98,250 TPD
3	Iron Ore Export (Bulk Cargo)	20,000-68,250 TPD
4	General & break bulk Cargo	15,00 TPD – 22,000 TPD
5	Fertilizer and FRM (Bulk/break bulk Cargo)	15,000 TPD – 22,000 TPD
6	Liquid	7,000 TPD – 1,20,000 TPD
7	LNG (Cryogenics)	94,000 TPD
8	LPG (Cryogenics)	13,650 TPD

2.5.6.3 Cargo Storage and Handling

2.5.6.3.1 Coal/Iron Ore-Import

Coal/Iron Ore will be stacked in the stockyard areas initially before evacuation by rail/road. Number of separate stockpiles need to be provided to cater for different grades of coal. However, following parameters shown in **Table 2-15**.

Table 2-15: Cargo Specification for Import/Export of Bulk Cargo

S. No.	Parameters	Coal	Iron-Ore
1	Density	800 kg / cu.m	2400 kg / cu.m
2	Maximum Lump size	100 (up to 150) mm	50 (up to 150) mm
3	Avg. base width of stack	40 – 50 m	40 – 50 m
4	Angle of repose	37 deg	35 deg
5	Extra space for circulation	25% approx.	25% approx.

2.5.6.3.1.1 Unloading Mechanism

Coal/Iron Ore will be unloaded with unloader which moves on the rail which will be installed on the berth. Mechanical grab of unloader crane will pick up the cargo from the ship hold and unload the material in to the hopper. Hopper will load the conveyor with control/ discharge gate/ belt feeder which will retrieve coal from hopper & discharge on the Jetty conveyor for onward transportation to coal storage yard through series of conveyors.

2.5.6.3.1.2 Stock Yard

Cargo will be stacked in coal yard by mechanized/semi-mechanized handling system. Coal/Iron Ore cargo received by belt conveyor system from the jetty will be stacked in the yard through yard conveyors along stockyard using stacker cum reclaimer. Each yard conveyor will be equipped with one stacker cum reclaimer machine.

2.5.6.3.1.3 Evacuation of Coal/Iron Ore Cargo

Coal/Iron Ore will be reclaimed from stockyard through stacker cum reclaimer and conveyed towards reclaiming conveyors which will discharge material in wagon loading silo. An in-motion wagon loading arrangement with conveyor connectivity has been planned. The rake consists of 59 wagons (maximum) of 68 MT capacities each subject to wagon carrying capacity & density of coal.

2.5.6.4 Coal/Iron Ore-Export

Coal and Iron Ore has been considered as export cargo for coastal movement. Hence, Coal/Iron Ore being stacked in mechanized/semi-mechanized way by import stream will be reclaimed in mechanized/semi-mechanized way for export through belt conveyor system from stockyard up to jetty and through ship loaders to vessels. Specifications are given in **Table 2-15.**

2.5.6.5 Design Specification for steel Yard

The storage yard paving shall be suitable for the following vehicles;

- Tractor/Trailer trucks suitable for maximum loads of 56 MT
- Heavy duty Fork – Lift trucks

Asphaltic and Block Pavements shall be designed in accordance with the recommendation as per standard code of practice.

Block Pavement Material

Block pavement shall generally consist of rectangular or shaped pavers of the interlocking types, 100 mm thick and laid in a herringbone pattern. A 20 mm thick sand bedding layer shall be laid below the concrete blocks.

Asphaltic Pavement material

Asphaltic pavement shall generally consist of 130 mm thick asphaltic base course laid in one layer and a 50 mm thick layer of surfacing wearing course

2.5.6.6 Multipurpose Material Import/Export

The storage area is designed to handle all type of multi-purpose cargo such as fertilizer, FRM, steel other bulk cargo, project cargo etc. The choice of yard system is determined by the volume of material to be handled and its stacking heights, and the space available for storage.

2.5.6.6.1 Specifications of Yard

Yard drainage system design shall be based upon the runoff quantity, the intensity of rainfall and area of drainage. There shall not be any backflow during high tide-monsoon conditions. 30~40m high lighting mast will be adopted for yard lighting.

2.5.6.6.2 Operation Modes in Yard

It has been anticipated that the internal transportation of cargo will be carried out using heavy-duty fork-lift, trucks and other smaller lifting plants, as per requirements. These will operate to and from railcars and trucks and the identified temporary storage / lifting area of the storage yard.

2.5.7 Design Size Vessel

The revised master plan is planned for handling of following vessel sizes.

Table 2-16: Design Vessel Size

S. No	Vessel Size	Type	LOA (m)	Beam (m)	Depth (m)	Draft (m)
1	2,50,000 DWT	Bulk Carrier	335	55	25.9	19.9
2	18,000 / 20,000 TEU	Container Ship	400	60	32.5	16.0
3	3,00,000 DWT	Liquid Carrier	330	58	31	21.2
4	2,65,000 m^3	LNG Carrier/ Temporary FSRU	345	53.8	-	12.0
5	85,660 m^3	LPG Carrier	249.8	35.5	22.9	12.9
6	2000 DWT	Barges	65	11	3.9	1.22

However, berths will be planned to have berthing facility for Handymax size vessels also.

2.5.7.1 Parcel Size

The expected parcel sizes of the cargo are indicated in table below.

Table 2-17: Proposed Parcel Size of Cargo

Sr. No	Cargo Type	Average Parcel Size
1.	Coal Import (Bulk Cargo)	1,50,000 MT
2.	Coal Export (Bulk Cargo)	1,50,000 MT
3.	Container	8000 TEUs
4.	General & break bulk Cargo (Bulk Cargo)	55,000 MT
6.	Fertilizer and FRM (Bulk / Break Bulk Cargo)	55,000 MT
7.	Liquid	40,000 MT – 1,70,000 MT
8.	LNG (Cryogenics)	1, 35,000 cu.m.
9	LPG (Cryogenics)	44,000 MT

2.5.8 Berthing Facilities

The number of berths required, is a function of cargo type and volume, and the expected cargo handling rates. Certain cargoes can be handled at the same (multi-purpose) berth, while others require dedicated facilities. Other factors that would influence are as given below.

- Vessel sizes and parcel sizes
- Number of operational days per year
- Number of working hours per day
- Time required for peripheral activities and
- Allowable berth occupancy

2.5.8.1 Operational Time

It is assumed that proposed RMP facilities will work round the clock, seven days a week. Allowing 15 days weather downtime, the effective number of working days will be 350 days / year, subject to limiting current and tide conditions.

2.5.8.2 Time Required for Peripheral Activities

Apart from the time involved in the handling of cargo, additional time will be required for other activities such as the berthing and de-berthing of the vessels, customs clearance, cargo surveys, positioning and hook up of equipment, waiting for clearance to sail, etc. As per industry standards, these activities are assumed to take on an average 6 (six) hours per vessel call. However, this does not include downtime due to currents and tidal conditions.

2.5.8.3 Allowable Level of Berth Occupancy

Berth occupancy is expressed as the ratio of the total number of days per year that a berth is occupied by a vessel (which includes the time lost in peripheral activities), to the number of port operational days in a year. The berth occupancy percentage is an indication of the time that a vessel calling at the port will have to wait on an average for a berth. Higher berth occupancy will entail a longer pre-berthing detention, and lower level berth occupancy will ensure the least waiting time.

The main consideration while planning the number of berths, is to ensure that the ratio of waiting time to service time be kept at an acceptable level, in order to avoid paying demurrage.

2.5.8.4 Berth/Quay length required

Development of 5 Berths with total quay length of ~1900 m and 2 Port Craft Berths are approved as a part of existing port, out of which three berths are constructed and operational. Fourth and Fifth berths are not yet constructed. As part of Revised Master Plan development, additional quay length of ~9567 m for berths, quay length of 1250 m for barge berths & ~12 port craft facilities are proposed (including existing approved 2 port craft). Total quay length of berth proposed as a part of revised master plan will be ~11467 m in addition to 1250 m long barge berths & 2 no SPM's are also proposed. Port Craft facilities will be executed progressively with the berth execution and location of port craft to be finalized adjacent to the berth for smoother operation. Type of berth and type of cargo is commercial and as per the business requirement. Hence revised master plan development is proposed with flexibilities to accommodate all berths (existing as well as proposed) as multipurpose.

2.5.9 Navigation Facilities

As a prerequisite for planning the layout of the proposed Revised Master plan development of the Kattupalli port and related backup facility, it is essential to set the basic criteria for the design of various components like navigational aspects to handle different types of vessels for likely use for the transportation of cargo. These conditions are related to the marine environmental conditions at the location.

The main aim of the approach channel is to safely move the vessels visiting the port from the sea to the berthing area. The alignment of approach channel largely depends on the sea bed topography and other oceanographic conditions. The following aspects should be considered in the development of approach channel.

- The channel should be oriented so as to reach the deep-water contours in shortest possible distance. This is done to optimize the dredging quantity.
- Channels should be as straight as possible and curvatures should be avoided particularly near the harbour entrance.

The dimensions of the navigation channel are dependent on the vessel size, the behaviour of the vessel when sailing through the channel, the environmental conditions (winds, currents and waves) and the channel bottom conditions. Channel design primarily involves determination of the safe channel width and depth for the dimensions of the design vessel.

The existing approach channel is a one-way channel and the dimensions of the navigational facilities are as follows.

- Navigation channel – 2.325 km long (Outer) and 910 m long (Inner)
- Outer channel – 180 m wide and (-) 14 m CD dredged depth
- Inner channel – 215 m wide, (-) 14 m CD dredged depth

The widening & deepening of the approach channel will be required for the proposed RMP development. The proposed approach channel dimensions are as follows:

- Navigation Channel – 5 km long (2 way) at (-) 27 m CD dredged depth
- Outer channel – 500 m wide and (-) 27.0 m CD dredged depth
- Inner channel – 500 m wide and (-) 25 m CD dredged depth
- Berth Pockets of all bulk & multipurpose berth except Existing Berth 1, 2 & 3 (-) 20.5 m CD dredged depth
- Berth Pockets of all VLCC (-) 25 m CD dredged depth

The total dredging quantity estimated for the port expansion plan is around 85 MCM.

2.5.9.1 Channel Width

The width of the proposed navigational channel is 500 m used for the transportation of the cargo vessels for 2-way movement simultaneously. The maximum beam of largest vessel is 60 m for 3,00,000 DWT VLCC vessels and 60.0 m for 18,500 TEUs container vessel.

For the proposed RMP, widening & deepening of the existing channel has been envisaged to meet the requirement of the cargo volumes.

2.5.9.2 Channel Depth

The depth in the channel should be adequately greater than the static draft of the vessels using the waterway to ensure safe navigation. Generally, the depth in the channel is determined by following factors.

- Vessel's loaded draft
- Trim or tilt due to the loading 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

Based on the PIANC guidelines, the following general recommendations on under keel clearances shall be adopted to determine the dredge depths:

- Open sea area (in outer approach channel): for those exposed to strong and long stern or quarter swell, where speed may be high, gross under keel clearance should be about 20% of the maximum draft of ships.
- Channel: for sections exposed to strong and long swell, gross under keel clearance should be about 15% of the draft.
- Channel: less exposed to swell, gross under keel clearance should be about 10% of the draft.
- Manoeuvring and berthing areas for those exposed to swell (without full protection of breakwater): gross under keel clearance should be about 10 to 15% of the draft.
- Manoeuvring and berthing areas protected (full protection by breakwater): gross under keel clearance to be about 7% of the draft.

Considering the above factors and guidelines given in PIANC, the under-keel clearance is taken as 15 % of the draft of the maximum size of the vessel in the channel and manoeuvring in existing and proposed approach channel has been considered as sheltered area. The maximum fully laden draft for design vessel 2,50,000 DWT is 19.5 m for bulk carrier, 16.0 m for 18,500 TEU container vessels and for 22.6m for (3,00,000 DWT) VLCC.

Based on above considerations, under keel clearance to be adopted in proposed crane roll-on facility development may be 15% of vessel draft in channel, basin area and in the berth pocket. From the above considerations, the depths required in the navigation channel at the proposed port are worked out and presented below.

Table 2-18: Dredged Depth of Proposed Channel

Description	Max. Draft of vessel (m)	UKC (m)	Water Depth required (m)
Approach Channel	22.6	3.45 (15% UKC)	27
Basin Area	17/22.6	1.7/2.26 (10% KC)	20.5/25
Berth Pocket	17/22.6	1.7/2.26 (10% UKC)	20.5/25

Hence, from the above table it can be seen that for safe manoeuvring of the vessel in the approach channel and the basin area (-) 25/27 m CD dredge depth is required and for berth pocket (-) 20.5/25 m CD dredged depth is required and same is considered in the development plan.

2.5.9.3 Manoeuvring Area

The location of the manoeuvring area or the turning basin, required to swing and berth the vessels, is very important and its design must provide the proper configuration, the proper dimensions and access. The size of the manoeuvring area is a function of the length and manoeuvrability of the vessels and the time available for executing the turning manoeuvre.

The optimum configuration of such basin would be circular. By considering environmental conditions and the fact that vessels will be assisted by tugs, the diameter of the turning circle is required to be kept as 1.7 to 1.8 times length of the vessel. However, for the 400 m long vessel, minimum 700 m dia turning circle is required.

The dimensions and sizing of the manoeuvring and the basin area has been carried out in such a manner that 700 m dia turning circle will be available in the inner basin.

2.5.9.4 Navigational Aids

The proposed development of berths as per the RMP and its related backup facility involves creating an approach channel of 500 m wide base width having (-) 27 m CD depth of approach channel and turning circles. These areas will be delineated by appropriate navigational aids. Also, it will be quite useful to establish a well-marked navigation line, by installing two navigation marks / leading light towers, one in the front near the high-water line and the other at the rear. These marks will distinctly demarcate the channel.

The height and spacing in between the towers must be designed suitably with adequate day marks and night leading lights, fulfilling the navigational needs of vessels approaching the port facility. The following navigational aids are available in existing approach channel.

- Channel marker buoys
- Fairway buoy and Turning circle buoys
- Front and rear leading light
- Berth corner lights

In existing approach channel the buoyage system follows IALA standards as applicable to “Region A” countries. One fairway buoy has been installed at the entrance of the channel. The channel is marked with 19 lateral buoys spaced at a distance of 1 NM. Turning circle is marked with 2 cardinal buoys. The visibility of the fairway buoy and navigational buoy is 10 NM and 5 NM respectively in fair weather. The navigational buoys are fitted with GPS system and fairway buoy is having a recon transmitting code letter “D”.

However, the addition or change in the location of these buoys will be required once the entire channel widening as per the proposed RMP development get completed.

2.5.9.4.1 Fairway Buoy

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.

The characteristics of the fairway buoy will be as follows:

- Type - Fibre Reinforced Plastic (FRP) (3 m dia.)
- Radar Reflector - Fitted
- Light characteristics - Fl RW 105 10 m LED 20W Halogen Lamps
- Power - Solar with backup battery for optimum autonomy.
- Anchoring arrangement - with 32 mm diameter chain and 3.0 T anchor weight

2.5.9.4.2 Channel Marker Buoys (CMB)

There will be a pair of CMB at the beginning of the channel on either side. Thereafter two pairs of CMB are provided along the channel at a spacing of 1 km. The channel marker buoys will have the following characteristics:

- Type - FRP (3 m dia.)
- Day mark - Single Green, Cone type (Starboard buoy) & Single Red, Can type (Portside buoy)
- Radar reflector - Fitted
- Light characteristics - Fl G 3s 2 m (star board buoys)
- LED 20 W Halogen Lamps
- Power - Solar plus backup battery for optimum autonomy.
- Anchoring arrangement - with 32 mm diameter chain and 3.0 T anchor weight

2.5.9.4.3 Front and Rear Leading Light

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 will be having following criteria:

- 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:
- 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 lighting system.

2.5.9.4.4 Vessel Traffic Management System (VTMS)

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

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

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

2.5.10 Harbour Crafts

All vessel-handling operations inside the port area will be assisted by tugs. The number and capacity of the tugs will depend upon the size of the largest vessel, and number of vessels to be handled. The effect of wind on container vessels is highest. The largest vessel likely to be handled will be 18,500 TEU container vessel. Tugs will be sufficient to handle vessels up to 18,500 TEU, 2,50,000 DWT bulk vessels or 3,00,000 DWT VLCC vessel. Tug boats will be used for maintenance of the navigational aids, channel buoys and fenders, etc.

The bollard pull of the tugs shall be compatible with capacity of on-board bollards in the vessels to be towed. For smaller bulk vessels, lesser capacity of the same tugs will be used. Tugs will be provided with appropriate towing gear with necessary pollution control equipment.

It is envisaged that each cape size bulk carrier requires assistance of 3 to 4 tugs whereas a panamax size ships require 2 to 3 tugs of 50 MT bollard-pull capacities for manoeuvring and berthing operations including a standby tug. In addition, for each shipping movement an escort tug is expected to move in the navigational channel along with the ship. The turnaround time for an escort tug is ~4 hours, which includes following activities.

- Attach Tug and manoeuvre 0.50 Hrs.
- Transit the channel at average 5 knots 1.95 Hrs.
- Tugs return for next ship at 8 knots 1.22 Hrs
- Total 3.67 Hrs.

However, on many occasions the tugs could combine the ship departure and ship arrival operations to optimize their movements. Based on this it has been assessed that about 10 to 12 tugs would need to be provided for proposed RMP development.

2.5.11 Liquid Terminal: Storage and Handling

The Liquid Terminal for proposed RMP will be developed in line with business requirement of liquid cargo. Tanks would be used to store Class A, B, C, Non - Classified Chemicals & Petroleum products, Hazardous and Non Hazardous (chemicals & Petroleum Products), Cryogenic Gases (Upto -162 degree Celsius, Pressurized Gases) such as PoL, Crude oil, hazardous and non-hazardous chemicals, non-classified hydrocarbons, edible and non-edible oils, and other specialty commodities like CBFS, Bitumen, etc. Other facilities such as Pump house, Manifolds, TLF, TULF, Utility blocks, Substation, Control room, pavement, drainage, lighting and formation level, OWS, ETP is taken into account while designing the terminal. Necessary arrangements / accessories as per the standards would be provided at the storage tank for the safe containment of the products. A cross- country pipe line for transportation of liquid can be provided as and when required. The pipeline may pass through CRZ area. Alignment of the same will be finalized at the time of requirement.

2.5.11.1 General Layout

General layout of the Liquid terminal provides following facility.

- Storage tank facility
- Pump house

- Truck loading & Unloading facilities
- Access road to liquid terminal

2.5.11.2 Operation Modes in Liquid Terminal

Import Operations:

Vessel carriers will discharge their cargo, using the vessel's pumps, through the marine unloading arms or hoses into the onshore pipeline system (Dock lines). The unloading arms or hoses are connected to the pipeline system through a pipeline manifold. Since some of the allocated land parcels for the tank farm is close to the jetties, the cargo can be directly pumped to the tank farm without the need of booster pumps.

Product will be imported from various locations and discharged at terminal jetty to the storage tank. Product will be distributed in local market through truck loading facility with the enclosures.

An empty tank truck will be pre-weighed on a weigh bridge before proceeding to the TLF. The empty weight on the truck shall be entered into the tanker loading software. Further the required quantity to be filled into the tanker would be feed in from the control room. The field operator will check the alignment and line up prior to commencing of tank truck filling operation. The field operator or the control room will initiate the tanker filling operation as per predefined set-up. This need to be worked out in detailed engineering and incorporated in the design.

Export Operations:

Road tankers will get unloaded at Tanker unloading facility (TULF) and fill Storage tanks in Liquid terminal with the help of unloading pumps at TULF. The Storage tanks contents will then be evacuated into vessel carriers via dock lines with the help of export pumps in the terminal.

Dock line cleaning:

Pig launching/receiving station at both ends (Jetty and Tank farm) will be installed.

2.5.11.3 Tank Arrangement

- Petrochemical and Petroleum tanks shall be located in dyke enclosures with roads all around the enclosure.
- Dyke enclosure shall be able to contain the complete contents of the largest tank in the dyke in case of emergency.
- The height of tank enclosure dyke shall be as per Standards - Petroleum and Explosives Safety Organization (PESO).
- Tanks shall be arranged in maximum two rows so that each tank is approachable from the road surrounding the enclosure.
- The tank height shall be as per Oil Industry Safety Directorate (OISD), GoI standards.

2.5.11.4 Metering

A metering facility shall be provided at the service platform for the following purposes.

- Continuous pressure recording of each pipeline, with alarm in case of surge pressures as a safety precaution
- Continuous temperature recording of each pipeline as a safety precaution

- Flow and density measurements

2.5.11.5 Design Specification for Liquid Terminal

Design Criteria

- Valve shall be selected for long & leak proof service.
- Normal design conditions of temperature and pressure will be most severe conditions expected to co-exist under usual long-term operation conditions. These usual conditions include all operation and control functions such as throttling, bypassing and blowing to be used for operation and control.
- Design Temperature is the most severe sustained fluid temperature. Design Temperature will be the maximum fluid operating temperature with safety margin (5 to 20%).

Codes and Standards

The design and construction shall be carried to ensure that the most stringent Indian or International Design Codes are applied. The design codes and standards (**Table 2-19**), which shall be considered as minimum requirements. Latest version of these shall be followed.

Table 2-19: List of the Codes for Liquid Terminal

Code	Description
ASME B 31.3	Chemical plant and Petroleum Refinery Piping
ASME B 31.4	Liquid transportation systems for Hydrocarbons, Liquid Petroleum Gas
ASME B 16.5	Steel pipe flanges and flanged fittings
ASME B 16.9	Factory Made Wrought Steel Butt Weld Fittings
ASME B 16.10	Face to Face & End to End Dimensions of Ferrous Valves
ASME B 16.11	Forged Steel Fittings Socket
ASME B 16.34	Steel Valves Flanged and Butt-Welding Ends
ASME B 16.20	Ring Joint Gaskets and Grooved for Steel Pipes Flanges
ASME B 16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME B 16.25	Butt Welding Ends
ASME B 18.2	Square & Hex. Bolts and Screws
ASME B 36.10	Welded and Seamless Wrought Steel
ASME B 36.19	Stainless Steel Pipe
API 1102	Liquid Petroleum pipeline crossing rail, roads and Highways
API 650	Storage Tank design.
ASME Sec-VIII, Div 1	American Standard for Vessel Design
IS 803	Storage Tank Design (Indian STD)
OISD-STD-114/117	Safe Handling of Hazardous Chemicals/Fire Protection facilities for petroleum Depots and Terminals
OISD-STD-118	Layout for Oil and Gas installation
OISD-STD-144/156	Recommended Practices on Storage and Handling of Bulk Liquefied Petroleum Gas
SIGTTO	Society of International Gas Tanker and Terminal Operators
OISD-194	Standard for Storage & Handling Of Liquefied Natural Gas (LNG)
NFPA 59A	Standard for the Production, Storage and Handling of Liquefied Natural Gas.

2.5.11.6 Internal Road within Liquid Terminal

The main road approaching to the liquid terminal will have two lanes. The road network is planned so that it provides easy access for maintenance, fire-fighting, escape during emergency and dead end should be avoided. Single lane roads will have 4 m width, with minimum 0.5 m shoulder on each side. The width of double lane roads is 8 m. Intersections and corners shall be of sufficient width and radius to permit fire tender, with a minimum turning radius of 15 m, to turn corners without reversing.

2.5.12 LNG Handling Storage and Regasification

Cryogenic Gases (Upto -162 degree Celsius, Pressurized Gases) will be handled. Typical handling requirements for LNG and LPG are presented below

2.5.12.1 LNG Scheme

LNG is stored in LNGC at cryogenic temperature of -162°C and pressure of around 0.13 barg (near to saturated condition). LNG is transferred through number of cargo pumps of LNGC to onshore storage tanks using unloading arms and unloading lines.

LNG is unloaded from ship via liquid unloading arms and vapour is transferred to ship storage (to maintain pressure) via vapour return arm. These arms are equipped with flexible coupling which engages/disengages quickly as per requirement. These couplings are normally known as “Powered Emergency Released Coupling” (PERC) and have double block valve. These coupling disengage automatically upon detection in abnormal ship movement or activation of emergency shutdown system (ESD).

During no ship unloading (or Holding mode), arms are isolated, drained and purged with nitrogen. LNG in the arms (during holding mode) is drained to the Jetty drain drum. From unloading arms, LNG is transferred to onshore LNG tanks through two unloading lines (36” size each). In order to maintain the LNG unloading lines at cryogenic temperature when unloading operation is not taking place (i.e. in holding mode of Plant); LNG from the onshore storage In-tank pump discharge is circulated between the unloading lines. During circulation one line takes LNG from tanks to the jetty while the other returns it back to the unit. A minimal amount of LNG is send to the tank inlet lines (from In-Tank pump discharge) to maintain receiving lines cold during holding mode.

During ship tanker unloading, the LNG stream is sampled and analysed using the dedicated sampling Unit. The density of LNG in the tanker relative to that stored in the Tanks shall decide mode of filling (top/bottom) in the tanks. This implies that if the LNG is heavy, top filling shall be used and vice versa. This is to facilitate the mixing of LNG in the tanks to prevent the stratification in the tanks that can cause “Roll over phenomenon” thereby generating large amount of BOG.

A small LNG flow is always maintained to LNG tanks through LNG filling risers to keep the lines cold. The bypass valves of tank top/bottom filling valves are always kept open for this purpose.

2.5.12.2 Marine Side Facilities

The following marine side facilities shall be provided:

- LNG jetty berth (including but not limited to breasting dolphins, mooring dolphins, fenders and catwalks)
- LNG jetty head
- LNG jetty trestle accommodating pipe rack and access road to the jetty head
- The mooring hooks and mooring monitoring system
- Ship berthing system
- The monitoring of met ocean data needed to be available for the ship
- Any measures to secure the piling of the jetty head, trestle and flare trestle as cathode protection of piles, etc.

The jetty shall be designed to accommodate LNG carriers in the size range of 20,000 m^3 to 265000 m^3. To accomplish this, the LNG berth will include breasting and mooring dolphins, fender systems, mooring hooks, mooring line tension monitoring system and a LNG carrier docking assistance system.

The LNG berth is to provide a platform to support the mechanical equipment required for unloading LNG carriers. The LNG trestle shall provide structural support from the terminal to the LNG unloading platform for the LNG unloading piping, auxiliary mechanical and utilities, control and electrical systems, and access roadway.

2.5.12.3 LNG Handling

The principal components of the ship-to-shore LNG transfer system are the ships' pumps, the marine unloading arms, pipeline manifolds and connected cryogenic pipelines to handle LNG in liquid form at particular temperature.

2.5.12.3.1 Marine Unloading/Loading Arms

Marine unloading / loading arms of required diameter would be provided on the central unloading platform. Unloading arm will have the sufficient capacity of pumping along with one vapour return arm. The unloading arms are moved with a remote-controlled hydraulic system located on the berth. After connection is completed, the communication cable is connected to shore and the emergency shutdown system is tested. After the unloading arms are cooled, the LNG will be transferred from the carrier to the storage tanks using the carrier's pumps.

2.5.12.3.2 Pipelines

It is proposed to provide required numbers and sufficient diameter of pipelines for transfer of LNG from berth to tank farm area. To allow for expansion of these cryogenic pipelines, loops shall be provided at every regular interval along the length of the pipelines.

A cross- country pipe line for transportation of LNG will be provided as and when required. The pipeline may pass through CRZ area. Alignment of the same will be finalized at the time of requirement.

2.5.12.4 Tankages

The LNG will be stored near atmospheric pressure and in full-containment LNG tanks that typically consist of the following facilities.

- Primary inside tank made of a "cryogenic material" such as 9% Nickel steel, aluminium alloy or reinforced pre-stressed concrete
- Insulation or loose insulation material (such as perlite) surrounding the inner nickel steel tank (sides, floor and roof)
- Outer tank will be reinforced, pre-stressed concrete designed to independently store both the LNG liquid and vapour
- Domed roof will be reinforced, pre-stressed concrete

The LNG will be stored near atmospheric pressure and in full-containment LNG tanks that typically consist of the following facilities.

Part or type	Definition
Inner tank (or primary container)	A flat bottomed, self-supporting, vertical metallic 9% Ni steel cylinder with a suspended deck. During normal and accidental conditions, the inner tank is designed so as to retain the full liquid content. The inner tank (by opposition to “outer tank”) is sometimes used as a global term for the

Part or type	Definition
	whole of the inner tank, the cryogenic system, the suspended deck, internals and inner accessories outer tank (or secondary container).
Outer Tank (or Secondary Container)	A flat bottomed, vertical cylinder designed to content liquid from the inner tank in the event of leak or accidental event. A self-supporting reinforced/prestressed concrete tank equipped with a reinforced concrete dome and designed to achieve the following functional objectives : • In normal tank service, to provide the primary vapour containment of the tank, to retain the thermal insulation of the primary container and to prevent moisture ingress that may lead to the degradation of the insulation system • In case of leakage of the primary container, to contain all liquid product and to remain structurally vapour tight. Venting release is acceptable but shall be controlled. • Some other functions have to be provided, for defined accidental cases: o Resistance against a flying objects impact o Resistance against fire o Resistance against blast o Containment of liquid during an OBE (Operating Basis Earthquake)
Full Containment Tank	A container in which the inner container is surrounded by a secondary container designed to contain LNG in the event of a spill from the inner container and where the secondary container is enclosed by a concrete roof designed such that excess vapour caused by a spill of LNG from the primary container will discharge through the relief valves (or the definition given by the BS 7777 [superseded since 2006]: "A double tank designed and constructed so that both the inner tank and the outer tank are capable of independently containing the refrigerated liquid stored. The outer tank is intended to be capable of both containing the refrigerated liquid and controlled venting of the vapour resulting from product leakage after a credible event"). The inner tank contains the liquid under normal operating conditions. The outer dome is supported by the outer tank. The outer tank is intended to be capable of both containing the refrigerated liquid and controlled venting of the vapour resulting from product leakage after a credible event.

The LNG shall be contained in the tanks at its cryogenic temperature of approximately -162 °C near atmospheric pressure. Two full containment concrete roof LNG storage tanks shall be built. The working capacity of each tank shall be 180000 m^3.

The LNG storage tanks shall have a design pressure of 290m barg and a maximum boil-off rate of 0.05% per day of gross tank contents. All pipe works connections to the tank, including those for filling and emptying, shall be made through the tank roof.

The LNG storage tanks shall be equipped with density monitoring to indicate stratification and potential rollover problems and allow early operator action. The tanks shall be designed to be top or bottom loaded from a LNG carrier to avoid stratification. The bottom loading shall be accomplished using a standpipe inside the tank. The top loading shall be carried out using separate piping connections in the top of the tank. In addition, facilities shall be provided to circulate and mix the stored product in the event of stratification occurring. This shall be undertaken by pumping LNG from the bottom of the tank and reintroducing the LNG to the tank using either the top or bottom fill lines.

Temperature instruments shall be furnished in the wall and floor of the LNG storage tank to monitor the temperature profile. Automatic continuous tank level gauging, temperature monitoring, and density measurement shall be provided.

2.5.12.5 Boil off Gas Handling System

Excess vapour generated during LNG unloading into the LNG storage tanks and boil-off gas generated in normal operation are compressed by the boil-off compressors and condensed in sub-cooled LNG delivered by the low pressure LNG pumps in a vessel so-called BOG recondenser.

The BOG recondenser has two sections:

- The upper section is a packed tower for mixing gas and LNG resulting in the gas to be condensed.
- The lower section is as buffer vessel for feeding LNG to the high pressure LNG pumps with a net positive suction head (NPSH) above the minimum value required by the HP pump manufacturer.
- The LNG required for condensing the vapour is delivered into the upper section of the BOG recondenser while the balanced LNG send-out is flowing directly to the lower section of the BOG recondenser; the LNG coming out from the BOG recondenser is so sub-cooled and provides a medium suitable for being pumped by the high pressure LNG pumps (a safety margin of minimum 2°C below the saturation temperature of the BOG recondenser out-coming LNG shall be considered).

The BOG recondenser shall be designed on the following basis:

- Condensation of the BOG generated by three LNG storage tanks.
- Condensation of the BOG generated during a LNGC unloading process at the design rate of 15 000 m^3/h.
- A provision of 3 000 m^3 (n)/h additional boil-off gas to take into account the truck loading facilities.
- Floating pressure 1 barg - 4 barg.
- Hold-up of the lower section designed for 1 minute based on 12 MMTPA send-out.
- The BOG recondenser shall be protected by two pressure safety valves (2 X 100%) for on-line maintenance.
- Piping shall be arranged around the BOG recondenser for maintenance only (cold LNG circulation to HP pumps suction header).

2.5.12.6 Regasification Unit

<u>Shell and Tube Vaporiser</u>

High pressure LNG from LNG HP Pumps is vaporized in these shell & tube vaporizers (STV). The shell and tube vaporizers (STV) are made up of tubes assembly installed in a shell casing in which the glycol water will circulate. These STVs are specially designed heat exchanger for LNG service. 4 W + 1S configuration of STV (each of duty 38 MW) is envisaged for Kattupalli LNG Plant.

Below Table shows plant send out capacity with variation in ambient temperature and number of STV in operation:

Ambient Temperature	Plant Capacity	STV	SCV
>21°C	120% (685.2 tons/hr)	4 Nos (1 Standby)	No SCV operation
13°C-21°C	102.8% (587 tons/hr)	5 Nos	No SCV operation
10°C-13°C	100% (571 tons/hr)	5 Nos (402 Tons/hr from STV)	One SCV (169 tons/Hr)

The vaporizers operating pressure is floating with the delivery gas pipeline network, which could vary between 50 to 90 barg.

The flow instrument in the downstream NG line, with pressure temperature compensation measures the flow rate through Shell & Tube Vaporizer, and controls it by manipulating LNG inlet flow control valve.

The heating medium for the vaporizer is 36% Glycol-Water mixture. The selection of heating medium is important to eliminate the chance of freezing of the medium, thereby affecting the performance of the vaporizer.

Process Control

Low temperature overrides on NG outlet side set at 0°C and on the glycol water side are provided for LNG inlet flow control valve. These temperature controllers provide low temperature override to LNG Flow controller, which controls the flow of LNG to STV. The ultimate protection against low temperature of NG outlet and hence against the freezing of glycol water mixture is provided by Low Low Temperature trip (set at –5°C) on NG outlet side, which will close LNG inlet shutoff valve. As mentioned earlier the operating pressure of the vaporizers on NG side is floating with the delivery gas pipeline network. High pressure override is provided by pressure controller on the downstream of Gas Metering Station, which will reduce the LNG flow in case of high pipeline pressure. The primary protection against high pressure is provided by High High Pressure trip set at 91 barg (hold) upstream of Gas Metering Station, which will shut off the gas send out by stopping all LNG HP Pumps and closing all STV LNG inlet shut off valves Pressure Safety Valve for STV is set at 130 barg (hold), which is designed for relieving 110% of the rated throughout of the vaporizer, provides the ultimate protection against over pressure. The low-low pressure of the gas send out line is detected by Low Low pressure alarm (set at 65 barg) on the downstream of Gas metering Station, which will give an alarm on the control room board. On glycol-water side, full flow is always maintained through the STVs. The energy optimisation is achieved by controlling the number of operating fans for the air heaters. Low Low glycol-water inlet flow to the top and the bottom of STV will close LNG inlet shut off valve of STV to prevent the possibility of freezing.

Tube rupture of STV, if it happens, is detected by High High Pressure trip (set at 8 barg: hold) on STV shell side and High High Temperature trip (set at –5°C) in the outlet line of glycol-water, which will trip STV by closing STV LNG inlet shut off valve.

Rupture Disk (set at 10 barg) is for ultimate safety of the shell side, during tube rupture case. After detecting tube rupture NG outlet valve of STV, inlet MOV (Motor Operated Valve) and/or manual isolation valve shall not be closed until LNG inventory in the STV is fully vaporized. If it is closed immediately on detection, it could cause higher pressure on the tube side.

Glycol Water:

Glycol water circulation shall be through glycol water pumps (1W+1S). No flow control is envisaged for Glycol water. Low-Low temperature trip on Glycol water line (outlet of STV) shall initiate interlock to prevent GW freezing temperature.

Submerged Combustion Vaporiser

A Back-up LNG Vaporizer (Submerged Combustion Vaporizer) will be used as back up capacity to allow maintenance and to meet gas market peak requirements. The Back-up LNG vaporiser may also be used during period of exceptionally low ambient air temperature to meet the Send-out requirement. Back-up LNG Vaporizer is a fired water bath heater using Fuel Gas. The Back-up LNG vaporiser first water fill will be supplied from the fresh water system or by a road tanker if the fresh water quality is not suitable. But once in operation, the combustion water generated by the combustion of the fuel gas will make-up for any water loss and blowdown. Excess water will then be disposed to the waste water treatment. Since flue gas is in contact with the water bath, the water pH will decrease continuously. To keep the pH within acceptable limit, chemical have to be dosed regularly in the water bath, according to the Back-up LNG vaporiser vendor recommendation. LNG flow control scheme of SCV shall be similar to STV. Detail control scheme of SCV fuel gas and flue gas temperature to be developed in detailed engineering based on vendor input.

However, Selection of regasification unit will be carried out during detailed design stage. Use of Open Rack vaporiser (ORV) may also be explored.

2.5.12.7 LNG Metering System

The metering station, equipped with custody transfer meters, shall be implemented with several metering lines in parallel including, one ultra-sonic type flow meter.

2.5.12.8 Flare and Blowdown System

The LNG storage and re-gasification does not involve combustion of any anthropogenic fuel. Thus, the ambient air quality is not likely to be affected due to the proposed project. The system shall include elevated flare and pilot burner. The flare design shall consider the heat radiation to surrounding personnel and equipment so that safe distances are maintained. Emissions during LNG flaring are not expected to be significant. CO_2 in small quantities will be released to atmosphere during flaring; however, their contribution to ground level concentrations (GLCs) will be insignificant. Possibility of LNG coming out as fugitive emission is ruled out due to robust system design.

2.5.12.9 LNG Draining Facilities

In areas where LNG spill could occur, effluent shall be released by a network of open trenches into an impounding basin. In storage tank and process areas, buried pipes shall not be used in order to avoid hazard arising from gas confinement or gas spreading into an underground network.

2.5.12.10 Safety Systems

The regulatory framework identifies the regulatory requirements that are applicable for the project.

- The statutory i.e. legal requirements
- LNG project rules
- Industry codes and standards
- 3rd party rules (i.e. investment bank, Assurance Company etc.)
- Good practices to be applied

This framework is represented in a table in which the most relevant requirements are listed and is intended to provide a guide to the project phases to which each regulation may apply.

The table is meant to identify in a first step, the applicable regulatory requirements governing safety and is not exhaustive. During each step of the project the applicable list shall have to be further developed in parallel with the stepwise project development since as each new stage is reached the regulatory issues become more specific and are more and more detailed.

Regulatory Framework:
The following LEGISLATION, RULES, CODES AND STANDARDS are mandatory requirement during project phase; • NFPA 59A "Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG)" and all its annexes. • OHSAS 18001 - Occupational Health and Safety specification

The following documents shall be followed; • ISO 9000 - quality management systems (including safety aspects)

2.5.12.11 LNG Spillage, Gas Leakage, Flame and Smoke Detection

These detection systems are intended to rapidly and reliably detect any LNG spillage or flammable gas leakage and any fire condition in the terminal.

Continuously operating detection systems will be installed at every location, outdoors and indoors, where leaks are credible. Flashing lights and loudspeakers are distributed on the field to warn the people on site of any abnormal situation.

The arrangement of detectors is such as to always provide redundancy and to prevent false and deceptive alarms. Voting technique and cross-zone arrangement is used where justified.

The detections system shall comply with NFPA 72 requirements.

The following detection devices will be provided:

- LNG spillage detection LNG spills are detected by low temperature sensors (RTD's) which are protected against accidental damage.
- Flammable gas detection

The flammable gas detectors are of the infra-red type. Along critical fences, open path type gas detectors shall be installed.

Fire Detection:

Flame Detection:

The flame detectors are of the ultraviolet/infrared (UV/IR) type.

Heat Detection:

High temperature detectors are provided for protection of tank relief valves fires and activation of tailpipe extinguishing packages. The heat detectors are of high temperature thermistor strip type or of temperature-sensitive pneumatic type.

Smoke Detection:

Smoke detectors are of the double ionisation chamber type and are used in building technical rooms.

Manual Call Points:

The manual call points shall be of the break-glass type. They shall be provided in the plant areas covered by flame and/or combustible gas detectors and located along escape routes from these areas.

The three types of fire detectors shall be considered such as Optical fires detectors, smoke detectors and heat detectors. The Optical fires detectors consist of Infrared Fire detectors, UV Fire detectors, UV/IR Fire detectors, Triple IR Fire detectors and CCTV Flame detectors. The smoke detectors consist of Optical smoke detectors, Ionization-type smoke detectors and High sensitivity smoke detectors. The heat detectors shall be of the kind Fusible link detectors.

Loss of Containment Detection:

- Hydrocarbons gas detection
- Hydrogen gas detection
- Low temperature spill detection

The flammable gas detectors can be of different types such as Point Flammable Gas Detectors, Open path gas detectors, Ultrasonic Gas Detectors etc.

The Fire and Gas system shall alert operations personnel of a fire and/ or gas release situation. It shall include as a minimum:

- Early detection of flammable gases
- Early detection of fire
- Initiation of audible and visual alarms to warn of fire and gas hazards
- Initiation of the relevant automatic actions (extinguishing agent discharge where appropriate, closure of isolation dampers)
- Initiation of alarms at the CCR (Central Control Room) and display points geographically on the Fire and Gas system via custom graphics displays
- Initiation of emergency shutdown by automatic or manual operation.

LNG Spill Detectors:

Areas where cryogenic liquid spills can collect shall be equipped with spill point detectors at the outlet of the spill channel e.g. at the re-condenser and at the send-out pumps.

2.5.12.12 Truck Loading Facility

- A LNG truck loading station shall be implemented consisting of 1 truck loading bays having common weighbridge
- Each loading bay shall be designed to export 50m^3/h LNG

2.5.12.13 NG compressor for conversion to CNG

Reciprocating compressor with minimum 3 stages giving discharge pressure of 255 Kg/cm^{2}g with suction pressure of 19 kg/cm^{2}g will be provided. Suction pressure may vary and regulator to limit the suction pressure to 26 kg/cm^{2}g. The gas temperature after cooler shall not exceed 52°C considering maximum ambient temperature of 45°C for design. The compressors size shall be for Type A/Type B guaranteed flow with no negative tolerance for gas composition with suction pressure of 19 kg/cm^{2}g, suction temperature of 35°C and discharge pressure of 255 kg/cm^2 g.

The priority fill system shall ensure the filling of vehicle, high bank of cascade, medium bank of cascade and low bank of cascade in correct order. The priority fill panel shall be designed to ensure filling of vehicle, storage cascade in correct order. Design of priority fill system shall be selected to achieve maximum flow rate through combined flow from compressor and 3 banks cascade (3000 water litres for Type A & 2025 water litres for Type B compressor) arrangement.

2.5.13 Floating Storage and Regasification Unit (FSRU)

Depending on the business requirements, LNG/LPG will also be handled through FSRU mode in addition to land-based terminal as part of RMP. It is pertinent to mention that the impacts and Risks scenarios related to FSRU is much lesser than the impact and Risk predicted for Onshore LNG terminal (as the maximum inventory considered in Risk Assessment will not exceed 1,80,000 m^3) and hence the measures considered for Onshore Terminal will holds good for FSRU.

The technical details of the FSRU are given below:

- Size of the vessel – Maximum LOA is 345 m

- Storage size – 1,25,000 m^3 to 2,16,000 m^3 (Average 1,70,000 m^3)
- LNG Containment System – Moss or membrane
- Regasification method – Open Loop (using Seawater)
- Send out rate – 2 MTPA (nominal) with peak of 2.5 MTPA
- NG pipeline – 30 inch pipeline from metering station connecting to gas grid
- No buffer tank
- Boil off gas handling – BOG compressor
- NG Distribution Network – NG pipeline (dedicated pipelines) or pipeline by GAIL/Others

The FSRU receives LNG feedstock from LNG Carriers (LNGCs), which unload the LNG feed stock via hose transfer. The unloading takes place with the LNG Carrier moored to the FSRU in a side by side configuration. The LNG imported is stored in the four on-board storage tanks within the FSRU. The feedstock is regasified on the FSRU and exported as high pressure gas to onshore facilities via HP gas unloading arm on LNG Berth.

The FSRU will be a self-contained unit with its own on-board crew of 27-30 persons. The FSRU will generate its own potable water through equipment installed on-board and shall have captive power generation facility. The LNG shall be unloaded through flexible hoses. The FSRU will have on-deck regasification facility. Send out of high pressure NG to the jetty deck will be by Double Counterweight Marine Arm (DCMA) type arms placed on the unloading platform of the LNG jetty. The FSRU and the Jetty will follow all applicable Indian and international design and operations codes and industry specific guidelines (e.g. IS/BIS (Bureau of Indian Standards), OISD (Oil Industry Safety Directorate), NFPA (National Fire Protection Association), SIGTTO (Safety of International Gas Tanker and Terminal Operators), OCIMF (The Oil Companies International Marine Forum) etc.) applicable to the LNG industry fitting and commensurate to LNG industry.

2.5.14 LPG Handling

The principal components of the ship-to-shore LPG transfer system are the ship pumps, the marine loading / unloading arms, pipeline manifolds and connected pipelines to handle butane, Propene and LPG.

2.5.14.1.1 Marine Unloading/Loading Arms

Marine unloading / loading arms of required diameter would be provided on the central unloading platform. The loading / unloading arms are moved with a remote-controlled hydraulic system located on the berth. After connection is completed, the communication cable is connected to shore and the emergency shutdown system is tested.

2.5.14.1.2 Pipelines

It is proposed to provide required numbers and sufficient diameter of pipelines for transfer of LPG from berth to tank farm area. To allow for expansion of these pipelines, loops will be provided at every regular interval along the length of the pipelines. The pipelines shall also be insulated with adequate material to limit heat ingress through outside environment.

A cross- country pipe line for transportation of LPG will be provided as and when required. The pipeline may pass through CRZ area. Alignment of the same will be finalized at the time of requirement.

2.5.14.1.3 Tankages

The cargo will be stored near atmospheric pressure and in full-containment LPG tanks. Total six tanks of 25000 MT capacities each are proposed to be provided in phased manner. However, the dimensions and parameters of the LPG tank and pipelines may change during detail design stage.

Modelling studies were conducted for intake and out fall locations and two separate locations were suggested where the cold-water discharge is not mixed. Model results are discussed in **Section 4.4.3.4** of **Chapter 4**.

LPG storage and handling procedures are listed below

2.5.14.2 Plant Throughput

LPG terminal will be operation in stage wise manner i.e. Stage 1A and Stage 1B. During Stage 1A LPG terminal shall be designed to send LPG/Butane/Propane via cross country pipeline and tanker loading facility with dispatch capacity of 440 MT/hr and during Stage 1B overall dispatch capacity will be 776 MT/hr.

2.5.14.3 Marine Unloading/Loading Arms

Marine unloading/loading arms would be provided on the central unloading platform. The loading / unloading arms are moved with a remote-controlled hydraulic system located on the berth. After connection is completed, the communication cable is connected to shore and the emergency shutdown system is tested.

2.5.14.4 Pipelines

It is proposed to provide required numbers and sufficient diameter of pipelines for transfer of LPG from berth to tank farm area. To allow for expansion of these pipelines, loops will be provided at every regular interval along the length of the pipelines. The pipelines shall also be insulated with adequate material to limit heat ingress through outside environment. However, the exact alignment will be finalised during the detailed engineering. A cross-country pipe line for transportation of LPG will be provided as and when required.

2.5.14.5 Storage Tanks for Propane/Butane

Storage tank is vertical flat bottom, double wall, full containment refrigerated storage tank, which is designed to store Propane/Butane/Propylene from jetty. The function of these tanks is to store Propane/Butane/Propylene. These tanks are identical in all respects and Propane/Butane/Propylene can be stored in any of these tanks. The pumping capacity of each tank is 25000 MT.

Propane/Butane/Propylene is pumped by ship pump through marine unloading arm to storage tanks through two marine unloading arm at the rate of 600 MT/hr each.

The tank operating pressure is 700 mm WC (Holding mode) to 1200 mm WC (Unloading mode). Corresponding tank material temperature at this holding pressure of 700 mm WC are approximately -44.4°C in case of propane, -4.4°C in case of Butane and -46.4°C in case of Propylene.

The expected temperature of cargo ship inventory during unloading operation are -42.7°C in case of propane, -2.9°C in case of Butane and -44.9°C in case of Propylene. The temperature of cargo shall vary a little based on the composition/level of impurity. LPG is pumped to truck loading stations and cross country pipeline by pumping propane & butane by Propane/Butane Transfer Pumps followed by heating & then blending.

2.5.14.6 Transfer Pumps

There are submersible centrifugal pumps situated in the tank. These pumps are provided for following functions:

- Transfer of propane/butane for heating and then to blending plant for production of LPG for tanker loading.
- Pre-cooling of unloading lines prior to ship unloading.

Each tank is provided with automatic flow control valve meant for minimum flow return and designated flow return to facilitate production of LPG of different ratio of Propane & Butane. During phase 1A total three pumps will be installed with provision to install one more pump, which shall be installed during phase 1B.

2.5.14.7 Propane/Butane Heating Train

Propane and Butane/Propylene are heated in separate heating trains to 15°C in two steps. Preheating of refrigerated propane liquid at -44.4°C is performed in Propane Heater - I and preheating of refrigerated Butane at -4.4°C is done in Butane Heater - I by condensing hot propane vapors at 37°C to avoid freezing problems by direct heating with steam. The propane used for heating Propane and Butane/Propylene is vaporized in a kettle type Propane Vaporizer-I and Propane Vaporizer-II by condensing steam. The steam condensate is used to heat the Propane and Butane/Propylene to 15°C in Propane Heater - II and Butane Heater - II respectively.

2.5.14.7.1 LP Steam Heating

In the vaporizers, the liquid propane is vaporized at a pressure of 12.5 Kg/cm^{2}G with L.P. steam at 3.5 Kg/cm^{2}G. The condensate coming from the shell side of Propane Heater-II and Butane Heater -II are collected in steam condensate receiver. This condensate will be transferred to condensate polishing unit through steam condensate pumps.

2.5.14.7.2 Steam Blender and Blending Control

Butane is mixed with Mercaptan in Static Blender. Propane, Butane and Mercaptan are mixed in Static Blenders at a certain ratio in order to make LPG as per IS-4576, which depends upon the composition of commercial propane and Butane stored in the storage tank. Provision is made to mix Propane and Butane from bullets.

Blending ratio depends on the composition of commercial propane & commercial butane stored in tanks and also composition of condensate from bullets Propane Heater-II and Butane Heater – I.

Online blending control system is provided to make LPG as per IS specifications. The vapor pressure of the mixture is supervised by continuous measurement at the downstream of static blender with the help of two online vapour pressure analyzer’s.

Ethyl Mercaptan is injected for the odourization of liquid LPG/ Butane/Propane. The blended LPG is filled into the road tankers via loading arms. The ratio of blending streams is determined by processor & controlled by flow measurement and regulation on the propane & butane streams.

If the vapour pressure of the mixture exceeds the desired value, the flow ratio of Propane & Butane is corrected by the blending control system and the off specification product is returned back to Propane/Butane bullets.

2.5.14.8 Road Tanker Loading

The blended LPG as per the IS specification (IS-4576/IS-14861) is filled into road tankers via loading arms. There are two road tankers filling gantries, each gantry with 8 Nos. loading points. Bay allocation can be changed for simultaneous tanker loading of domestic LPG, Automotive LPG, Propane and Butane.

Facility for sick tanker unloading is provided at one bay in each gantry. Propane sick tanker will be unloaded in Propane bullet and Butane & LPG sick tankers will be unloaded in Butane bullet. In future during propylene send out case propylene will be routed via Domestic LPG path for tanker loading facility.

Sick tanker unloading is done by unloading pumps situated near TLF (Tanker Loading Facility). The vapours of road tanker are either recovered by connecting the suction of BOG compressors or are evacuated to the flare header.

2.5.14.9 LPG Booster Pump

LPG booster pump is provided to pump domestic/Automotive LPG by cross country pipeline at maximum flow rate of 440 MT/hr.

2.5.14.10 Flash Compressor

These compressors are used to compress the vapours generated in the storage tank during ship unloading and during the precooling operation. Propane and Butane storage tanks are provided with compressor.

These are oil flooded screw type compressors. Each one is having two stages. For propane/propylene service both stages will be operating in series and for butane service, only first stage will be in operation. Start stop of these compressors depends on the tank pressures. From each tank the compressor suction line is running up to a suction separator. Suction separators are provided for both Flash and BOG compressors.

2.5.14.11 Condensers and Receiver for Flash Compressors

Compressed vapours from both flash compressors are further condensed into Propane/Butane Flash condensers and then stored into Propane/Butane Flash Condensate Receivers. Propane/Butane from Propane/Butane Flash Condensate Receivers are pumped to Propane/Butane bullets by Propane/Butane Flash Condensate Pumps.

2.5.14.12 Boil-off Compressor

The normal boil-off vapours from the storage tanks are compressed separately through boil-off compressors. Propane & commercial butane storage tanks are provided with compressors.

Boil-off compressors are oil flooded screw type of compressors. Each one is having two stages. For propane service, both the stages of the compressors are in service.

For butane service first stage is in operation. Start-stop of these compressors depend on the tank pressures.

2.5.14.13 Condensers and Receivers for Boil–off Compressors

Compressed vapours from both boil-off compressors are further condensed into Propane /Butane BOG condenser and then stored into two separate receivers Propane/Butane BOG Condensate receiver.

Propane/Butane condensate from BOG Condensate receivers are pumped to bullets by Propane/Butane BOG condensate pumps and also it is routed to the Boiler to be used as boiler fuel.

2.5.14.14 Propane/Butane Bullets

Propane/ Butane Bullets are mounded bullets. Propane/Butane condensates received in BOG Condensate receivers and Flash Condensate receivers is transferred to Propane/Butane Bullets through BOG Condensate pumps and Flash condensate pumps.

Propane/Butane mounded bullets are emptied by Propane/Butane Bullet pumps discharging to the blending system. During zero send out Propane/ Butane condensate can be fed to Propane/Butane Storage tank-I and II.

2.5.14.15 Precooling Operation

The pre-cooling operation is one of the requirements prior to the ship unloading operation.

During precooling operation, cold Propane/Butane from the Storage Tank I & II is pumped into one of the unloading line going to the Jetty Area, from where it flows towards the Propane/Butane Storage Area and returns into the tank through the other unloading line. The flash gas generated during this operation will be catered by flash compressor.

For precooling during propylene/propane unloading scenario two additional lines shall be installed (in future) from storage tank till jetty to avoid any contamination of propylene and propane inventory.

2.5.14.16 Emptying Unloading Line

For emptying unloading line the contents in the unloading line will be transferred to the Storage Tank. After ship unloading operation is complete, field Operators should open all isolation valves on the recently operated unloading lines. Hand-control valve on the recently operated unloading lines is to be kept 5 to 10% open for at least one or two days until temperature in the recently operated unloading lines rises. During this period, a portion of the hold-up liquid will get transferred to tank due to expansion.

DCS Operator shall close hand-control valve using hand controller. Field Operator shall open all isolation valves including ON/OFF valves.

Hot vapours from the Flash compressor discharge are introduced subsequently in unloading line by opening isolation valves. Hot vapours will enter line and push the liquid toward the jetty and then is pushed into the Storage Tank by other unloading line.

After the evacuation of liquid is completed, Field Operators shall close all ON/OFF valves in liquid evacuation loop and close Hand-control valve using hand controller.

During this period, DCS operator has to closely monitor the rise in tank pressure and carry out loading, unloading of the compressor based on tank pressure whenever required.

2.5.14.17 Sick Tanker Unloading

During filling of tanker if any tanker becomes sick the following procedure is to be followed to evacuate the tanker.

Butane/LPG Sick Tanker Unloading:

Field operator will ensure that Sick tanker is connected properly to Butane bullet through Vapour balancing line. Field operator will ensure that Sick tanker bottom is connected to pump which will transfer the liquid butane/LPG to Butane Bullet.

Sick tanker unloading is done by unloading pumps located near TLF. After sick tanker unloading is complete, close isolation valve on vapor line. The remaining vapors of road tanker are either recovered by connecting to the suction of BOG compressors or vented to the flare header. Remove coupling from sick tanker top. Drain the liquid propane/butane from sick tanker bottom to flare header.

Pure Propane and Propylene Sick Tanker Unloading:

Field operator will ensure that Sick tanker is connected properly to Propane/Propylene Bullet through Vapour balancing line. Since there is no pressure difference available in sick tanker and Bullet, Pump is required to transfer Sick Tanker Liquid to Propane/Propylene bullet.

Field operator will ensure that Sick tanker bottom is connected to pump which will transfer the liquid butane/LPG to Butane Bullet.

Sick tanker unloading is done by unloading pumps located near TLF. After sick tanker Unloading is complete, close isolation valve on vapour line. The remaining vapours of road Tanker are either recovered by connecting to the suction of BOG compressors or vented to the flare header. Remove coupling from sick tanker top. Drain the liquid propane/butane from sick tanker bottom to flare header. EPC contractor shall further develop the procedure for unloading of sick tanker based on Configuration of gantry and tanker.

2.5.14.18 LPG Barge (Pressurized) Loading for Export

The Barge size is expected to handle LPG will range from 1800 to 5000MT. The pressurized LPG loading rate will be about 220t/hr. LPG product will be diverted to ship loading line in-lieu of TLF. The process and the jetty system shall be designed to handle the pressurized LPG export system safely. The process conditions considered for the barge are (i) Operating Pressure - 6 to 13 kg/cm^{2}g (ii) Operating Temperature - 15 to 45deg C (iii) Design Pressure - 18 kg/cm^{2}g (iv) PSV Set Pressure - 17.6 kg/cm^{2}g. Also the terminal shall be designed to handle vapour from barge during emergency. The vapour from ship shall be routed to the terminal's flare system. The initial vapour load considered for designing the vapour line is 12t/hr.

2.5.14.19 Floating Storage and Offloading (FSO)

Depending on the business requirements, LPG will also be handled through FSO mode in addition to land-based terminal as part of RMP. FSO is planned with a maximum storage capacity of the compartments of vessel not more than 25000 MT (interim arrangement) as a part of Revised Master Plan. It is pertinent to mention that most of the impacts and Risks scenarios predicted for Onshore LPG terminal will remain same or less compared to FSO and the measures suggested for Onshore LPG terminal will holds good for FSO.

The FSO is a permanently moored floating vessel for storage and offloading of LPG. It is permanently moored (stationed) for operation using a turret mooring system (tower like structure attached to the FSO). The FSO's mooring system will be installed at the forward end while the offloading platform will be installed at the rear end.

2.5.15 Container Terminal

The major factors effecting the area requirement for the container terminal are as given below.

- Utilization Factor
- Dwell time
- Stack height

2.5.15.1 Utilization Factor

Utilization factor of the yard is depends on the RTG size. For Container Terminal facility 6 wide + 1 truck lane and 1 over 5 high RTG crane has been selected. However, for this layout and RTG system 0.6 utilization factors has been assumed.

2.5.15.2 Box Sizes

Presently in India the proportion of 20' boxes is relatively high as compared to world standards. This is basically due to existing road infrastructure and also due to lower stowage factors and hence, the smaller boxes are more economical. Internationally the ratio of TEU / Box is around 1.4 and there is an on-going trend towards larger boxes. However, it can be assumed that in India the ratio of TEU / Box shall ultimately reach 1.3. For a typical distribution, the critical container weight for mixes of 20' and 40' containers has been considered about 23 MT.

2.5.15.3 Dwell Time

A Container Terminal capacity is directly proportional to the dwell time. In a fully operating and well managed terminal, 10 days for imports is quite practicable.

The **Table 2-20** shows, for different type of container cargo different dwell times has been considered for detailed calculations.

Table 2-20: Dwell time for different Container Yards

Yard Type	Dwell Days
20' Export / Import & 40' Export / Import	
MTs (other than ICD)	10
Fulls (Other than ICD)	10
Reefer	10
ICD (Fulls + MTs)	10
Transhipment	
20' Transhipment	20
40' Transhipment	20

2.5.15.4 Stack Height

The import stack height must be kept in such a way that it easily reaches, prevents congestion or extra handling operations. Each container is destined for a particular client and/or destination and each must therefore be easily accessible. For the proposed facility stack height of 4 to 5 m has been considered. **Table 2-21** shows the stack height which has been considered for the yard area calculation.

Table 2-21: Stack Height for different Container Yards

Yard Type	Stack Hight (m)
20' Export / Import & 40' Export / Import	
MTs (other than ICD)	5
Fulls (Other than ICD)	5
Reefer	4
ICD (Fulls + MTs)	5
Transhipment	
20' Transhipment	5
40' Transhipment	5

Following calculation represents the requirements for Container Yard. However, certain assumption has been done to evaluate the requirement of TGS such as Peaking factor as 1.20, yard utilization as 0.6. etc.

Total Ground Slots required for ICD and Reefer is about 79200. Based on the total required TGS, the yard area has been worked out considering 7 wide container stacks with 1 truck lane. The RTG arrangement has been done back to back position with additional high-mast space after every 4 RTG modules. Each alternate module has been spaced for the truck passing lane for having flexibility of the container cargo movement in yard. The provision of reefer platforms has been also kept in the terminal. Detailed planning shall be reviewed again during execution phase.

2.5.16 SPM

Single point mooring (SPM) is a floating buoy/jetty anchored offshore to allow handling of liquid cargo such as petroleum products for tanker ships. Two no’s of SPM will be located at 6.7 km (approx..) from the shore-facility and connected using sub-sea and sub-oil pipelines, these single point mooring (SPM) facilities can even handle vessels of massive capacity such as VLCC. The offshore-anchored loading buoy is divided into different parts having dedicated functionality. Mooring and anchoring system, buoy body and product transfer system are the main parts of the SPM[5].

The SPM is moored to the seabed using mooring arrangement which includes anchors, anchor chains, chain stoppers etc. The mooring arrangement is such that it permits the buoy to move freely within defined limits, considering wind, waves, current, and tanker ship conditions. The buoy is anchored to the seabed using anchor chains (legs) which are attached to the anchor point (gravity based or piled) on the seabed. Chain stoppers are used to connect the chains to the buoy.

The part of the Single Point Mooring System (buoy body) which is floating above the water has a rotating part which connects to the tanker. The rotating part allows the tanker to get stable at its desired position around the buoy. The tanker is usually moored to the buoy by means of a hawser arrangement, which consists of nylon or polyester ropes shacked to an

[5] *Source: www.marine insight.com*

integrated hook on the buoy deck. Chafe chains are connected at the tanker end of the hawser to prevent damage from tanker fairlead. The mooring systems used for such offshore operations follow the standards put forth by Oil Companies International Marine Forum (OCIMF).

The product transfer system is located at the heart of the mooring buoy. The system transfers products to the tanker from the Pipeline End and Manifold (PLEM) (geostatic location) located on the seabed. Flexible hoses known as risers connect the subsea pipelines to the buoy's product transfer system. The buoy is connected to the tankers using floating hose strings, which are provided with breakaway couplings (A special type of coupling with a break point which will break at a predetermined break load, activating internals valves which will automatically close at both ends and prevent further release of products) to prevent oil spills

2.5.17 Dredging and Reclamation

Dredging will be carried out at proposed berthing areas and for widening of existing approach channel. The estimated quantity of total dredging is 85 Mm^3. Entire dredged material will be used for reclamation of proposed backup areas and level-raising of low-lying areas upto approximately + 5 m CD.

Total proposed quantity for reclamation including landfilling is estimated about 138 Mm^3 which will be used for reclaiming 1145 Ha area. Maintenance dredging quantity is estimated about 1.25 (Avg) – 3.2 (Max) Mm^3/annum. The maintenance dredging material will be disposed at the offshore disposal ground as identified through hydro dynamic modelling study.

Additional material if required for level raising and area development will be sourced tentatively from Satyavedu (Chittoor District, Andhra Pradesh) - 65 km from the site, Walajah (Tamil Nadu) - 140 km from the site; Karadipudur (Tamil Nadu) - 80 km from the site. However, other quarry sites will also be explored if need during the execution of the project for which necessary permission from local competent authority will be obtained if required. Ready mix concrete will be made out of the basic raw material on site itself. Batching plants of respective size and capacity as per requirement will be installed at the site. If required, temporary load out facilities with storage for transport of raw materials at suitable site, through barges will also be explored. Impacts due to dredging and reclamation are discussed in **Section 4.5.2.8** of **Chapter 4**.

2.5.18 Operational Time

It is assumed that proposed RMP facilities will work round the clock, seven days a week. Allowing 15 days weather downtime, the effective number of working days will be 350 days / year, subject to limiting current and tide conditions.

2.5.19 Internal Roads

The approach road leading to the container terminal, dry bulk & liquid terminals widens out near the main terminal gates where security checks will be undertaken.

2.5.19.1 Road structure

The approach roads to the container terminal and dry bulk & liquid terminal area are designed taking into consideration the density of traffic and the wheel pressure of the tractor trailers, tankers, trucks, etc. All roads are designed to IRC 20-ton axle load.

2.5.19.2 Maintenance of Road

Road maintenance work is to be carried out as per IRC Code 82-1982. The Maintenance work will involve following tasks.

- Restoration of rain cuts
- Maintenance of earthen shoulders
- Maintenance and repairs work in connection with bituminous work viz. filling potholes and patch repairs, fog seal, crack fill, resurfacing of carriageway, etc.

However, major maintenance by resurfacing the carriageway will be required in every 5 years.

2.5.19.3 Street Lighting

Street lighting will be installed on the roads street light poles of sufficient height at sufficient spacing with 15-20 Lux average level of illumination.

2.5.20 External Connectivity

2.5.20.1 Proposed Road Connectivity

The Kattupalli Port has good network of roads and railways. NH-5 (Chennai-Kolkata) is about 15.9 km from project site. The project site is connected to NH-5 at Panchetty and Jaganathapuram via two routes.

- Route 1: Kattupalli port-Minjur-Elavembedu-Ponneri-Panchetty
- Route 2: Kattupalli port-Minjur-Elavembedu-Jaganathapuram

A 100 m wide ROW for Road Corridor is also proposed by TNRDC as Northern Port Access Road (NPAR) to connect both Ennore and Kattupalli Port to NH-5.

A Four (4) lane TPP road is also existing which also improves the road connectivity to the Kattupalli Port. The North Port Access Road mentioned above in its first phase links to this TPP Road at Vallur Junction.

The existing road connectivity to Kattupalli port is given in **Figure 2-41**.

Figure 2-41: Road Connectivity to Kattpalli Port

2.5.20.2 Proposed Railway Connectivity

For the rail connectivity of Kattupalli port, the nearest IR network is Chennai-Howrah trunk route of double line electrified section with the provision of automatic signalling.

Presently, there is railway line near to the Kattupalli port which is serving to the NCTPS and KPL as siding and is taking off from Attipattu & Attipattu Pudunagar with the provision of Y junction on existing main line of Chennai – Howrah route which is under the administrative control of southern railway's chennai division of Indian railways.

The rail connectivity to existing Kattupalli port is also proposed from the nearby railway line and is termed as southern link. However, in parallel to RMP to cater immediate cargo evacuation requirement, connecting to southern rail link is being taken up and separate CRZ clearances for the same has been obtained by MIDPL.

In future the existing facility of southern connectivity of the Kattupalli port, will not be sufficient to cater the projected increase in traffic of the port as well as operationally there will be need of another railway link to the Kattupalli port which is proposed from Minjur station, situated on the north side of existing railway link and is termed as northern link. Rail corridor lengths within and outside the port has been mentioned in the **Table 2-22**. However, feasibility of alignment of proposed corridor will be checked during detailed study.

Table 2-22: Details of Rail Corridor

Details off Rail Corridor		
	Northern Link (Double Line)	Southern Link (Double Line)
Inside Port	12.32 Km (Running Length)	2.29 Km (Running Length)
Outside Port	1.5 Km (Running Length)	3.74 Km (Running Length)

Over and above, sufficient number of reception and dispatch yard lines will be provided as per the requirement.

Following facilities has been proposed to handle the projected traffic in proposed RMP of Kattupalli Port

- Construction of new operation/commercial building, Rest room facility for railway crew and Guard
- Wagon Loading Silos - 8 no with full rake length Pre & Post line with each silo
- Fertilizer - 3 lines of full rake length with engine escape facility and with Godowns
- Container handling yard - 15 lines of full rake length
- Liquid handling line - 2 no with decanting and loading facilities
- R&D yard with suitable traction facility
- Loco Spurs
- Sick wagon sidings
- In-Motion weigh bridges
- In northern connectivity, augmentation of existing Minjur SSP at take-off point by providing separate circuit breaks to isolate ports line from railway main line. Provision of new SSP at crossing station for maintenance & isolation of OHE in case of faulty condition
- In Sothern connectivity, provision of new SSP for maintenance & isolation of O.H.E in case of faulty condition

2.5.20.3 Proposed Inland Waterway Connectivity

Buckingham Canal is passing through the proposed RMP, which has also been declared as prestigious National Waterway-4 project by GoI. NW-4 has a vast coverage having a length of more than 1000 km connecting the coastal areas from Pondicherry to Kakinada. It also connects inland area via Krishna & Godavari Rivers. In NW-4 barges of capacity 300 Tons (40m X 9m) will be navigating, which requires 1.5 m draft.

To augment the efficacy of NW-4 and treating it as great opportunity, evacuation by waterways is also proposed just like railways and roadways in RMP.

Waterway Evacuation is considered approximately 5% of total projected traffic.

Two 'weirs' at both ends of berthing area are proposed which will maintain same water level as that of Buckingham Canal all around the year and will also not obstruct water flow during heavy monsoon season.

2.5.21 Amenities/Facilities

2.5.21.1 Communications & Automation Facilities

Provisions will be made in the civil works for the installation of fibre optic data and telephone cables by the installation of ducts and draw pits to allow connection between the operation area, administration building, the gate house, customs, and all other major installations. In general duct runs for data cables will follow the main service routes.

The automation system at the port will be designed for controlling and safety of the port facilities. Dedicated control rooms are proposed in material handling facilities, LPG/LNG re-gasification facilities, container terminal facility, overall port operation centre which will be designed to monitor and controlling the process, utility, jetty, fire & gas and other port operational area as per OISD & port guidelines.

Emergency shutdown systems are proposed in all critical areas. DCS/ SCADA /PLC systems are proposed in Material Handling facilities, LPG/LNG re-gasification facilities, container terminal facility.

Preliminary HAZOP and risk assessment study has been carried out as part of EIA (presented in **Section 7.1** of **Chapter 7**) and detailed HAZOP and risk assessment study will be done during design stage for critical process like LPG/LNG for process safety and recommendation will be implemented during design stages.

Port operation related automation like Fuel management system, Port information management system, GPS, Tugs and Dredger fleet management system will be implemented during design stages.

2.5.22 Water and Power Availability

2.5.22.1 Water Availability

Water supply for proposed RMP development will cover the following.

- Potable water for consumption of operating personnel
- Potable water for ships calling at the port
- Water for construction activity
- Water for dust suppression system
- Water for fire fighting
- Water for greenbelt development

Water requirement during construction activity will be approximately 0.8 MLD, which will be met through the bowsers and existing water supply system. Water requirement during operation phase of RMP will be 30 MLD, which will be met by proposed desalination plant of total capacity 30 MLD. The source of water for this desalination plant is sea water. Suitable intake and outfall location has been proposed based on modelling studies (**Section 4.4.2.2** of **Chapter 4**). Raw water of 75 MLD will be sourced from sea and reject of 45 MLD will be discharged back into sea. Feasibility of groundwater use will also be explored which will be finalized during the course of detailed study and necessary permissions will be obtained from the competent authority.

Sewage generated during construction phase, 20 KLD will be treated in STP. Sewage and effluent generated during operation phase will be treated in STP and ETP respectively. Estimated capacity of Modular STP and ETP for RMP will be 240 KLD and 1500 KLD respectively. Treated STP water will be recycled for horticulture use and treated ETP water will be recycled and used for sprinkling and sanitary application.

Process water for Cryogenic facilities will be taken from sea and discharged back in to the sea. Estimated quantity of process water is approximately 120,000 cu.m /hr for proposed RMP.

Best suitable location of intake and outfall, for regasification, has been proposed based on modelling studies presented in **Section 4.4.2.2** of **Chapter 4**. Sea water may be utilized for fire-fighting purpose.

2.5.22.2 Desalination Plant System

Desalination plant details are listed below

Existing Desalination Plant details with in port limits

Govt., of Tamil Nadu and CMWSSB has established a 100MLD sea water desalination plant at Kattupalli Minjur. The quantity of raw water drawn at intake is 235 MLD and quantity of product water produced is 100MLD.The selected process for the Desalination Plant at Minjur is Reverse Osmosis (RO) Membrane Conventional Method. The reject water from the RO is discharged into the sea at the outfall location through 1600 mm diameter HDPE pipeline.

Proposed Desalination Plant details

A 30 MLD seawater desalination plant is proposed by MIDPL to meet the water requirement for proposed Revised Master Plan. The quantity of the raw water drawn will be 75 MLD and quantity of product water produced will be 30 MLD. The final product water will be utilized for the operational purpose for MIDPL.

Intake and Outfall

Intake and outfall location for the proposed Desalination Plant has been studied through modelling studies. Details are provided in **Section 4.4.2.2** of **Chapter 4**.

Desalination Process:

Desalination refers to a water treatment process whereby salts are removed from saline water to produce fresh water. The proposed desalination process will make use of Reverse Osmosis (RO) technology to remove salt from sea water, thereby producing fresh product water as well as high salinity brine. The flow of Desalination plant process is attached herewith. The main elements in the desalination process are:

1. Seawater intake;

2. Pre-treatment of feed water, which would include screening, clarification, floatation and filtration to remove suspended solids;

3. Desalination, making use of RO technology, in which pressurized feed water passes through a series of membranes which allow only water (low saline permeate) to pass through and salts and organic matter to accumulate in brine;

4. Post-treatment (remineralisation and disinfection) of process water; and

5. Discharge of brine from the desalination process.

A Sea Water reverse osmosis system consists of four major components/processes:

- Pre-treatment,
- Pressurization,
- Membrane separation, and
- Post-treatment stabilization.

The following description illustrates the basic components of a reverse osmosis system.

Pre-treatment:

The incoming feed water is pre-treated to be compatible with the membranes by removing suspended solids, adjusting the pH, and adding a threshold inhibitor to control scaling caused by constituents such as calcium sulphate.

Pressurization:

The pump raises the pressure of the pre-treated feed water to an operating pressure appropriate for the membrane and the salinity of the feed water.

Separation:

The permeable membranes inhibit the passage of dissolved salts while permitting the desalinated product water to pass through. Applying feed water to the membrane assembly results in a freshwater product stream and a concentrated brine reject stream. Because no membrane is perfect in its rejection of dissolved salts. a small percentage of salt passes through the membrane and remains in the product water. Reverse osmosis membranes come in a variety of configurations. Two of the most popular are spiral wound and hollow fine fibre membranes. They are generally made of cellulose acetate, aromatic polyamides. or, nowadays, thin film polymer composites. Both types are used for brackish water and seawater desalination, although the specific membrane and the construction of the pressure vessel vary according to the different operating pressures used for the two types of feed water.

Stabilization:

The product water from the membrane assembly usually requires pH adjustment and degasification before being transferred to the distribution system for use as drinking water or industrial purpose. The product passes through an aeration column in which the pH is elevated from a value of approximately 5 to a value close to 7. In many cases. this water is discharged to a storage cistern for later use.

<u>Proposed Pipelines</u>

It is proposed to lay pipelines to accommodate the full capacity of plant to carry raw water. Treated water through HDPE pipeline (to avoid corrosion) from desalination plant to port and the reject water is disposed off using GRP pipelines.

<u>Technological Consideration for Desalination Plant</u>

Desalination Plant is proposed near the existing WTP. Treatment broadly would comprise following units:

Clarification + Oil & Dissolved gases removal + Depth Filtration + Fine Filtration + RO Membrane unit

<u>Clarification</u>

Various clarifier options are available such as Conventional Clarifiers, Solids re-circulation Clarifiers, Sludge Blanket Clarifiers, Dissolved Air Floatation, Lamella Clarifiers and Tube Settlers.

Lamella clarifiers and Tube Settlers require about half the foot print area of Conventional Clarifiers and Solids re-circulation Clarifiers. The power consumption of Lamella clarifiers and Tube Settlers is also less in comparison with Sludge Blanket Clarifiers and Dissolved Air Floatation units. However, tube settler clarifiers are selected over Lamella clarifiers for the desalination plant.

Oil & Dissolved gases removal

Chlorination, Aeration and Dual media filters options are available for Oil & gas removal. Dual Media filters are used commonly for this application in view of no power requirement and chlorine requirement. The same are proposed for Kattupalli Desalination Plant.

Filtration

Pressure filters and Gravity filters are 2 commonly used methods of depth filtration. In case of Kattupalli, Pressure Filters (DMF+PSF) are proposed to reduce the construction time, avoid re-pumping after filtration and in view of small capacity of the desalination plant.

Fine Filtration

The RO membranes require in feed water with Silt Density Index (SDI) < 3. Suspended solids of size above 5 micron are not allowed in RO system to avoid any damage to RO membrane/element. In order to remove the suspended solids of micron sizes in DMF, PSF and Micron Cartridge Filters are introduced before RO system as fine filtration.

The filtration and fine filtration units get combined in Ultra-Filtration membranes, however they are much higher in capital cost. Hence micron cartridge filtration (5 Micron size) is proposed for fine filtration. Following are the basic reasons of using Micron Cartridge Filter in RO System:

1. The ability of cartridge filters to remove suspended particulates, colloids and larger colour causing organics from the feed stream greatly impacts the performance and longevity of any RO equipment

2. Micron Cartridge Filter are designed to decrease SDI, Colour and turbidity which are the key factors that impacts on life of RO membrane.

3. In general, 5 to 10 micron bacteria in width or length for non-spherical species are found, hence the micron filter of 5 micron size will be able to remove most of the bacteria and cyst in water.

Reverse Osmosis Trains

It is proposed to use of Sea water RO membranes for treating TDS higher than 35,000 mg/L. In this case separate set of pumps will be required. Eventually there will be 2 trains of SWRO and cost of RO section of the plant will be substantially higher.

Recirculation of concentrated brine back to inlet to increase the salinity of the resultant feed to RO. However the operating cost will be higher in view of higher feed water TDS.

Presently SWRO membranes are available which work on varying TDS from 2000 to 45,000 mg/l. At Kattupalli the scheme being proposed comprises varying the operating head of the RO system to match the TDS requirement. Hence common SWRO trains will be fed with 2 pumps in series, for pressures between 5 – 15 bar, the 1st High Pressure (HP) pump will become operational which will also be operated on variable speed and for pressures between 15 and 40 bar, the 2nd High Pressure pump shall be operated in series, this system will give higher recovery at lower TDS for the same pressure. The average operating pressure will be in the range 18-40 bar and hence the operating costs will also be much lower. Considering the overall advantages of lower capital & operating costs, this option of 2 SWRO trains with 2 High Pressure pumps in series operating at variable recovery is proposed for Kattupalli Port.

SWRO trains will reduce the TDS in the range 250 – 1500 mg/L, however the water will be devoid of necessary minerals, hence it proposed to have 2 trains of SWRO only to cater to the requirement of potable water. The recovery shall be designed for 85%. Re-Mineralisation shall be provided for the product water so generated to make it suitable for potable use.

Outfall / Reject Disposal System

Reject from RO System (Brine) shall be conveyed to sea shore near jetty from SWRO plant. Concentrated Brine which coming from RO, itself has pressure, so this pressurised brine can be transported to the disposal point through GRP / HDPE Pipe of suitable diameter/ diffuser arrangements.

The entire treatment process is given below:

The RO system shall be of single stage designed for a total permeate water production of 30 MLD. RO unit will be designed for an inlet TDS of above 35000 and will have a overall recovery of 40%. In order to allow for better flexibility in operation and maintenance and at same time to reduce the capital cost of the plant. The RO unit shall be based on two (2) number of trains/streams.

The RO units shall consist of High pressure pumps, RO membranes housed in pressure vessel, Energy recovery device, Booster pump and interconnecting pipes with header and valves. The treated water form Micron Cartridge filter shall divide into two streams as per recovery. One stream will directly pumped to RO membrane by high pressure pump. Other stream will pass through energy recovery device which will increase the feed pressure and further through booster pump. The booster pump will compensate the pressure between the energy recovery side stream to high pressure pump side stream. Both streams shall combine and pumped to RO stream. There will be one (1) high pressure pump, Energy Recovery device and booster pump for each train. Each of the pump and its drive motor shall be mounted on a single base frame. These pumps are operation by variable frequency Drive.

The Influent seawater entering the RO membrane at high pressure will divided into two stream, the permeate stream which is free form dissolved solids that leaves RO Membrane at low pressure and RO reject stream. Enriched with dissolved solids leaves at high pressure.

RO membrane act as a filter retaining all the dissolved species bigger than 1 Angstrom (eg. Bacteria, virus, organic matters) as well all monovalent and bivalent ions. The membranes selected for the process were the spiral wound membranes due to the lowest energy requirements and low cost as compared to other tubular, plate-and-frame and hollow fiber modules.

The most frequently used energy recovery devices are Pelton Turbine & Pressure Exchanger. In the Energy Recovery Device the pressure available in the RO reject brine stream is transferred to RO feed stream and thereby reduces the pumping cost., As the energy recovery of pressure exchanger is more than turbine, press exchanger type energy recovery system is considered. Pressure Exchanger type energy recovery device which recover 95% of the energy form the RO reject and transfer the pressure to the feed seawater. The permeate water will pass through suck back tank, degasser and finally stored in permeate storage tank. The suck back tank is to protect the RO membrane and Degasser to remove the dissolved CO_2 from the permeate water. The permeate water from the storage tank will be pumped after suitable pH correction. The brine from RO modules, PSF & UF back wash & the rinse water, overflow/drain cleaning and all other drain flow are collected in a common tank and form there, outfall water will be pumped by 3 x 50% Reject water pump back to sea and disposed into the sea with proper diffuser to dilute the brine without affecting marine ecological system.

Chemical Cleaning & RO Flushing System

RO skid will be provided with flushing arrangement. The RO membranes will be cleaned regularly with RO cleaning chemical solution. A dedicated set of solution preparation tank and pump, cartridge filter etc. will be provided for this purpose for RO system.

This system comprises of a chemical solution preparation tank, a micron cartridge filter unit, chemical cleaning pump & flexible hoses cleaning of membrane is carried out at a regular duration for any deposition of organic salts, suspended matters, microbiological impurities on membrane surface over a continuous period of usage. The cleaning chemical is passed in the same direction as that of feed water flow to remove the deposition from membranes. Prescribed chemical solution of required concentration is prepared in tank. It is re-circulated with the help of chemical cleaning pump and micron cartridge filter through RO system at specified flow rate and pressure after primary flushing with permeate water. After cleaning, permeate shall be used for RO system flushing and final cleaning. The RO plant including chemical cleaning will be manually initiated and operated by PLC with necessary manual intervention.

2.5.22.3 Power Availability

The power distribution system planned is simple to operate and maintain high reliability, being accessible for inspection and repair with safety.

Designing of electrical distribution system ensures that voltage at the utilization equipment is maintained within the tolerance limits under all load conditions since poor voltage regulation is detrimental to the life and operation of the equipment.

The electric power requirement during construction phase will be approximately 2 MVA which will be sourced from the existing power source and 125 KVA from DG Sets. Electricity requirement during operation in RMP will be approximately 100 MVA. During operation of RMP, power back up in form of DG sets will be available to the tune of approximately 40 MVA. Diesel consumption for the same in RMP will be to the tune of 1350 Lit/hr respectively and Tamil Nadu Electricity Board (TNEB) will provide additional power supply from the Athipattu substation to the existing substation in the port premises to meet the power demand.

2.5.22.3.1 Lightning Protection

Lightning protection will be provided for all structures in accordance with Indian Standard code of practice IS: 2309-1969 or other internationally recognized standards. The system will be complete with air terminations, down conductors, testing joints and electrodes.

2.5.22.3.2 Area Lighting

Adequate provision for general and security lighting of the jetties and other port areas, and access roads etc. will be provided. The plant lighting system includes the normal AC lighting and emergency AC lighting which contributes together 100% lighting as well as emergency DC lighting in selected areas of the plant during plant emergency conditions. The emergency AC lighting will provide about 30% of the total AC lighting in select areas.

The plant lighting (illumination level) is varying at different locations of the plant depending on the utility and nature of work expected to be carried out at that area.

Following approximate average levels of illumination will be ensured while designing the lighting system.

- Terminal and Stacking area: 15 Lux
- Roads and Permanent ways: 20 Lux
- Car Park and Parking Area: 15 Lux
- Jetties: 15 Lux
- Container Yard: 35 Lux
- Control Room and Equipment: 300 Lux
- Office Rooms, Relay Rooms: 300 Lux
- Switchgear Rooms, MCC Rooms: 150 Lux

2.5.22.4 Buildings

2.5.22.4.1 Administration Buildings

The Administration Buildings shall house office for finance, marine, operation, marketing, planning, environmental safety and engineering departments with conference hall, banks/ATM, HR & Admin, commercial, Horticulture, CSR, canteen and parking facility etc. It will be a building of RCC structures with pile foundations with a floor area of 1500 m^2. There are three such buildings proposed in the RMP at different locations.

2.5.22.4.2 Port and Marine Operations Building

The Vessel Traffic Management Service (VTMS) Control Centre will be located in this building. It will have a commanding view of the access and entrance channels and the berths. This will house the VTMS operator work stations with facilities to monitor and control the complete Vessel Traffic Management System. The building will have control towers for housing the control panels and ancillary equipment and will also be provided with suitable communication systems to contact ground staff. The port and marine operation building is having total area of 1000 m^2 of RCC structures with suitable foundations.

2.5.22.4.3 Port User Buildings

Three Port User Buildings are proposed which would consist of offices for shipping companies, cargo agents, freight forwarders, stevedore services, custom agents, Canteen and parking facility. It will be a building of RCC structures with pile foundations with floor area of 2500 m^2. The planning, interior and exterior finishes and sanitary facilities will be in accordance with modern architectural practice.

2.5.22.4.4 Electrical Buildings

Various substations and control rooms will be located near Switch yard and it the other area as per requirement. Smaller satellite substations and electrical rooms will be provided at various locations in the terminal areas as well as at rear of the berths.

2.5.22.4.5 Main Gate House Complex

These mainly consist of gates for entry and exit of truck trailers and other vehicles, staff buses, etc. Three main gate house complexes are planned, in which three buildings with an area of 500 m^2 each are proposed. Sufficient numbers of incoming and outgoing gates will be provided to avoid traffic congestion at each terminal gate complex. There will be provision of cabins for customs and security personals near the main entrance and exit gates of the terminals to ensure speedy implementation of customs and security regulations.

2.5.22.4.6 Rail Administration Building

Rail operation and various other activities (Signalling & control, FOIS, Running Rooms, C&W staff, Loco shed, sick wagon shed, stores) related to the rail operations will be controlled through various buildings comprising of total area of approx. 500 m² with RCC or Pre-engineering building with suitable foundation. These buildings will be located near rail tracks inside port at various suitable locations for rail operations.

2.5.22.4.7 Workshop/Stores

These mainly comprise of a central maintenance / stores buildings having total area of 2250 m² will be located at the rear of the container terminals. The building will be provided with suitable foundation. This building comprises a repair workshop and servicing facilities for mechanical and electrical repairs for all plant and equipment. This will also house the spare part warehouse and the offices of the workshop and service facility staff.

2.5.22.4.8 Fuelling Station

Two fuelling stations of 300 m² of RCC structures with suitable foundation will be provided inside the port to cater to the requirements of ITV's and other vehicles used. The **Table 2-23** shows proposed building with area summary.

Table 2-23: List of the Buildings with area summary

Name of the Building	Approx. Area (m²)	Nos	Area, (m²)
Administration Building	1500	3	4500
Port and Marine Operations Building	1000	1	1000
Port User Building	2500	3	7500
Electrical Buildings	500	8	4000
Main Gate House Complex	500	3	1500
Rail Administration Building	250	2	500
Workshops	750	3	2250

The above list of the buildings along with the area is tentative and subject to change based on the business scenario and type of cargo.

2.5.23 Requirement of Basic Raw Material

The requirement of the basic raw material for RMP will be as given below.

Coarse aggregate – 32.5 MMT

Fine aggregate (Sand) – 21 MMT

Stone – 50MMT (Breakwaters will be developed either through rocks/slag or any other suitable materials which will also be explored for using in combination while carrying out detailed engineering)

Dredge Material – 85 Mm^3

However, Basic raw material for construction is available in near vicinity of Kattupalli port. Ready mix concrete will be made out of the basic raw material on site itself. Batching plants of respective size and capacity as per requirement will be installed at the site.

2.5.24 Seawater Intake and Outfall System

To meet the sea water requirement for the LNG/LPG plant an intake system is proposed. Also a marine outfall is planned to discharge the return cooling water from the LNG/LPG terminal proposed as a part of Revised Master Plan. The seawater intake quantity is 1,20,000 m^3/h. The discharge is through a pipeline with a diffuser system at the point of disposal. The disposal location is finalised based on the modelling studies carried out by M/s DHI. This location has been finalized as it is getting easily dispersed to achieve sea water ambient temperature and also it does not have any recirculation issue.

- Intake system – 431449.36 Easting (m); 1471780.45 Northing (m), UTM 44 at -25 m CD depth
- Outfall system – 431417 Easting (m); 1472902 Northing (m), UTM 44 at -11.5 m CD depth – based on the MP layout

2.5.25 Environment Management

2.5.25.1 Dust Suppression System

Dust suppression equipment will be provided for efficient control of dust pollution on environment during storage and handling of coal, iron ore and other dry bulk cargo at berth and stockyard. An efficient dust suppression system will contain dust particles before it is airborne. A common system consisting of suitable pump, storage tank, nozzles for dust suppression at discharge / feeding points of belt conveyors have been proposed at each transfer tower for efficient dust control system. In addition to above suitable spray system shall also be provided at ship unloader, stockyards & wagon loading station. Various measures such as physical buffer, green buffer, wind Shield and DSS is envisaged for dust control at following locations.

- Ship unloader discharging in to hoppers
- Stockyards
- Discharge and feeding points of conveyors
- Rapid loading system
- Sprinklers / nozzles will be provided to control dust emission at various points or areas

Dry Fog Dust Suppression System for Receipt and Discharge Points:

Dust Control System works on the principle of agglomeration. Dust particles released from a material handling plant which become air borne, are made to pass through a blanket of extremely fine dry fog. Plain water is mixed with compressed air in a ratio through highly efficient acoustic nozzles which produces millions of minuscule water droplets which when kept entrapped within an enclosure in a dust generating transfer point, can efficiently contain and control even fine dust particle.

Each application point shall be provided with requisite number of Dual-fluid Dry Fog Acoustic oscillating type Nozzles. Flow Control Box is provided for a group of nozzles to regulate the pressure of compressed air and water as per requirement. Maximum moisture addition is within 0.1 %.

Dust Suppression (Plain Water) System for Stockpile Area and Track Hopper:

Wet suppression has proved to be the most effective means for controlling fugitive dust emissions from stockpiles. Moisture is added to capture the dust particles that are already airborne. It is basically designed to prevent lift off of dust from stockpile and road area. It also consists of a Plain water nozzle system for conveyor area and a Track hopper system. The nature and particle size of dust generated in the material handling system changes with change in size and characteristic of the material. In practice, the size of the dust particles has a very wide spectrum. A careful control of Air and Water Flow & Pressure is therefore necessary to obtain optimum dust suppression results. For this purpose, pressure regulators are provided in the system. Dust control is accomplished by spraying water on Mobile hopper & Truck receipt area discharge chute. Water is sprayed in at regular intervals depending on the site condition. The dust control is achieved by the agglomeration of dust particles with finely atomized water droplets equal to/close to/larger than the dust particles as the case may be, the collision between the water droplets and dust particles plays an important role in the process of agglomeration and heavier mass thus formed settles down to the source. Plain water dust suppression has been considered for top of Mobile hopper & Truck receipt area discharge chute. The system has been designed to control dust nuisance of the working environment during un-loading of coal from Grab & at the peripheral location of discharge chute of belt feeder towards truck receipt. In addition, Wind screens will be provided along stack yard.

2.5.25.2 Wastewater management

2.5.25.2.1 Storm Water management and Treatment

Water used for dust suppression in the conveyor transfer points and the stockyards will get absorbed to the extent of the property of the material and remaining water will be collected through proper drainage. During rainy season the rain water over vast stockyard area will also to be collected. For this purpose, the stockyard ground level will be provided with a slope in each of stockyard from the centre to the sides. For collecting water draining out of the stockyards RCC toe drains will be constructed along the length of each row and interconnected to finally lead it to a settlement pond. Settling ponds will be constructed out of concrete. The settled materials will be retrieved and sent back to respective cargo stockyard. The supernatant water will be used for dust suppression.

The storm water runoff of remaining port will be diverted through site grading into the storm water drainage system and will be discharged into sea with suitable outfall arrangement. The details about the storm water management system are provided in **Section 7.3.4** of **Chapter 7**.

2.5.25.2.2 Sewage and Effluent Treatment

Sewage generated from toilet blocks, canteens etc. and effluent generated from liquid tank washing, ship waste reception facilities etc. will be treated in Sewage Treatment Plant and Effluent Treatment Plant respectively. Modular STP of 240 KLD capacities will be developed within the operational area. Modular ETP of 1500 KLD will also be developed within the operational area. Treated sewage will be used for dust suppression, irrigating greenbelt and other requirements. ETP water will be recycled and used for sprinkling and sanitary application.

Sea disposal of treated effluents will also be explored in future for which separate modelling studies will be conducted to identify appropriate outfall location for discharge of treated effluent as per marine discharge standards as prescribed by CPCB. Necessary approval shall be obtained.

2.5.25.3 Solid Waste Management at Port areas

Municipal wastes in the form of canteen wastes, domestic wastes, paper etc., will be generated at Port areas. The solid wastes will be segregated into bio-degradable and non-biodegradable wastes. The degradable wastes will be composted and suitably used for the greenbelt. The anticipated municipal solid waste generation during RMP will be about 0.75 TPD of which 60% will be bio-degradable and 40% will be non-biodegradable. The entire waste generated shall be handled through 5R (Reduce, Recycle, Re-use, Recover & Reprocess) and Zero waste to Land fill initiatives

The hazardous wastes like Used oil, spent oil, Wastes/Residue containing oil, Pig wastes, Oil soaked rags, Cotton waste, discarded containers, barrels & Used Battery and Sludge from ETP will be categorized and disposed through TNPCB/CPCB approved vendors. Hazardous wastes will be handled as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (as amended).

2.5.25.4 Waste Reception Facility

Ships/vessels calling at port will not be permitted to dump any wastes/bilge water/ballast water during the berthing period. The waste reception facilities shall be developed as per the Guidelines issued by Government of India (GoI). The collected wastewater will be treated in ETP / sent to approved vendors for further treatment and the bilge water will be collected by authorized waste recycler and taken for further treatment. Hold washing will not be permitted in the port limit and MARPOL regulation will be implemented. Hazardous wastes will be handled as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (as amended). Hazardous wastes will be disposed through approved TNPCB /CPCB vendor.

The detail of Hazardous waste expected during port operations is given in **Table 2-24**.

Table 2-24: List of Hazardous Wastes

S. No.	Details of Unit Process generating Hazardous Waste as listed in column 2 of Schedule -1	Details of waste stream as indicated in column 3 of Schedule -1	Solid/Semi solid/liquid oily Tarry Slurry Others	Quantity generated/ handled/ year	Waste Management proposed	Possible Source
1.	Schedule I/5-Industrial operations using mineral or synthetic oil as lubricant in hydraulic systems or other applications	5.1 Used or spent Oil	Liquid/Oily	1800 KL/Annum	MS drums, Generation, Collection, Storage, and sold out to registered recycler	From Lube Oil for Equipments, pumps, Vehicles other machineries
2.	Schedule I/3 Cleaning, emptying and maintenance of Petroleum Oil storage Tanks including ships	3.3-Sludge and filters contaminated with oil	Solid/Liquid/ Oily	60 T/Annum	Concrete storage sheds, Generation, Collection, Storage, Reception, Disposal to authorized recyclers	From operational areas / Ships
3.	Schedule I/5-Industrial operations using mineral or synthetic oil as lubricant in hydraulic systems or other applications	5.2 Wastes or residues containing Oil	Solid/Others	500 T/ Annum	MS Drums, Collection, Storage and Transport to TNPCB/CPCB approved TSDF/CHWIF	From Workshops and maintenance of equipments, pumps, conveyors, minor spill clean ups, rail line etc.,

S. No.	Details of Unit Process generating Hazardous Waste as listed in column 2 of Schedule -1	Details of waste stream as indicated in column 3 of Schedule -1	Solid/Semi solid/liquid oily Tarry Slurry Others	Quantity generated/ handled/ year	Waste Management proposed	Possible Source
4.	Schedule 21-Production and / or Industrial use of paints, Pigments, Lacquers, varnishes, plastic and Inks.	21.1 Process wastes, residues and sludges	Solid & Slurry	20 T/ Annum	Collection, Storage and Transport to TNPCB/CPCB approved TSDF/CHWIF	From structures paintings.
5.	Schedule I/33-Handling of hazardous chemicals and wastes	33.1 Empty barrels/containers /liners contaminated with hazardous chemicals /wastes	Solid	200 T/ Annum	MS drums, Concrete storage shed, Generation, Collection, Storage, and sold out to registered recycler	From operational area
6.		33.2 Contaminated cotton rags or other cleaning material	Solid	150 T/ Annum		From operational areas
7.	Schedule I/3-Cleaning, emptying and maintenance of petroleum oil storage tanks including ships	3.1 cargo residue, washing water and sludge containing oil	Liquid	3000 T/ Annum		From operational area
8.		3.2 cargo residue and sludge containing chemicals	Solid	100 T/Annum		
9.		3.3 Sludge and filters contaminated with oil	Semi Solid	50 T/ Annum	Collection, Storage and Transport to TNPCB/CPCB approved TSDF/CHWIF	
		3.4 Ballast water containing oil from ships	Liquid	3000 Kl/Annum	MS Tanks, Generation, Collection, storage, Reception, Disposal to authorized recyclers / for Captive Recovery and Reuse after separating oil from water using Oil Water Separator	From Ships
10.	Schedule I /34.De-contamination of barrels/containers used for handling of hazardous wastes/chemicals	34.2-Sludge from treatment of waste water arising out of cleaning I disposal of barrels /	Liquid/Oily	50 T/ Annum	Collection, Storage, Reception, Disposal to TSDF, Gummidipoondi/ authorized	From operational area

S. No.	Details of Unit Process generating Hazardous Waste as listed in column 2 of Schedule -1	Details of waste stream as indicated in column 3 of Schedule -1	Solid/Semi solid/liquid oily Tarry Slurry Others	Quantity generated/ handled/ year	Waste Management proposed	Possible Source
		containers			recyclers	
11.	Schedule I/35- Purification and treatment of exhaust air/gases, water & waste water from the processes in this schedule and common industrial effluent treatment plants (CETP's)	35.3 Chemical sludge from waste water treatment	Solid/Semi Solid	50 T/ Annum	MS drums, Collection, Storage, Reception, Disposal to TSDF, Gummidipoondi/ authorized recyclers	Waste water treatment plant and sewage treatment plant
12.		35.4 Oil and grease skimming	Solid/Semi Solid	0.75 T/Annum		

The nearest TSDF is located at ~22 km Gummidipoondi village. It is Integrated Common Hazardous Waste Treatment Storage & Disposal Facility (ICHWTSDF) at EPIP SIPCOT, Pappankuppam (V) Gummidipoondi (T), Tiruvallur (D), Tamil Nadu by Tamil Nadu Waste Management Limited in an area of 66 acres. This ICHWTSDF has Secured Landfill and Landfill After Treatment capacity is 300000 TPA, Incinerator HW and BMW of 1.5 TPH, E Waste recycling facility of 16 TPD, Plastic recycling facility of 2 TPD, Spent solvent recovery facility of 5 KLPD, Alternative Fuel and Raw Material Waste of 50000 TPA, Paper recycling facility of 2 TPD, Waste oil or used oil recovery facility 2 KLPD and Bio medical waste facility of 5 TPD. The details of E-waste are given in **Table 2-25**.

Table 2-25: List of E-Waste

S. No.	Details of E-Waste	Type of waste	Quantity generated/ handled/ year	Waste Management proposed	Possible Source
1.	E Waste such as Wiring/Electrical, CRT, LCD, Fluorescent Lamps, Incandescent Lamp, Batteries, LED, computer and its parts	Solid	2 TPA	Collection, Storage and Transport to authorized Recyclers.	E Waste Components

2.5.25.5 Summary of Environmental Aspects

Summary of potential types of pollution in port and measures to reduce the same are given in **Table 2-26**.

Table 2-26: Measures to Reduce Pollution

S. No.	Type	Remarks
1.	Air Pollution	• Covered conveyor and transfer points • Dust suppression system at stockyard, transfer towers, at berth/unloaders, at wagon (un)loading, at track hoppers, at truck loading silos, discharge and feeding points of conveyors etc., • Use of specialised unloaders • Wind screens will be provided along stack yard • Proper house keeping • Trucks before leaving the loading area shall be covered with tarpaulin and also the railway wagons • Trucks tyres and areas susceptible for coal dust before leaving premises shall be cleansed washed to remove coal particles. • Greenbelt

S. No.	Type	Remarks
2.	Noise	• Noise attenuation will be practised for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers. The attenuation devices will be properly maintained. • Workers exposed to excessive noise will use appropriate Personal Protecting Equipment (PPE) including ear plugs, muffs, or both when engineering or administrative controls are not feasible to reduce exposure. • Greenbelt will attenuate the increase in noise levels at landside facility. • To ensure that all the transportation vehicles construction machinery will be periodically checked for minimal noise generation to comply OHSAS and ambient noise standards in the surrounding area. • Labelling equipment at a prominent location to indicate the approximate level of noise it generates in operation will be done.
3.	Soil	• Dredged material will be used for reclamation and any excess/unused dredge material will be disposed at an offshore dumping site • Construction waste will be used within port site for filling of low lying areas. Other wastes which can be re-cycled will be sold. • General refuse generated on-site will be collected in waste skips and separated from construction waste.
4.	Water Pollution	• STP • ETP • Settling pond at coal and iron ore stockyard • Storm water drainage system for Inside and some portion of outside port area
5.	Solid Waste	• 5 R (Reduce /Reuse/Recover/Recycle and Re Process) principle shall be explored • Solid Waste Management Rules, 2016 will be followed for environmental sound management of respective waste • Hazardous waste Management Rules, 2016 will be followed for environmental sound management of hazardous waste. • OSHA standards will be adopted • Hazardous wastes will be disposed through approved TNPCB/CPCB vendors

2.5.26 Fire Fighting Facilities

2.5.26.1 Dry Bulk Berths and Stockyards

The firefighting system at the port will be capable of both controlling and extinguishing fires. It is proposed to install Fire Hydrant System, which will be designed to give adequate fire protection for the facility based on Indian Standard or equivalent and conform to the provisions of the Tariff Advisory Committee's fire protection manual.

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

- Proposed bulk import / Export berths
- Bulk import and bulk export stockyards
- All galleries of bulk import and bulk export conveyors

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

The hydrant service will consist of ring mains to cover the facility, with its pump, located in a common pump house. Adequate arrangement with jockey pumps, pressure switches, etc. will be provided to maintain the required pressure in the hydrant system. The operation of pumps provided for the system will be automatic.

2.5.26.2 Container Terminal

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

The fire hydrant system will be sea water based and designed to ensure that an adequate quantity of water is available at all times, at all areas of the facility where a potential fire hazard exists. There will be provision for connecting the system to the potable water supply in order that the system can be flushed and rested on potable water after a fire-fighting event.

The fire-fighting system will consist of ring main with spur lines to cover the facilities in the yard. Hydrants will be provided at sufficient spacing. Each hydrant connection will be provided with a suitable length of hose and nozzle to permit effective operation. The main fire-fighting pumps will be provided in the pump house located at the western end of the berth.

2.5.26.3 Liquid Jetty and Tank Farm Area

Jetty

The liquid jetty will be provided with fixed fire-fighting facilities according to the requirements of OISD Guidelines. Sea water will be used for fire-fighting facilities. The facilities will include a pump house on trestle, tower mounted water/foam monitors as well as hydrants and water curtains. The proposed firefighting facility for the jetty broadly consists of following.

- A sea water pump house with a control room on top along the approach trestle at adequate safety distance from the loading platform / manifold.
- Two tower mounted foam/water monitors
- Monitors of stand pipe type at Jetty service platform
- Water curtain system at jetty service platform and on the two breasting dolphins.
- Fire hydrants on the jetty service platform, breasting and mooring dolphins and on the pile and trestle
- Leak detection/ Alarm system.

On the fire hydrant line standard double headed hydrants are proposed for installation one on each of the breasting and mooring dolphins and two nos. on the service platform. In addition, it is proposed to provide similar fire hydrants on the pile trestle from the pump room to the jetty along with pipeline at a required spacing.

At any given point of time the fire hydrant pipe line will be capable of supplying water enough for feeding hydrants and the water curtains located on the service platform, breasting and mooring dolphins.

For the jetty and pipeline trestle it is proposed to have fire gas detector and an air sampling type detector. A sampling type detector consists of piping or tubing distribution from the detector unit to the areas to be protected. An air pump draws air from the protected area back to the detector through the air sampling ports and piping. At the detector the air is analysed for the fire products.

It is also proposed to have an alarm system which comes into operation automatically through the fire gas detector and the sampling type detector. This can also be manually operated for conveying fire alert message.

Tank farms

The firefighting system inside the tank farms will be as per the norms of OISD. The fire-fighting system will comprise of a jockey pump (electric driven), main pumps (diesel engine driven), fire water ring main with monitors & spray, foam system for storage tanks. Besides, the fire alarm system consisting of break glass type manual call points at field & fire alarm panel in the fire pump-house/control room.

The fire water header is kept pressurized with the jockey pump and on loss of pressure due to opening of hydrants on the header, the pressure switches activate the pump contacts & main pump start in sequence to ensure adequate pressure and flow is maintained in the system.

The storage tanks have spray rings with nozzle on shell and foam chamber attached to foam nozzle of the Tank. The foam chamber is connected by foam water line to the fixed foam tank outside the dyke. In the event of fire to the liquid in two of the storage tanks, the foam system is activated & foam poured on the top of the burning liquid surface. For the other tanks in the vicinity of this affected tank, the spray system is activated and the tank surface kept cool. Further the small water monitors, hydrants help in large quantity of water being poured onto the tank roof / shell. Small fires will be doused with portable wheeled extinguishers. The manual call points provided in the various areas are for fire warning. In the event of fire being noticed by any personnel, the break glass type call button if pressed will activate the hooter & alarm at the fire alarm panel in Pump-house.

2.5.26.4 LNG/LPG Terminal

A centralized spill, fire and combustible gas alarm and control system provides input to an information management system. Automatic detection devices, manual alarms and audible and visual signalling devices will be generally strategically located throughout the terminal. Automatic detection devices include flame, fire and heat, smoke, low temperature and combustible gas detectors. Emergency shutdown system (ESD) incorporates in the design of the terminal and provides the operators with the capability of remotely shutting down the entire or selective portions of the terminal. The unloading arms are generally equipped with Powered Emergency Release Couplers (PERCs). The PERC maintains containment integrity and prevents damage to the unloading arms in the event of an emergency. Fire-fighting facilities will be provided in the LNG / LPG terminal which operates through centralized alarm & control system. Following fire- fighting facilities will be provided for the LNG / LPG terminal including jetty:

- Fire water storage facility
- Fire water pumps (Motor & Engine driven)
- Motor driven jockey pumps
- Fire water distribution network
- Fire hydrant & hoses
- Fixed deluge spraying system
- Monitors
- Water curtains wherever required
- Clean agent system
- Mobile & Portable fire-fighting equipment
- Appropriate Building protection
- Fire Tender

2.5.27 Greenbelt Development

Adequate greenbelt all along the project boundary and landscaped green spaces will be provided which will serve as lung space. About 97.5 Ha will be developed as greenbelt and other areas. Treated sewage will be used for irrigating greenbelt. Existing Greenbelt development plan was given in **Figure FD0203**. Details of Greenbelt Development (Coverage, Species, budget, Monitoring etc.) are given as part of Greenbelt Development Plan in **Section 9.3** of **Chapter 9**.

2.6 Coastal Regulation Zone (CRZ) Compatibility

Physical demarcation of HTL, LTL and delineation of CRZ boundaries for the project site were carried out by NCSCM which is one of the MoEF&CC authorized agencies.

- HTL, LTL and CRZ demarcation indicate that the proposed storage areas for liquid/gas/cryogenic/ port back up, RoRo and Project/Break Bulk cargo are falling beyond CRZ area.
- Cargo handling operations at berths and transportation, SPM operations, Intake outfall facilities of Desalination and LNG/LPG etc. are envisaged in CRZ area.
- The activities proposed within CRZ area are permissible as per CRZ notification, 2011/2019
- Proposed port location does not contain environmentally sensitive areas such as National parks / marine parks, sanctuaries, wildlife habitats, corals / coral reefs. It also does not include breeding and spawning grounds of fish and other marine life, area of outstanding natural beauty / historically / heritage area, area rich in genetic diversity.

The project development falls in CRZ IB, CRZ III, CRZ IV and the activities proposed within CRZ area are permissible as per CRZ notification, 2011/2019. The project layout superimposed on HTL, LTL and CRZ map is given as **Attachment 1**. Super imposition of RMP layout on Approved CZMP is given as **Attachment 2**.

The CRZ compatibility of the proposed facilities with respect to CRZ Notification, 2011 and 2019 is given in **Table 2-27**.

Table 2-27: CRZ Compatibility of the proposed facilities as per CRZ Notification, 2011 and 2019

S. No	Proposed Facilities	Falling in CRZ area with Classification	Permissible / Not permissible as per CRZ notification 2011, amended till date	Applicable Clause no. of CRZ Notification 2011, amended till date	Applicable Clause no. of CRZ Notification 2019
1	Multipurpose Storage/ Liquid / Gas/Cryogenic Storages areas (With all Operation facilities)	CRZ I (B), CRZ III & CRZ IV	Permissible	3(iv)(a); 4(i)(a)&(f); 8(I)(i)(b)&(c) 8(I)(ii)(f) 8(III)A(iii)(e)(f)(h) 8(III)B(ii)&(iii)&(iv) And Annexure II	2 (2.1.2); 2.3 (2.3.1)(2.3.3)[6] 2.4 (2.4.1);(2.4.2) 5 (5.1.2) (i)(a)(ii)(iii)(iv)(v)(ix)(x)(xiv)(xv)(xviii) (5.3)((ii)(b)(d)(5.4)(ii)(a)(c)(d) (iii)(v)(xiii) And Annexure II

[6] *The NDZ shall not be applicable in the areas falling within notified Port limits*

S. No	Proposed Facilities	Falling in CRZ area with Classification	Permissible / Not permissible as per CRZ notification 2011, amended till date	Applicable Clause no. of CRZ Notification 2011, amended till date	Applicable Clause no. of CRZ Notification 2019
2	Multipurpose/ Liquid / Gas/Cryogenic - Berths / barges	CRZ I (B) & CRZ IV	Permissible	3(iv)(a); 4(i)(a)(f); 8(I)(i)(c) And Annexure II	2 (2.1.2); 2.3 (2.3.1)(2.3.3); 2.4 (2.4.1);(2.4.2) 5 (5.1.2) (i)(a)(ii)(iii)(iv)(v)(ix)(x)(xiv)(xv)(xviii) 5.4)(ii)(a)(c)(d)(iii)(v)(xiii) And Annexure II
3	Single point mooring	CRZ IV	Permissible	3(ii)(a)(iv)(a)(c) 4(i)(f)	2.4 (2.4.1);(2.4.2) 5.4)(ii)(a)(iii)(v)(xiii) And Annexure II
3	Common Operation Building and Other facilities	CRZ I (B) & CRZ III	Permissible	3(iv)(a) and 4(i)(a)(f)	2 (2.1.2); 2.3 (2.3.1)(2.3.3) 5 (5.3)((ii)(b)(d)
4	Utility Corridor (Pipeline / Road / Rail/ transmission etc.)	CRZ I (B) & CRZ III	Permissible	3(iv)(a); 4(i)(a)(f) 8(I)(i)(b)(c); 8(I)(ii)(g) 8(III)(a)(iii)(e,f,g,h,;8(III)(b)(ii,iii,v,vi)	2 (2.1.2); 2.3 (2.3.1)(2.3.3) 5 (5.3)((ii)(b)(d)
5	Outfall pipeline and diffuser system	CRZ I (B) & CRZ III, CRZ IV	Permissible	3(iv)(a); 4(i)(a)(f); 4(ii)(d)(f); 8(I)(i)(b)(c);	2 (2.1.2); 2.3 (2.3.1)(2.3.3) 5.4)(ii)(a)(iii)(v)(xiii) And Annexure II
6	Seawater Intake Pipeline	CRZ I (B) & CRZ III	Permissible	3(iv)(a); 4(i)(a)(f); 4(ii)(d)(f) 8(I)(i)(b)(c);	2 (2.1.2); 2.3 (2.3.1)(2.3.3) 5 (5.3)((ii)(b)(d)
7	Dredging /Reclamation/Dumping	CRZ IV(A), CRZ III, CRZ I(B), CRZ IV	Permissible	3(i)(a); 3(iv)(a); 3(iv)(c); 4 (i) (f); 8(I)(i)(c)	2 (2.1.2); 2.3 (2.3.1)(2.3.3) 5.4)(ii)(a)(iii)(v)(xiii) And Annexure II

2.7 Project Cost

The capital cost estimates have been prepared for the proposed RMP development of the project. These are based on the project descriptions and drawings given under the relevant sections of the present report. The basis of the costing is as follows:

- The cost estimates of civil works have been prepared on the basis of current rates for various items of work prevailing in the region and also on the past costs for similar works elsewhere. No escalation has been considered.
- The costs of equipment and machinery are based on budgetary quotations with the manufacturers and also in-house data. The costs include all taxes and duties.

- All costs towards overheads, labour, tools, materials, insurance, financing costs, etc., are covered in the rates for individual items.
- The costs towards plant and machinery include manufacture, supply, installation and commissioning of the respective items.

Total capital cost for the proposed Revised Master Plan development is estimated to be **Rs. 53,031 Crores**. The cost estimates of various heads are worked out based on current rates and it is summarized in **Table 2-28**.

Table 2-28: Capital Cost for Proposed Development

S. No.	Description	Proposed Revised Master Plan (Rs. In Crores)
1	Breakwater	2,117
2	Dredging & Reclamation	2,172
3	Berths & Jetties	4,017
4	Railway works	952
5	Approach roads & Drainage	2,317
6	Utilities, Buildings, Area grading	5,311
7	Ground Improvement Works	2,569
8	Compound Wall/ Fencing all around port boundary	54
9	Yard development work (Civil, Mechanical, Electrical & Instrumentation	33,522
	Total	**53,031**

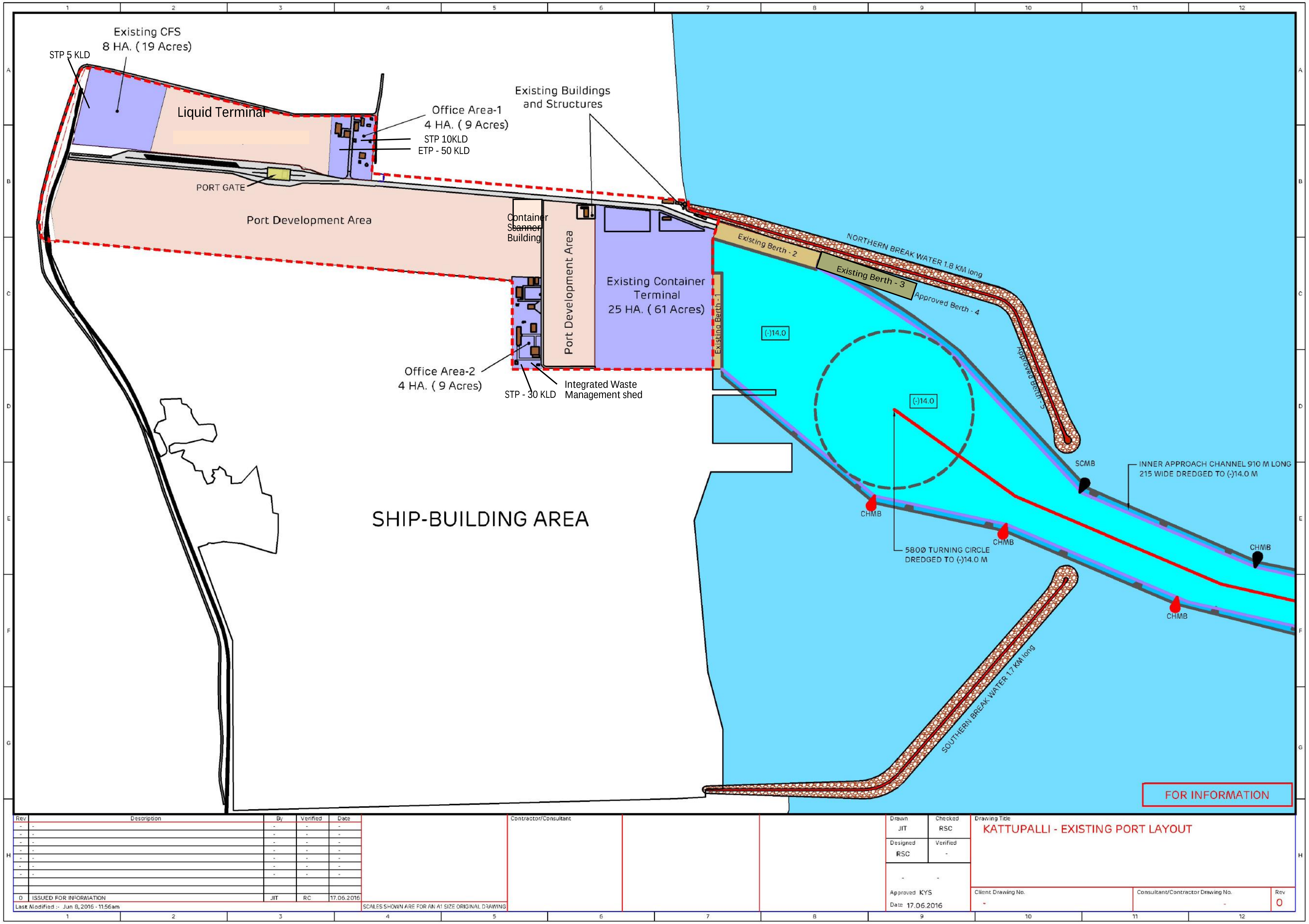
Following assumptions are made about this table:

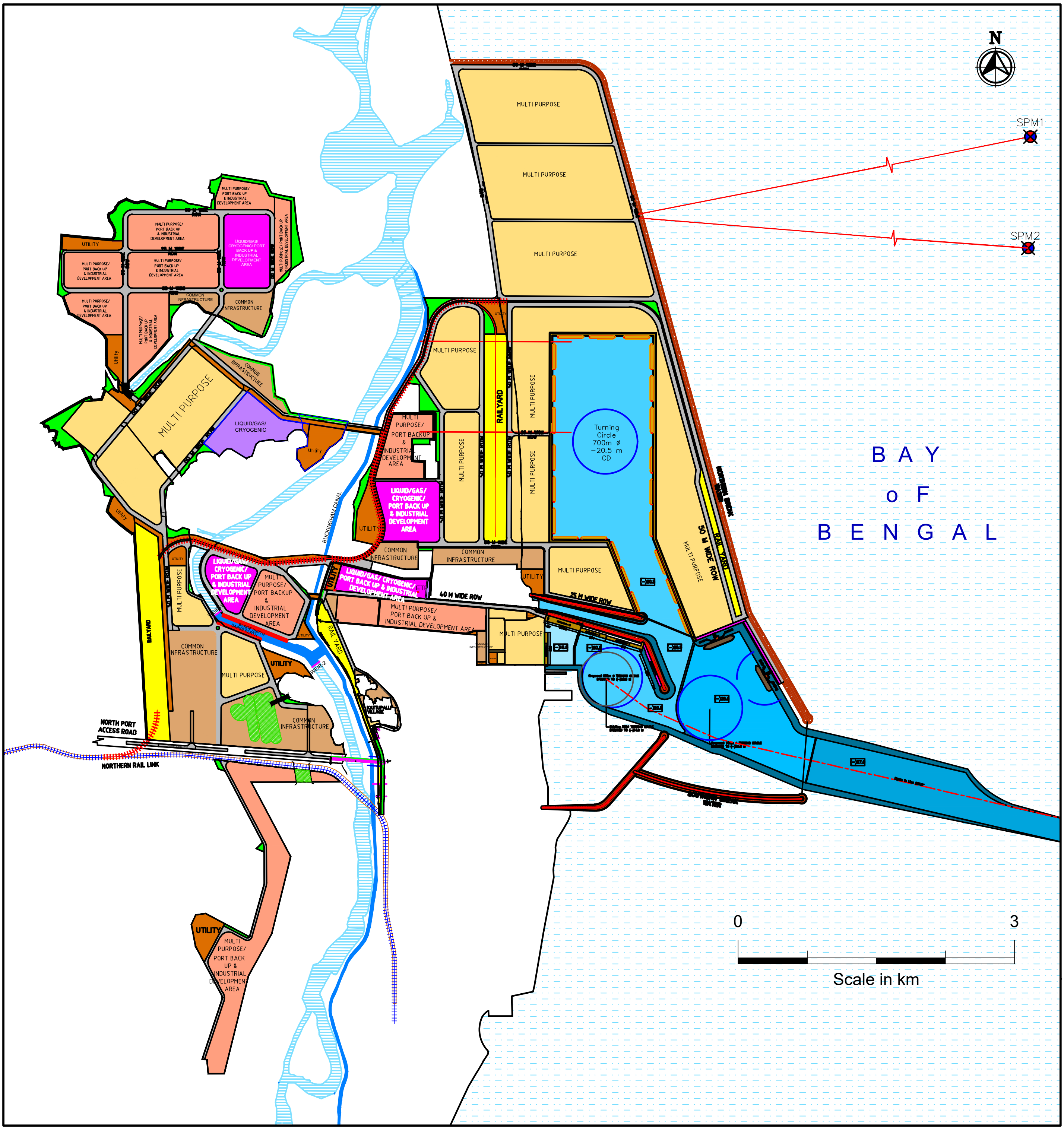
- The numbers represented here are indicative. Capital costs are based on rational cost estimate exercise although actual costs will not be known until the final development.
- Reasonable assumptions on tax / duty, expected to be applicable on the indigenous / imported component of the capital cost, have been made in the capital cost estimation.

2.8 Project Development Schedule

The proposed RMP is prepared considering development in next 15-20 years.

Figures


Existing CFS
8 HA. (19 Acres)
STP 5 KLD
Liquid Terminal
Office Area-1
4 HA. (9 Acres)
STP 10KLD
ETP - 50 KLD
Existing Buildings
and Structures
PORT GATE
Port Development Area
Container
Scanner
Building
Port Development Area
Existing Container
Terminal
25 HA. (61 Acres)
Existing Berth - 1
Existing Berth - 2
Existing Berth - 3
Approved Berth - 4
Approved Berth - 5
NORTHERN BREAK WATER 1.8 KM long
(-)14.0
(-)14.0
Office Area-2
4 HA. (9 Acres)
STP - 30 KLD
Integrated Waste
Management shed
SCMB
INNER APPROACH CHANNEL 910 M LONG
215 WIDE DREDGED TO (-)14.0 M
CHMB
CHMB
CHMB
CHMB
580Ø TURNING CIRCLE
DREDGED TO (-)14.0 M
SHIP-BUILDING AREA
SOUTHERN BREAK WATER 1.7 KM long
FOR INFORMATION
Rev
Description
By
Verified
Date
0
ISSUED FOR INFORMATION
JIT
RC
17.06.2016
Last Modified :- Jun 8, 2016 - 11:56am
SCALES SHOWN ARE FOR AN A1 SIZE ORIGINAL DRAWING
Contractor/Consultant
Drawn
JIT
Checked
RSC
Designed
RSC
Verified
Approved KYS
Date 17.06.2016
Drawing Title
KATTUPALLI - EXISTING PORT LAYOUT
Client Drawing No.
Consultant/Contractor Drawing No.
Rev
0



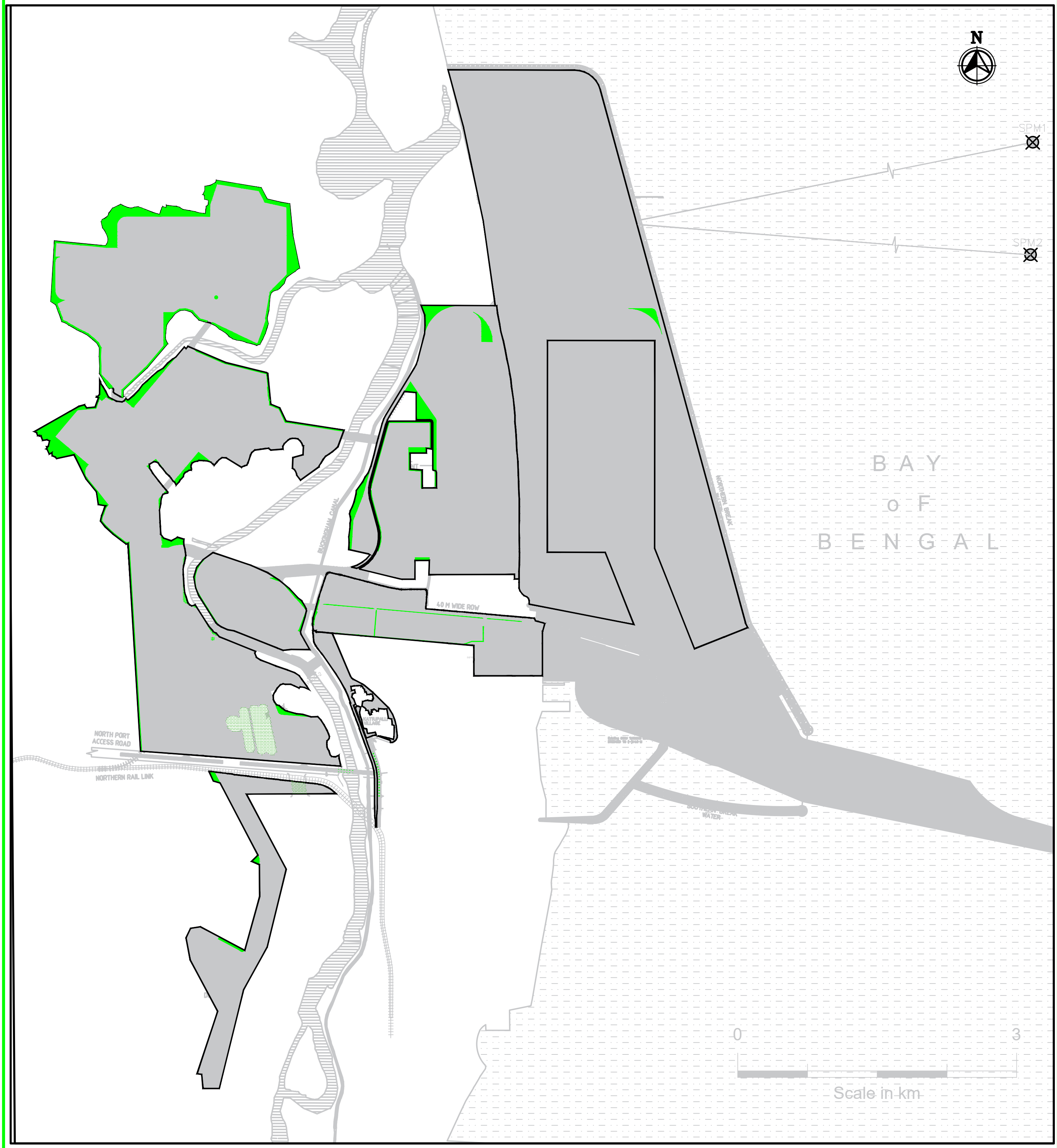
LEGEND:

- PROJECT BOUNDARY
- MULTIPURPOSE
- MULTI PURPOSE/ PORT BACK UP & INDUSTRIAL DEVELOPMENT AREA
- LIQUID/GAS/CRYOGENIC
- LIQUID/GAS/CRYOGENIC/ PORT BACK UP & INDUSTRIAL DEVELOPMENT AREA
- GREEN BELT AREA
- COMMON INFRASTRUCTURE
- UTILITY AREA / CORRIDOR
- ROAD ROW
- RAIL YARD
- MANGROVE & 50 MTR BUFFER ZONE
- RAIL CORRIDOR
- MULTIPURPOSE/LIQUID BERTH
- MULTIPURPOSE/LIQUID/ CRYOGENIC/GASES BERTH
- SINGLE POINT MOORING (SPM)

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

PROJECT:	CEIA/EMP FOR KATTUPALLI PORT EXPANSION	PROJECT NO: C1161303
TITLE:	REVISED COMPREHENSIVE MASTER PLAN	DATE: 24.10.2020
		MADE: BNK
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0202 REV: 0

TBA



LEGEND:

- PROJECT BOUNDARY
- GREEN BELT AREA
- MANGROVE & 50 MTR BUFFER ZONE

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

PROJECT: CEIA/EMP FOR KATTUPALLI PORT EXPANSION	PROJECT NO: C1161303
TITLE: GREENBELT DEVELOPMENT PLAN	DATE: 24.10.2020
	MADE: VSU
L&T Infra Engineering — L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0203 — REV: 0

AUTO PATH: L:\PORTS\2016\C1161303 - CEIA KATTUPALLI PORT EXPANSION\DRAWINGS\REPORT DWGS\R7-DRAFT EIA\FD0203 - GREENBELT DEVELOPMENT PLAN.DWG

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Chapter 3
Description of Environment

Chapter 3 Description of Environment

3.1 Preamble

This chapter details with the location of site, existing features, meteorological conditions, oceanographic conditions, environmental aspects, ecological aspects, social aspects, road & rail connectivity and other infrastructure facilities covering the terrestrial and marine environment baseline data and also the terrestrial and marine bio-diversity. Secondary data collected from various sources has also been included in this chapter.

Following are the various environmental attributes monitored for both terrestrial and marine environment.

Terrestrial Environmental Components	Marine Environmental Components
• Meteorology ○ Temperature ○ Relative Humidity ○ Rainfall ○ Wind Speed & Direction ○ Solar Radiation	• Marine Water Quality ○ Physico-Chemical Parameters • Sediment Quality ○ Physico-Chemical Parameters
• Ambient Air Quality ○ Particulate matter <10-micron size (PM_{10}) ○ Particulate matter <2.5-micron size ($PM_{2.5}$) ○ Sulphur Dioxide (SO_2) ○ Nitrogen Dioxide (NO_2) ○ Carbon Monoxide (CO) ○ Ozone (O_3) ○ Lead (Pb) ○ Ammonia (NH_3) ○ Benzene (C_6H_6) ○ Benzo(a)Pyrene (BaP) ○ Arsenic(As) ○ Nickel (Ni)	• Biological Parameters ○ Primary productivity ○ Phytoplankton ○ Zooplankton ○ Macrobenthos ○ Meiobenthos ○ Microbial load
• Ambient Noise Levels ○ Day equivalent noise levels ○ Night equivalent noise levels	• Marine Biodiversity Survey • Marine Ecology
• Inland Water Quality ○ Groundwater Quality ○ Surface Water Quality	
• Soil Quality	
• Flora & Fauna (Terrestrial Ecology)	

3.2 Study Area and Study Period

An area within 15 km radius from project boundary has been earmarked for the study as the PIA/study area. As per the Ports and Harbours EIA guidance manual released by MoEF&CC on February 2010, an area within 5 km radius from project boundary for primary data generation and 15 km radius as a buffer study area for secondary data generation is considered. A map showing the study area is given as **Figure FD0102**.

Baseline environmental monitoring was carried out covering **Three (03) Seasons** and same data was utilised for the establishment of baseline conditions for both terrestrial and marine environment. The seasons under consideration for terrestrial and marine environmental surveys are as follows

- Winter (January 2018 – February 2018)
- Summer (March 2018 – May 2018)
- Pre-Monsoon (June 2018 – September 2018)

Baseline data generation was completed and secondary data collection completed as per MoEF&CC Office memorandum dated August 29, 2017.

In line to ensure the accomplishment of ToR conditions MIDPL has also assessed Biodiversity of the area, for estuary and coastal region, collected three season's data in the coastal region as well as estuarine region at proposed site covering the northern end of the project and saltpans present in the western Korattalaiyar including survey during monsoon season (November, 2019).

3.3 Environmentally/Ecologically sensitive Areas

The environmental sensitive areas covering an aerial distance of 15 km from project boundary is given in **Table 3-1**.

Table 3-1: Environmentally Sensitive Areas within 15 km Radius

S. No	Classification	Name/Identity	Aerial Distance (km) (within 15.0 km) Proposed project location boundary & Direction
1.	Areas protected under International conventions, National or local legislation for their ecological, landscape, cultural, heritage or other related value	Pulicat Sanctuary Boundary (Andhra Pradesh side)	14.5, NW
		Pulicat Sanctuary Boundary (Tamil Nadu side)[7]	~2.1, NW
2.	Areas which are important or sensitive for ecological reasons – wetlands, mangroves, watercourses or other water bodies, coastal zone, biospheres, mountains, forests	Pulicat Lake	7.2, NW
3.	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration	Sparse Mangroves	>50 m
4.	Inland, coastal, marine or under groundwater	Buckingham canal	>0.05 km, W
		Bay of Bengal	Adjacent, E
		River Kosisttalaiyar (Tidal influenced)	Adjacent
		Korattalaiyar River	6.3, SW
		Aranai River	4.2, W
5.	State, National and International boundaries	Andhra Pradesh	14.5 NW
6.	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas	• SH-104 • Athipattu Railway station	• 1.2 W • 2.7, SW
7.	Defence installations	-	-
8.	Densely populated or built-up area	• Vallur camp • Minjur Town	• 3.2 , SSW • 5.4, SW

[7] *Pulicat Wildlife Sanctuary, Tamil Nadu boundaries vide G.O .Ms .No.1247, Forests and Fisheries dated 22nd September 1980. The areas (village boundaries) covered and also the areas included by the boundaries described above shall be the "Pulicat Lake Birds" Sanctuary. As per the Minutes of 34th ESZ Expert Committee Meeting for the declaration of Eco Sensitive Zone (ESZ) around Wildlife Sanctuaries/National Park held on 06th March 2019, in the MoEF&CC Tamil Nadu government has decided not to propose any eco sensitive zone for Pulicat Birds Sanctuary. PCCF & CWLW, Government of Tamil Nadu presented that "no ecological requirement of any other buffer area for the conservation management of the sanctuary which is only seasonal in nature at the time of arrival of birds".*

S. No	Classification	Name/Identity	Aerial Distance (km) (within 15.0 km) Proposed project location boundary & Direction
		• New Manali Town • Ponneri Town	• 7.4, SSW • 9.9, W
9.	Areas occupied by sensitive man-made land uses (hospitals, schools, places of worship, community facilities)	Above towns are having schools, health centres and places of worship.	
10.	Areas containing important, high quality or scarce resources (groundwater resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)	There are seasonal water bodies present in the Study area in the form of lakes and ponds.	
11.	Areas already subjected to pollution or environmental damage (those where existing legal environmental standards are exceeded)	-	-
12.	Areas susceptible to natural hazard, which could cause the project to present environmental problems (earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions)	Project site falls under seismic Zone III (moderate earthquake zone) as per IS 1893 (Part I) 2002 of Indian Seismic map. This project site is not influenced by high frequency cyclonic disturbances. Structural design has factored these aspects.	

3.4 Physical conditions

The Kattupalli Port is located towards North of Kamarajar (Ennore) Major Port near Kattupalli village of Ponneri Taluk, Thiruvallur District, Tamil Nadu. The geographic location of the Kattupalli port is at Latitude $13^0$18'57.26"N and Longitude $80^0$20'45.68"E. In the study area (15.0 km radius from the project boundary) total of 108 villages including hamlets are falling in three talukas (Gummidipoondi, Ponneri and Mathavaram) in Thiruvallur district. The land area in the study area is flat while some parts of the study area are undulated and some of the areas are hilly. The sandy strip of the coast is replete with casuarina plantations.

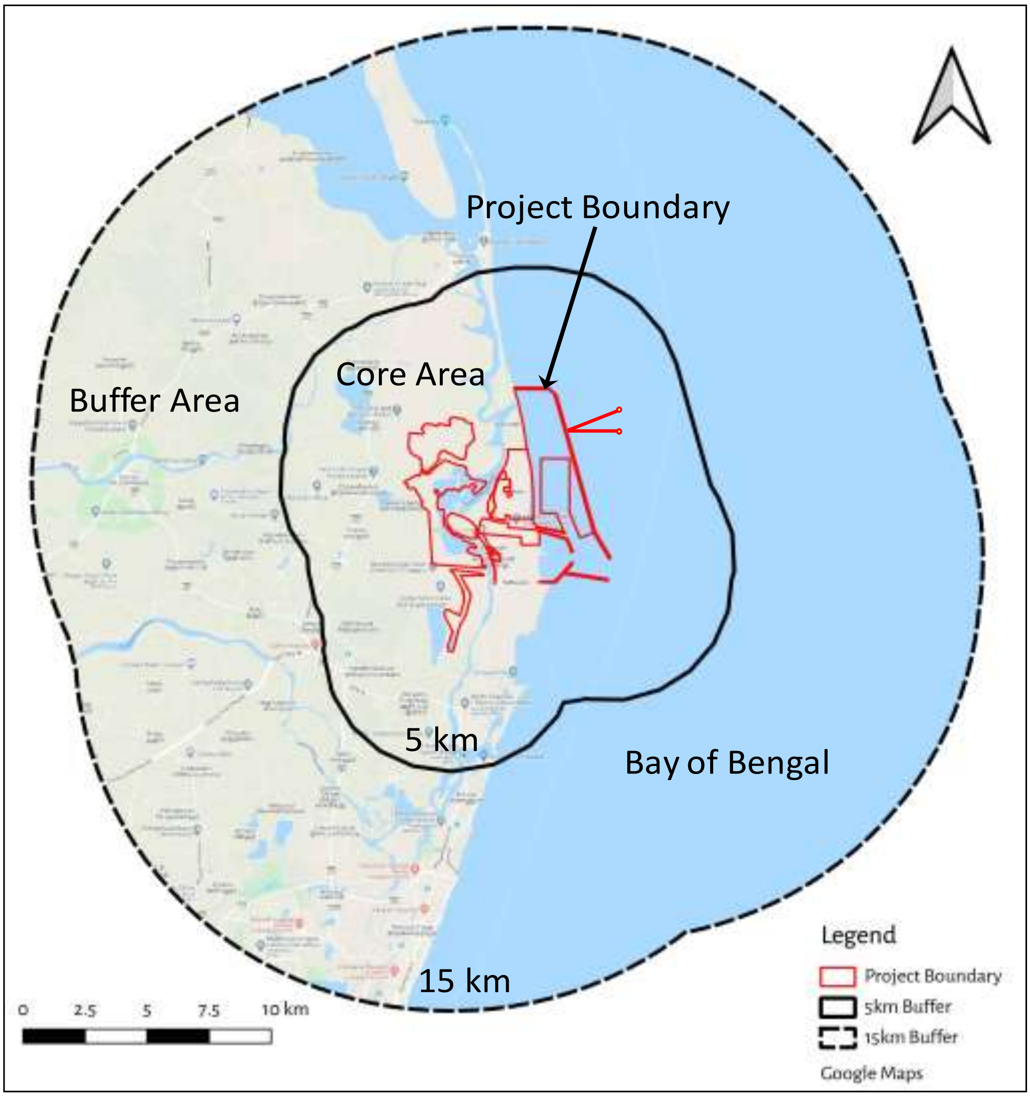


Figure 3-1: Project boundary (core area) and buffer area of PIA

3.4.1 Climatic Conditions

The district enjoys a tropical climate. The period from April to June is generally hot and dry. The weather is pleasant during the period from November to January. Usually mornings are more humid than afternoons. The relative humidity varies between 65 and 85% in the mornings while in the afternoon it varies between 40 and 70%.

The annual mean minimum and maximum temperature are 24.3 °C and 32.9°C respectively. The day time heat is oppressive and the temperature is as high as 41.2°C. The lowest temperature recorded is of the order of 18.1°C.

The average rainfall of the district is 1104 mm. Out of which 52% has been received during Northeast monsoon period and 41% has been received during Southwest monsoon period[8].

[8] ENVIS 2015. Thiruvallur District ENVIS Centre, Tamilnadu

3.5 Land Environment

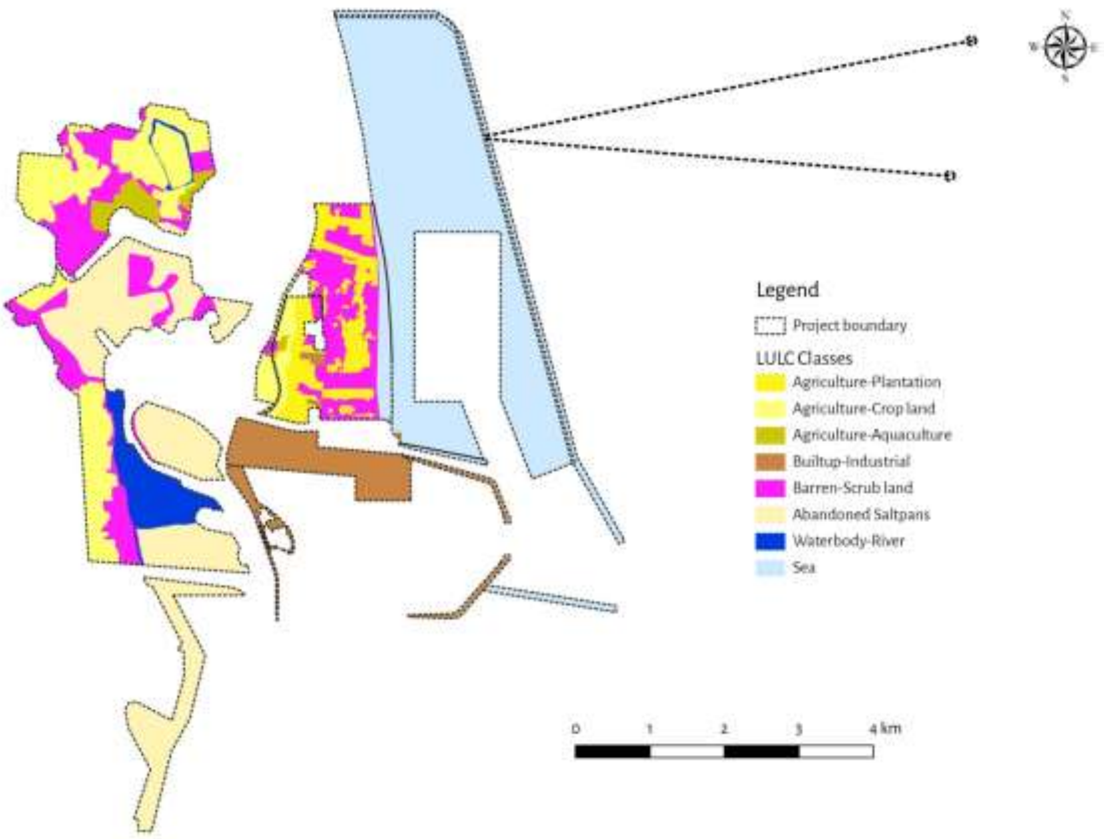
3.5.1 Land Use and Land Cover

3.5.1.1 Land Use pattern in Project Site

The site is comprised of Sea, Abandoned-Saltpans, Agriculture-Cropland, Builtup-Industrial, Agriculture-Plantation, Waterbody-River, Barren-Scrub land, Agriculture-Aquaculture. LULC pattern of project site is presented in **Table 3-2** and LULC map for project area is shown in **Figure 3-2**.

Table 3-2: Land Use Land Cover Pattern of Project Site

LULC Classes	Area (sq.m)	Area (Ha)	Area (acres)	%
Builtup-Industrial	1741419.88	174.142	430.31	7.04%
Agriculture-Cropland	2789746.53	278.975	689.35	11.28%
Agriculture-Plantation	1140847.79	114.085	281.91	4.61%
Agriculture-Aquaculture	427031.57	42.703	105.52	1.73%
Barren-Scrub land	585303.67	58.530	144.63	2.37%
Abandoned-Saltpans	8077630.92	807.763	1996.00	32.67%
Waterbody-River	1001054.53	100.105	247.36	4.05%
Sea	8965465.11	896.547	2215.39	36.26%
Total	24728500.00	2472.85	6110.47	100.00%



(Source: NRSC Bhuvan)

Figure 3-2: LULC Map for Project Site

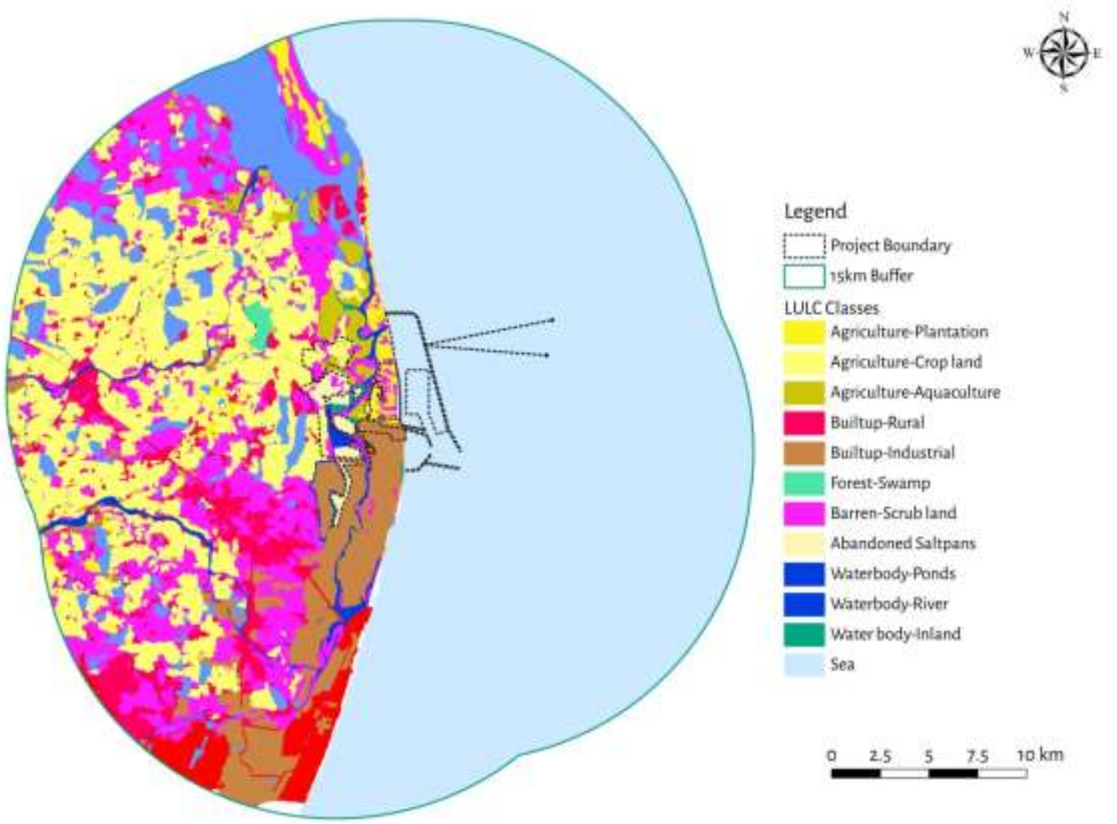
3.5.1.2 Study area Land Use Pattern (10 km Radius)

A 15 km study area from the project site was considered to understand the LU/LC pattern of the area around the project site. LU/LC map is presented in **Figure 3-3**.

LU/LC statistics of study area is presented in **Table 3-3**. The study area mostly comprises of Bay of Bengal, Abandoned-Saltpans, Agriculture-Crop Land, Wasteland-ScrubLand, Reservoir/Lakes/Ponds, Builtup-Mining/Industrial, Builtup-Rural, Agriculture-Aquaculture, Builtup-Urban, River/Stream/Canals, Agriculture-Plantation, Forest-Swamp, Inland Wetland.

Table 3-3: Land Use/Land Cover Statistics of Study Area

LULC Classes	Area (sq.m)	Area (Ha)	Area (acres)	%
Builtup-Urban	20612002.32	2061.20	5093.28	1.84%
Builtup-Rural	44263336.96	4426.33	10937.58	3.96%
Builtup-Mining/Industrial	56260159.71	5626.02	13902.03	5.03%
Agriculture-Crop Land	171193978.7	17119.40	42302.46	15.31%
Agriculture-Plantation	16336638.38	1633.66	4036.82	1.46%
Agriculture-Aquaculture	673112.886	67.31	166.33	2.72%
Forest-Swamp	2129526.303	212.95	526.21	0.19%
Wasteland-ScrubLand	125629431.1	12562.94	31043.35	11.24%
Abandoned-Saltpans	9917630.921	991.76	2450.67	40.11%
Inland Wetland	1506073.497	150.61	372.15	0.13%
Reservoir/Lakes/Ponds	86496526.78	8649.65	21373.51	7.74%
River/Stream/Canals	18769399.49	1876.94	4637.97	1.68%
Sea	564387365.4	56438.74	139461.53	50.47%
Total	1118175182.51	111817.52	276303.88	100.00%



(Source: NRSC, Bhuvan)

Figure 3-3: LU/LC pattern for the 15 km study area

3.5.2 Natural Resources of Study area

3.5.2.1 Forest Resources

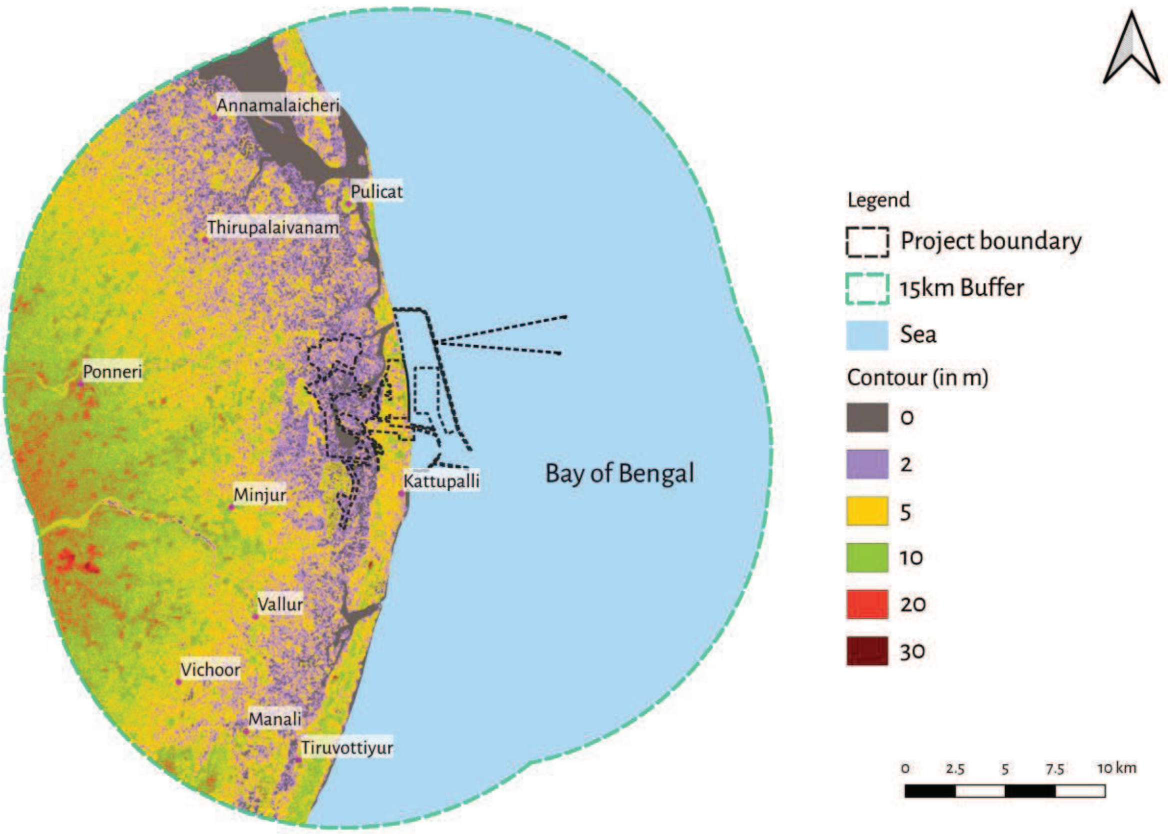
In the study area of 15 km radius from the project boundary, no forest land is identified.

3.5.2.2 Agricultural Resources

Paddy is the major crop cultivated in this district. Other major crops of the District are Groundnuts, Sugarcane, Cereals, Millets and Pulses.

3.5.3 Topography

The Kattupalli port back-up area was reclaimed to a height of (+) 4.0 to (+) 5.0 m CD which serves as the cargo storage yard for the port. The study area falls in 0 to 20 m contour. Contour map for the study area is shown in **Figure 3-4**.



(Source: SRTM 1 arc second – 2002)

Figure 3-4: Study area Contour Map

3.5.4 Geology and Mineral Resources of study area

The mineral deposit in the district is very meager. The area is mainly consists of savadu /gravel clay with sand, rough stone and black granite[9]. The rock formations in the district are Sedimentary rocks of about 80% and Hard rock is about 20%. Also, Alluvium and Marine

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[9] Source: Brief Industrial Profile of Thiruvallur District (2012-2013), Government of India, Ministry of Micro Small and Medium Enterprises (MSME)

deposits exist in the district. The project site falls in coastal sediments and alluvium areas. Study area Geology and Mineral Map shown in **Figure 3-5**.

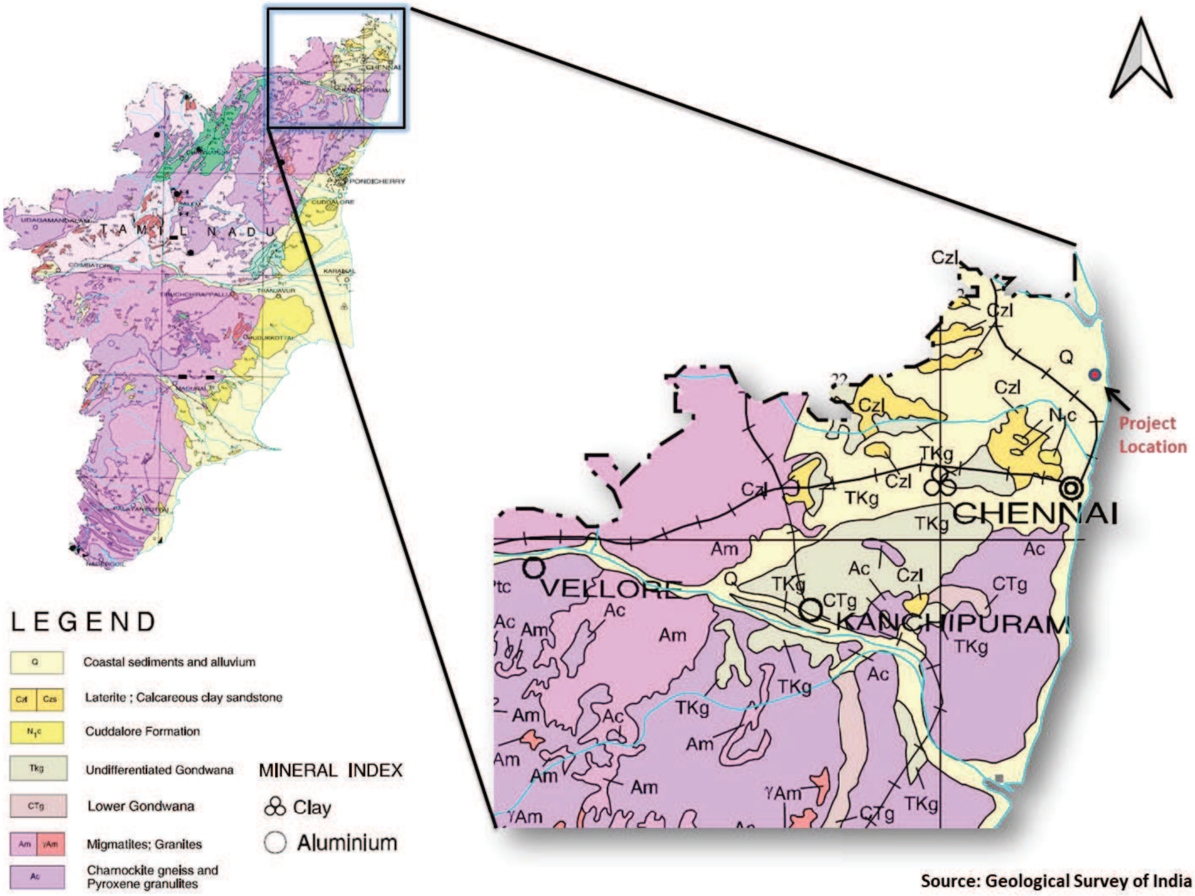


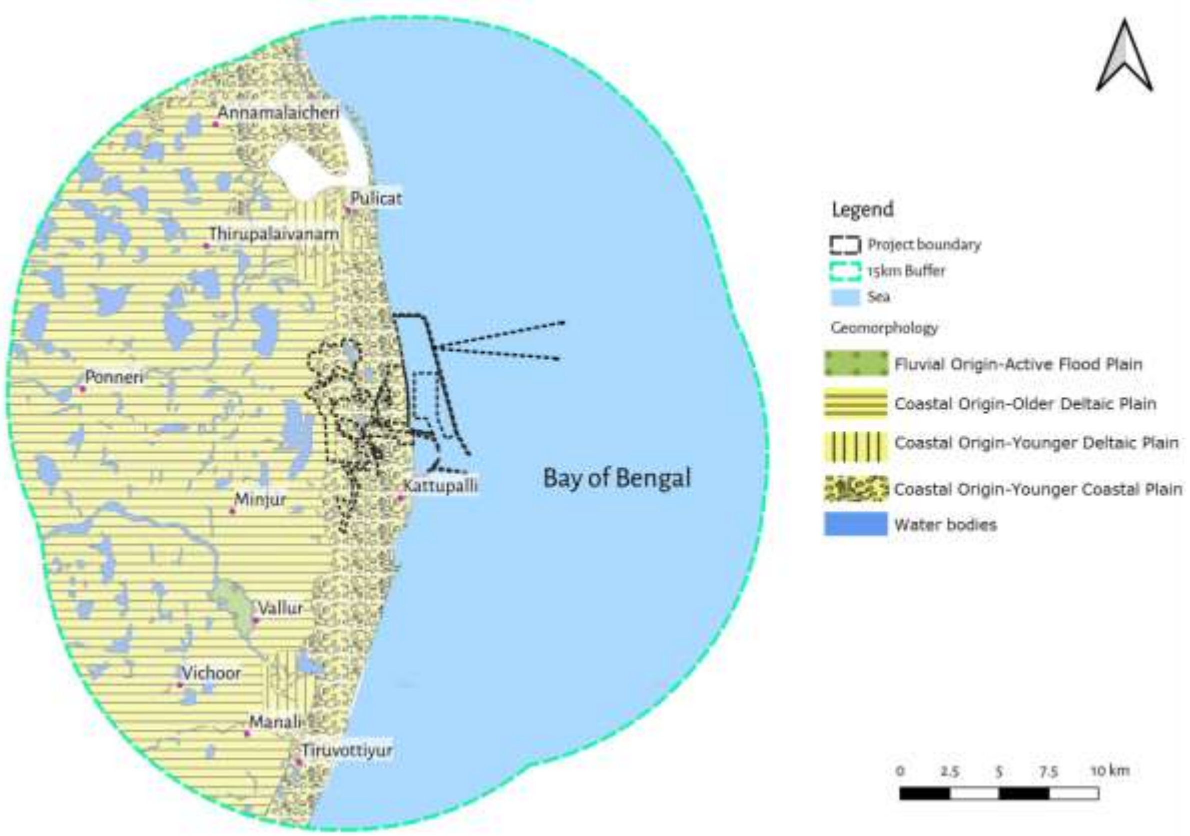
Figure 3-5: Study area Geology and Mineral Map

3.5.5 Geomorphology

The elevation of the district ranges from 183 m AMSL in the west to sea level in the east[10]. Four cycles of erosion gave rise to a complex assemblage of fluvial, estuarine and marine deposits. The major part of the area is characterised by an undulating topography with innumerable depressions which are used as irrigation tanks.

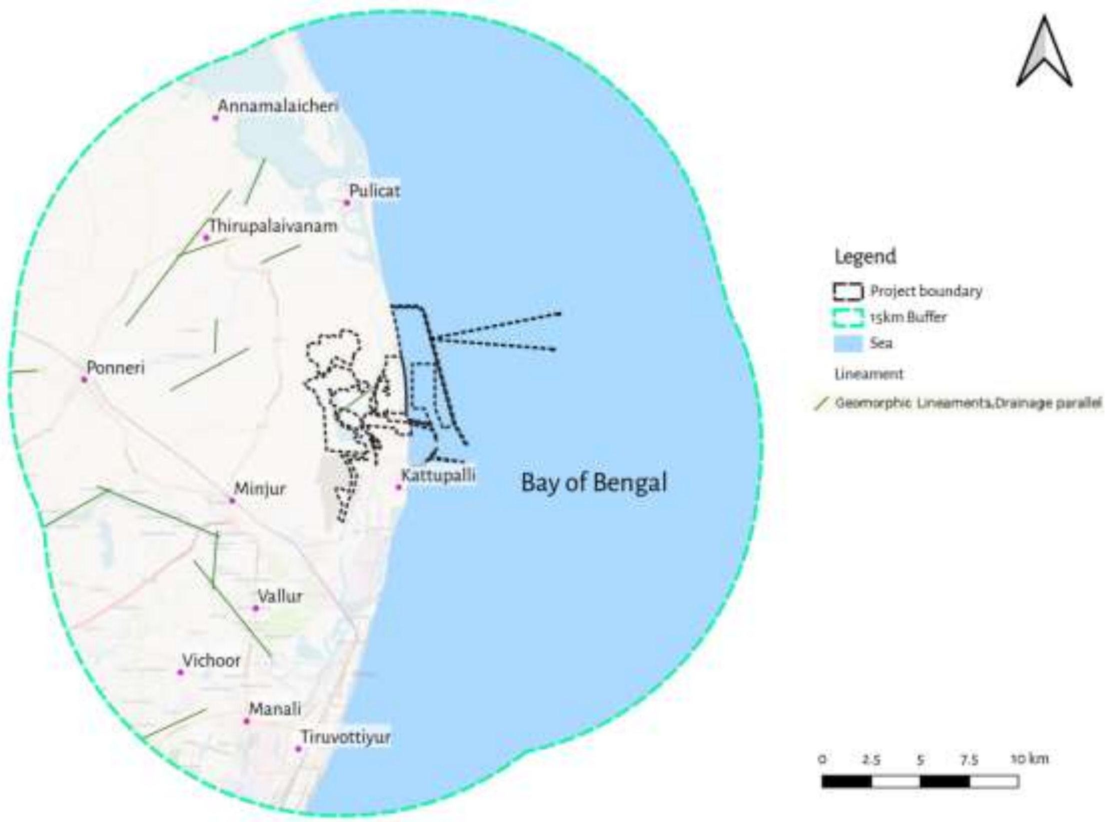
The coastal plains display a fairly lower level or gently rolling surface and only slightly elevated above the local water surfaces or rivers. The straight trend of the coastal tract is resultant of development of vast alluvial plains. The project site falls in water bodies, coastal origin-younger coastal plain and coastal origin-older deltaic plain. Study area Geomorphology and Lineament Map was given in **Figure 3-6** to **Figure 3-7**.

[10] *Source: District Ground Water Brochure Tiruvallur district,2007-GoI, Ministry of Water Resources, Central Ground Water Board South Eastern Coastal Region, Chennai*



(Source: Bhuvan-NRSC 2005-2006)

Figure 3-6: Study area Geomorphology



(Source: Bhuvan-NRSC 2005-2006)

Figure 3-7: Study area Lineament Map

3.5.6 Soil Profile of Study area

Soils in the district have been classified into i) Red soil ii) Black soil iii) Alluvial soil iv) Colluvial soil. Alluvial soils occur along the river courses and eastern part of the coastal areas. Sandy coastal alluvium (arenaceous soil) are seen all along the sea coast as a narrow belt suitable for casuarina plants. Saline and alkaline soils are also noticed in some patches of Ponneri taluk Tiruvallur District.

3.5.7 Soil Quality Monitoring

In order to assess the quality of soil at different locations in the study area, various land use categories were taken into account. Soil sampling was carried out at Seven (07) locations in the study area. Soil quality monitoring locations are given in **Table 3-4**. Map showing the soil monitoring locations is given as **Figure FD0301**.

Table 3-4: Details of Soil Quality Monitoring Locations

Station Code	Location	Distance (km) from Project boundary	Azimuth Directions
S1	Attipattu	2.3	SW
S2	Kattupalli	Within the site	
S3	Kalanji	Within the site	
S4	Karungalikuppam	0.6	N
S5	Kattur	1.5	NW
S6	Uranambedu	Within the site	
S7	Neidavayal	3.2	W

3.5.7.1 Results and Discussions

Soil analysis was carried out as per **IS: 2720** and overall analytical results were given in **Table 3-5** and details are presented in **Appendix F**.

Table 3-5: Soil Quality Analysis

S. No	Parameter	Units	Min	Max
1	pH	--	5.51	7.97
2	Bulk Density	g/cm^3	1.25	1.76
3	Electrical Conductivity	µmhos/cm	30	315
4	**Particle Size Distribution & Texture Classification**			
	Sand (4.0 mm to 0.075)	%	7	74
	Slit (0.074 to 0.005 mm)	%	5	87
	Clay (Less than 0.005 mm)	%	4	78
5	Infiltration Rate	mm/hr	3.7	52
6	Cation Exchange Capacity	meq/100g	1.6	1.829
7	Permeability	cm/s	0.00001	0.000427
8	Water Holding Capacity	%	24.1	60.2
9	Porosity	%	38.3	49.8
10	Total Kjeldahl Nitrogen	mg/kg	42	279
11	Phosphorus	mg/kg	178	1768
12	Sodium	mg/kg	107	739
13	Potassium	mg/kg	326	1705
14	Copper	mg/kg	2.4	17
15	Manganese	mg/kg	46	134
16	Iron	mg/kg	3520	9251
17	Chromium	mg/kg	BDL	BDL
18	Cadmium	mg/kg	BDL	BDL
19	Lead	mg/kg	12	33
20	Zinc	mg/kg	6	1198

S. No	Parameter	Units	Min	Max
21	Nickel	mg/kg	1	9.4
22	Sodium Adsorption Ratio	millimole/L	0.238	0.37

Inferences on soil quality are provided below.

- Soil Texture: At Kattupalli, Kalanji, Karungalikuppam villages, silt was dominant, at Attipattu village, Silty loam is dominant, at Kattur, Neidavayal villages Sandy loam is dominant and at Uranambedu village Clay is found to be dominant
- pH of soils ranged between 5.51 to 7.97 for all the seasons indicating that the samples are slightly acidic as well as alkaline in nature
- Electrical Conductivity varied between 31 µmhos/cm during Winter season 315 µmhos/cm during Summer season.
- Total Kjeldahl Nitrogen as (N) varied between 42 mg/kg during summer and pre-monsoon seasons respectively to 279 mg/kg during winter season.
- Phosphorous as (P) varied between 178 mg/kg during summer season to 1768 mg/kg during winter season.
- Potassium (K) varied between 326 mg/kg during pre-monsoon to 1705 mg/kg during summer
- Sodium Absorption Ratio varied between 0.238 millimole/L during pre-monsoon to 0.37 millimole/L during summer
- Infiltration Rate varied between 3.7 mm/hr during summer to 52 mm/hr during winter.
- Water holding Capacity varied between 24.1% during winter to 60.2% during pre-monsoon.
- Bulk density varied between 1.25 gm/cc to 1.76 gm/cc both during summer respectively
- Porosity varied between 38.3 %v/v during summer to 49.8 %v/v during winter
- Zinc (Zn) varied between 6 mg/kg during pre-monsoon to 1198 mg/kg during winter
- Cadmium (Cd) is below detectable limits at all locations during the study period
- Chromium (Cr) is below detectable limits at all locations during the study period
- Copper (Cu) varied between 2.4mg/kg during pre-monsoon to 17.0 mg/kg during winter
- Iron (Fe) varied between 3520 mg/kg during summer to 9251 mg/kg during winter
- Manganese (Mn) varied between 46 mg/kg during summer to 134 mg/kg during pre-monsoon
- Lead (Pb) varied between 12 mg/kg to 33 mg/kg during pre-monsoon respectively
- Nickel (Ni) varied between 1.0 mg/kg during summer to 9.4 mg/kg during pre-monsoon
- Sodium varied between 107 mg/kg to 739 mg/kg during winter
- Cation Exchange Capacity varied between 1.6 meq/100g during pre-Monsoon to 1.829 meq/100g during summer
- Permeability varied between 0.0000106 cm/s during winter to 0.000439 cm/s during summer

3.6 Water Environment

3.6.1 Hydrological Parameters

3.6.1.1 Drainage Pattern of Study Area

The drainage pattern of the study area is mainly governed by Araniyar, Korattalayar rivers. The drainage pattern, in general, is dendritic. All the rivers are seasonal and carry flood water during monsoon period. Korattaliar river empties into the Ennore creek which is located 4.4 km South from the proposed expansion boundary. Aranai river empties into the Pulicat lake which is located 7.2 km North from the proposed expansion boundary. The Kosasthaliyar river and Buckinham canal is connecting Ennore creek and Pulicat lake which is passing between the proposed expansion plan facilities. Drainage pattern of study area is shown in **Figure 3-8.**

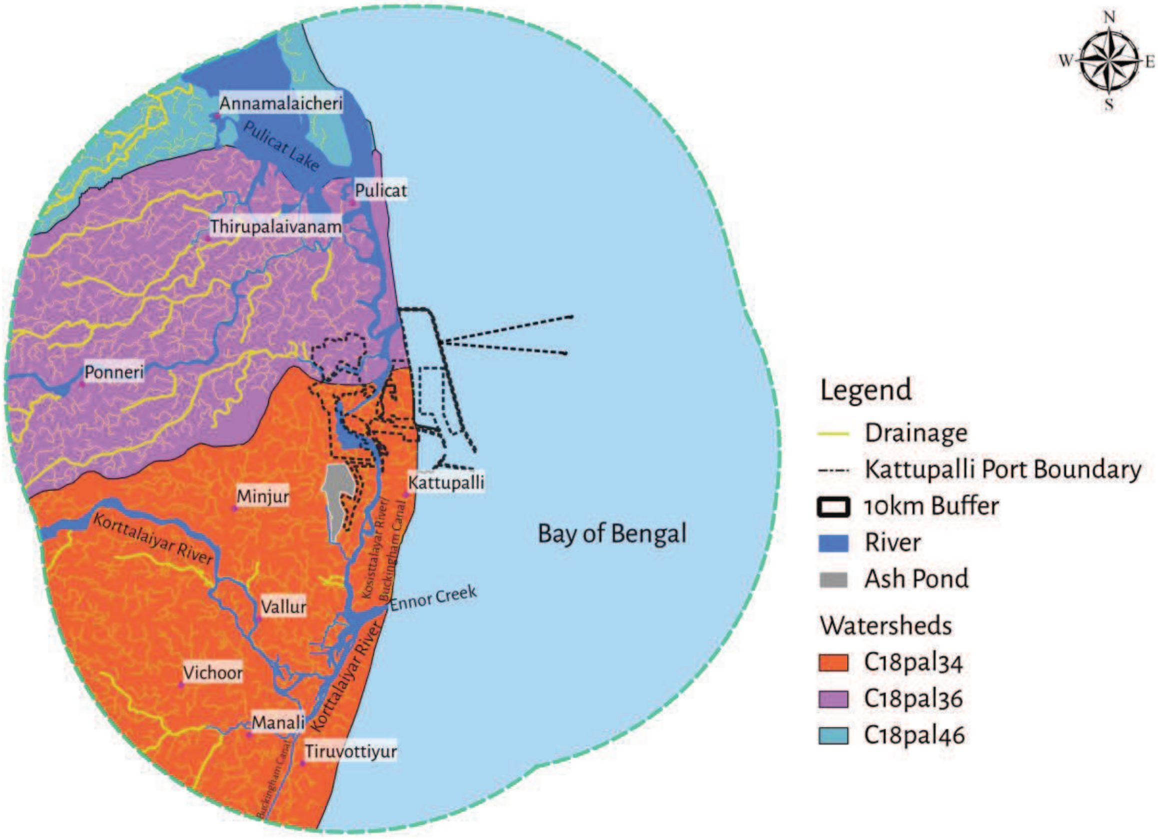


Figure 3-8: Drainage Pattern of Study Area

3.6.2 Water Quality Assessment

The baseline status of water quality has been assessed through the identification of water resources and appropriate sampling locations for surface and groundwater in the study area. The sampling locations for both surface and groundwater are shown in **Figure FD0301**. Water sample analysis with respect to physico-chemical, nutrient demand and bacteriological parameters having relevance to public health and aesthetic significance are selected to assess the water quality status.

The prevailing status of water quality has been assessed during the study period as per the standards. The water samples were collected in and around 15 km radial distance where Two (02) sampling stations for surface water and Five (05) sampling stations for groundwater were selected for the study area and analysed in accordance with standard test methods.

3.6.2.1 Surface Water Quality

Total ***Two (02)*** surface water monitoring locations were identified for assessment in different villages around the project site based on the usage of surface water by the settlements/ villages in the study area. Standard methods prescribed for surface sampling and analysis was adopted and compared with ISI-IS: 2296-1982 –Tolerance Limits for Inland Surface Water. Details of Surface water quality monitoring locations are given in **Table 3-6**. The results of surface water quality assessed during study period are given as **Appendix F**.

Table 3-6: Details of Surface Water sampling Locations

Station No.	Location	Distance from Project Boundary (km)	Azimuth Directions
SW1	Buckingham canal at Attipattu	2.3	SW
SW2	Buckingham canal at Karungali kuppam	0.6	N

3.6.2.1.1 Results and Discussion on Surface Water quality

- Colour ranged between 10 Hazen units during winter to 30 Hazen units during Pre-Monsoon and winter
- pH ranged between 6.77 during summer season to 8.12 during Winter, which shows the slightly alkaline nature of water
- Turbidity ranged between 10.4 NTU in pre-monsoon season to 74 NTU in Winter
- Electrical Conductivity (EC) ranged between 45358 µmhos/cm during winter season to 74020 µmhos/cm during summer season, indicating high presence of salts in water during summer.
- Salinity ranged between 23 ppt during winter to 33.9 ppt during summer
- Total Dissolved Solids (TDS) ranged between 29483 mg/l during winter season to 40412 mg/l during summer season, indicating high presence of dissolved solids in water during summer.
- Total Alkalinity ranged between 125 mg/l during summer to 373 mg/l during Pre-Monsoon
- Flouride ranged between 0.62 mg/l during Pre-Monsoon to 1.13 mg/l during summer
- Phosphates ranged between 0.91 mg/l during Pre-Monsoon to 1.65 mg/l during summer
- COD ranged between 121 mg/l during winter season to 157 mg/l during summer season
- DO ranged between 3.8 during pre-monsoon season to 4.6 mg/l during summer season
- Total Hardness (as $CaCO_3$) ranged between 4394 mg/l during winter season to 6963 mg/l during summer season
- Calcium (Ca) ranged between 283 mg/l during winter season to 464 mg/l during summer season
- Magnesium (Mg) ranged between 869 mg/l during pre-monsoon season to 1392 mg/l during summer season
- Chlorides (Cl) ranged between 12719 mg/l during winter season to 18744 mg/l during summer season
- Sulphates (SO_4) ranged between 2027 mg/l during summer season to 2317 mg/l during winter season
- Nitrates (NO_3) ranged between 2.98 mg/l during pre-monsoon season to 10.47 mg/l during summer season
- Sodium (Na) ranged between 12025 mg/l during pre-monsoon season to 16418 mg/l during summer season
- Potassium (K) ranged between 234 mg/l during pre-monsoon season to 329 mg/l during summer season
- Zinc (Zn) ranged between 0.124 mg/l during winter season 2.47 mg/l during summer season
- Lead (Pb) ranged between 0.208 mg/l during Pre-Monsoon season 0.325 mg/l during summer season
- Copper (Cu), Manganese (Mn), Arsenic (As) Selenium (Se) and Cyanides (CN) are reported <0.001mg/l at all sampling locations and seasons respectively

- Mercury (Hg) is <0.001 mg/l during winter, and ranged between 0.02 mg/l during summer to 0.05 mg/l during pre-monsoon season
- Remaining sampled parameters are below detectable limits at all locations during the study period
- Total coli-forms recorded were 1820 MPN/100 ml during summer season to 2965 MPN/100 ml during winter
- Faecal coliforms (FC) were not recorded at all sampling locations during study period

The parameters for surface water samples are compared with the limits specified of Class C, drinking water source with conventional treatment followed by disinfection as per ISI-IS: 2296-1982, and are within the limits except Iron, TDS, Chloride, Sulphates, BOD, Cadmium and Lead at all locations during all seasons.

3.6.2.2 Hydrogeology-Ground Water Scenario

The district is underlain by both porous and fissured formations. The important aquifer systems in the district are constituted by i) unconsolidated & semi-consolidated formations and ii) weathered, fissured and fractured crystalline rocks.

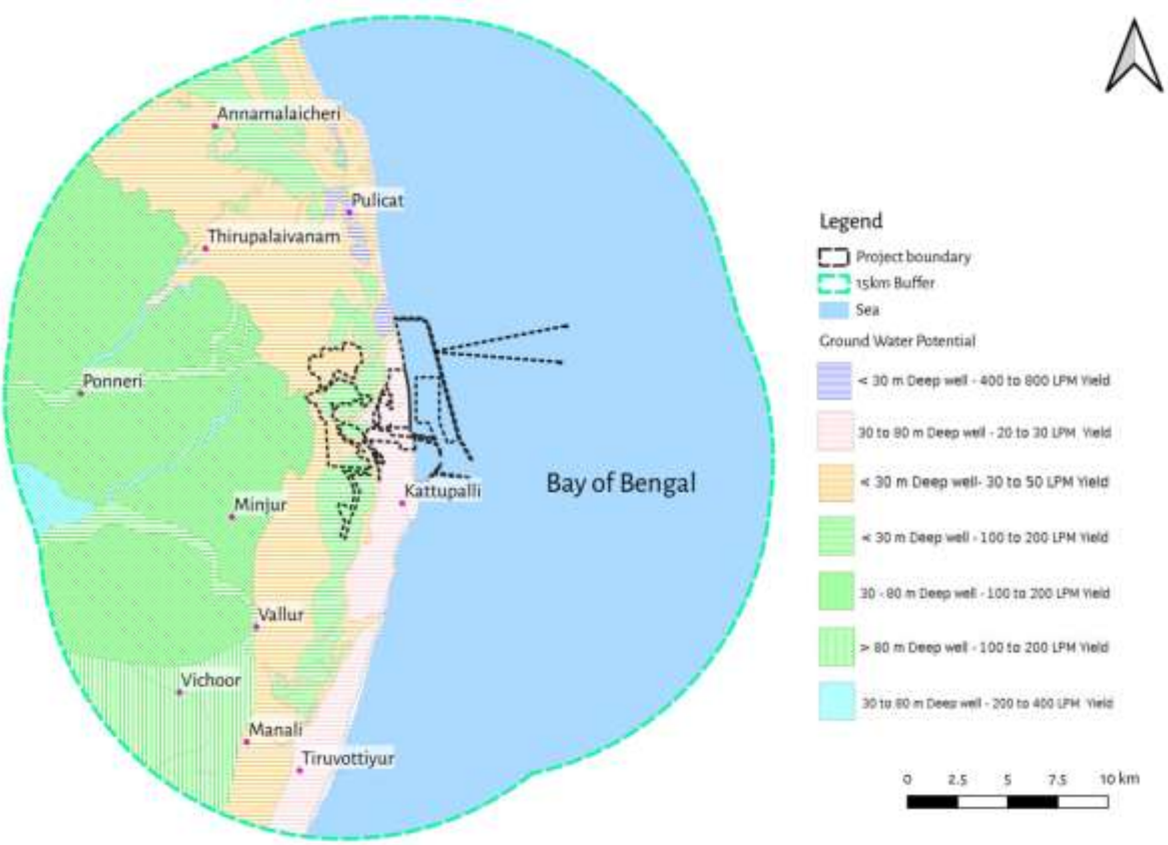
The porous formations in the district include sandstones and clays of Jurassic age (Upper Gondwana), marine sediments of Cretaceous age, Sandstones of Tertiary age and Recent alluvial formations. Quaternary formations comprising mainly sands, clays and gravels are confined to major drainage courses in the district.

The maximum thickness of alluvium is 30.0 m. whereas the average thickness is about 15.0 m. Ground water occurs under phreatic to semi-confined conditions in these formations and is being developed by means of dug wells and filter points.

Ground water generally occurs under phreatic conditions in the weathered mantle and under semi-confined conditions in the fissured and fractured zones at deeper levels. The thickness of weathered zone in the district is in the range of 2 to 12 m. The depth of the wells ranged from 8.00 to 15.00 m bgl. The yield of large diameter wells tapping the weathered mantle of crystalline rocks ranges from 100 to 500 lpm and are able to sustain pumping for 2 to 6 hours per day.

Central Ground Water Board (CGWB) categorized 6 blocks as over-exploited[11] and 2 blocks as critical out of 14 blocks in the district.

[11] *District Ground Water Brochure of Tiruvallur District, Tamil Nadu, Central Ground Water Board: Ministry of Water Resources, South Eastern Coastal Region, Chennai, 2007*



(Source: NRSC Bhuvan)

Figure 3-9: Ground water potential map of study area

As the ground water in the alluvial aquifer in the eastern part of the district is in hydraulic connection with the sea, the district is also vulnerable to saline water ingress. Flow of saline water from the Buckingham canal and the presence of a few salt pans along the coast have also contributed to the salinization of ground water in the area.

3.6.2.3 Ground Water Quality

Total Five (05) groundwater monitoring locations were identified for assessment in different villages around the project site based on the usage of groundwater by the settlements/ villages in the study area.

Groundwater sample analysis with respect to physico-chemical, nutrient, oxygen demand and bacteriological parameters having relevance to public health and aesthetic significance are selected to assess the water quality status. Standard methods prescribed for groundwater sampling, analysis was adopted and compared with drinking water quality standards of IS: 10500 (2012). Description of Groundwater sampling locations are given in **Table 3-7** and are shown in **Figure FD0301**. The ground water quality results are presented in **Appendix F**.

Table 3-7: Details of Groundwater Sampling Locations

Station Code	Name of the Location	Distance (Km) from Project Boundary	Azimuth Directions
GW1	Kattupalli	Within the site	
GW2	Kalanji	Within the site	
GW3	Ramanathapuram	Within the site	
GW4	Uranambedu	Within the site	
GW5	Neidavayal	3.2	W

3.6.2.3.1 Results and Discussion on Ground Water quality

- Colour ranged between 5 Hazen units during winter to 39 Hazen units during Pre-Monsoon
- pH is slightly alkaline and ranged between 6.74 during summer season to 7.54 during pre-monsoon season
- Electrical Conductivity (EC) varied between 154 µmhos/cm during winter season to 3450 µmhos/cm during summer season
- Total dissolved solids varied between 91 mg/l during winter season to 1930 mg/l during summer season
- Total alkalinity varied between 18 to 380 mg/l both during winter season respectively
- Total hardness (as $CaCO_3$) varied between 36 to 384 mg/l both during winter season respectively
- Total Alkalinity ranged between 18 mg/l during winter to 380 mg/l during winter
- Flouride ranged between 0.32 mg/l during winter to 1.55 mg/l during pre-monsoon
- Phosphates is below detectable limitsl during all seasons
- Salinity ranged between 0.036 ppt during summer to 1.08 ppt during summer
- Calcium (Ca) varied between 7.6 to 81 mg/l both during winter season respectively
- Chlorides (as Cl^-) varied between 20 to 598 mg/l both during summer season respectively
- Total Residual Chlorine observed below detectable limit of 0.1 mg/l
- Fluorides as (F^-) varied between 0.32 mg/l during winter season to 1.55 mg/l during Pre-Monsoon season
- Nitrates (NO_3) varied between 1.26 mg/l during winter season to 15.2 mg/l during summer season
- Total Nitrogen is observed below detectable limit of 1.0 mg/l
- Copper and Manganese are observed below detectable limit of 0.05 mg/l
- Total phosphates observed below detectable limit of 0.01 mg/l
- Ammonia is observed below detectable limit of 0.1 mg/l
- Phenolic Compounds are observed below detectable limit of 0.001mg/l
- Cyanides, Arsenic, Lead and Selenium are observed as <0.01 mg/l at all the locations
- Chromium is observed below detectable limit of 0.05 mg/l
- Mercury (Hg) is observed below detectable limit of <0.001 mg/l at all the locations
- Total coliforms and Faecal coliforms were not reported at all locations.
- Remaining sampled parameters are below detectable limits at all locations during the study period

Groundwater samples are within the limits specified for drinking water quality standards as per IS: 10500 (2012) except colour at Ramanathapuram and Urnambedu, Turbidity, Iron (Fe), Sulphates at Urnambedu, Flouride at all locations.

3.7 Marine Environment

3.7.1 Coastal Hydrology/Geomorphology

3.7.1.1 Met Ocean Data Analysis

This section describes the analysis of measured data on water levels and currents for the pre-monsoon period (February to March 2020)[12]. The measurement locations are shown in **Figure 2-9**.

3.7.1.1 Water Levels

Pre-monsoon water level data was reviewed at two locations inside the Pulicat Lake (W1P) and Ennore Creek (W3K) for a period of 30 days. The data was recorded with respect to Mean Sea Level (MSL) and at every 15 minutes interval. **Figure 3-10** shows the water level variation at W1P and W3K locations. Maximum tidal range at W1P and W3K are 0.44m and 0.94m respectively. The tides are semidiurnal in nature with the period of 24 hrs and 52min.

The change in water levels is combined due to astronomical tide, wind setup, wave set up, barometric pressure and global sea level rise. The phase of the tide also varies from south to north. The highest water level is seen where the influence of bottom relief and the configuration of the coast are prominent. Asymmetry in water levels are seen at W1P and W3K and it is more predominant during the neap phase of the tide.

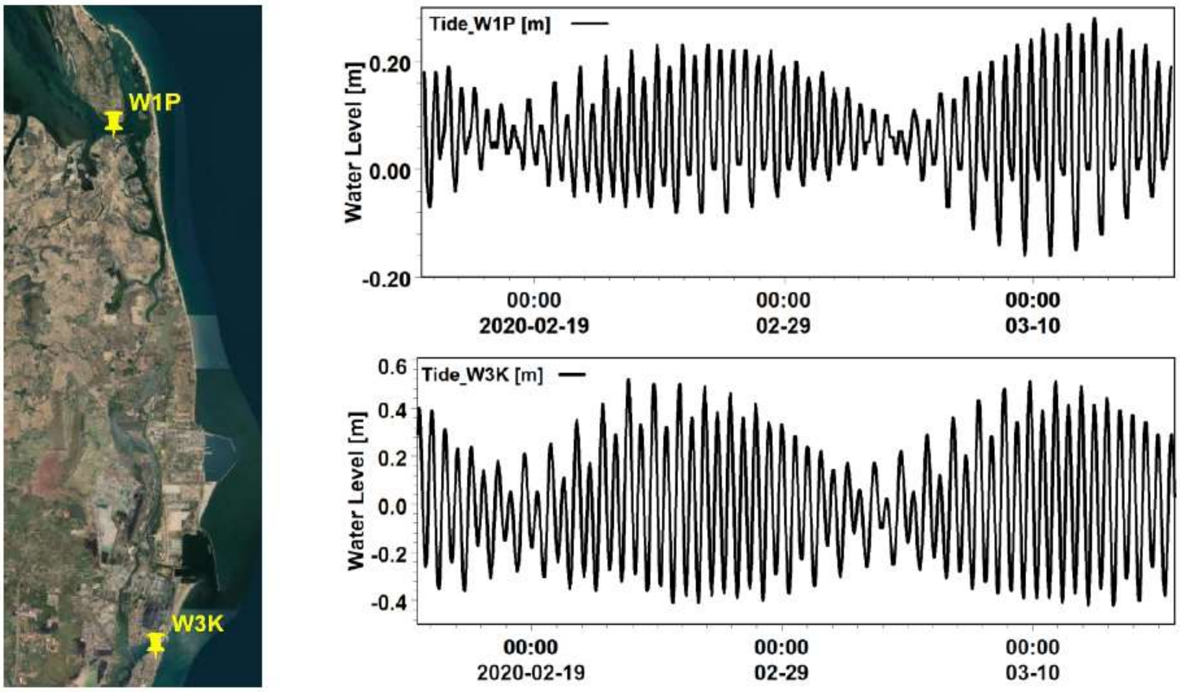


Figure 3-10: Water level variation w.r.t MSL at W1P and W3K Locations

[12] *Shoreline Management Studies, Mathematical Modelling studies for Development of Kattupalli Port Master Plan –DHI (India) Water & Environment Private Limited*

3.7.1.2 Currents

Pre-monsoon currents in the project area are primarily forced by tide and wind components. Major driving mechanism of current variability is attributed to wind in the Bay of Bengal, which reverses with monsoons. It has also been reported that periods of peak monsoon do not coincide with times of maximum current speed. **Figure 3-11** shows the variation of current speed at all the measured locations (C1, C2 and C3) during the measurement period. Maximum current speed at C1, C2, and C3, are 0.17m/s, 0.25m/s, 0.27m/s respectively. The mean current speeds are 0.04m/s, 0.07m/s, and 0.09m/s.

The current direction at C1, C2 and C3 is represented as current roses in **Figure 3-12**. The current direction at C1 which is immediate north of Katupalli north breakwater is aligned in NW and SE direction. At C2 between Katupalli port and Pulicat creek, the currents are shore parallel and predominantly northwards. At C3, near Pulicat creek, the currents are aligned in NW direction. The current data indicates that nearshore currents coincide with coastal currents and its direction is northerly during pre-monsoon. But at station C1, which is immediate north of Katupalli port, is influenced by breakwater, do not show any particular trend in the direction.

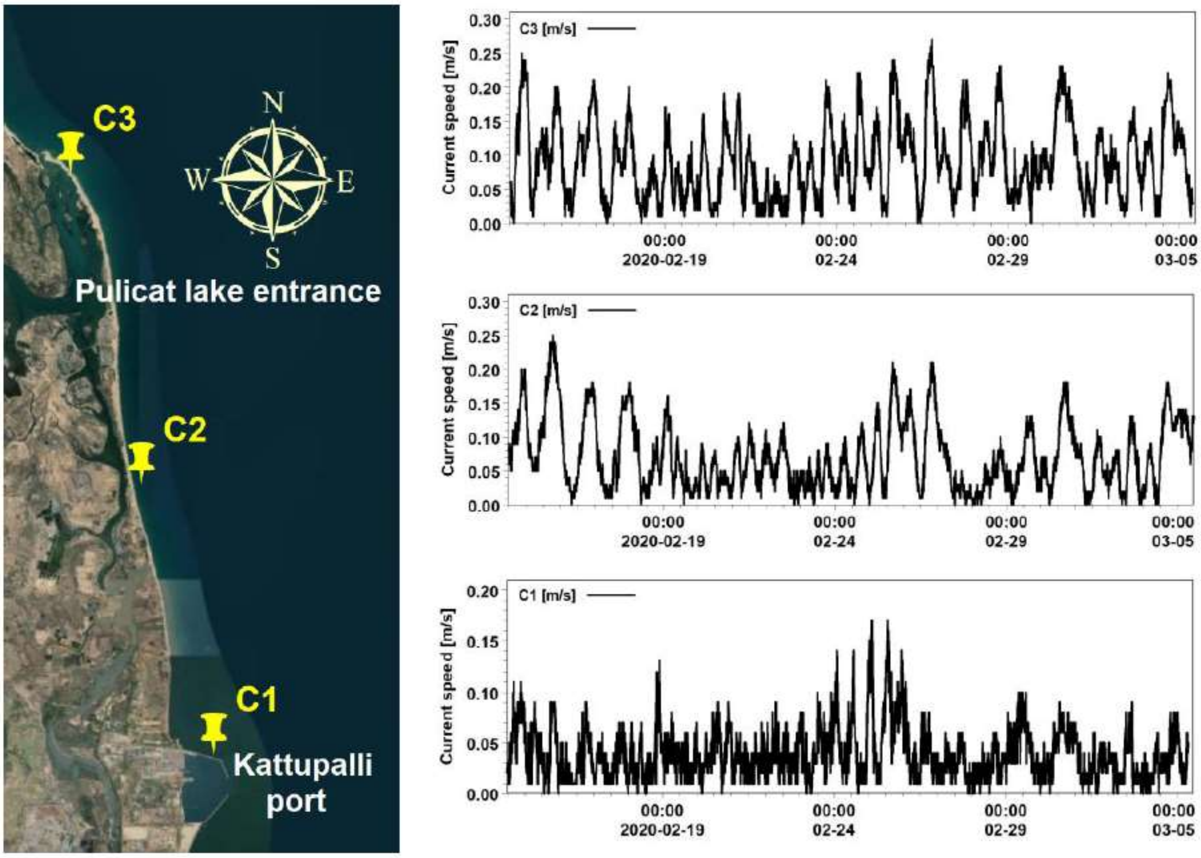


Figure 3-11: Measured current speed at C1, C2 and C3 locations

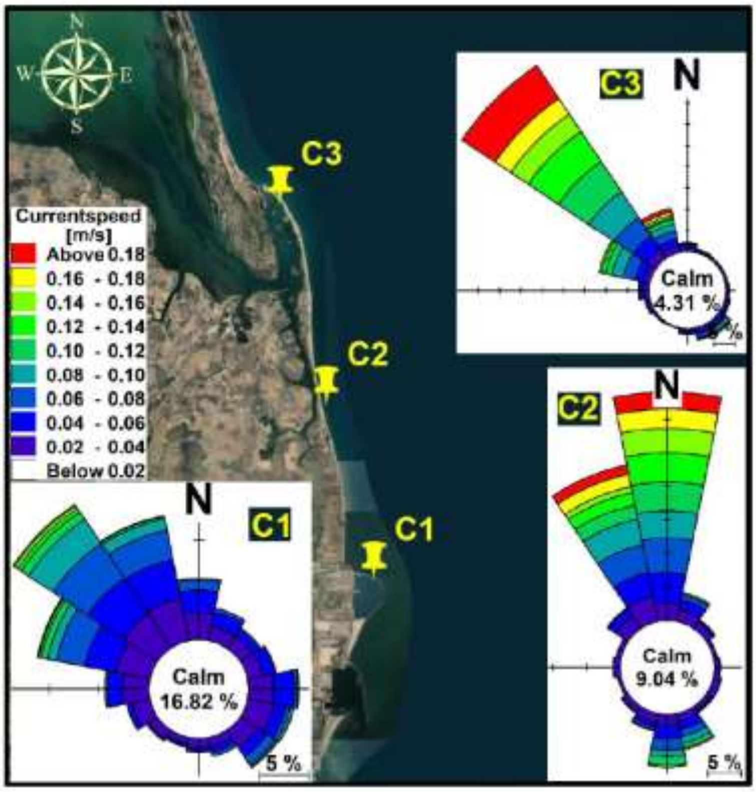


Figure 3-12: Measured current direction at C1, C2 and C3 locations

3.7.1.3 Tides

Mean High High Water (MHHS) at Chennai port is 0.5 m above MSL. Mean High High Water is the average height that the tide reaches on a Spring Tide. Spring tides basically occur when there is a new moon or a full moon. Spring tides rise furthest up the shore at high tide and go out furthest at low tide (i.e. maximum tidal range occurs). Tidal levels and datum for Chennai (NHC Chart No. 3039) is given in the **Table 3-8.**

Table 3-8: Tide Levels

Description	Tide Level (m) with respect to Chart Datum (CD)
Mean High High Water, MHHW	(+) 1.1
Mean High Low Water, MHLW	(+) 0.8
Mean Sea Level (MSL)	(+) 0.6
Mean Low High Water MLHW	(+) 0.4
Mean Low Low Water Spring MLLW	(+) 0.1

3.7.1.4 Offshore Wind

The predominant wind direction was observed to be North East and South East. The maximum magnitude of these were observed to be 12m/s or 24 kts. Hence winds of 25 kts, gusting upto 32 kts were applied during the simulations. **Figure 3-13** shows the offshore wind rose diagram.

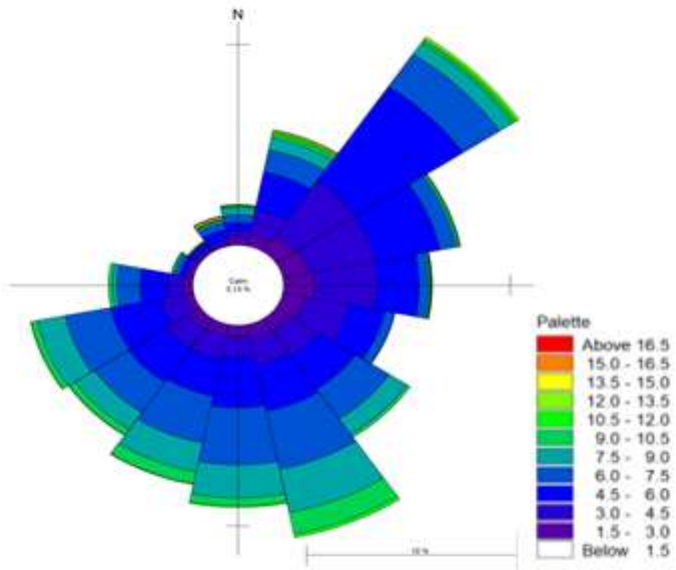


Figure 3-13: Offshore wind rose diagram

3.7.1.5 Waves

The waves in the region were predominantly from the South Westerly direction. The max wave height was observed to be 3.0m. Wave rose diagram was shown in **Figure 3-14**. The maximum significant wave height estimated at Kattupalli port due to 2016 Vardah cyclone is 5.15m.

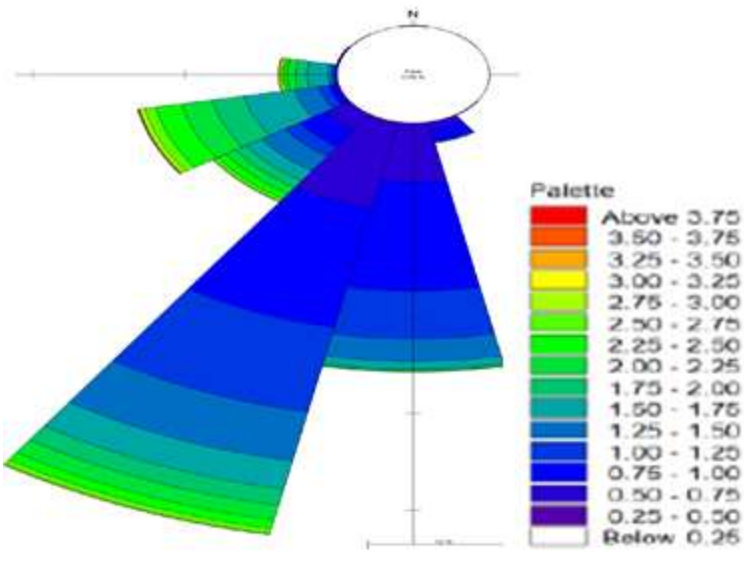


Figure 3-14: Wave Rose Diagram

3.7.1.6 Bathymetry

Seabed information from Ennore to Pulicat creek was mapped using single beam echosounder (**Figure 3-15**). The data was collected for the area 30km alongshore (north to south) and 10km at cross shore (east to west). The data was collected up to a water depth of 35m with respect to Chart Datum.

The data indicates that coastal environment show more variation in the cross-shore direction than the alongshore direction. Also, the seabed at Katupalli Port is complex with varied slope between Ennore Creek and Pulicat Creek. The slope at the south of Ennore port is relatively steep (1 in 300) at Ennore Creek, while the slope on the north of Katupalli port is flat (1 in 500) with submerged shoals extending in north-easterly direction.

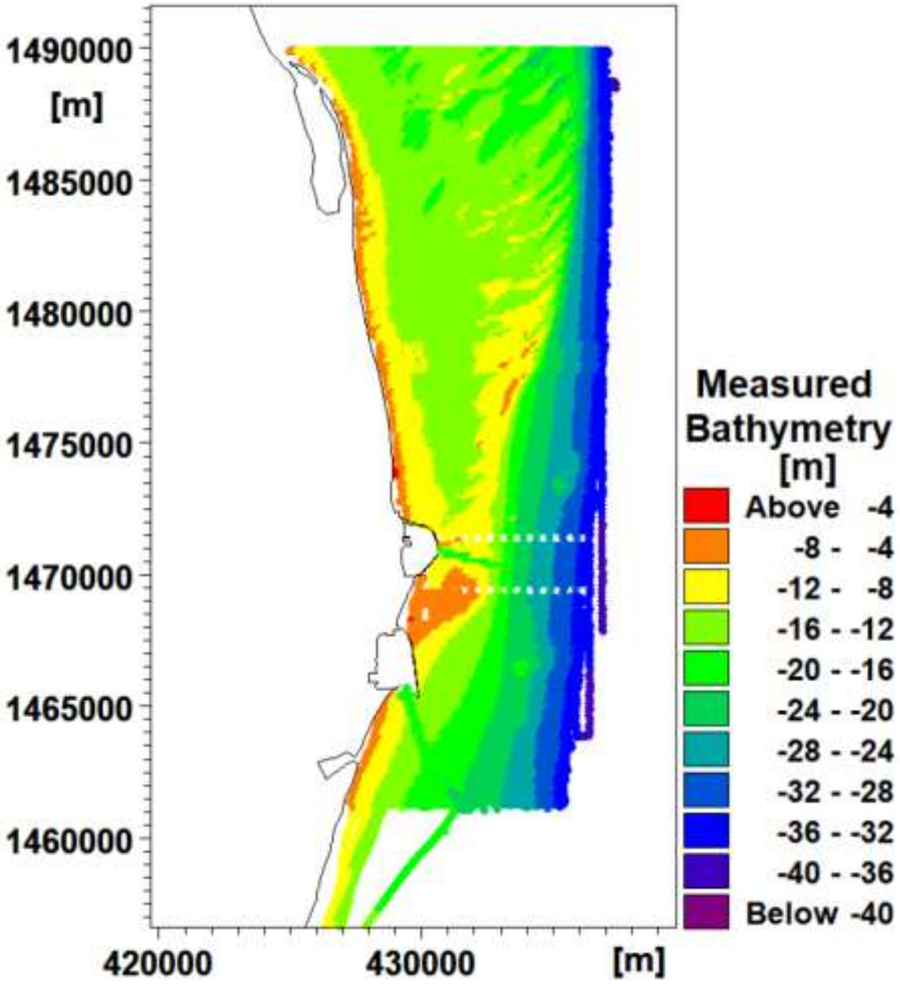


Figure 3-15: Bathymetry data: Ennore to Pulicat Creek

3.7.2 Marine Environmental Parameters and Analysis

Marine monitoring was done to determine the parameters such as physico-chemical, biological, nutrients, heavy metals, bacteriological, phytoplankton and zooplankton in sea/harbour water and sediment. The monitoring was done at Ten locations for three seasons viz. winter, summer and pre-monsoon.

3.7.2.1 Sea/Harbour Water Physicochemical Parameters

Temperature (°C): The water temperature fluctuated from 28.0°C to 33.0°C. The minimum value was recorded at MSL-6 at Sub-Surface level during Pre-Monsoon season and maximum was recorded at MSL-1 and MSL-3 during Summer Season and at sub-surface levels of MSL-7, & MSL-8 during Winter Season respectively. A map showing monitoring locations is given as **FD0302.**

Salinity (‰): The major variable in the coastal environment is salinity, the water salinity varied from 30 ‰ to 35 ‰. The salinity was found to be lower at MSL-1 during Pre-Monsoon, MSL-4 & MSL-6 during Winter Season and higher at sub surface levels of MSL-6 & MSL-8 during Summer season and also at sub-surface level of MSL-6 during Pre-Monsoon season respectively

pH: The water pH varied between 7.9 and 8.3 with minimum at MSL-4 during Summer and Pre-Monsoon Season respectively and maximum at Sub-surface levels of MSL-5 during Summer and Pre-Monsoon Season and also at Sub-surface levels of MSL-7 & MSL-9 during Winter Season respectively.

Total Suspended Solids: Concentrations of suspended Solids are important parameter in water quality management. The Total Suspended solids values ranged between 48.1 and 142.4 mg/l. The minimum value was recorded at MSL-5 during summer season and the maximum was recorded at Sub-surface level of MSL-6 during Pre-Monsoon season.

Turbidity: The turbidity values were ranged between 4.6 and 8.7 NTU. The minimum level was recorded at MSL-5 during summer season and the maximum level at Sub-surface level of MSL-4 during Pre-Monsoon season.

Dissolved Oxygen (mg/l): The Dissolved oxygen is an index to study the productivity of an Environment. The Dissolved Oxygen level in the water varied between 3.6 and 5.9 mg/l. The lower value was recorded at Sub-surface level of MSL-7 during winter season and the higher value at MSL-8 during Summer season.

Biological Oxygen Demand (mg/l): The BOD values varied between 1.0 and 3.1 mg/l with minimum at MSL-8 and the maximum value was recorded at Sub-surface level of MSL-4 both during summer season respectively.

Detailed results for the above parameters are given in **Table 3-9,** and shown from **Figure 3-16** to **Figure 3-22**. Map showing the marine water and sediment monitoring locations are given as **Figure FD0302**.

Table 3-9: Seasonal Variations in Water Physico-chemical parameters

Parameters	Units		Value
Temperature	°C	Max.	33.0
		Min.	28.0
Salinity	‰	Max.	35.0
		Min.	30.0
pH		Max.	8.3
		Min.	7.9
TSS	mg/l	Max.	142.43
		Min.	48.08
Turbidity	NTU	Max.	8.7
		Min.	4.6
Dissolved Oxygen	mg/l	Max.	5.9
		Min.	3.6
Biological Oxygen Demand		Max.	3.1
		Min.	1.0

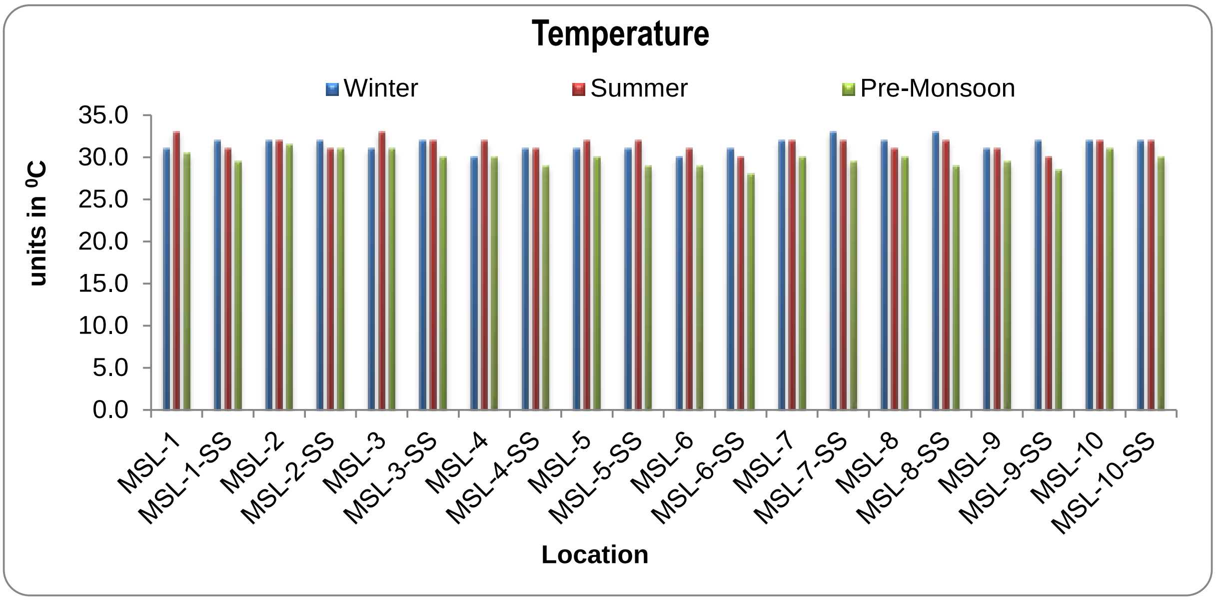


Figure 3-16: Variations in Temperature

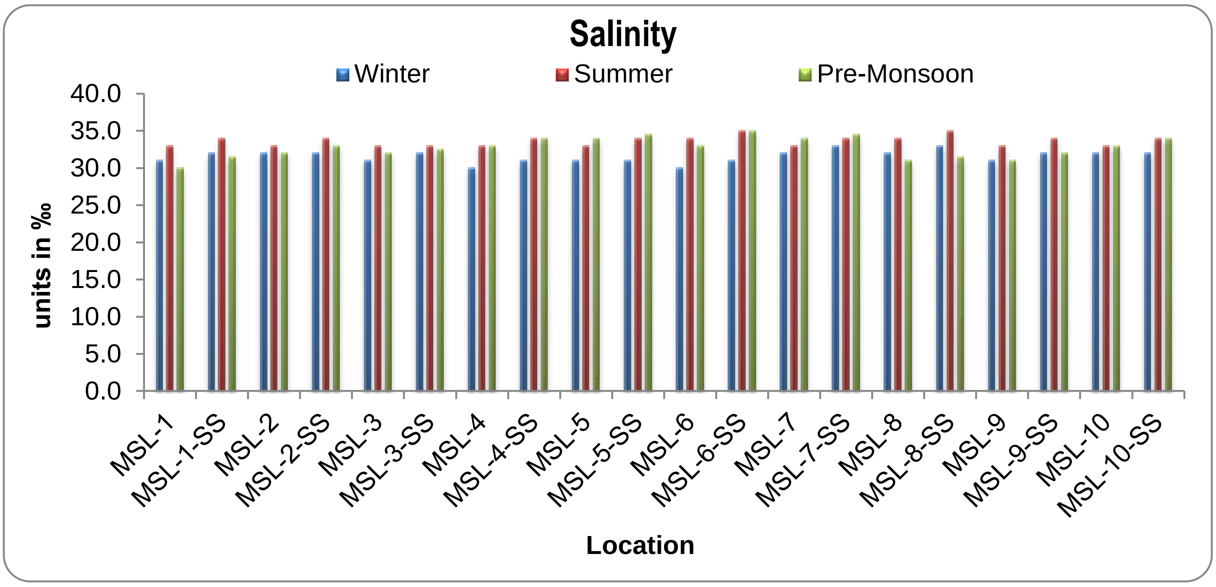


Figure 3-17: Variations in Salinity

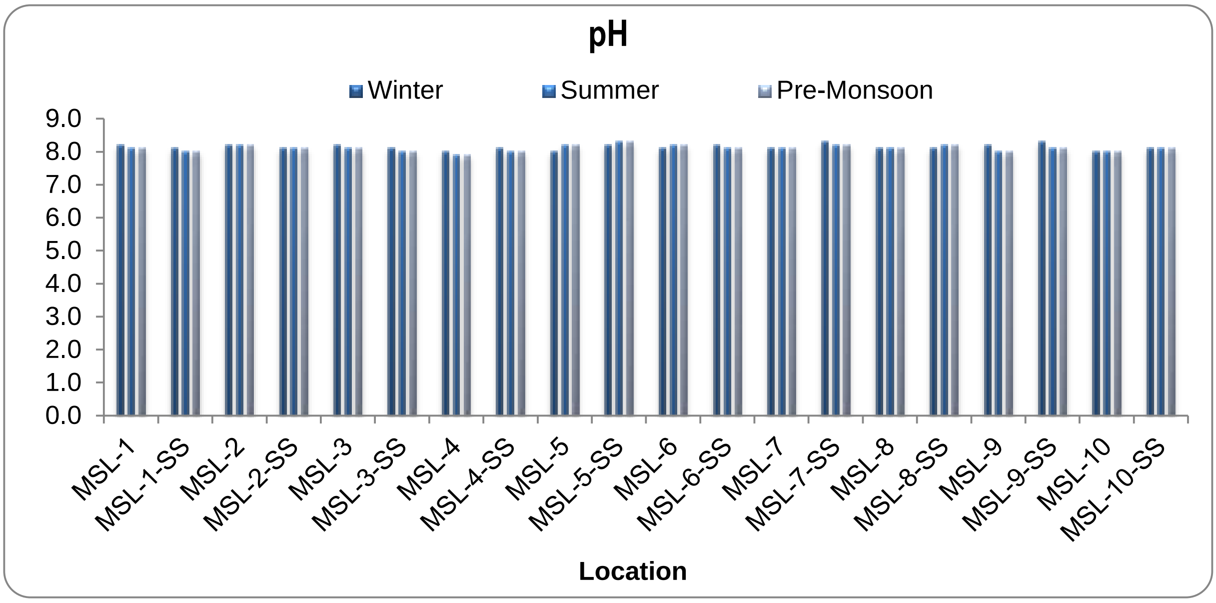


Figure 3-18: Variations in pH

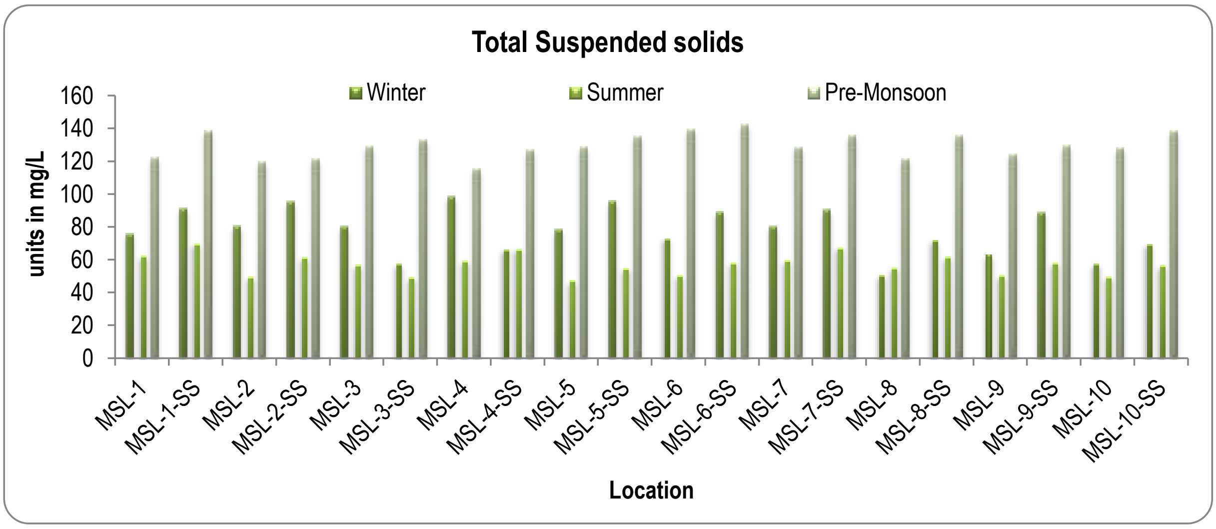


Figure 3-19: Variations in Total Suspended Solids

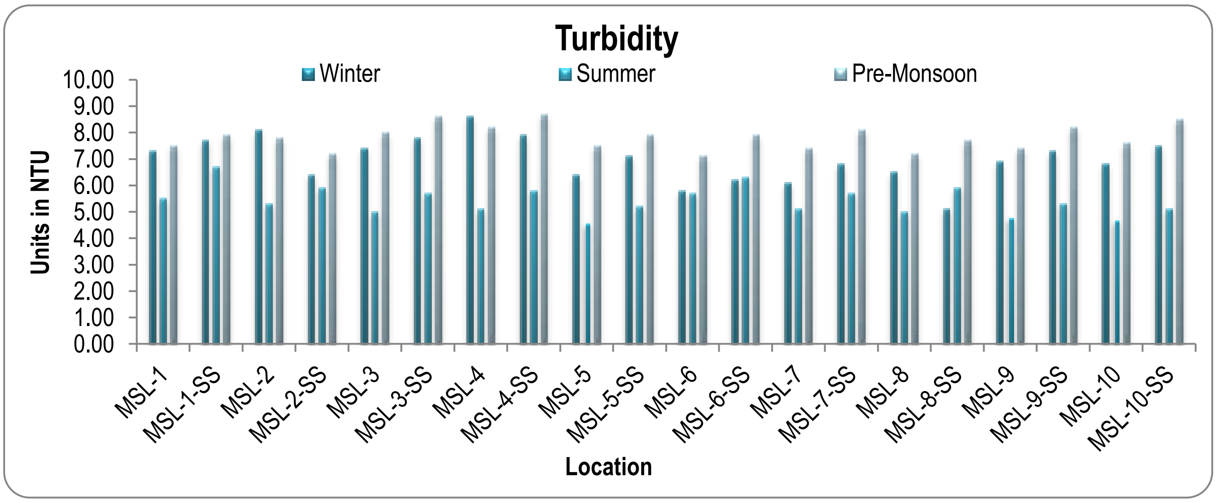


Figure 3-20: Variations in Turbidity

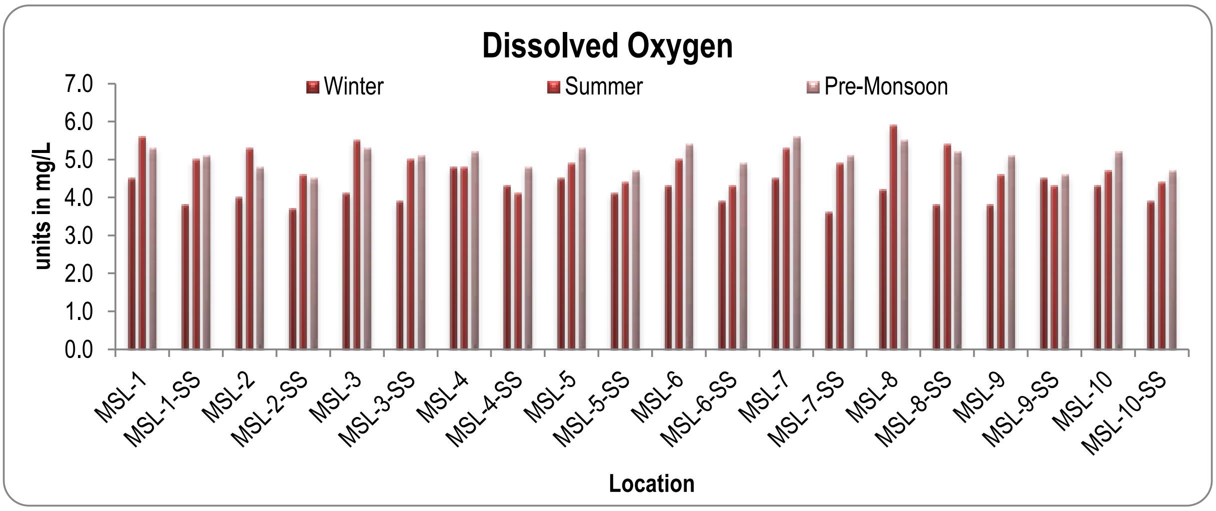


Figure 3-21: Variations in Dissolved Oxygen

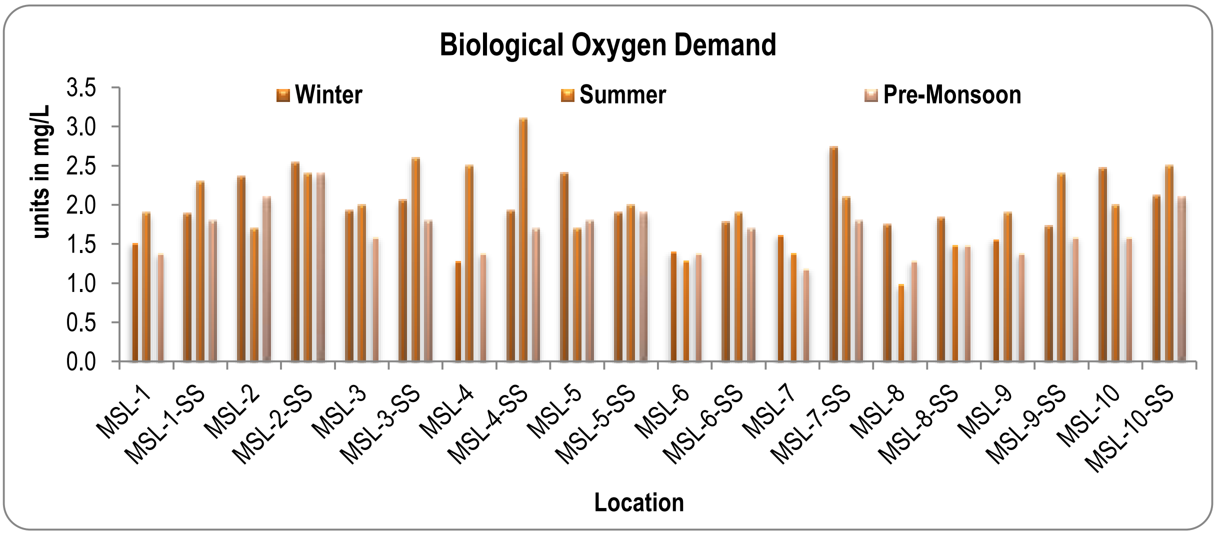


Figure 3-22: Variations in Biochemical Oxygen Demand

3.7.3 Nutrient Parameters

Nitrite (NO_2): Nitrite concentration varied from 0.23 to 2.26µmol/l with minimum at MSL-8 during winter season and maximum at Sub-Surface level of MSL-7 during Pre-Monsoon season.

Nitrate (NO_3): Nitrate concentration ranged between 2.51 and 5.67 µmol/l with minimum at MSL-9 during summer season and maximum at Sub-Surface level of MSL-4 during winter season.

Ammonical Nitrogen (NH_4): The ammonia concentration varied from 0.031 to 0.091 µmol/l. The minimum was recorded at MSL-8 and MSL-9 during summer season and the maximum value at sub-surface level of MSL-5 during Pre-Monsoon season.

Total Nitrogen: The Total nitrogen values ranged from 14.32 to 22.01µmol/l. The minimum value was recorded at MSL-9 during summer season and the maximum value at sub-surface level of MSL-9 during Pre-Monsoon season.

Inorganic Phosphate: The Inorganic phosphate value ranged between 0.23 and 1.74 µmol/l with minimum at MSL-7 during summer season and maximum at sub-surface level of MSL-5 during Pre-Monsoon season.

Total Phosphate: The Total phosphate value ranged from 1.01 to 3.28 µmol/l with minimum value at MSL-7 during winter season and the maximum value at sub-surface level of MSL-7 during Pre-Monsoon season.

Silicate: The silicate values ranged between 25.49 and 51.24 µmol/l. The minimum at MSL-8 during summer season and maximum at sub-surface level of MSL-6 during Pre-Monsoon season.

Particulate organic carbon: The particulate organic carbon level ranged between 104.06 and 143.64 µgC/l with minimum at MSL-9 during summer season and maximum at sub-surface level of MSL-6 during Pre-Monsoon season.

Petroleum hydrocarbons: PHC level in water fluctuated from 0.301 and 0.963µg/l. The minimum was recorded at MSL-6 during summer season and the maximum was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Detailed results for the above parameters are given in **Table 3-10** and shown from **Figure 3-23** to **Figure 3-31.**

Table 3-10: Seasonal Variations in Water Nutrient parameters

Parameters	Units	Min.	Max.
Nitrite (NO_2)	µmol/l	0.23	2.26
Nitrate (NO_3)		2.51	5.67
Ammonical Nitrogen (NH_4)		0.031	0.091
Total nitrogen		14.32	22.01
Inorganic Phosphate		0.23	1.74
Total Phosphate (TP)		1.01	3.28
Silicate (SiO_4)		25.49	51.24
Particulate organic carbon	µgC/l	104.06	143.64
Petroleum hydrocarbons	µg/l	0.301	0.963

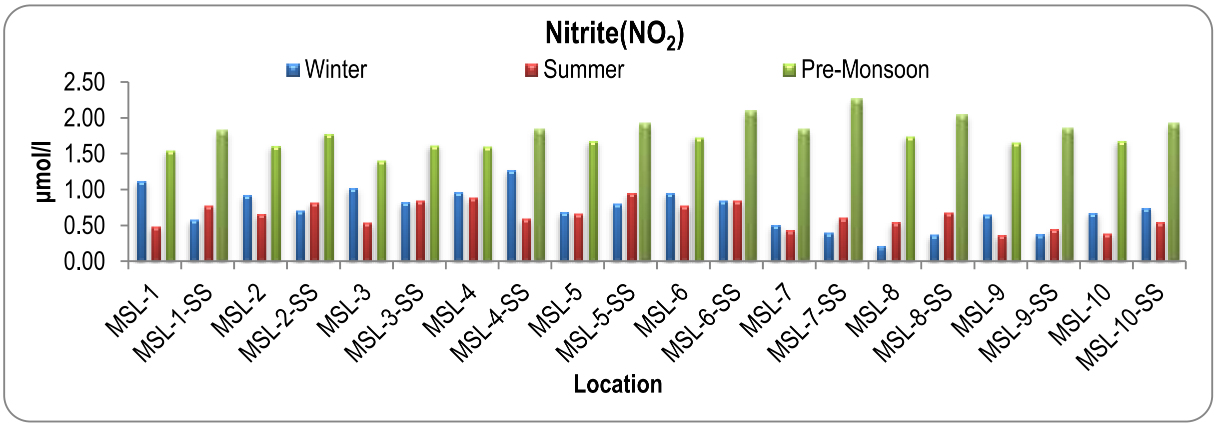


Figure 3-23: Variation of Nitrite Concentration

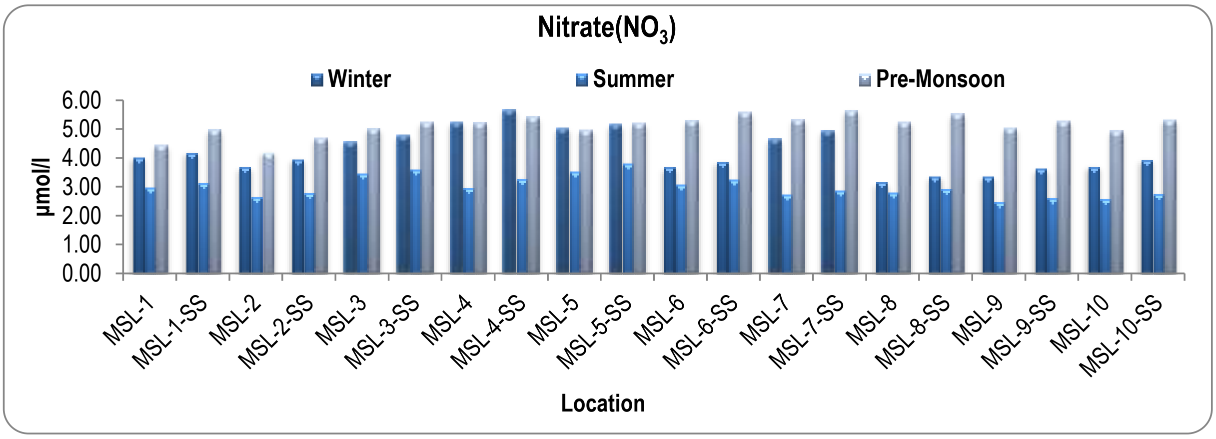


Figure 3-24: Variation of Nitrate Concentration

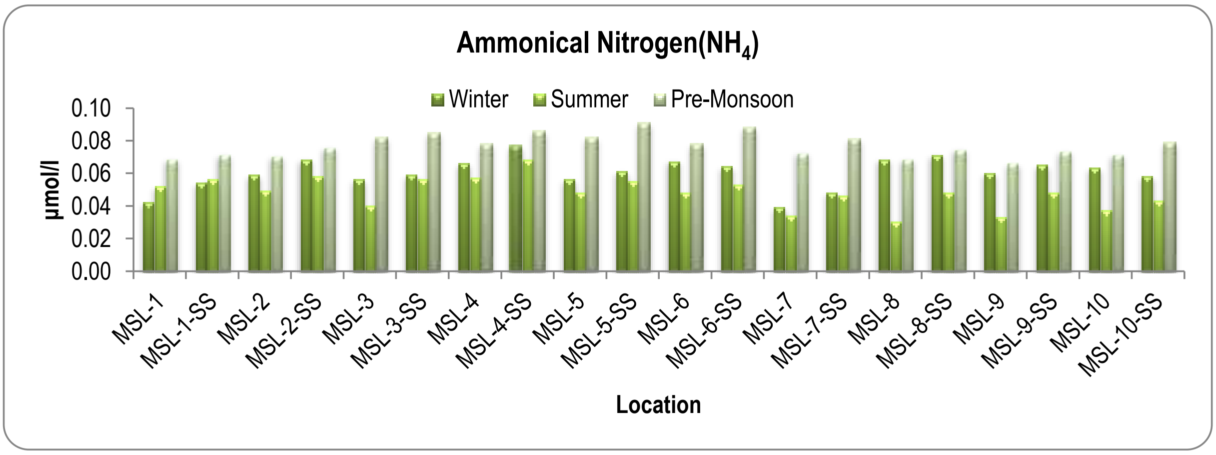


Figure 3-25: Variation of Ammonia Concentration

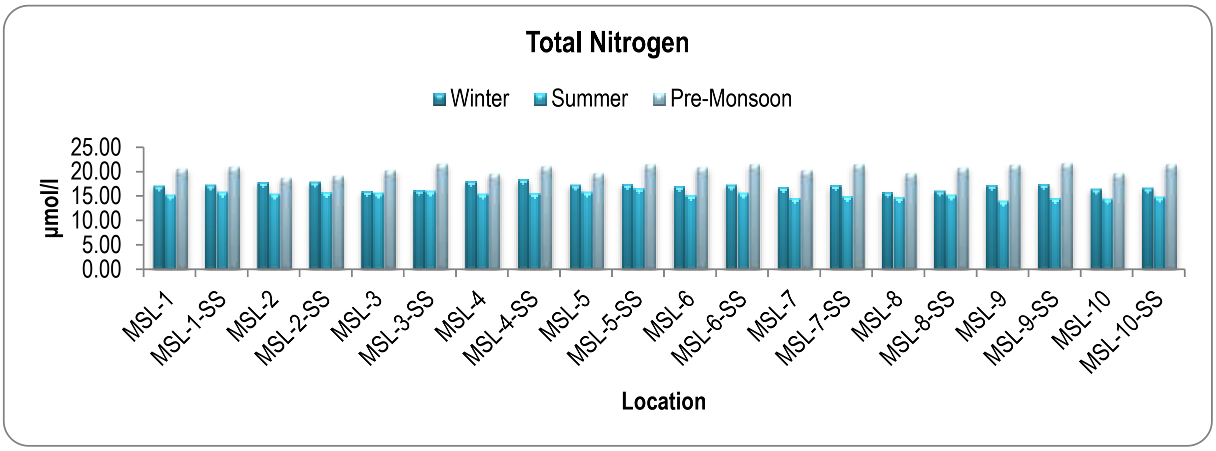


Figure 3-26: Variation of Total Nitrogen Concentration

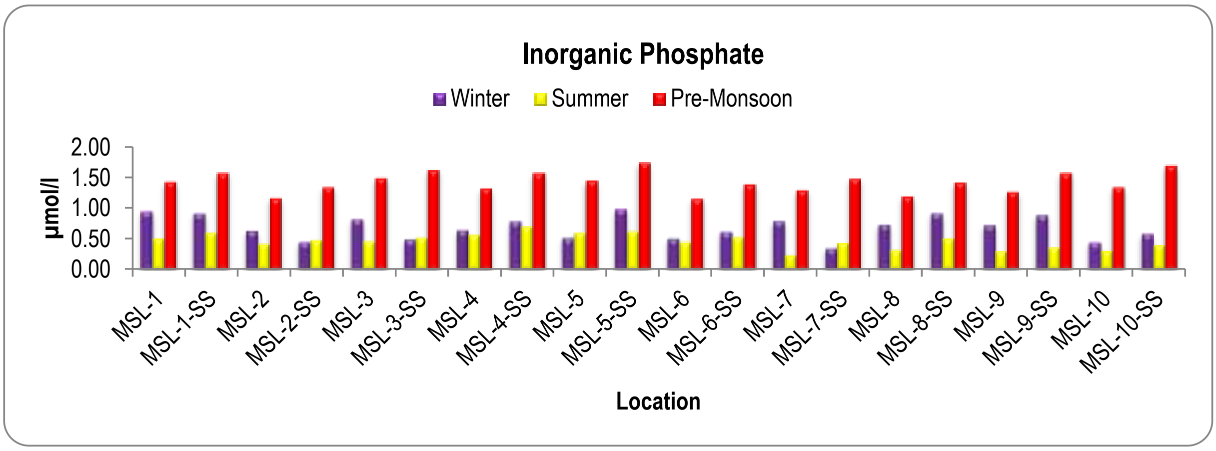


Figure 3-27: Variation of Inorganic Phosphate Concentration

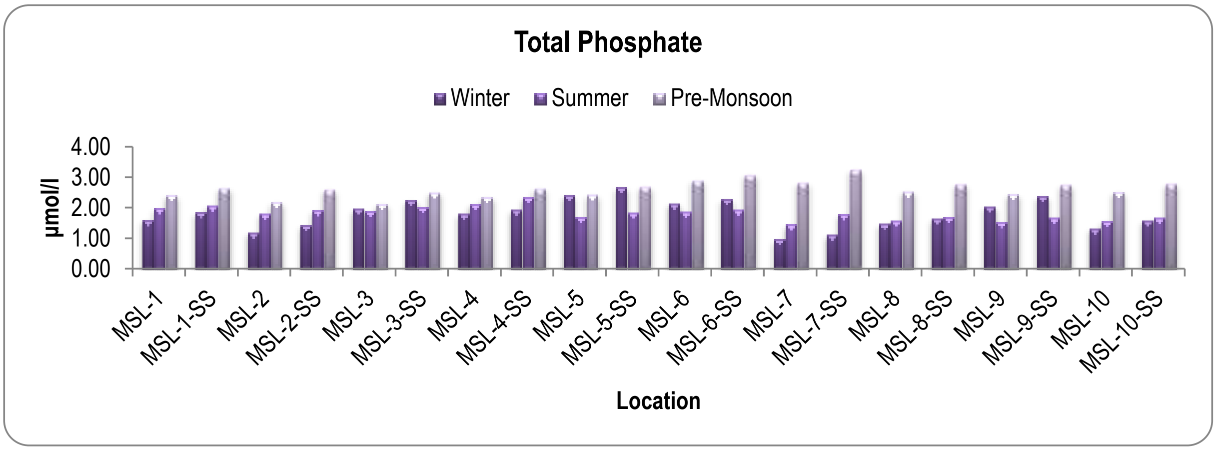


Figure 3-28: Variation of Total Phosphate Concentration

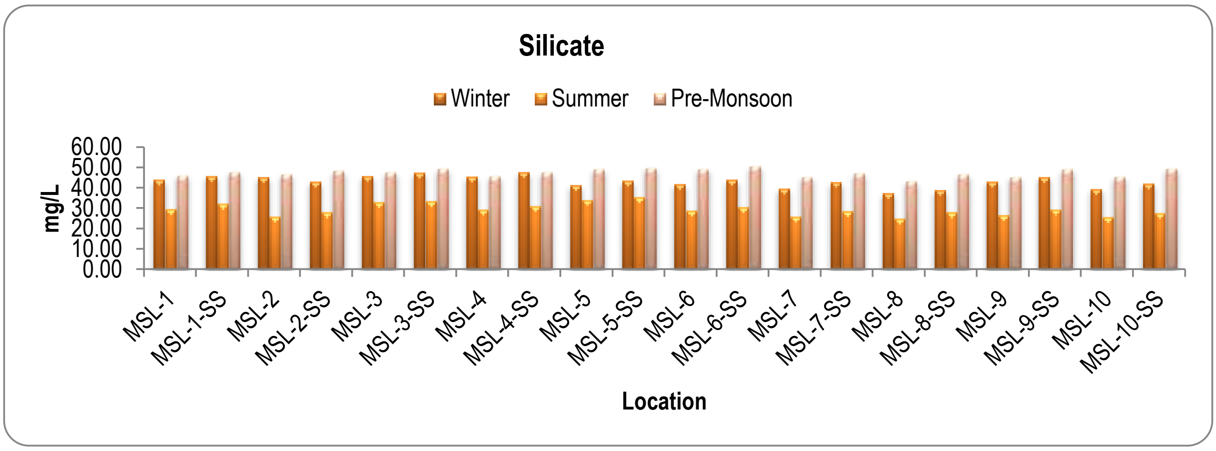


Figure 3-29: Variation of Silicate Concentration

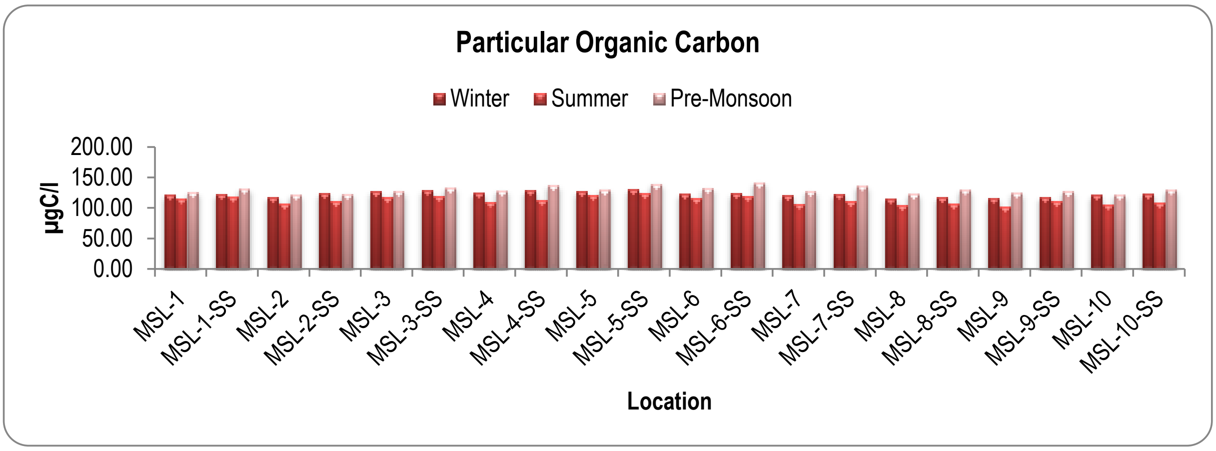


Figure 3-30: Variation of Particulate Organic Carbon Concentration

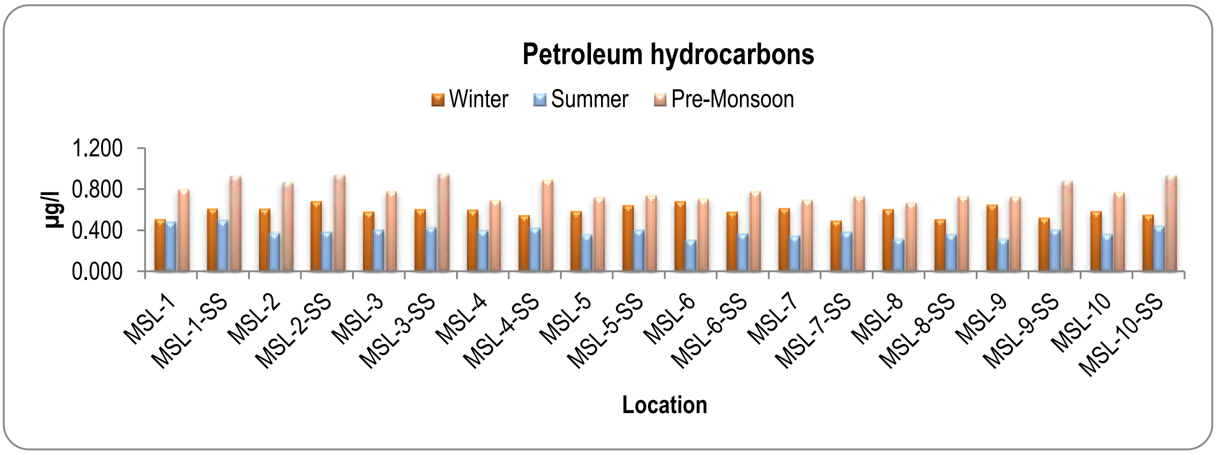


Figure 3-31: Variation of Petroleum hydrocarbons Concentration

3.7.4 Heavy Metals

A heavy metal is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides. One definition is, metals with a density greater than 5 g/cm^3.Heavy metals are stable and can't be broken down, which makes it easy for them to accumulate in the environment. The order of toxicity (from low to high) has been suggested as follows: cobalt, aluminium, chrome, lead, nickel, zinc, copper, cadmium and mercury. In marine environments however, three metals are of primary concern: lead, mercury and cadmium.

Cadmium: The Cadmium concentration varied from 1.52 to 3.21µg/L. The minimum was recorded at MSL-7 during summer season and the maximum was recorded at sub-surface level of MSL-2 during Pre-Monsoon season.

Copper: The copper concentration varied from 13.41 to 21.05µg/L. The minimum was recorded at MSL-5 during summer season and the maximum value was recorded at sub-surface level of MSL-2 during Pre-Monsoon season.

Iron: The iron concentration varied from 13.01 to 24.02µg/L. The minimum was recorded at MSL-6 during summer season and the maximum was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Zinc: The zinc level varied from 18.02 to 26.98µg/L. The minimum was recorded at MSL-10 during winter season and the maximum was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Lead: The Lead concentration ranged from 2.62 to 5.39µg/L with minimum was recorded at MSL-7 during summer season and the maximum value was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Mercury: The mercury level varied from 0.19 to 0.85µg/L. The minimum was recorded at MSL-6 during summer season and the maximum value was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Manganese: The Manganese concentration varied from 35.01 to 51.83µg/L. The minimum was recorded at MSL-7 during summer season and the maximum was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Nickel: The Nickel level varied from 1.31 to 3.27µg/L. The minimum was recorded at MSL-10 during winter season and the maximum level was recorded at sub-surface level of MSL-3 during Pre-Monsoon season.

Chromium: The chromium level varied from 1.2 to 3.28 µg/L. The minimum was recorded at MSL-5 during summer season and the maximum value was recorded at sub-surface level of MSL-7 during Pre-Monsoon season.

Detailed results for the above parameters are given in **Table 3-11** and same in **Figure 3-32** to **Figure 3-40**.

Table 3-11: Seasonal Variations in Water Heavy Metals

Parameters	Units	Min.	Max.
Cadmium (Cd)	µg/l	1.52	3.21
Copper (Cu)		13.41	21.05
Iron (Fe)		13.01	24.02
Zinc (Zn)		18.02	26.98
Lead(Pb)		2.62	5.39
Mercury (Hg)		0.19	0.85
Manganese (Mn)		35.01	51.83
Nickel (Ni)		1.31	3.27
Chromium (Cr)		1.2	3.28

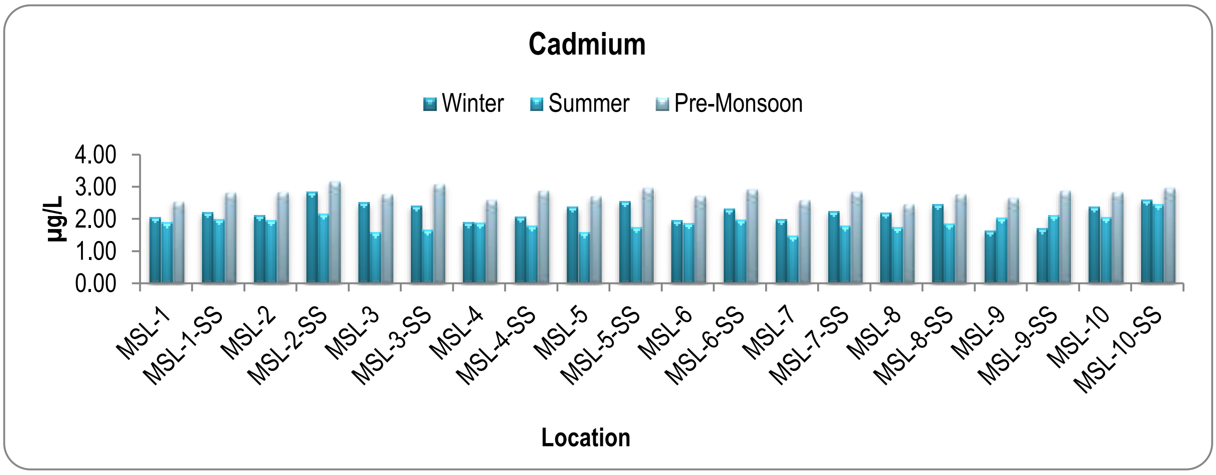


Figure 3-32: Variation of Cadmium Concentration

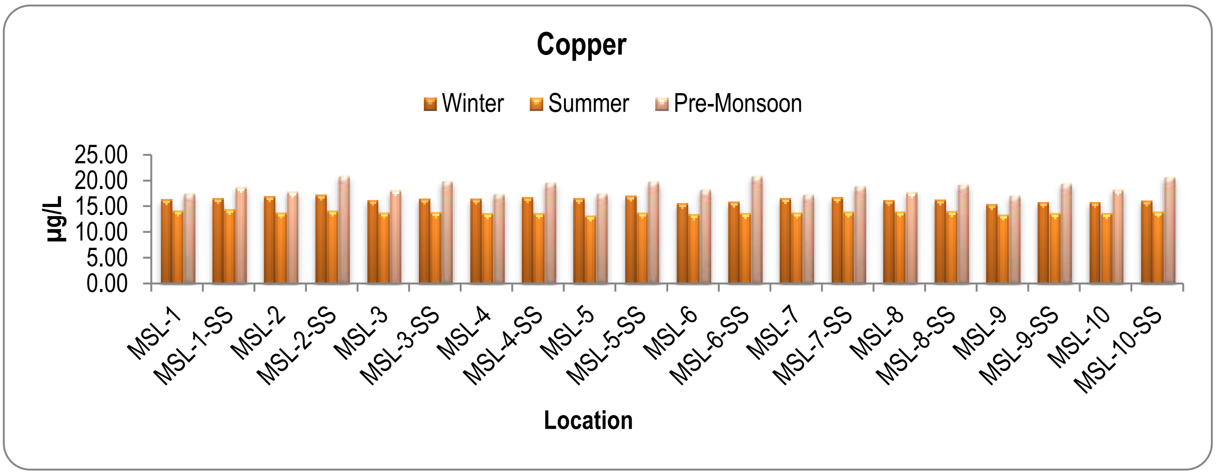


Figure 3-33: Variation of Copper Concentration

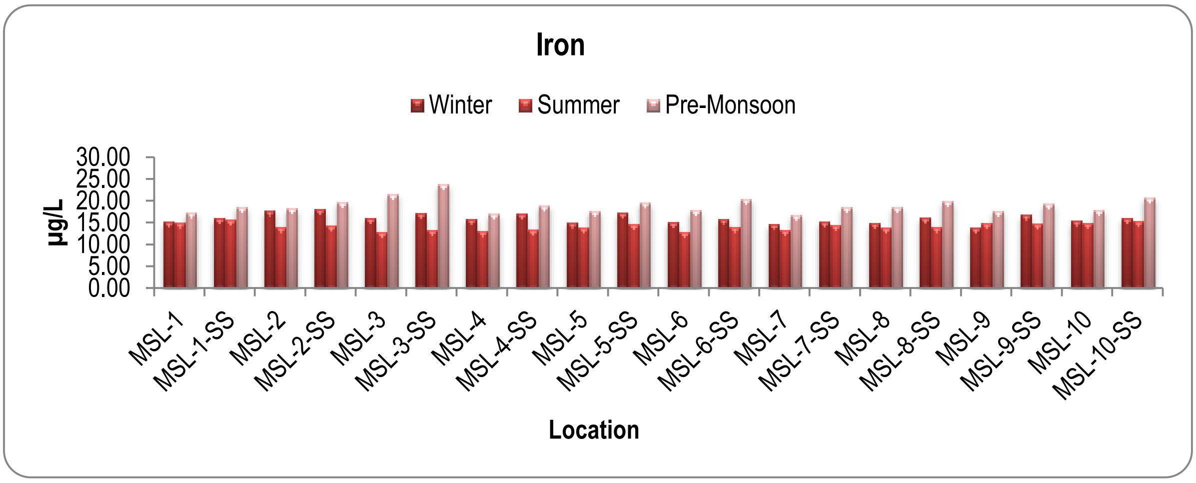


Figure 3-34: Variation of Iron Concentration

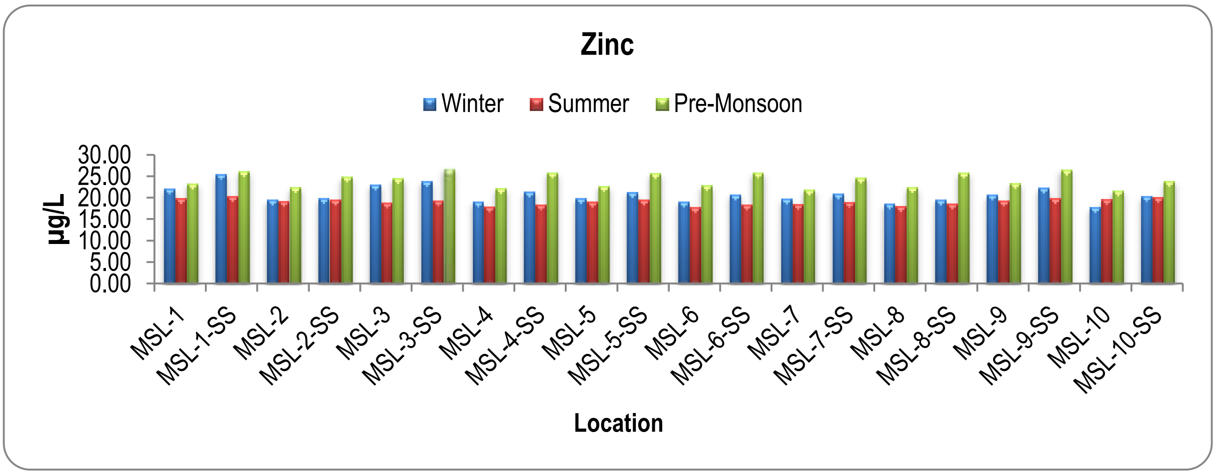


Figure 3-35: Variation of Zinc Concentration

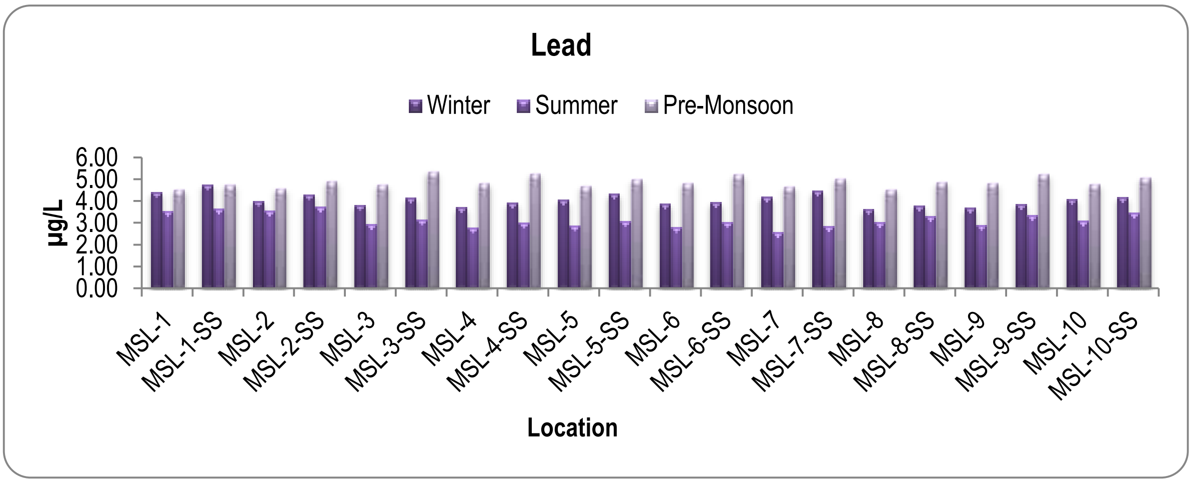


Figure 3-36: Variation of Lead Concentration

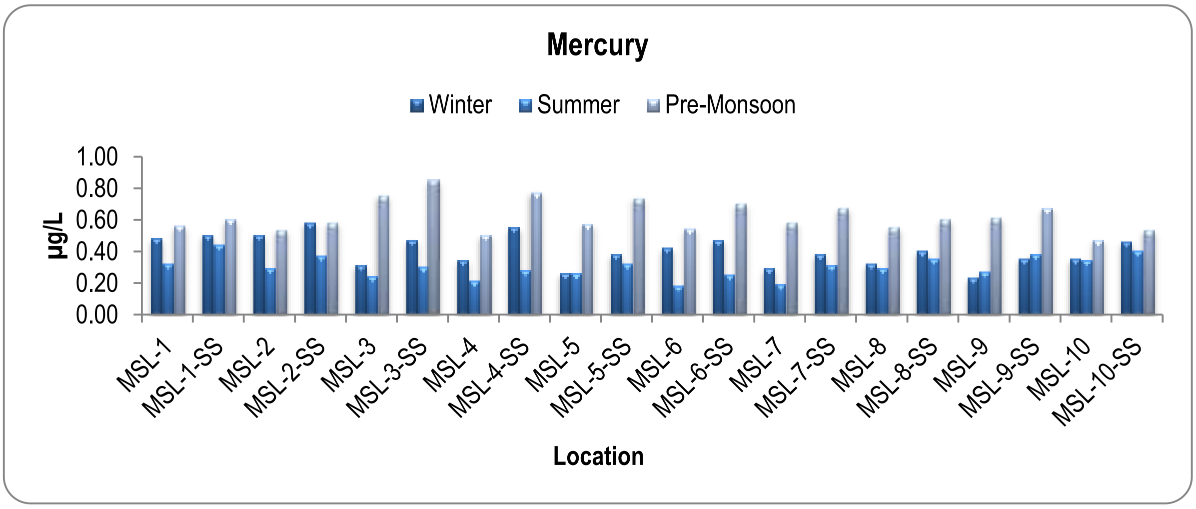


Figure 3-37: Variation of Mercury Concentration

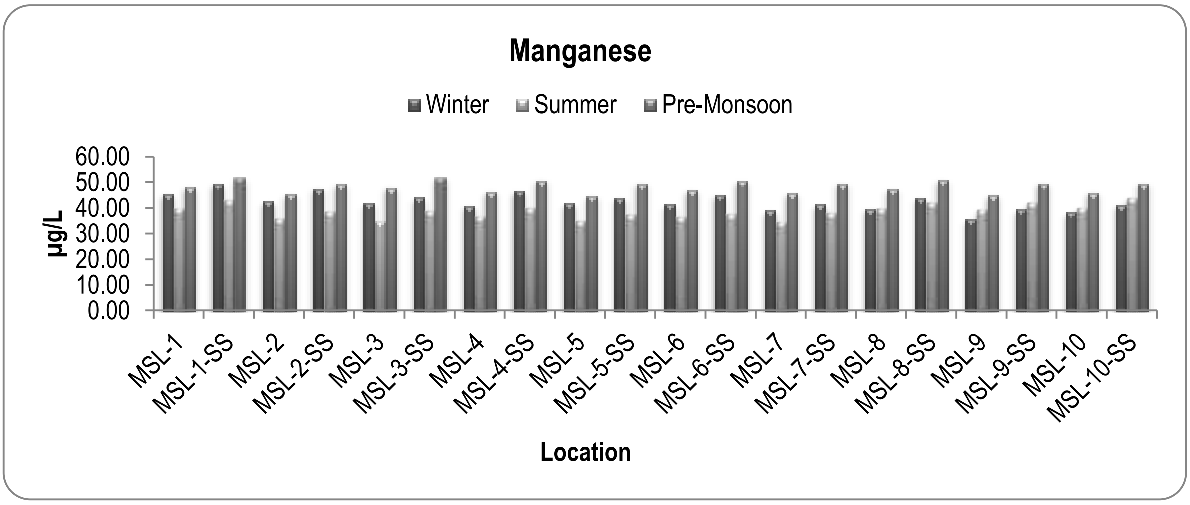


Figure 3-38: Variation of Manganese Concentration

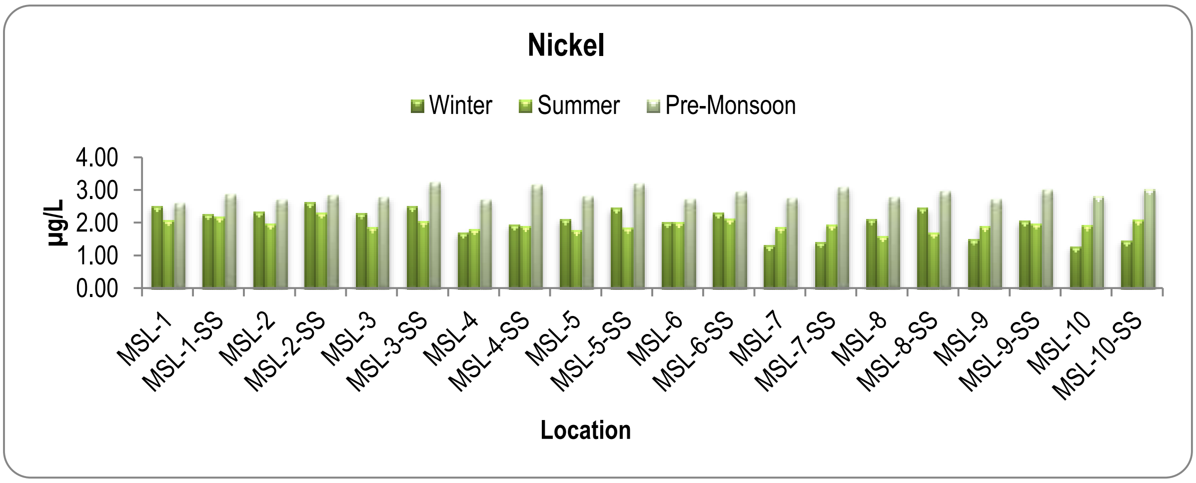


Figure 3-39: Variation of Nickel Concentration

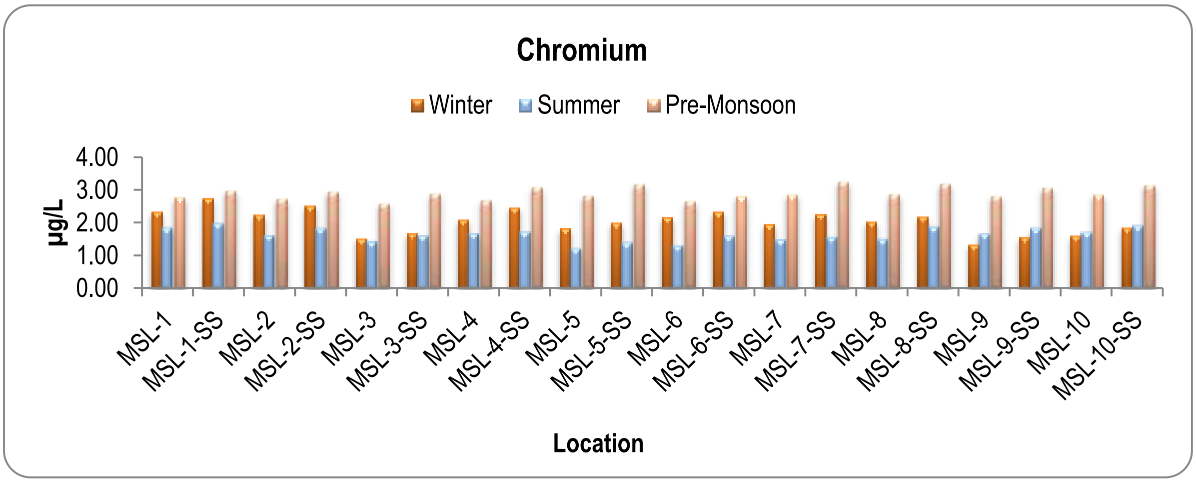


Figure 3-40: Variation of Chromium Concentration

3.7.5 Biological Parameters

The biological parametrs include chlorophyll-a, phaeopigment, total biomass and primary productivity. The parameters were measured at Ten locations for three seasons viz., summer, winter and pre-monsoon.

Chlorophyll-a

The chlorophyll-a in water sample varied from 0.505 to 1.414 mg/m^3, with minimum value was recorded at MSL-2 during Pre-Monsoon season and maximum value at ML-6 during Winter season.

Phaeopigment

Phaeopigment ranged between 0.029 mg/m^3 at MSL-3 during Winter season and 1.36 mg/m^3 at MSL-6 during summer season.

Total Biomass

Total Biomass varied between 1.020 ml/100 m^3 during Winter Season and 49.434 ml/100 m^3 during Pre-Monsoon season both at MSL-7.

Primary Productivity

Primary Productivity varied between 3.49 mgC/m^2/hr during MSL- 5 at sub-surface in winter and 6.98 mgC/m^2/hr during Pre-Monsoon at MSL-7.

Detailed results for the above parameters are given in **Table 3-12** and shown from **Figure 3-41** to **Figure 3-44**.

Table 3-12: Seasonal Variations in Biological Parameters

Parameters	Units		
Chlorophyll-a (Chl a)	mg/m^3	Max.	1.414
		Min.	0.505
Phaeopigment		Max.	1.36
		Min.	0.029
Total Biomass	ml/100 m^3	Max.	49.43
		Min.	1.02
Primary Productivity	mgC/m^2/hr	Max.	6.98
		Min.	3.49

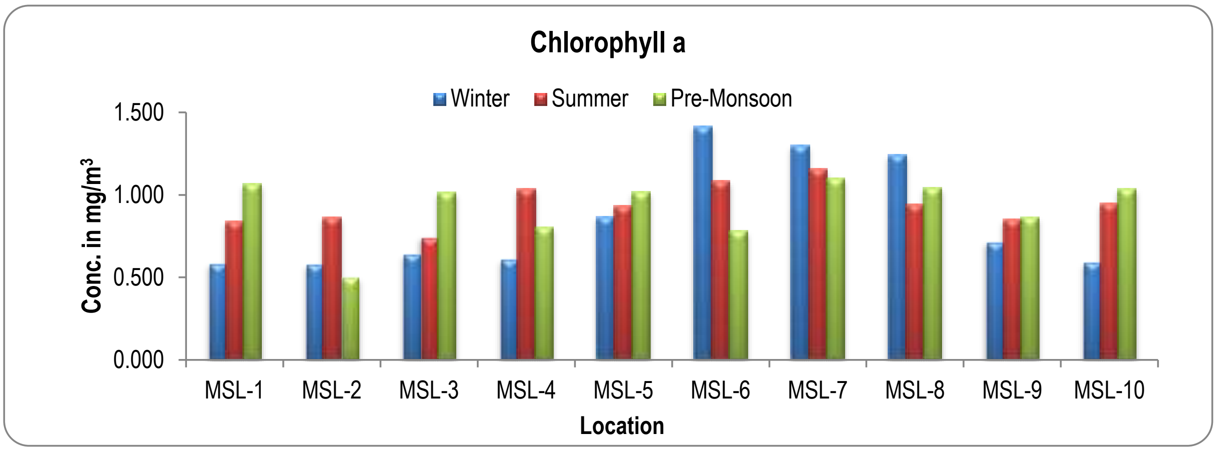


Figure 3-41: Variation in Chlorophyll a

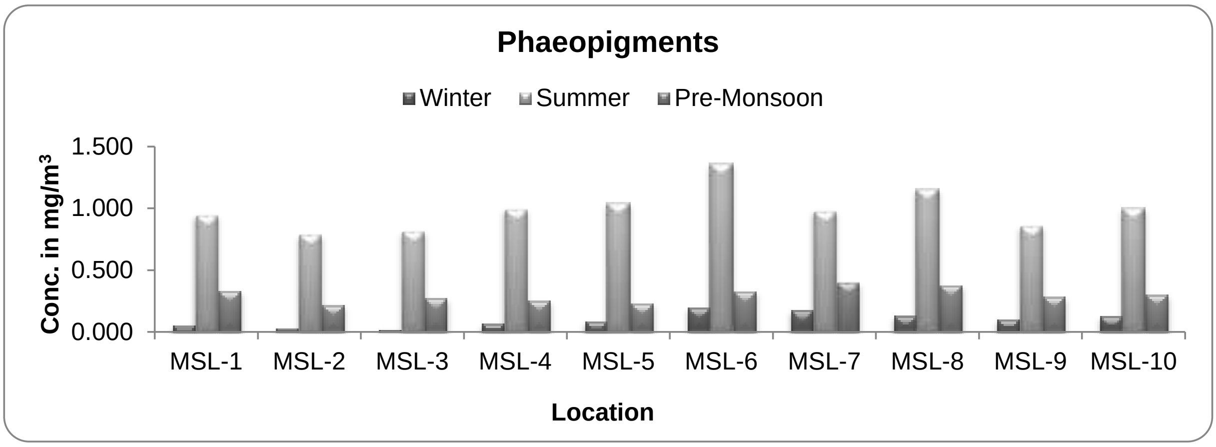


Figure 3-42: Variation in Phaeopigment

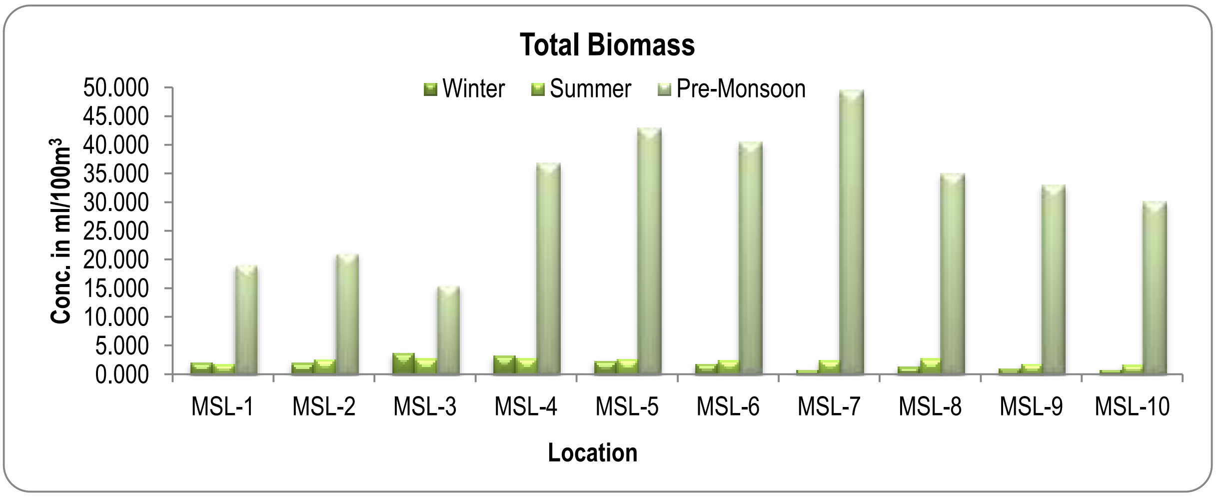


Figure 3-43: Variation in Total Biomass

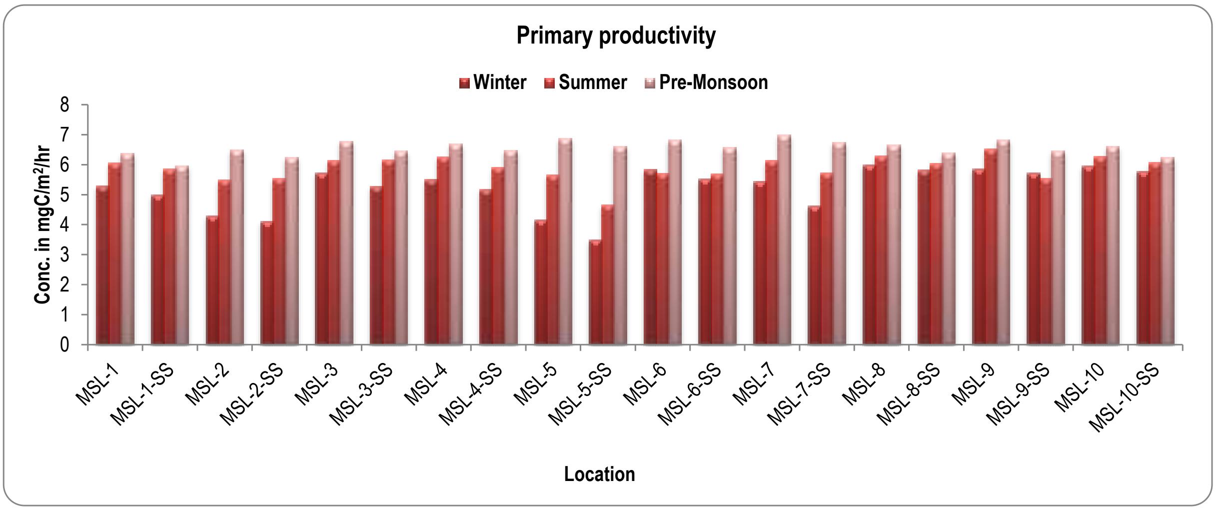


Figure 3-44: Variation in Primary Productivity

3.7.6 Bacteriological Parameters

The indicator and pathogenic bacteria isolated from water samples collected from the marine monitoring locations are described below.

Escherichia Coli (ECLO)

The *E. coli* like organisms ranged from 10 $x10^3$ to $17x10^4$ CFU/ml with a minimum at MSL-2 (Winter), MSL-4(Summer) & MSL-9 (Pre-Monsoon) and the maximum at MSL-3 (summer) & MSL-8 (winter).

Faecal Coliform (FCLO)

The Faecal Coliform ranged from 10 $x10^2$ to 16 $x10^5$ CFU/ml with a minimum at MSL-3 during Winter Season and the maximum at MSL-6(winter) & MSL-9(Summer).

Pseudomonas aeurginosa (PALO)

The *Pseudomonas aeurginosa* ranged from 50 $x10^1$ to 13 $x10^5$ CFU/ml with a minimum at MSL-2 during Winter Season and the maximum at MSL-8 during Pre-Monsoon season.

Streptococcus faecalis (SFLO)

The *Streptococcus faecalis* ranged from 10 $x10^2$ to 13 $x10^4$ CFU/ml with a minimum at MSL-1(Summer), MSL-3 (Winter), MSL-4 (Winter), MSL-6 (Pre-Monsoon) and at MSL-8(Summer) respectively and the maximum at MSL-3 during Pre-Monsoon season.

Shigella (SHLO)

The Shigella ranged from 70 $x10^2$ to 12 $x10^4$ CFU/ml with a minimum at MSL-1 during winter season and the maximum at MSL-2 (Pre-Monsoon), MSL-4(summer) and MSL-9(winter).

Salmonella (SLO)

The Salmonella ranged from 60 $x10^1$ to 13 $x10^3$ CFU/ml with a minimum at MSL-4 during winter season and the maximum at MSL-4(summer), MSL-5 (Pre-Monsoon) and MSL-7(Winter).

Total Coliform (TC)

The Total coliform in the samples varied from 19 $x10^2$ to 17 $x10^5$ CFU/ml with a minimum at MSL-1 & MSL-8 during Pre-Monsoon season and maximum at MSL-6(summer) & MSL-10(winter).

Total Viable Count -Total Heterotrophic Bacteria (TVC)

The Total Viable Count in the samples varied from 13 $x10^2$ to $20x10^4$ CFU/ml with a minimum at MSL-2 and the maximum at MSL-1 both during Pre-monsoon season respectively.

Vibrio Cholera (VCLO)

The *Vibrio cholera* colony was found to fluctuate from 60 $x10^1$ to 10 $x10^4$ CFU/ml with a minimum at MSL-1(winter) & MSL-3 (summer) and the maximum was observed at MSL-3 during Pre-Monsoon season.

Vibrio Parahaemolyticus (VPLO)

The *Vibrio parahaemolyticus* was found to fluctuate from 70 $x10^1$ to 10 $x10^4$ CFU/ml. minimum was observed at MSL-4 during winter season and the maximum was recorded at MSL-10 during Pre-Monsoon season.

The Details of the microbial variations in water were shown below in the **Table 3-13**.

Table 3-13: Seasonal Variations in water microbial populations (CFU/ml)

S. No	Microbial Indicator(CFU/ml)	CFU/ml	
		Minimum	Maximum
1.	*Escherichia coli* (ECLO)	$10x10^3$	$17x10^4$
2.	*Faecal Coliform (FCLO)*	$10x10^2$	$16x10^5$
3.	*Pseudomonas aeruginosa (PALO)*	$50x10^1$	$13x10^5$
4.	*Streptococcus faecalis (SFLO)*	$10x10^2$	$13x10^4$
5.	*Shigella (SHLO)*	$70x10^1$	$12x10^4$
6.	*Salmonella (SLO)*	$60x10^1$	$13x10^3$
7.	*Total Coliform (TC)*	$19x10^2$	$17x10^5$
8.	*Total Viable Count (TVC)*	$13x10^2$	$20x10^4$
9.	*Vibrio cholera (VC)*	$60x10^1$	$10x10^4$
10.	*Vibrio parahaemolyticus (VP)*	$70x10^1$	$10x10^4$

3.7.7 Phytoplankton

Phytoplankton is represented by 3 groups. Out of 77 Phytoplankton species 52 of them are Diatoms (68%), 19 Dinoflagelletes (24%) and 6 blue green algae (8%) were recorded during the sampling.

In plankton analysis, phytoplankton density was recorded minimum as 7775 at MSL-2 during Pre-Monsoon season to maximum as 17322 Cells/l at ML-6 during winter season.

Phytoplankton maximum diversity was observed at MSL-8 (47 species) during Pre-Monsoon season and minimum diversity of 36 species was recorded at MSL-10 (Winter), MSL-4 & MSL-7 (Summer) and at MSL-9 and MSL-10 (Pre-Monsoon) respectively..

In terms of numbers, *Tricodesmium erythraeum* was the most predominant species while *Fragilaria* sp. was the submissive species.

Detailed results for the above parameters are graphically shown in **Figure 3-45**.

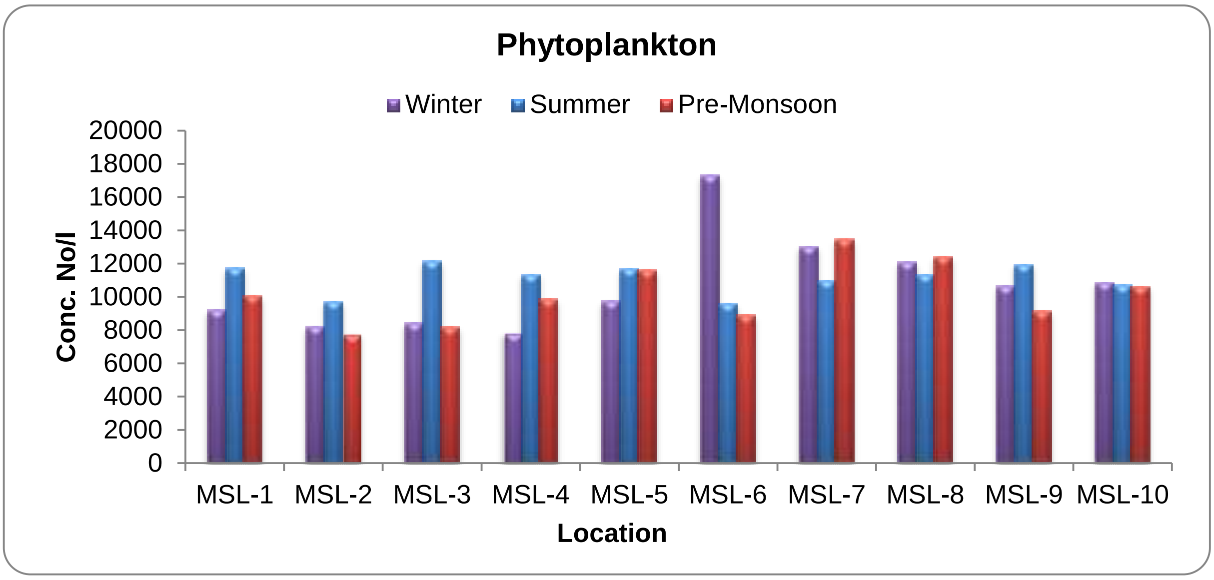


Figure 3-45: Variation in Phytoplankton Density

3.7.7.1 Phytoplankton Diversity Indices

The phytoplankton species diversity (H') varied from 2.634 to 3.862 with minimum at MSL-10 during winter season and maximum at MSL-2 during summer season. The species richness (d) ranged between 4.023 and 6.287 with minimum at MSL-4 during Pre-Monsoon season and maximum at MSL-9 during summer season. The species evenness varied from 0.708 to 0.972 with minimum at MSL-6 and maximum at MSL-2 both during summer season respectively. Diversity indices for Phytoplankton are given in **Table 3-14**.

Table 3-14: Diversity indices for Phytoplankton

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
1	MSL-1	3.164	2.823	3.261	4.789	5.819	4.774	0.84	0.968	0.857
2	MSL-2	2.973	3.862	2.774	4.309	4.858	4.981	0.935	0.972	0.721
3	MSL-3	3.155	3.286	3.293	5.073	5.148	4.885	0.756	0.947	0.865
4	MSL-4	2.895	3.347	3.309	4.789	4.396	4.023	0.789	0.962	0.809
5	MSL-5	3.543	2.935	3.254	4.527	4.485	4.808	0.835	0.753	0.85
6	MSL-6	3.083	3.263	2.818	4.812	5.254	4.789	0.964	0.708	0.793
7	MSL-7	3.468	2.895	3.441	6.098	5.952	4.892	0.766	0.711	0.91
8	MSL-8	3.105	3.159	3.222	5.545	4.749	4.911	0.862	0.913	0.846
9	MSL-9	3.099	2.913	3.166	5.006	6.287	4.838	0.901	0.725	0.8
10	MSL-10	2.634	3.471	3.087	5.159	4.635	4.376	0.94	0.794	0.801

3.7.8 Zooplankton

Zooplankton is represented by six groups. Out of 43 Zooplankton species, 14 species of them are Calanoida (33%), 7 of Spirotrichea species (16%), 7 of Larval forms (16%), 5 species each of Cyclopoida, Harpacticoida and others (12%) are recorded from sampling locations.

The zooplankton density varied from 4080 to 8616 Nos/m^3 with minimum at MSL-2 during Pre-Monsoon season and maximum was at MSL-6 during Winter Season.

Zooplankton diversity maximum was observed at MSL-6 during summer Season (28 species) and minimum at MSL-2 during Pre-Monsoon season (19 species).

In terms of numbers *Pontella danae*was the most dominant species while *Corycaeus danae and Pontella sp.* was the submissive species.

The details of Zooplankton species population density are graphically shown in the **Figure 3-46**.

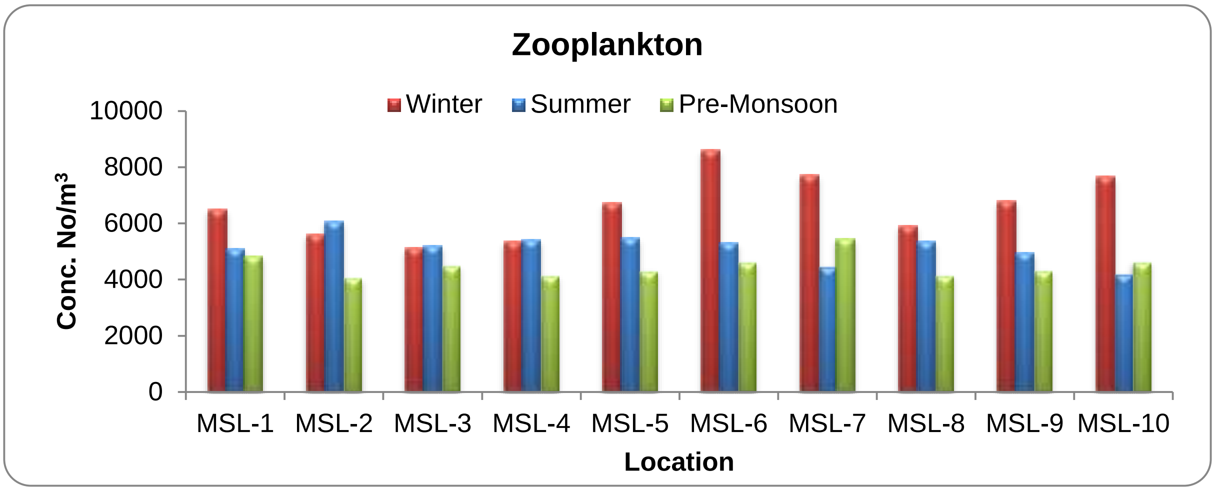


Figure 3-46: Variation in Zooplankton Density

3.7.8.1 Zooplankton Diversity Indices

The zooplankton species diversity (H') varied from 2.586 to 3.989 with minimum at MSL-2 during Pre-Monsoon season and maximum at MSL-7 during Winter Season. The species richness (d) ranged between 3.441 and 6.157 with minimum in MSL-4 during Pre-Monsoon Season and maximum in MSL-7 during summer season. The species evenness varied from 0.725 to 0.978 with the minimum in MSL-1 during summer season and maximum in MSL-7 during pre-Monsoon season. Zooplankton Diversity indices were given in **Table 3-15**.

Table 3-15: Zooplankton Diversity Indices

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
1	MSL-1	2.862	2.815	3.179	3.705	4.637	4.948	0.746	0.725	0.758
2	MSL-2	3.129	3.097	2.586	5.988	4.083	5.64	0.828	0.907	0.746
3	MSL-3	3.647	3.482	3.037	5.525	3.609	4.495	0.856	0.839	0.826
4	MSL-4	3.287	2.914	3.012	3.935	5.493	3.441	0.783	0.748	0.974
5	MSL-5	3.247	3.227	2.926	6.138	4.721	4.269	0.916	0.976	0.976
6	MSL-6	2.834	3.568	2.981	5.695	3.948	3.606	0.897	0.95	0.778
7	MSL-7	3.989	2.877	3.266	4.646	6.157	4.201	0.786	0.892	0.978

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
8	**MSL-8**	3.04	3.194	2.819	5.636	3.912	4.165	0.968	0.746	0.954
9	**MSL-9**	2.889	2.785	2.926	3.616	6.022	3.769	0.789	0.784	0.966
10	**MSL-10**	3.149	3.008	3.066	5.567	4.016	4.606	0.859	0.932	0.879

3.7.9 Bed Sediment Quality (Physico-Chemical and Biological Parameters)

3.7.9.1 Physical Parameters

The sediment composition is from clay to sand and is dominated by sand.

Sand: The percentage of sand ranged between 6.04% at MSL-6 during summer season and 57.48% at MSL-10 during Pre-Monsoon season for offshore locations. The percentage of sand ranged between 53.70% at INTL-2 during winter season and 61.80% during summer season for intertidal locations.

Silt: The silt percentage ranged between 23.20% during winter season and 50.39% during summer season both at MSL-5 for offshore locations. The silt percentage ranged between 24.30% at INTL-1 during summer season and 34.00% at INTL-2 during winter season for intertidal locations.

Clay: The Clay percentage ranged between 4.87% at MSL-10 during summer season and 58.20% at MSL-3 during winter season for offshore locations. The Clay percentage ranged between 11.95% at INTL-2 and 13.84% at INTL-1 both during summer season for intertidal locations.

pH: The sediment pH is alkaline in nature and varied from 8.32 at MSL-7 during Pre-Monsoon season to 8.69 at MSL-2 during summer season for offshore Locations. The sediment pH is alkaline in nature and varied from 8.32 at INTL-2 during Pre-Monsoon season to 8.74 for INTL-2 during summer season at intertidal Locations

Total Organic Carbon: The Sediment TOC ranged between 2.01 mg C/g at MSL-10 during summer season and 5.78 mg C/g at MSL-4 during winter season for offshore Locations. The Sediment TOC varied from 2.20 at INTL-1 during winter season to 3.96 at INTL-1 during Pre-Monsoon season for intertidal Locations.

The Details of Total organic carbon and pH are shown in the **Table 3-16** and graphically represented in **Figure 3-47** to **Figure 3-51**.

Table 3-16: Variations in sediment physicochemical parameters

Parameters	Units		Offshore	Intertidal
pH		Max.	8.69	8.74
		Min.	8.32	8.32
Sand	%	Max.	57.48	61.80
		Min.	6.04	53.70
Silt		Max.	50.39	34.00
		Min.	23.20	24.31
Clay		Max.	58.20	13.84
		Min.	4.87	11.95
TOC	mgC/g	Max.	5.78	3.96
		Min.	2.01	2.20

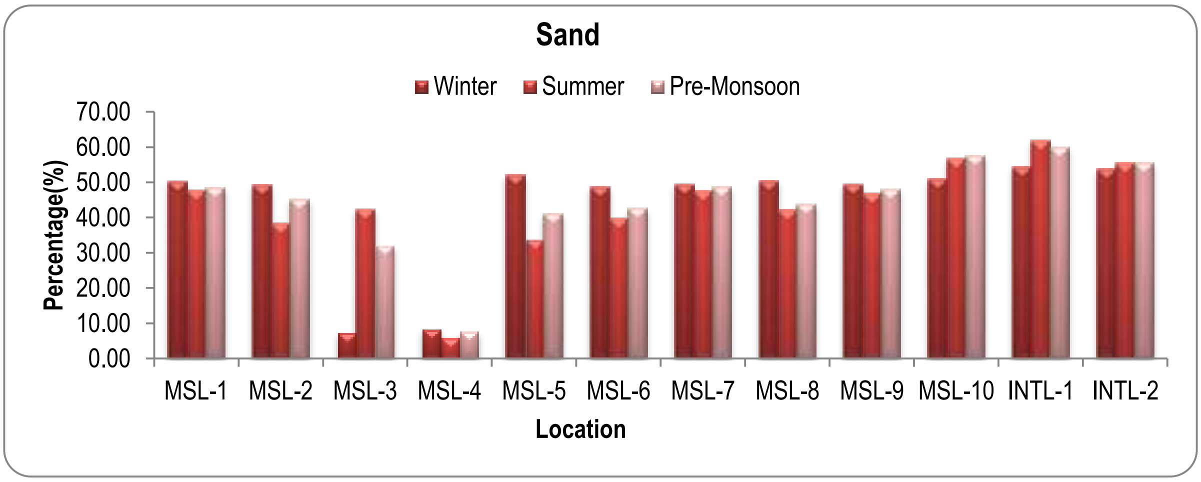


Figure 3-47: Variation in Percentage of sand

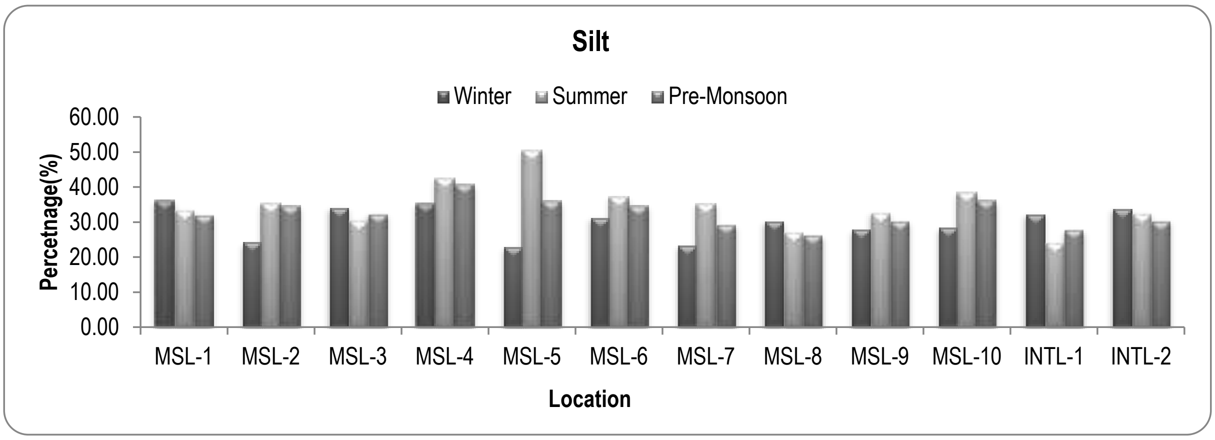


Figure 3-48: Variation in percentage of Silt

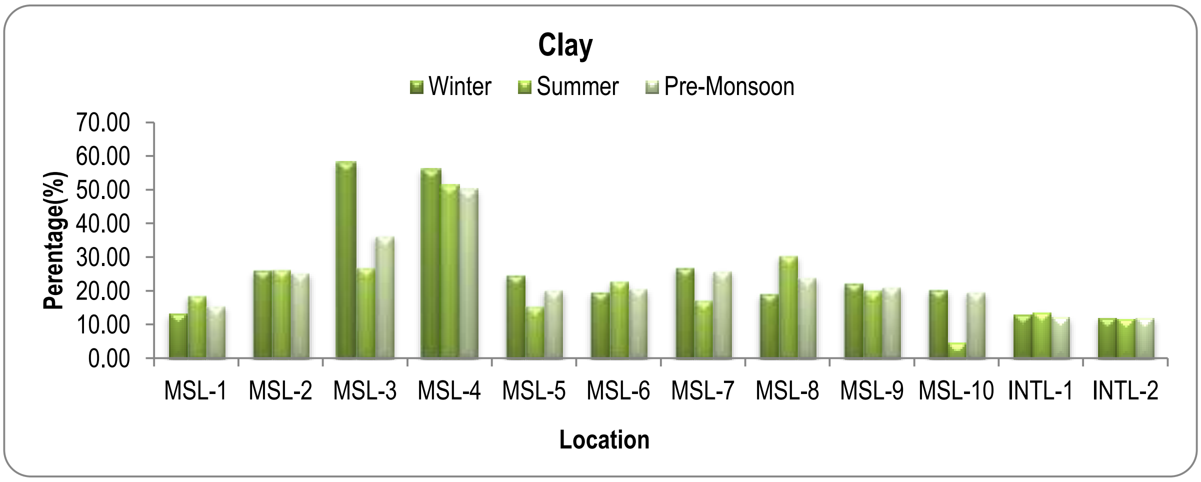


Figure 3-49: Variation in percentage of Clay

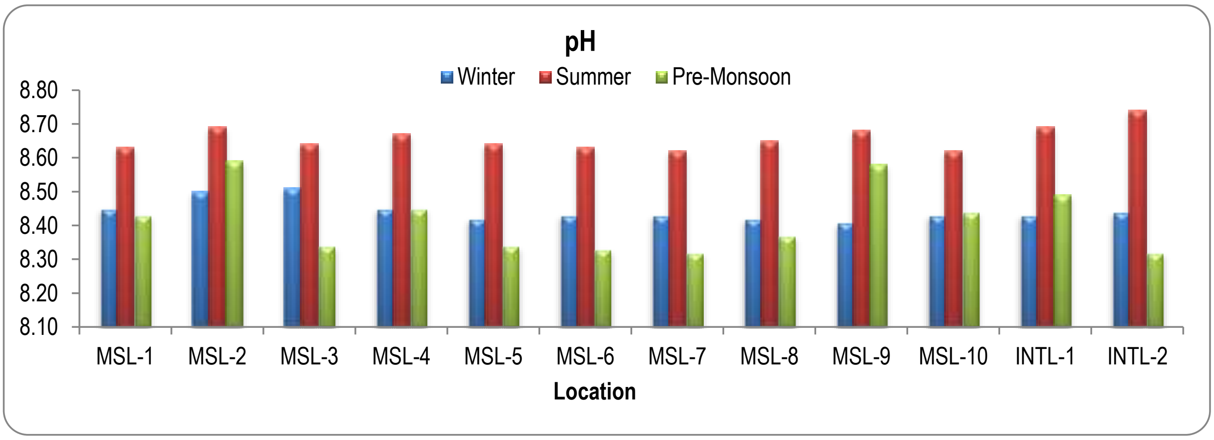


Figure 3-50: Variations in Percentage of pH

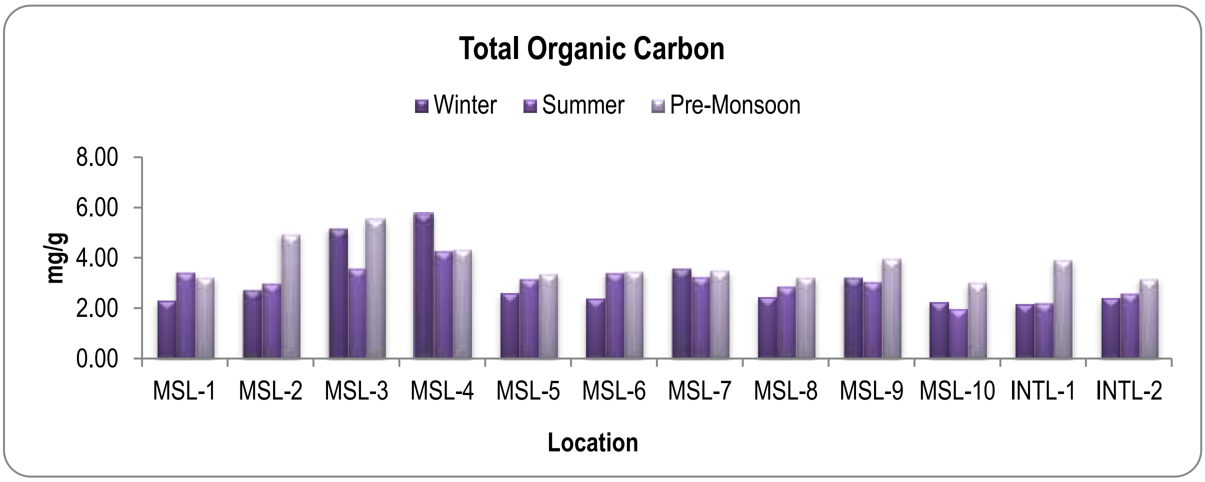


Figure 3-51: Variations in Total Organic Carbon

3.7.10 Heavy Metals - Sediment

Cadmium: Cadmium values for sediment sample ranged from 7.28 µg/g at MSL-4 and MSL-9 during summer season to 12.48 µg/g at MSL-2 during winter season for offshore locations. The values for intertidal locations are ranged between 7.03 µg/g at INTL-1 during summer season to 12.38 µg/g at INTL-2 during winter season.

Copper: The copper concentration ranged between 22.42 µg/g at MSL-3 (summer) to 28.33 µg/g at MSL-2 during winter season for offshore locations. The values for intertidal locations are ranged between 22.10 µg/g at INTL-1 during summer season to 27.85 µg/g at INTL-1 during winter season.

Iron: The iron concentration ranged between 1128.90 µg/g at MSL-9 during winter season to 1953.53 µg/g at MSL-3 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged between 1504.73µg/g at INTL-1 during Pre-Monsoon season to 1938.5 µg/g at INTL-1 during winter season.

Lead: The lead concentration ranged between 5.2 µg/g at MSL-7 during summer season to 10.99 µg/g at MSL-3 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged between 5.56µg/g at INTL-1 during summer season to 11.47 µg/g at INTL-1 during Pre-monsoon season.

Zinc: The Zinc concentration ranged between 11.9 µg/g at MSL-9 during winter season to 33.4 µg/g at MSL-2 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged between 19.6µg/g at INTL-2 during winter season to 31.9 µg/g at INTL-1 during Pre-Monsoon season.

Mercury: The Mercury concentration ranged between 0.6 µg/g at MSL-10 during winter season to 1.05 µg/g at MSL-2 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged between 0.64µg/g at INTL-1 during summer season to 1.03 µg/g at INTL-2 during Pre-Monsoon season.

Nickel: The nickel concentration ranged between 9.68 µg/g at MSL-9 during Pre-Monsoon season to 17.9 µg/g at ML-2 during winter season for offshore locations. The values in intertidal locations are ranged between 11.28 µg/g at INTL-1 during summer season to 17.78 µg/g at INTL-1 during winter season.

Manganese: The Manganese concentration ranged between 51.50 µg/g at MSL-5 during summer season to 90.47 µg/g at MSL-3 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged between 65.80µg/g at INTL-1 during summer season to 81.30 µg/g at INTL-1 during winter season.

Chromium: The chromium concentration ranged between 5.37 µg/g at MSL-3 & MSL-7 during summer season to 10.37 µg/g at MSL-2 during winter season for offshore locations. The values for intertidal locations are ranged between 5.22µg/g at INTL-1 during summer season to 10.86 µg/g at INTL-1 during winter season.

The details of sediment heavy metals are given in the **Table 3-17** and graphically shown in the **Figure 3-52** to **Figure 3-60**.

Table 3-17: Variations in sediment heavy metals

Parameters	Units		Offshore	Intertidal
Cadmium	µg/g	Max.	12.48	12.38
		Min.	7.28	7.03
Copper		Max.	28.33	27.85
		Min.	22.42	22.10
Iron		Max.	1953.53	1938.50
		Min.	1128.90	1504.73
Lead		Max.	10.99	11.47
		Min.	5.20	5.56
Zinc		Max.	33.40	31.90
		Min.	11.90	19.60
Mercury		Max.	1.05	1.03
		Min.	0.60	0.64
Nickel		Max.	17.90	17.78
		Min.	9.68	11.28
Manganese		Max.	90.47	81.30
		Min.	51.50	65.80
Chromium		Max.	10.37	10.86
		Min.	5.37	5.22

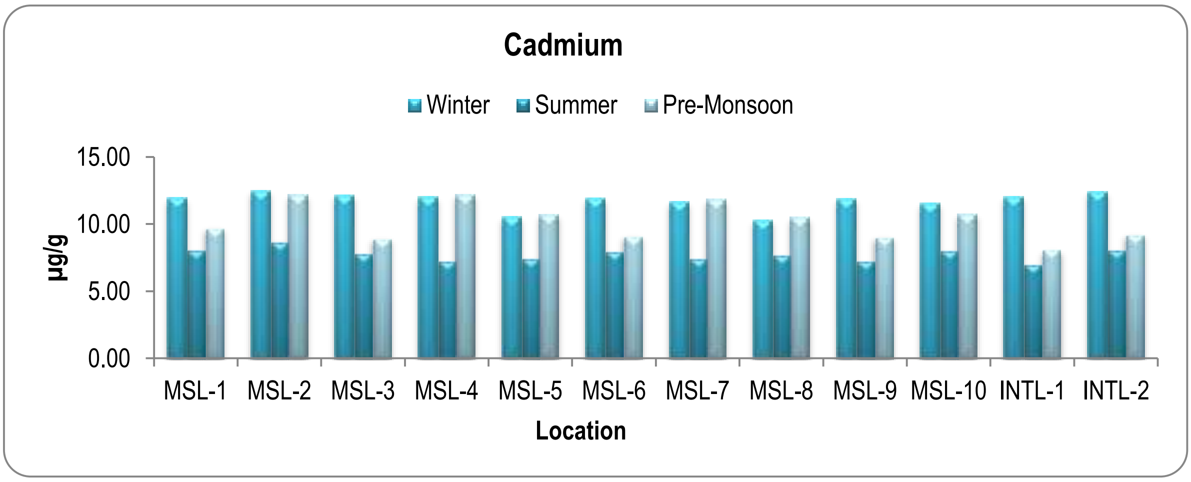


Figure 3-52: Variation of Cadmium Concentration

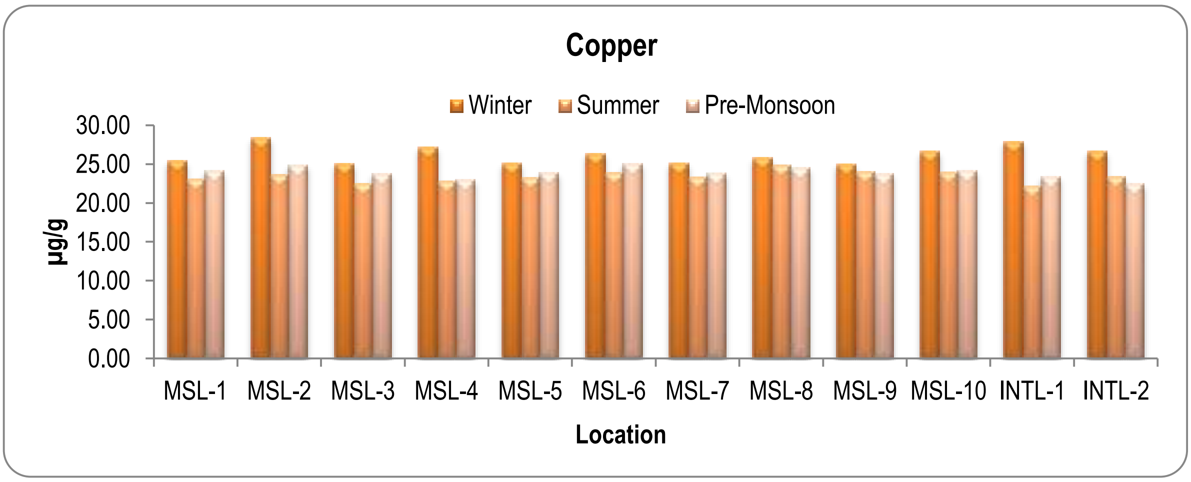


Figure 3-53: Variation of Copper Concentration

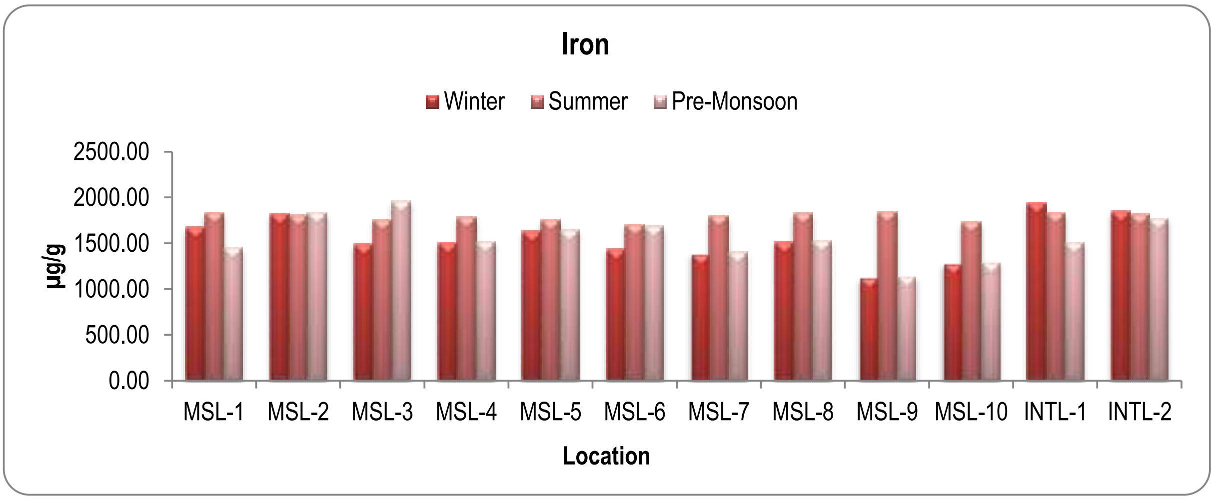


Figure 3-54: Variation of Iron Concentration

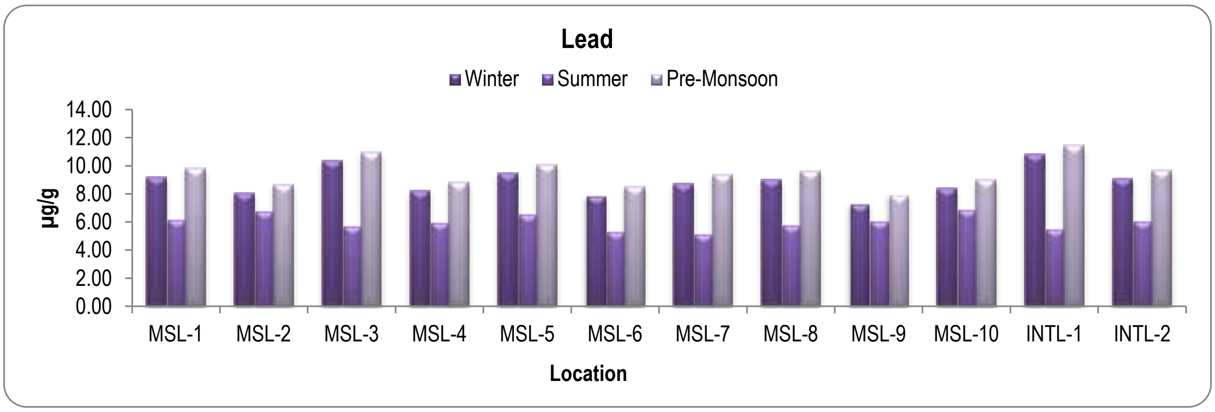


Figure 3-55: Variation of Lead Concentration

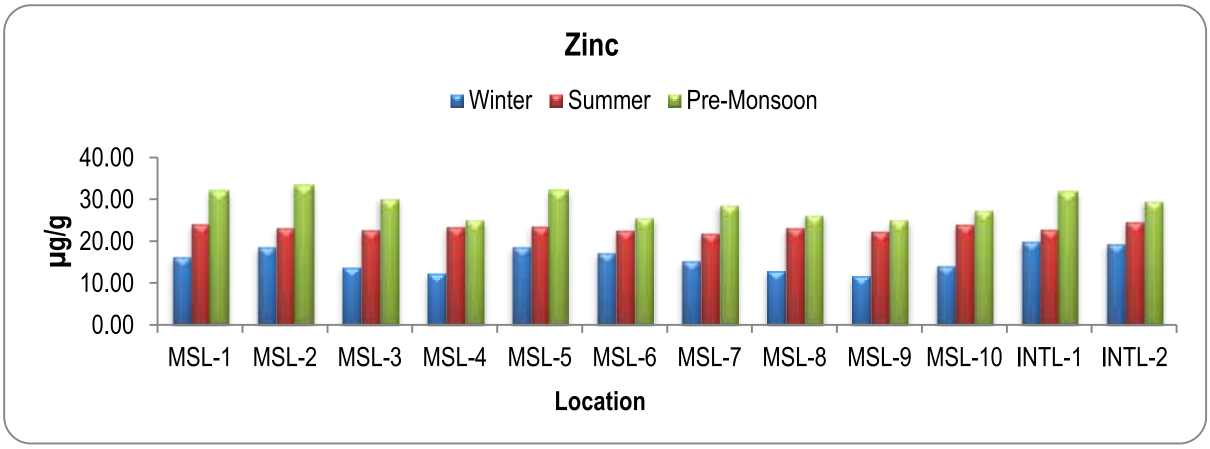


Figure 3-56: Variation of Zinc Concentration

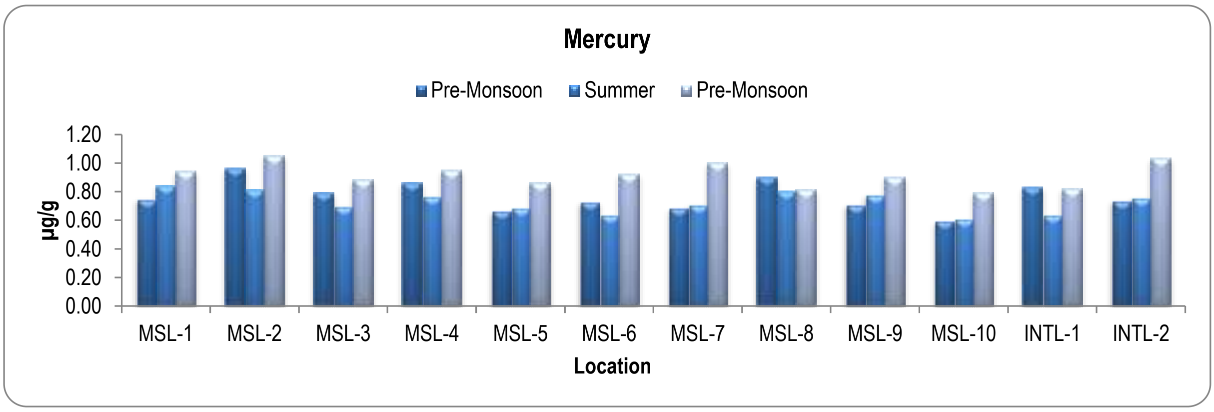


Figure 3-57: Variation of Mercury Concentration

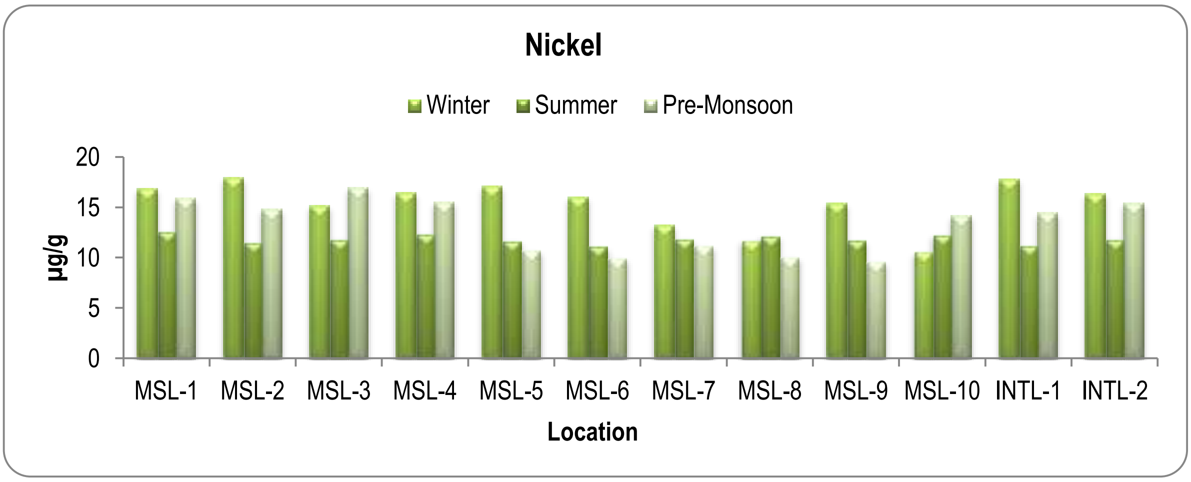


Figure 3-58: Variation of Nickel Concentration

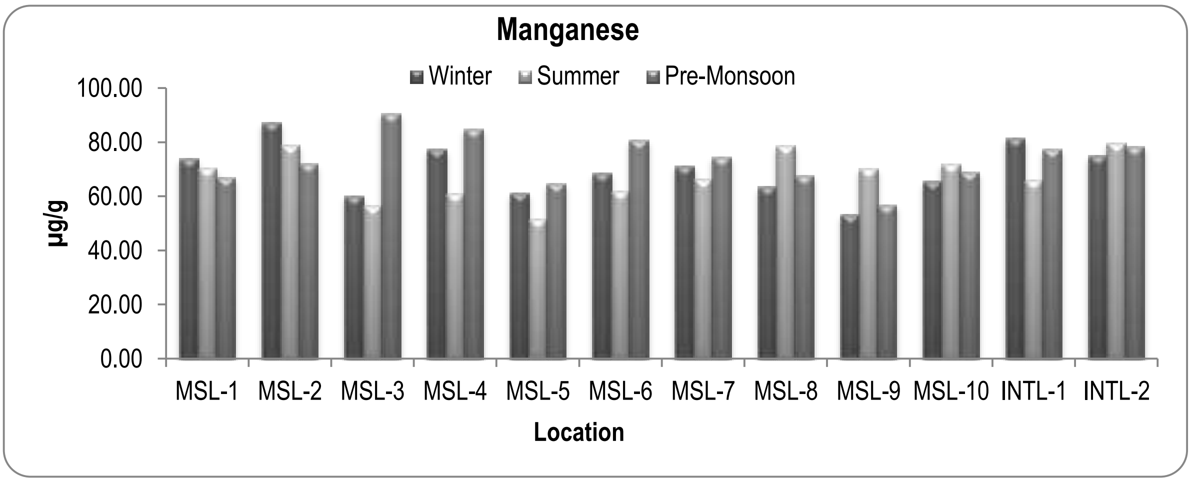


Figure 3-59: Variation of Manganese Concentration

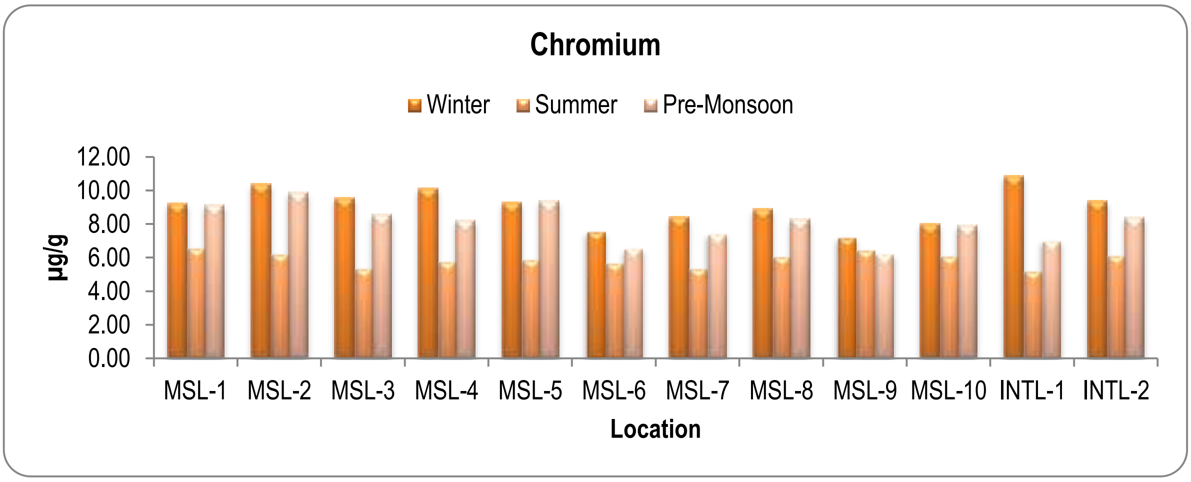


Figure 3-60: Variation of Chromium concentration

3.7.11 Microbial Population

The indicator and pathogenic bacteria isolated from sediment samples collected from the monitoring locations are described and the details are given below.

Escherichia coli (EC): The E. coli ranged from 19 x10^3 to 28 x10^5 CFU/g with a minimum at MSL-2 during Winter Season and the maximum at MSL-2 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 16 $x10^3$ to 22 $x10^5$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-1 during summer season

Faecal Coliform (FCLO)

The *Faecal Coliform* ranged from 15 $x10^3$ to 26 $x10^5$ CFU/g with a minimum at MSL-7 during summer Season and the maximum at MSL-5(Pre-Monsoon season) & MSL-8 (winter) for offshore locations. The values for intertidal locations are ranged from 15 $x10^3$ to 26 $x10^5$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-1 during summer season

Pseudomonas aeurginosa (PALO)

The *Pseudomonas aeurginosa* ranged from 13 $x10^3$ to 26 $x10^5$ CFU/g with a minimum at MSL-6 (summer), MSL-3 & MSL-5 during winter season and the maximum at MSL-10 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 11 $x10^2$ to 17 $x10^5$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-2 during Pre-monsoon season.

Streptococcus faecalis (SFLO)

The *Streptococcus faecalis* ranged from 14 $x10^3$ to 24 $x10^5$ CFU/g with a minimum at MSL6 during summer season and the maximum at MSL-6 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 10 $x10^2$ to 15 $x10^4$ with a minimum at INTL-2 during Winter Season and the maximum at INTL-1 during pre-monsoon season.

Shigella (SHLO)

The *Shigella* ranged from 11 $x10^2$ to 21 $x10^5$ CFU/g with a minimum at MSL-7 during summer season and the maximum at MSL-6 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 10 $x10^3$ to 19 $x10^5$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-1 during pre-monsoon season.

Salmonella (SLO)

The *Salmonella* ranged from 13 $x10^2$ to 24 $x10^5$ CFU/g with a minimum at MSL-6 during summer season and the maximum at MSL-6 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 90 $x10^1$ to 16 $x10^4$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-2 during Pre-monsoon season.

Total Coliform (TC)

The Total coliform in the samples varied from 18 $x10^3$ to 27 $x10^5$ CFU/g with a minimum at MSL-7 during Summer season and the maximum at MSL-7(Winter), MSL-9(summer), MSL-3 & MSL-5(Pre-monsoon) seasons for offshore locations. The values for intertidal locations are ranged from 16 $x10^2$ to 24 $x10^5$ with a minimum at INTL-2 during Winter Season and the maximum at INTL-2 during pre-monsoon season.

Total Viable Count -Total Heterotrophic Bacteria (TVC)

The Total Viable Count in the samples varied from 22 $x10^3$ to 27 $x10^5$ CFU/g with the minimum at MSL-2 during Pre-Monsoon Season and the maximum at MSL-10(summer) & MSL-5 (Pre-Monsoon) for offshore locations. The values for intertidal locations are ranged from 15 $x10^3$ to 28 $x10^4$ with a minimum at INTL-2 during Winter Season and the maximum at INTL-2 during summer season.

Vibrio cholera (VC): *Vibrio cholera* was found to range from 90 $x10^2$ to 14 $x10^5$ CFU/g with the minimum was observed at MSL-5 during summer season and the maximum at MSL-8 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 80 $x10^2$ to 15 $x10^4$ with a minimum at INTL-2 during Winter Season and the maximum at INTL-1 during Pre-Monsoon season.

Vibrio parahaemolyticus (VP): The *Vibrio parahaemolyticus* varied from 11 $x10^2$ to 19 $x10^5$ CFU/g with the minimum was observed at MSL-9 during summer season and the maximum were found at MSL-4 during Pre-Monsoon season for offshore locations. The values for intertidal locations are ranged from 11 $x10^2$ to 19 $x10^5$ with a minimum at INTL-1 during Winter Season and the maximum at INTL-1 during Pre-Monsoon season.

The details of Variations in sediment microbial populations are given in the **Table 3-18**

Table 3-18: Variations in sediment microbial populations (CFU/g)

S. No	Microbial Indicator(CFU/g)		Offshore	Intertidal
1.	*Escherichia coli* (ECLO)	Max.	$28x10^5$	$22x10^5$
		Min.	$19x10^3$	$16x10^3$
2.	*Faecal Coliform (FCLO)*	Max.	$26x10^5$	$26x10^5$
		Min.	$15x10^3$	$15x10^3$
3.	*Pseudomonas aeurginosa(PALO)*	Max.	$26x10^5$	$17x10^5$
		Min.	$13x10^3$	$11x10^2$
4.	*Streptococcus faecalis (SFLO)*	Max.	$24x10^5$	$15x10^4$
		Min.	$14x10^3$	$10x10^2$
5.	*Shigella (SHLO)*	Max.	$21x10^5$	$19x10^5$
		Min.	$11x10^2$	$10x10^3$
6.	*Salmonella (SLO)*	Max.	$24x10^5$	$16x10^4$
		Min.	$13x10^2$	$90x10^1$
7.	*Total Coliform (TC)*	Max.	$27x10^5$	$24x10^5$
		Min.	$18x10^3$	$16x10^2$
8.	*Total Viable Count(TVC)*	Max.	$27x10^5$	$28x10^4$
		Min.	$22x10^3$	$15x10^3$
9.	*Vibrio cholera(VC)*	Max.	$14x10^5$	$15x10^4$
		Min.	$90x10^2$	$80x10^2$
10.	*Vibrio parahaemolyticus (VP)*	Max.	$19x10^5$	$19x10^5$
		Min.	$11x10^2$	$11x10^2$

3.7.12 Benthos

3.7.12.1 Macrobenthos

Macrobenthos are represented by five groups for offshore sampling locations. Out of 64 Macrobenthos species, 41 of them are Polychaetes, 10 are Bivalves species, 8 are Gastropods species, 3 are Amphipods species and 2 are others.

Off shore Macro Benthic composition in terms of numbers shows that polychaetes (64%) are the most dominant followed by Bivalves (16%), Gastropods (12%), Amphipods (5%) and other species (3%).

The offshore Macrobenthos density varied from 575 to 1125 Nos/m^2 with minimum was at MSL-1 during Pre-Monsoon season and maximum at MSL-9 during summer season.

Offshore Macro benthos maximum diversity was observed at MSL-4 and MSL-9 (29 species each) both during summer season and minimum at MSL-4 and MSL-8 (16 species) during Pre-Monsoon season.

Macrobenthos are represented by five groups for intertidal sampling locations. Out of 54 Macrobenthos species, 33 of them are Polychaetes, 8 are Bivalves species, 8 are Gastropods species, 3 are Amphipods species and 2 are others.

Intertidal Macro Benthic composition in terms of numbers shows that polychaetes (60%) are the most dominant followed by Bivalves (15%), Gastropods (15%), Amphipods (6%) and other species (4%).

The intertidal macrobenthos density varied from 525 to 650 Nos/m^2 with minimum was at INTL-2 during Pre-Monsoon season and maximum at INTL-2 during winter and summer seasons respectively.

Intertidal Macrobenthos maximum diversity was observed at INTL-2 (21 species) during summer season and minimum at INTL-2 (17 species) during Pre-Monsoon season.

In terms of numbers *Cirratulus concinnus and Cirratulus concinnus* were the most dominant species while *Polydontes melanonlus, Ancistrolysis robusta* were the submissive species.

The details of macrobenthos population are graphically shown in **Figure 3-61.**

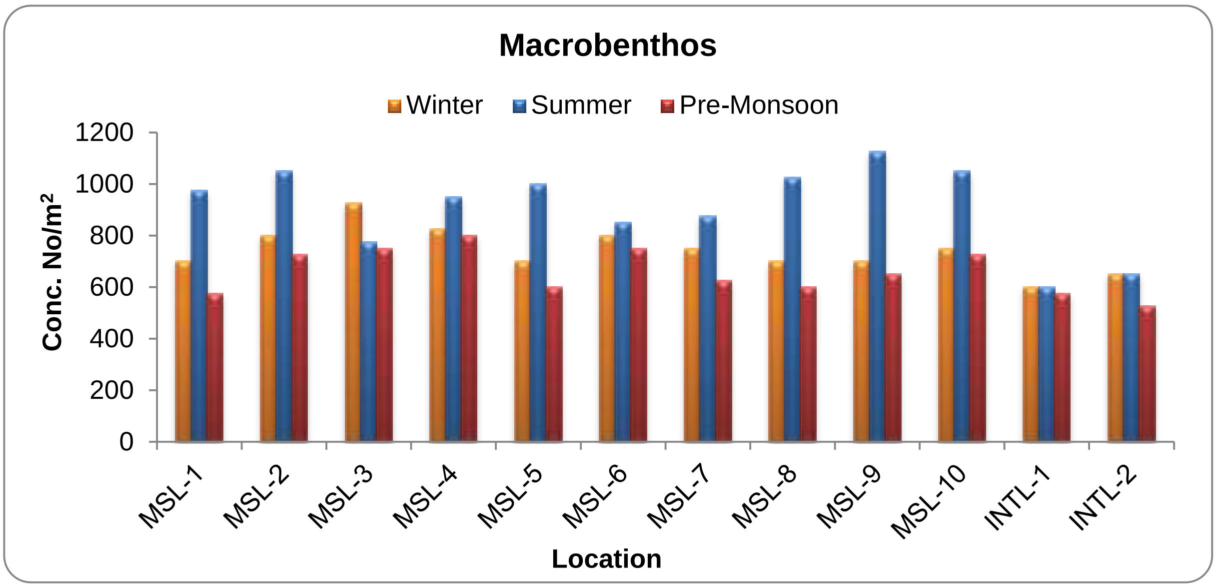


Figure 3-61: Variations in Population Density of Macro benthos

3.7.12.2 Diversity Indices

The macro-benthic species diversity (H') varied from 2.639 to 3.761 with minimum at MSL-2 during Pre-Monsoon season and maximum at MSL-3 during summer season for offshore locations. The values for intertidal locations regarding species diversity (H') varied from 2.561 to 3.241 with minimum at INTL-1 during Pre-Monsoon season and maximum at INTL-1 during winter season.

The species richness (d) ranged between 3.421 and 6.923 with minimum at MSL-10 during winter season and maximum at MSL-3 during Pre-Monsoon Season for offshore locations. The values for intertidal locations regarding species richness (d) ranged between 3.714 and 6.923 with minimum at INTL-1 during winter season and maximum in INTL-2 during Pre-Monsoon season.

The species evenness varied from 0.635 to 0.984 with the maximum in MSL-6 during winter season and minimum in MSL-1 during Pre-Monsoon Season for offshore locations. The values for intertidal locations regarding species evenness varied from 0.639 to 0.974 with the minimum at INTL-1 during Pre-Monsoon season and maximum at INTL-1 during winter season. Macro benthos Diversity indices are given in

Table 3-19**.**

Table 3-19: Macrobenthos Diversity indices

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
1	**MSL-1**	3.292	2.908	2.738	4.377	5.019	5.683	0.817	0.908	0.635
2	**MSL-2**	3.212	3.026	2.639	4.205	4.185	6.683	0.86	0.761	0.676
3	**MSL-3**	2.97	3.761	2.647	5.225	4.323	6.923	0.698	0.965	0.64
4	**MSL-4**	3.287	2.987	3.061	4.156	5.885	4.923	0.876	0.814	0.776
5	**MSL-5**	2.672	3.178	3.251	5.691	3.612	5.035	0.789	0.948	0.842
6	**MSL-6**	3.418	3.006	3.343	4.242	4.206	5.639	0.984	0.759	0.904
7	**MSL-7**	3.312	2.832	3.625	5.221	5.127	4.716	0.887	0.963	0.924
8	**MSL-8**	2.863	3.138	3.584	5.083	4.933	4.136	0.763	0.928	0.865
9	**MSL-9**	3.541	2.856	3.238	3.564	6.071	5.07	0.965	0.894	0.947
10	**MSL-10**	3.379	2.978	3.352	3.421	5.965	4.654	0.873	0.979	0.724
11	**INTL-1**	3.241	3.045	2.561	3.714	4.242	5.683	0.974	0.935	0.639
12	**INTL-2**	2.694	3.105	2.749	5.727	3.794	6.923	0.742	0.813	0.658

3.7.12.3 Meiofauna

Meiofauna are represented by four groups for offshore sampling locations. Out of 57 Meiobenthos species, 33 of them are Foraminiferans, 11 are Nematodes, 10 are Ostracodes and 3 are Harpacticoids.

Off shore Meiobenthic composition in terms of numbers shows that Foraminiferans (58%) are the most dominant followed by Nematodes (19%), Ostracodes (18%) and Harpacticoids (5%).

The offshore Meiobenthos density varied from 198 to 382 Nos/10cm^2 with minimum was at MSL-3 during Pre-Monsoon season and maximum at MSL-8 during winter season.

Offshore Meiobenthos Maximum diversity was observed at MSL-2 (35 species) both during summer season and minimum at MSL-3 (23 species) during winter season.

Meiofauna are represented by four groups for intertidal sampling locations. Out of 57 Meiobenthos species, 33 of them are Foraminiferans, 11 are Nematodes, 10 are Ostracodes and 3 are Harpacticoids.

Intertidal Meiobenthic composition in terms of numbers shows that Foraminiferans (58%) are the most dominant followed by Nematodes (19%), Ostracodes (18%) and Harpacticoids (5%).

The intertidal Meiobenthos density varied from 158 to 312 Nos/10cm^2 with minimum was at INTL-2 during Pre-Monsoon season and maximum at INTL-1 during winter season.

Intertidal Meiobenthos maximum diversity was observed at INTL-2 (35 species) during winter season and minimum at INTL-2 (25 species) during winter season.

In terms of numbers *Ammonia becarii* was the most dominant species while *Lagena semistriata* was the submissive species.

The details of meiofauna population are graphically shown in **Figure 3-62**.

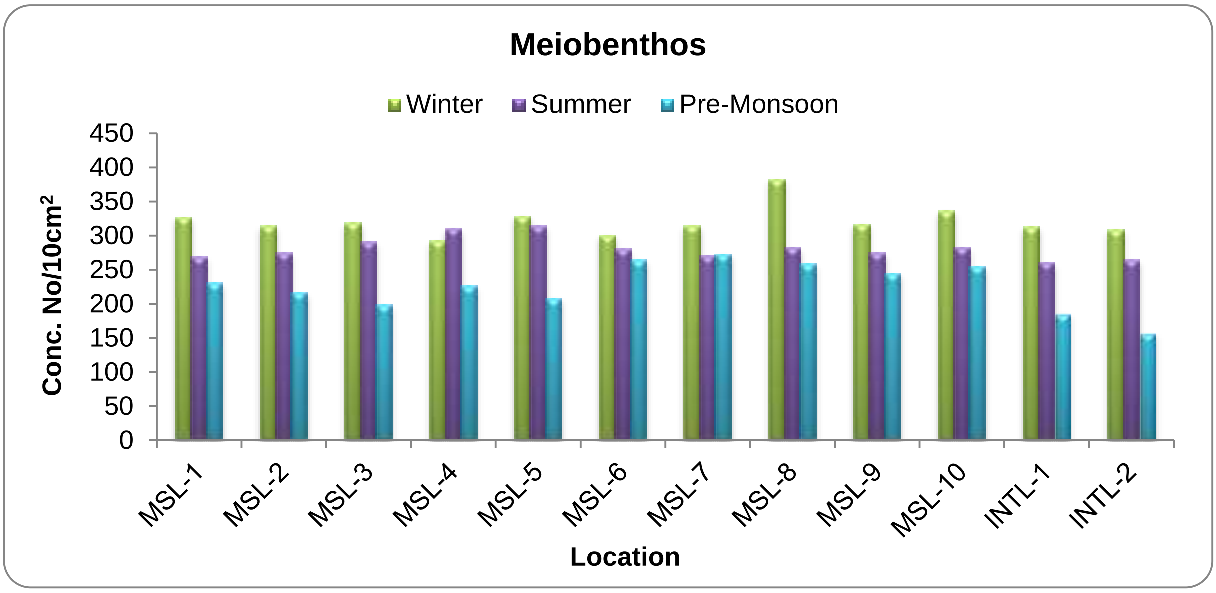


Figure 3-62: Variations in Population Density of Meiofauna

3.7.12.4 Meiobanthos Diversity Indices

The Meio-benthos species diversity (H') varied from 2.672 to 3.761 with minimum at MSL-5 during winter season and maximum at MSL-7 during Pre-Monsoon season for offshore locations. The values for intertidal locations regarding species diversity (H') varied from 2.694 to 3.351 with minimum at INTL-2 during winter season and maximum at INTL-1 during summer season.

The species richness (d) 3.421 to 7.323 with minimum at MSL-10 during winter season and maximum at MSL-3 during Pre-Monsoon Season for offshore locations. The values for intertidal locations regarding species richness (d) ranged between 3.714 and 6.038 with minimum at INTL-1 during winter season and maximum at INTL-2 during Pre-Monsoon season.

The species evenness varied from 0.614 to 0.984 with the minimum at MSL-4 during Pre-Monsoon Season and maximum at MSL-6 during winter season for offshore locations. The values for intertidal locations regarding species evenness varied from 0.605 to 0.974 with the minimum at INTL-1 during Pre-Monsoon season and maximum at INTL-1 during winter season. Meiobenthos Diversity indices are given in **Table 3-20**.

Table 3-20: Meiobenthos Diversity indices

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
1	**MSL-1**	3.292	3.372	2.908	4.377	4.723	5.019	0.817	0.744	0.708
2	**MSL-2**	3.212	2.853	2.856	4.205	5.057	4.185	0.86	0.868	0.731
3	**MSL-3**	2.97	3.011	3.105	5.225	6.753	7.323	0.698	0.865	0.669
4	**MSL-4**	3.287	3.398	2.987	4.156	4.467	5.885	0.876	0.735	0.614
5	**MSL-5**	2.672	2.941	3.178	5.691	5.392	3.612	0.789	0.853	0.728
6	**MSL-6**	3.418	3.279	3.316	4.242	5.679	4.206	0.984	0.726	0.741
7	**MSL-7**	3.312	3.569	3.761	5.221	4.895	4.242	0.887	0.855	0.906
8	**MSL-8**	2.863	3.628	3.538	5.083	5.672	4.933	0.763	0.912	0.914
9	**MSL-9**	3.541	3.478	3.426	3.564	4.379	4.042	0.965	0.974	0.896
10	**MSL-10**	3.379	3.292	3.045	3.421	4.495	5.965	0.873	0.805	0.865
11	**INTL-1**	3.241	3.351	2.936	3.714	5.325	5.427	0.974	0.797	0.605

Sl. No.	Location Code	Shannon diversity (H')			Margalef richness (d)			Pielou's evenness (J')		
		W	S	PM	W	S	PM	W	S	PM
12	**INTL-2**	2.694	2.863	2.847	5.727	3.918	6.038	0.742	0.762	0.638

3.7.12.5 Secondary Data Evaluation

As a part of Compliance to existing EC/CRZ Clearance and Consent to Operate order, MIDPL is carrying out regular environmental monitoring for various environmental attributes like air, water and noise for the development of Kattupalli Port and continuous data has been generated and half yearly compliance reports are submitted to Additional Principal Chief Conservator of Forests (C), Ministry of Environment, Forest and Climate Change, Regional Office (South Eastern Zone)and other authorities (CPCB, TNPCB and TNSCZMA) by MIDPL.

The following Marine monitoring data was extracted from MIDPL EC and CRZ compliance report for the period, October 2018 to March 2020. Sampling locations map is shown as **Figure 3-63**.

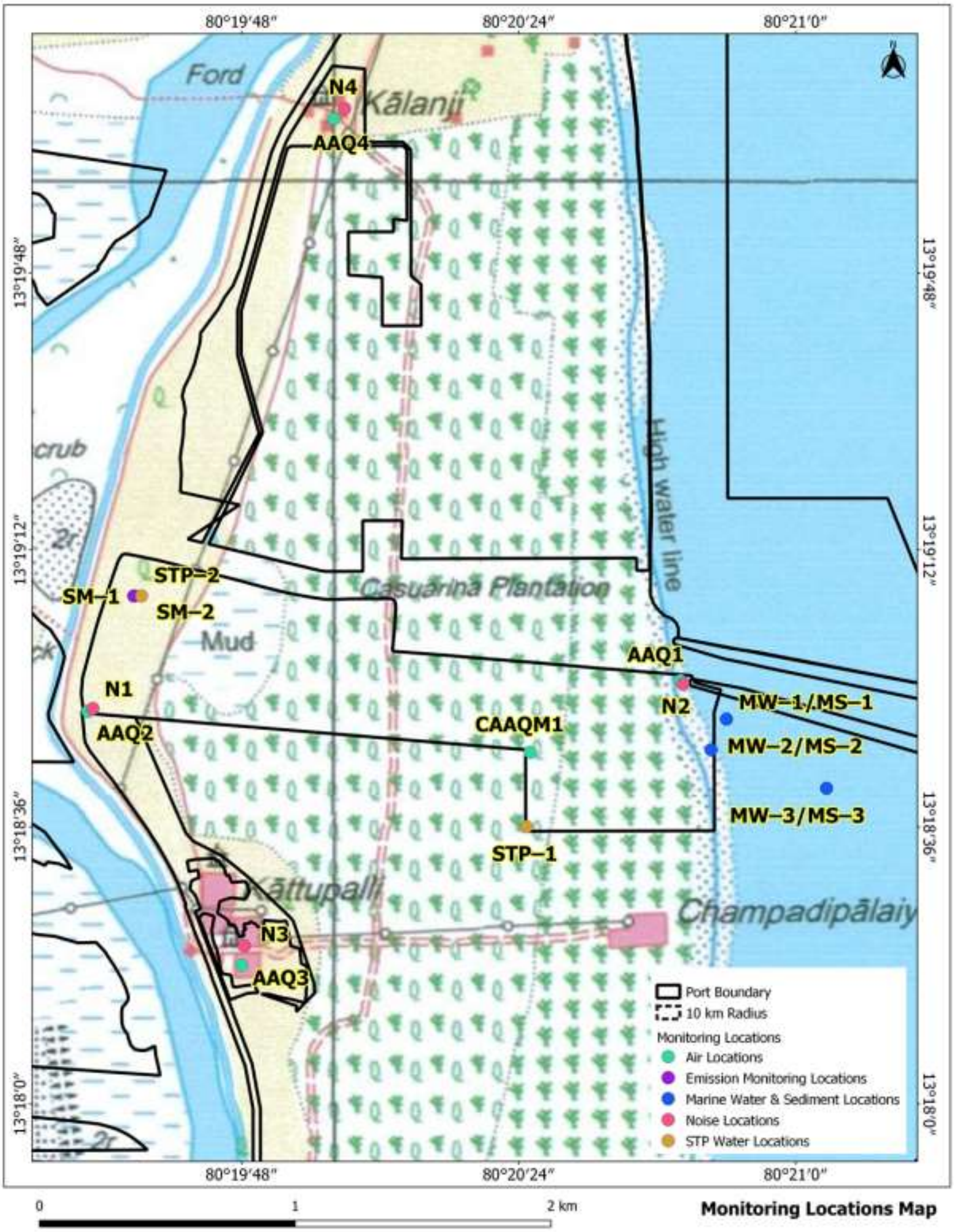


Figure 3-63: Existing Environmental Monitoring / Sampling locations

Secondary data analysis for the study area for Marine sediment

As a part of Compliance to existing EC/CRZ Clearance and Consent to Operate order, MIDPL is carrying out regular environmental monitoring for various environmental attributes like air, water and noise for the development of Kattupalli Port and continuous data has been generated and half yearly compliance reports are submitted to Additional Principal Chief

Conservator of Forests (C), Ministry of Environment, Forest and Climate Change, Regional Office (South Eastern Zone)and other authorities (CPCB, TNPCB and TNSCZMA) by MIDPL.

The following Marine monitoring data was extracted from MIDPL EC and CRZ compliance report for the period, October 2018 to March 2020

- Sand percentage has been varying between 21 and 35 with minimum at CB-1, CB -2 and CB-3 and Maximum at CB-2 locations.
- Silt percentage has been varying between 18 and 30 with minimum at CB-2 and Maximum at CB-1 locations.
- Clay percentage has been varying between 42 and 58 with minimum at CB-2 and Maximum at CB-1 locations.
- The iron concentration ranged between 10 µg/g to 24.6 µg/g both at CB-2.
- The Zinc concentration ranged between 207 µg/g to 298 µg/g both at CB-1.
- The chromium concentration ranged between 35 µg/g to 85 µg/g both at CB-1.
- Shanon Weaver Diversity Index (SWDI) has been varying between 2.24 and 2.29 with minimum at CB-1, CB-2 and Maximum at CB-2 locations.
- Benthic species density varying between 141 at CB-1 to 194 no/m^2 CB-2

Secondary data for the study area for Marine Surface Water

- The water pH varied between 7.19 and 8.33 both at CB-3.
- The BOD values varied between 9 and 27mg/l with minimum at CB-2, CB-3 and Maximum at CB-2.
- Concentrations of Total Dissolved Solids are important parameter in water quality management. The total Dissolved solids values ranged between 33086 and 42864 mg/l both at CB-1.
- Nitrite concentration varied from 3.07 to 7.03mgl/l both at CB-1.
- Nitrate concentration varied from 5.4 to 9.53mgl/l both at CB-1.
- The chlorophyll-a in water sample varied from 2.83 to 7.94 mg/m^3, with minimum value was recorded at CB-1 and maximum value at CB-2.
- The Primary Productivity values ranged from 6.35 to 10.46 mgC/m^{3}hr. The minimum value was recorded at CB-1 and maximum value at CB-2.
- Phytoplankton ranged from 86 to 291 No/ml at CB-1 and CB-2.
- Zooplanktons ranged from 64 to 187 No/ml at CB-1 and CB-2.

Secondary data for the study area for Marine Sub-Surface Water

- The water pH varied between 6.78 and 8.23 with minimum and Maximum both at CB-3.
- The turbidity values were ranged between 10 and 52 NTU. The minimum level was recorded at CB-1 and the maximum level at CB-2.
- The BOD values varied between 8 and 32mg/l with minimum at CB-1 and Maximum at CB-3.
- Concentrations of total Dissolved Solids are important parameter in water quality management. The total Dissolved solids values ranged between 31785 and 43942 mg/l with minimum at CB-1 and maximum at CB-2.
- Nitrite concentration varied from 3.2 to 7.38 mgl/l with minimum at CB-2 and maximum at CB-1.
- Nitrate concentration varied from 4.87 to 9.57mg/l with minimum at CB-2 and maximum at CB-1.
- The chlorophyll-a in water sample varied from 3.18 to 8.54 mg/m^3, with minimum value was recorded at CB-1 and maximum value at CB-3.

- The Primary Productivity values ranged from 7.12 to 10.71mgC/m^3hr. The minimum value was recorded at CB-1 and maximum value at CB-2.
- The Total phosphate value ranged from 1.9 to 8.09mgl/l with minimum value and the maximum value at CB-1.

The Secondary data of Ennore (Kattupalli) was also extracted from "*Sea Water Quality at Selected Locations along Indian Coast report, Status Report (1990-2015) by Coastal Ocean Monitoring and Prediction System (COMAPS) and Sea Water Quality Monitoring (SWQM)*".

- Salinity at shore and offshore ranged between 20 PPT to 33 PPT and 25 PPT to 33.19 PPT respectively.
- pH at shore was recorded between 7.12 and 8.2 and at offshore in between 7.80 to 8.2.
- Surface temperature varied between 24.70°C and 35.7°Cat shore and 24.90°C to 32.60°C at offshore.
- Suspended sediment concentration varied between 3.74 to 50 mg/l at shore and 9.27 to 43.8mg/l at offshore stations.
- The dissolved oxygen (DO) varied from 0.73 to 5.12 mg/l at shore and 3.63 to 5.37mg/l at offshore.
- The dissolved inorganic nitrogen (DIN) ranged between 0.20 μM to 7.83 μM at shore and 0.02 μM to 4.79 μM at offshore locations.
- The Dissolved inorganic phosphate reported maximum of 13.76 μM at shore
- Total dissolved silicate ranged in between 0.46 to 13.2 μM at shore and 0.79 to 12.72 μM at offshore stations.
- Total nitrogen ranged from 4.53 μM to 18.48 μM at shore and from 0.87 μM to 14.55 μM at offshore.
- Total phosphorous ranged between 0.13 μM to 2.14 μM at shore and 0.33 μM to1.47 μM at offshore
- Nitrate concentration in the coastal waters of Ennore ranged from 0.2 μM – 50.3 μM.
- The ammonium concentration ranged from 0.004 μM – 162.3 μM.
- Phosphate ranged from 0.02 μM – 13.8 Mm.
- Silicate showed a decreasing trend and, the values ranged from 0.4 – 95.9 μM.
- The phytoplankton biomass ranged from 0.01 – 26.8 mg/.
- Phytoplankton abundance ranged from 519 – 1778067 cells/l
- Zooplankton biomass and zooplankton abundance ranged from 0.01 to 9.6 ml/m^3 (and 31 – 36774 no./m^3
- In the Ennore shore, nutrient concentrations did not show any seasonal variability, probably due to surplus discharge of sewage (including domestic, industrial effluents and from other sources) throughout the year.

Water Quality Index of Kattupalli Region

As per Status Report (1990-2015) by Coastal Ocean Monitoring and Prediction System (COMAPS) and Sea Water Quality Monitoring (SWQM)[13]

- Water quality index has been developed in all the monitoring locations and based on the threshold values all the parameter was assessed and grades assigned.
- The faecal coliform found to be a critical indicator obtained 'very poor' condition
- The Oxygen (%) was at 'very poor' condition

[13] *Seawater Quality at Selected Locations along Indian Coast – Status Report (1990-2015), Ministry of Earth Sciences, Government of India*

The Ennore area was in Good condition for BOD as well as Chlorophyll indicator and moderate condition for Total nitrogen and Total phosphorous indicator.

3.8 Three Season Estuarine Study

MoEF&CC ToR recommendation suggested the "***Three season's data should be collected in the coastal region as well as estuarine region at proposed site. Data should be collected at mouth present in northern end of the project and saltpans present in the western Kosattalaiyar particularly during monsoon along with the other places***".

In line with above ToR requirement, Three Season Estuarine Study was conducted by Centre for Advanced Studies in Marine Biology, Annamalai University (a pioneering institute in the estuarine, marine and oceanographic studies) during September and November, 2019 and January, 2020 covering the Pre-monsoon, Monsoon and Winter seasons.

3.8.1 Environmental Monitoring Locations

The environment of the project region has been studied for the evaluation of baseline information during the Pre-Monsoon, Monsoon and Winter seasons and the seasonal variations in environmental conditions around the site were established through collection and analysis of water and sediment samples in the project region.

Monitoring locations were selected in such a way that the existing baseline conditions in the area shall be captured and in future likely effects of potential environmental impacts of the proposed project activities shall be monitored in the same locations.

Water and sediment samples for physicochemical, petroleum hydrocarbons, heavy metals and biological analysis were collected from Eight (8) locations.

The Coordinates of the sampling locations are given in the **Table 3-21** and map showing the sampling locations are given as **Figure 3-64**.

Table 3-21: Monitoring Locations

S. No.	Location Code	Latitude	Longitude
1	ML- 1	13°26'32.85"N	80°19'7.31"E
2	ML -2	13°23'29.80"N	80°19'36.43"E
3	ML- 3	13°21'31.98"N	80°19'55.74"E
4	ML -4	13°20'25.65"N	80°19'6.20"E
5	ML- 5	13°19'22.39"N	80°18'56.89"E
6	ML -6	13°16'42.20"N	80°19'29.32"E
7	ML -7	13°15'2.80"N	80°18'52.31"E
8	ML -8	13°14'5.75"N	80°19'39.78"E

Figure 3-64: Sampling Locations Map

3.8.1.1 Materials and Methods used for Sampling

Water samples were collected using Universal water sampler below the surface and transferred to the pre-cleaned polypropylene and glass containers. Sediment samples were collected using a Peterson Grab, transferred to clean polythene bags and transported to the laboratory. The samples were air-dried. The plant root and other debris were removed and stored for further analysis. Biological samples such as plankters were collected using the suitable plankton nets, benthos was collected from grab samplers and visual observations were made for floral analysis in the study area.

3.8.2 Estuarine Environment Monitoring Results

Estuarine Environment (Cumulative Results of Three Sampling Seasons (Pre-Monsoon (September, 2019), Monsoon (November, 2019) and Winter (January, 2020) is given below.

3.8.2.1 Water Physicochemical Parameters

Temperature (°C): The water temperature fluctuated from 27.6 to 29.1°C. The minimum value was recorded at ML-8 during Monsoon season and maximum was recorded at ML-2 during Winter Season.

Salinity (‰): The major variable in the coastal environment is salinity, the water salinity varied from 14.5 to 40.5 ‰. The salinity was found to be lower at ML-4 during Monsoon season and higher at ML-1 during Pre-Monsoon season.

pH: The water pH varied between 7.5 and 8.3 with minimum at ML-7 during Winter Season and maximum at ML-1 during Monsoon season .

Total Suspended Solids: Concentrations of suspended Solids are important parameter in water quality management. The Total Suspended solids values ranged between 73.65 and 156.69 mg/l. The minimum value was recorded at ML-5 during Pre-Monsoon season and the maximum was recorded at ML-7 during Monsoon season.

Turbidity: The turbidity values were ranged between 7.3 and 8.6 NTU. The minimum level was recorded at ML-5 and the maximum level at ML-1 both during Pre-Monsoon season respectively.

Dissolved Oxygen (mg/l): The Dissolved Oxygen level in the water varied between 4.20 and 5.5 mg/l. The lower value was recorded at ML-1 (Pre-Monsoon), ML-6 (Monsoon) and ML-8 (Winter) and the higher value at ML-5 during Pre-Monsoon season.

Biological Oxygen Demand (mg/l): The BOD values varied between 0.6 and 1.5 mg/l with minimum at ML-5 during Pre-Monsoon season and the maximum value was recorded at ML-1 during Pre-Monsoon season and at ML-8 during winter season respectively.

Detailed results for the above parameters are given in **Table 3-22** and shown from **Figure 3-65** to **Figure 3-71**.

Table 3-22: Seasonal Variations in Water Physico-chemical parameters

Parameters	Units		Value
Temperature	°C	Max.	29.1
		Min.	27.6
Salinity	‰	Max.	40.5
		Min.	14.5
pH		Max.	8.3
		Min.	7.5
TSS	mg/l	Max.	156.69
		Min.	73.65
Turbidity	NTU	Max.	8.6
		Min.	7.3
Dissolved Oxygen	mg/l	Max.	5.5

Parameters	Units		Value
		Min.	4.2
Biological Oxygen Demand		Max.	1.5
		Min.	0.6

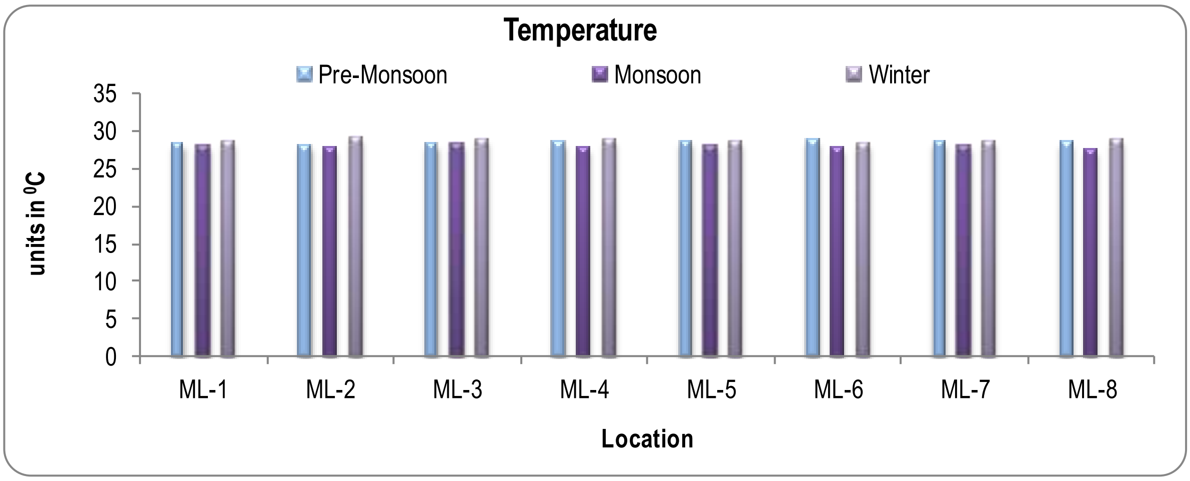


Figure 3-65: Variations in Temperature

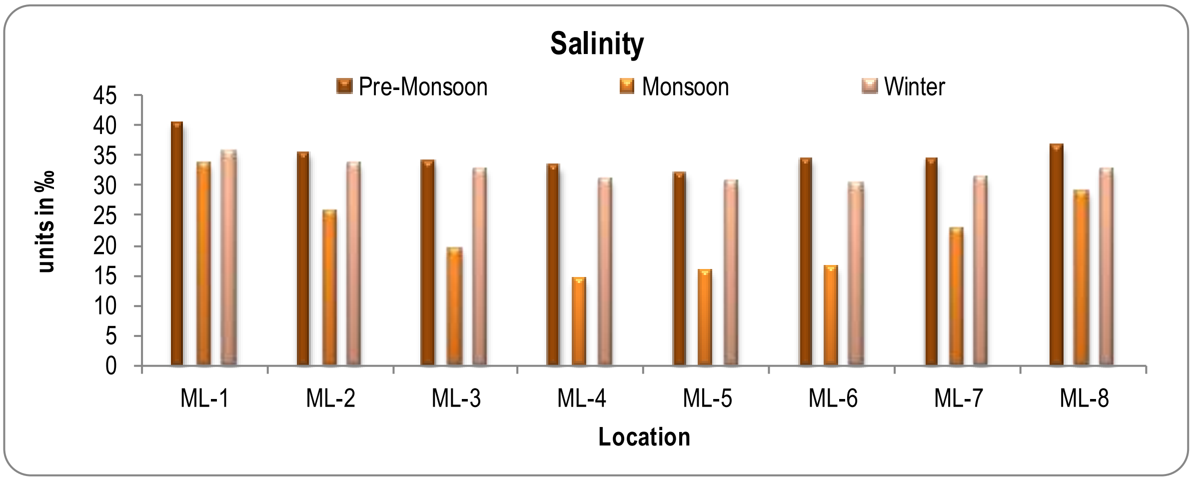


Figure 3-66: Variations in Salinity

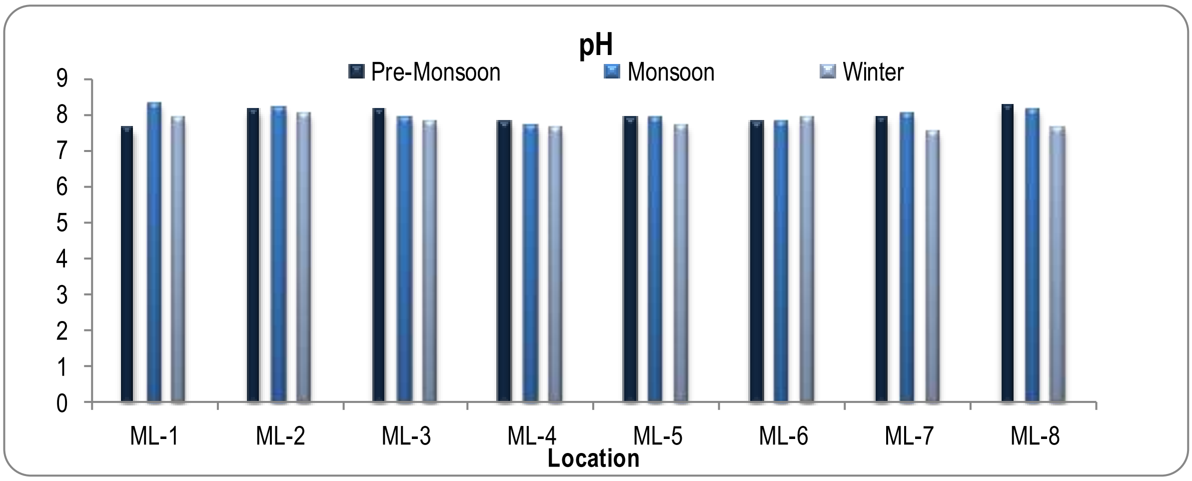


Figure 3-67: Variations in pH

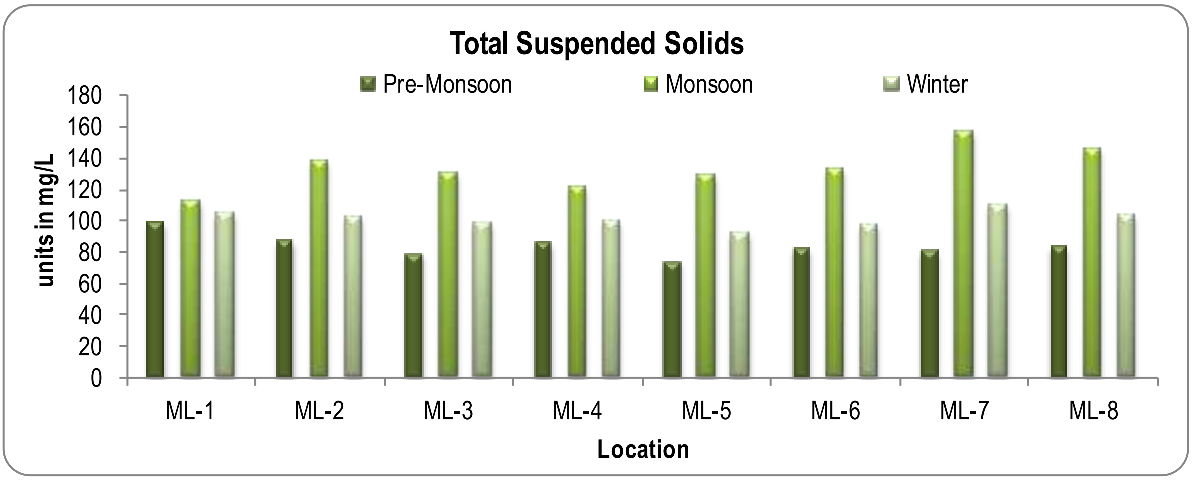


Figure 3-68: Variations in Total Suspended Solids

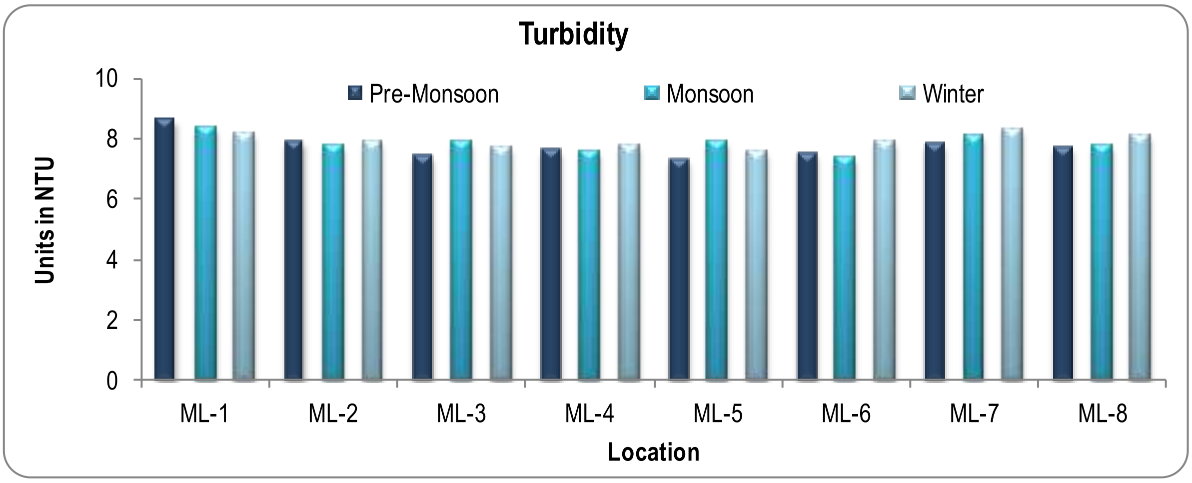


Figure 3-69: Variations in Turbidity

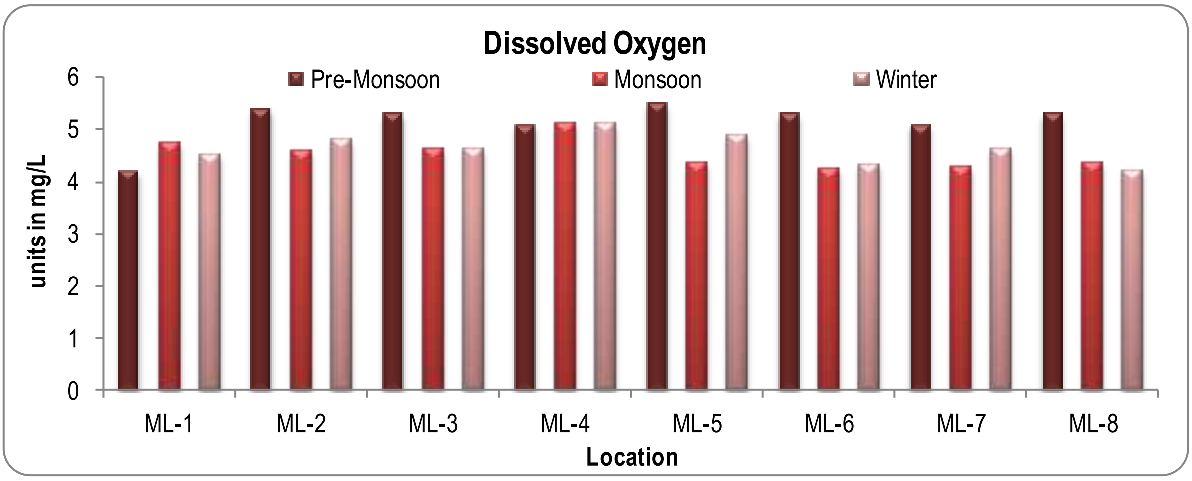


Figure 3-70: Variations in Dissolved Oxygen

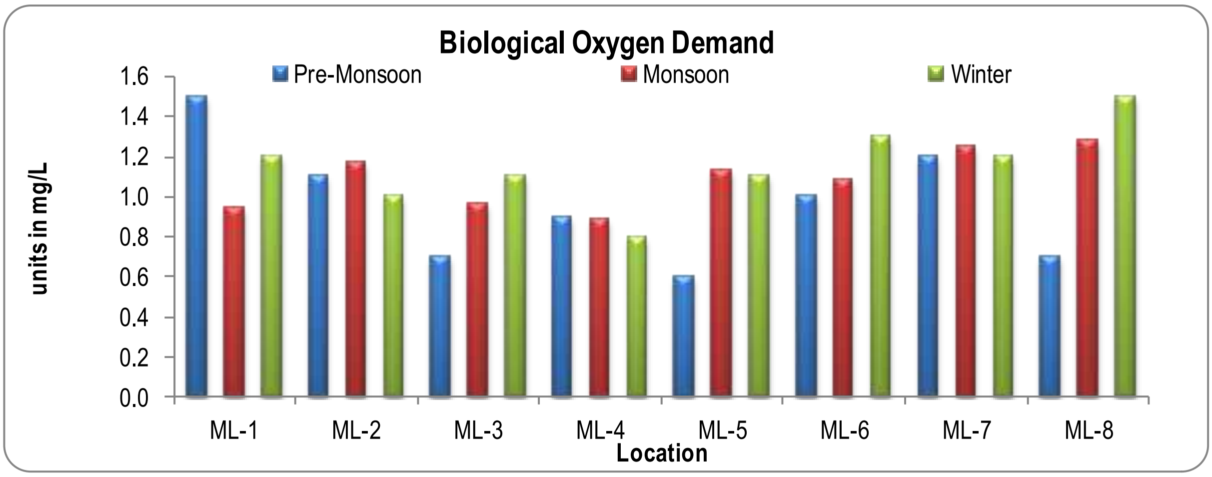


Figure 3-71: Variations in Biochemical Oxygen Demand

3.8.2.2 Nutrient Parameters

Nitrite: Nitrite concentration varied from 0.17 to 2.15 µmol/l with minimum at ML-5 during Pre-Monsoon season and maximum at ML-5 during Monsoon season.

Nitrate: Nitrate concentration ranged between 3.51 and 5.42 µmol/l with minimum at ML-4 during Pre-Monsoon season and maximum at ML-6 during Monsoon season.

Ammonical Nitrogen: The ammonia concentration varied from 0.051 to 0.095 µmol/l. The minimum was recorded at ML-3 during Winter Season and maximum at ML-8 during Monsoon season.

Total Nitrogen: The Total nitrogen values ranged from 14.84 to 21.75 µmol/l. The minimum value was recorded at ML-3 during Winter season and the maximum value at ML-6 during Monsoon season.

Inorganic Phosphate: The Inorganic phosphate value ranged between 0.87 and 1.64 µmol/l with minimum at ML-3 during Pre-Monsoon season and maximum at ML-7 during Monsoon season.

Total Phosphate: The Total phosphate value ranged from 1.41 to 2.76 µmol/l with minimum value at ML-6 during Pre-Monsoon season and the maximum value at ML-7 during Monsoon season.

Silicate: The silicate values ranged between 28.93 and 51.18 µmol/l. The minimum and the maximum values were recorded at ML-8 during Pre-Monsoon season and ML-8 during Monsoon season.

Particulate organic carbon: The particulate organic carbon level ranged between 115.32 and 141.48 µgC/l with minimum at ML-6 during Pre-Monsoon season and ML-3 during Winter season respectively maximum at ML-6 during Monsoon season.

Petroleum hydrocarbons: PHC level in water fluctuated from 0.456 and 0.914 µg/l. The minimum was recorded at ML-4 during Pre-Monsoon season and the maximum was recorded at ML-7 during Monsoon season.

Detailed results for the above parameters are given in **Table 3-23** and shown from **Figure 3-72** to **Figure 3-80.**

Table 3-23: Seasonal Variations in Water Nutrient parameters

Parameters	Units	Min.	Max.
Nitrite (NO_2)	µmol/l	0.17	2.15
Nitrate (NO_3)		3.51	5.42
Ammonical Nitrogen (NH_4)		0.051	0.095
Total nitrogen		14.84	21.75
Inorganic Phosphate		0.87	1.64
Total Phosphate (TP)		1.41	2.76
Silicate (SiO_4)	mg/l	28.93	51.18
Particulate organic carbon	µgC/l	115.32	141.48
Petroleum hydrocarbons	µg/l	0.456	0.914

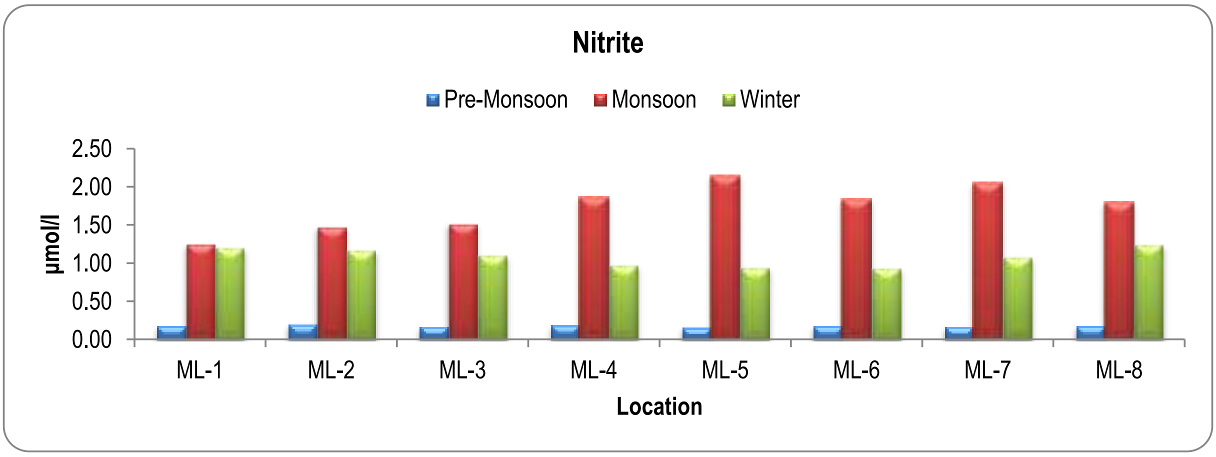


Figure 3-72: Variation of Nitrite Concentration

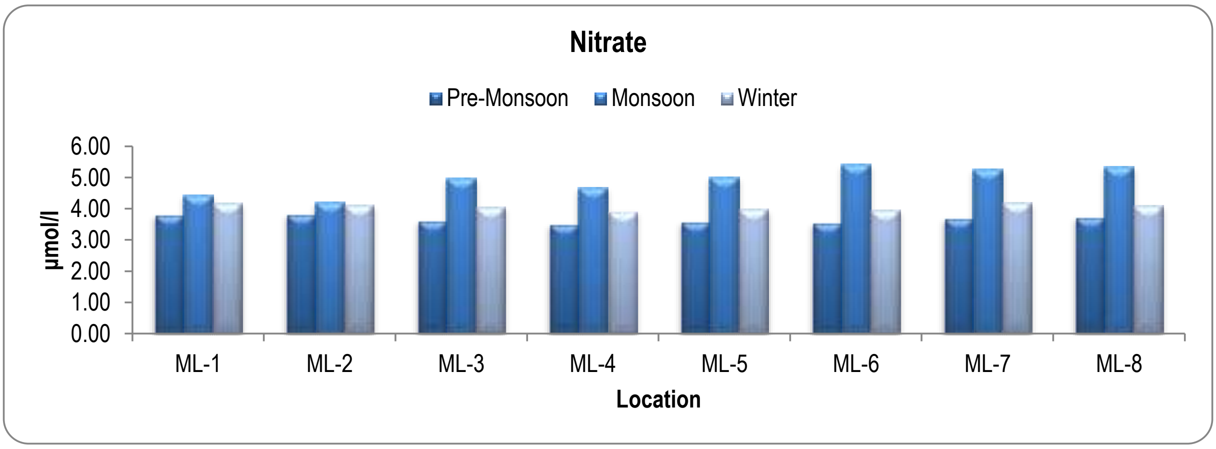


Figure 3-73: Variation of Nitrate Concentration

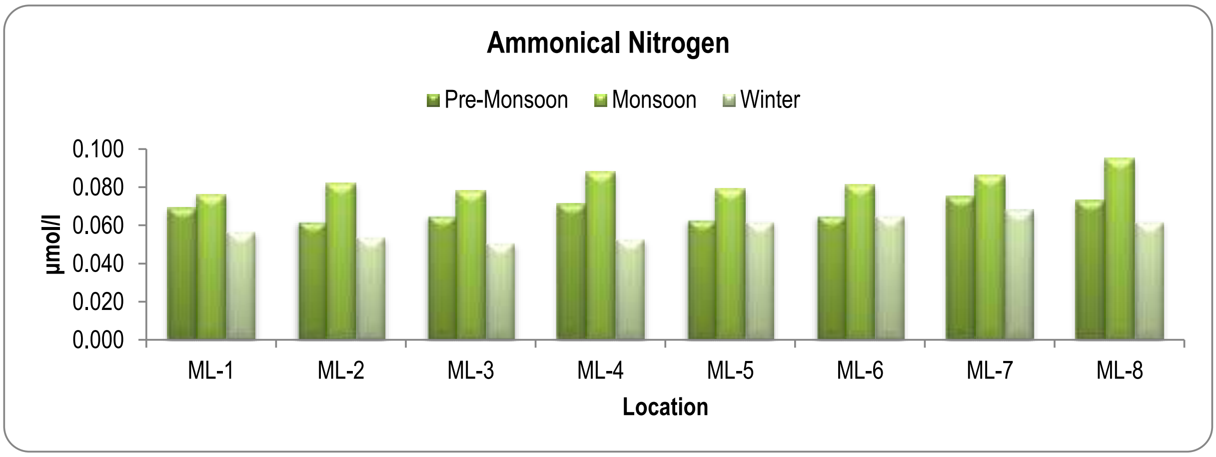


Figure 3-74: Variation of Ammoniacal Nitrogen Concentration

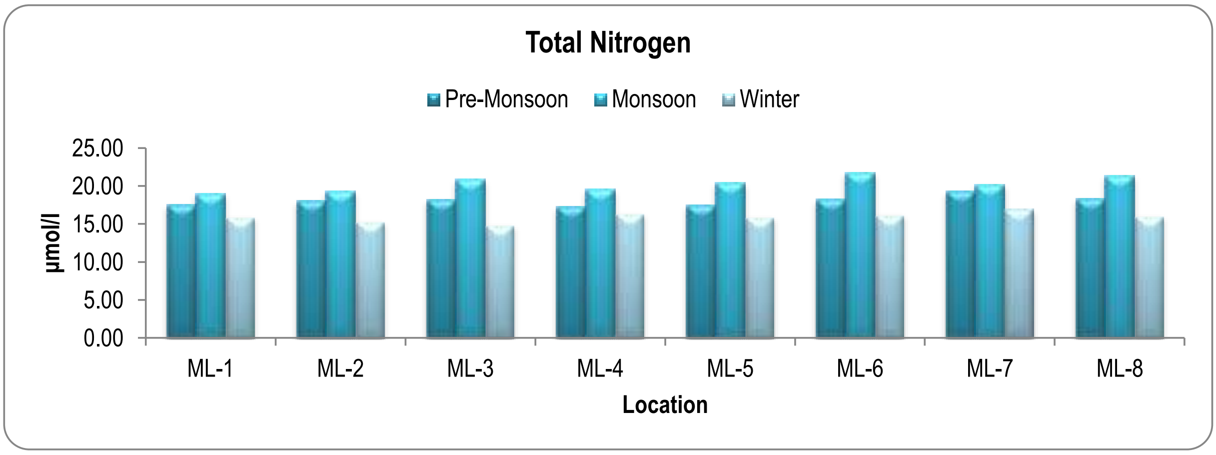


Figure 3-75: Variation of Total Nitrogen Concentration

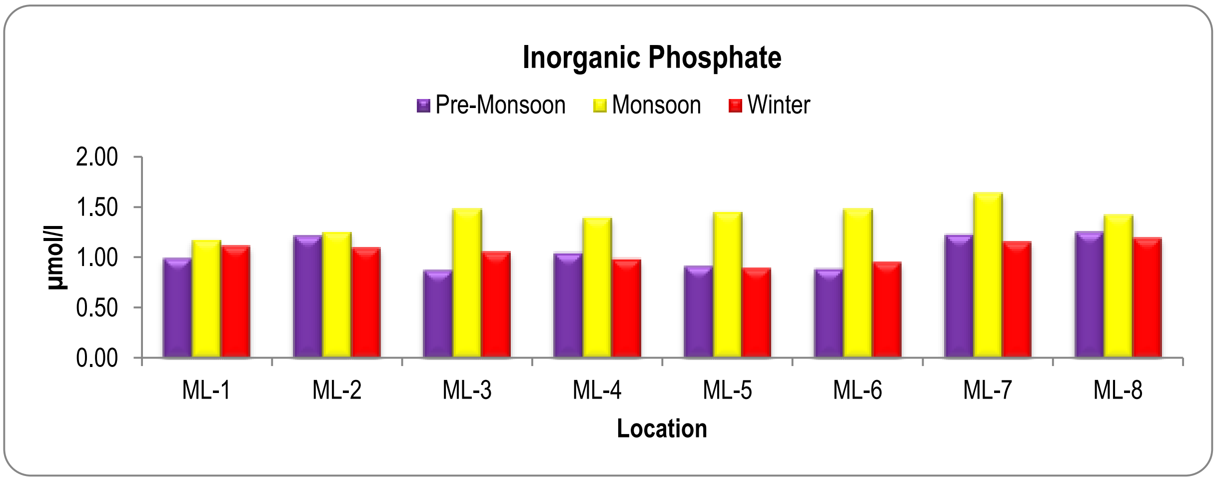


Figure 3-76: Variation of Inorganic Phosphate Concentration

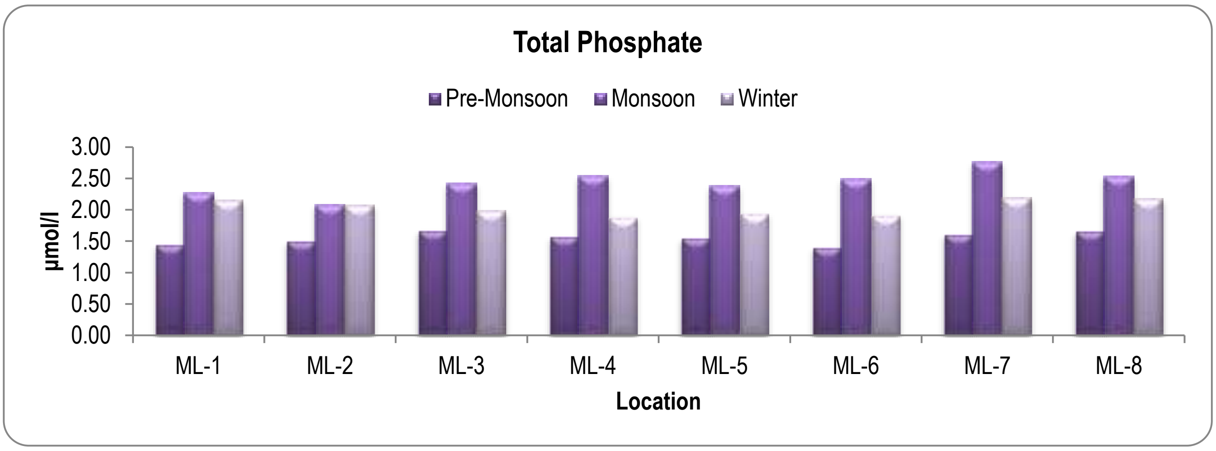


Figure 3-77: Variation of Total Phosphate Concentration

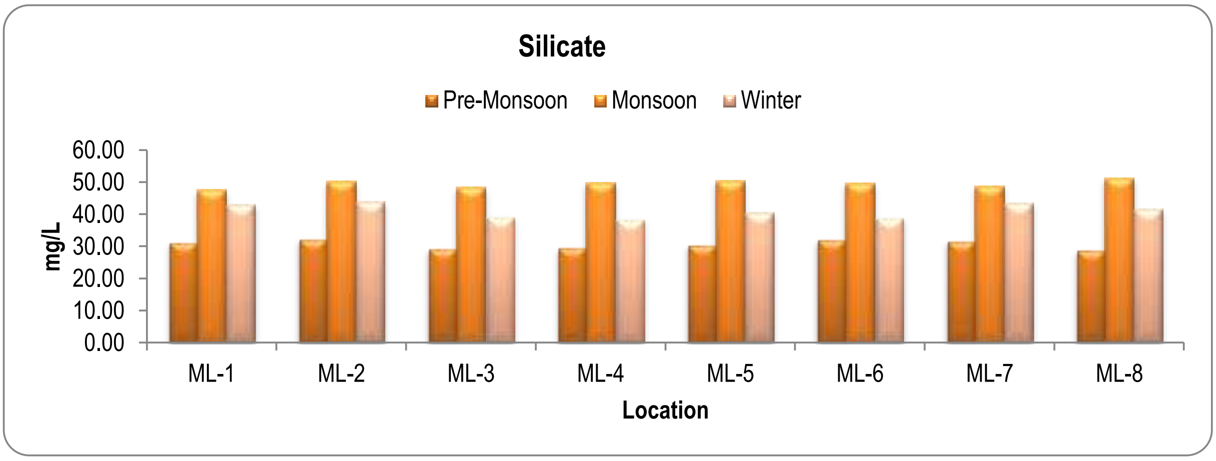


Figure 3-78: Variation of Silicate Concentration

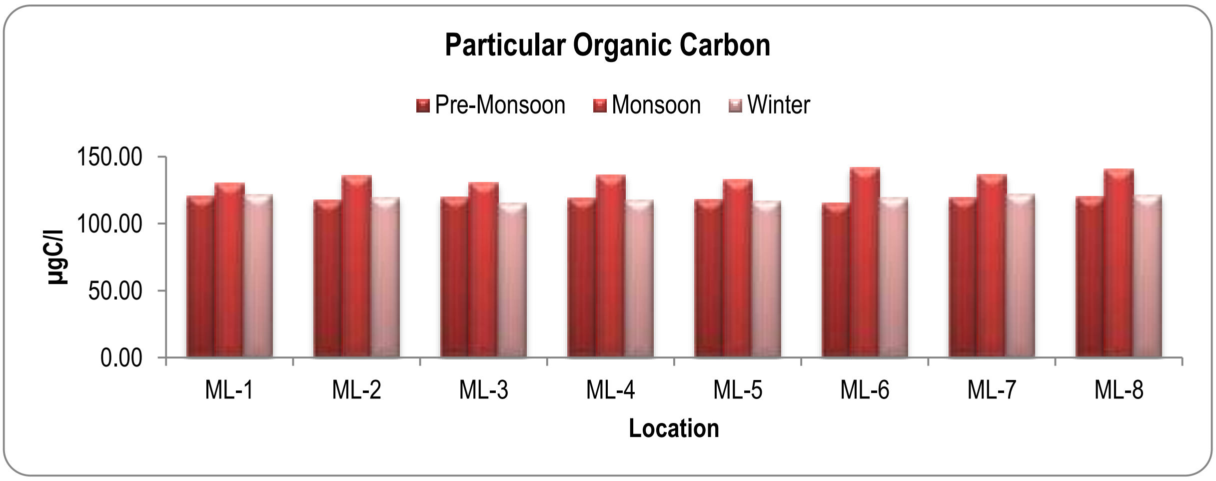


Figure 3-79: Variation of Particulate Organic Carbon Concentration

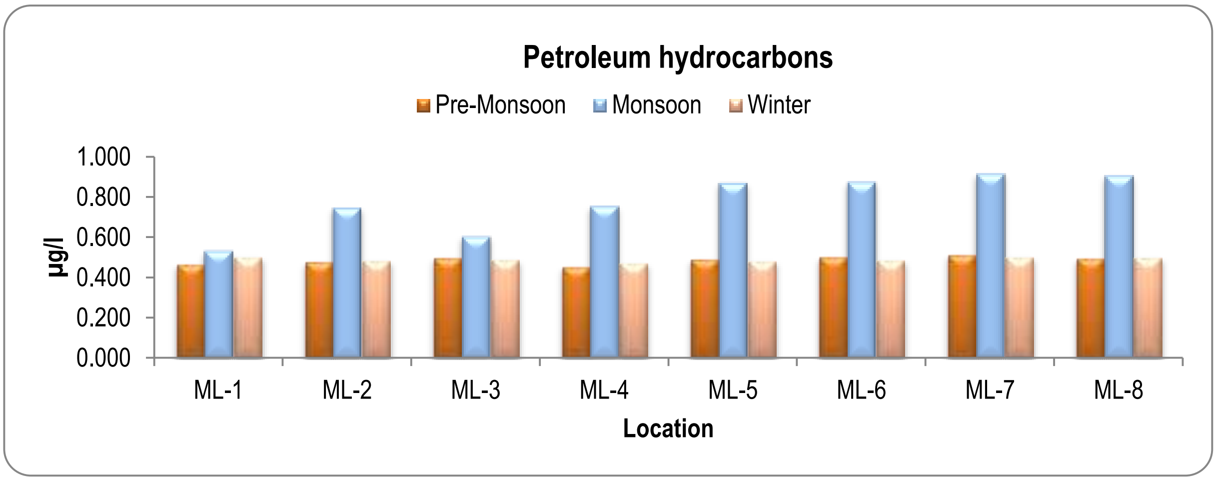


Figure 3-80: Variation of Petroleum hydrocarbons Concentration

3.8.2.3 Heavy Metals - Water

Cadmium: The Cadmium concentration varied from 1.63 to 2.39 µg/L. The minimum was recorded at ML-5 during Pre-Monsoon season and the maximum was recorded at ML-7 during Monsoon season.

Copper: The copper concentration varied from 16.61 to 20.14 µg/L. The minimum was recorded at ML-3 during Pre-Monsoon season and the maximum value was recorded at ML-8 during Monsoon season.

Iron: The iron concentration varied from 13.18 to 20.32 µg/L. The minimum was recorded at ML-3 during Pre-Monsoon season and the maximum was recorded at ML-8 during Monsoon season.

Zinc: The zinc level varied from 18.84 to 22.56µg/L. The minimum was recorded at ML-4 during Winter season and the maximum was recorded at ML-8 during Monsoon season.

Lead: The Lead concentration ranged from 2.08 to 3.14 µg/L with minimum was recorded at ML-4 during Monsoon season and the maximum value was recorded at ML-8 during Pre-Monsoon season.

Mercury: The mercury level varied from 0.39 to 0.81 µg/L. The minimum was recorded at ML-4 during Pre-Monsoon season and the maximum value was recorded at ML-1 during Monsoon season.

Manganese: The Manganese concentration varied from 36.67 to 42.19 µg/L. The minimum was recorded at ML-6 during Winter season and the maximum was recorded at ML-7 during Monsoon season.

Nickel: The Nickel level varied from 1.81 to 2.67 µg/L. The minimum was recorded at ML-4 during Pre-Monsoon season and the maximum level was recorded at ML-1 during Monsoon season.

Chromium: The chromium level varied from 1.69 to 2.56 µg/L. The minimum was recorded at ML-6 during Pre-Monsoon season and the maximum value was recorded at ML-1 during Monsoon season.

Detailed results for the above parameters are given in **Table 3-24** same was shown from **Figure 3-81** to **Figure 3-89**.

Table 3-24: Seasonal Variations in Water Heavy Metals

Parameters	Units	Min.	Max.
Cadmium (Cd)	µg/l	1.63	2.39
Copper (Cu)		16.61	20.14
Iron (Fe)		13.18	20.32
Zinc (Zn)		18.84	22.56
Lead(Pb)		2.08	3.14
Mercury (Hg)		0.39	0.81
Manganese (Mn)		36.67	42.19
Nickel (Ni)		1.81	2.67
Chromium (Cr)		1.69	2.56

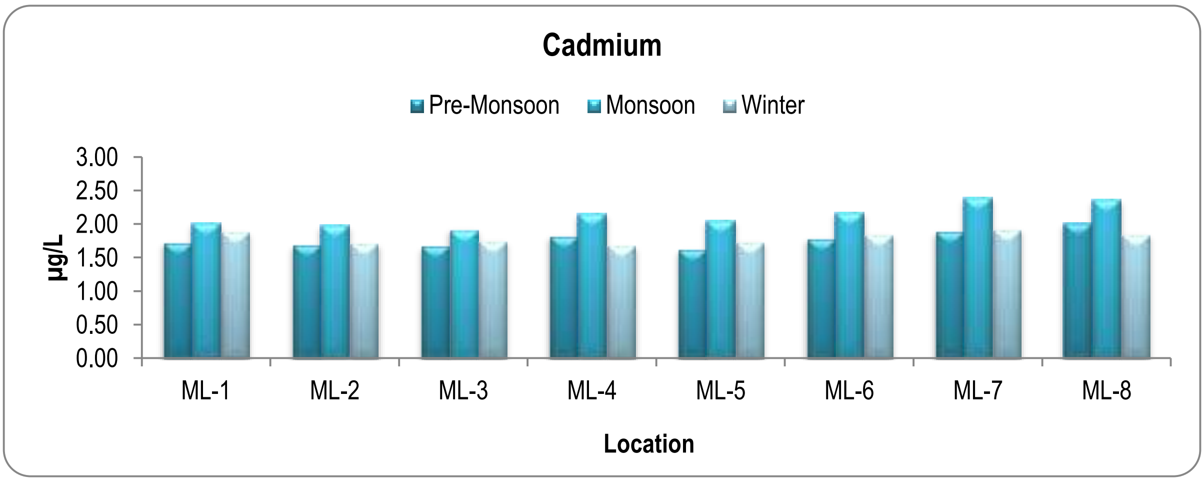


Figure 3-81: Variation of Cadmium Concentration

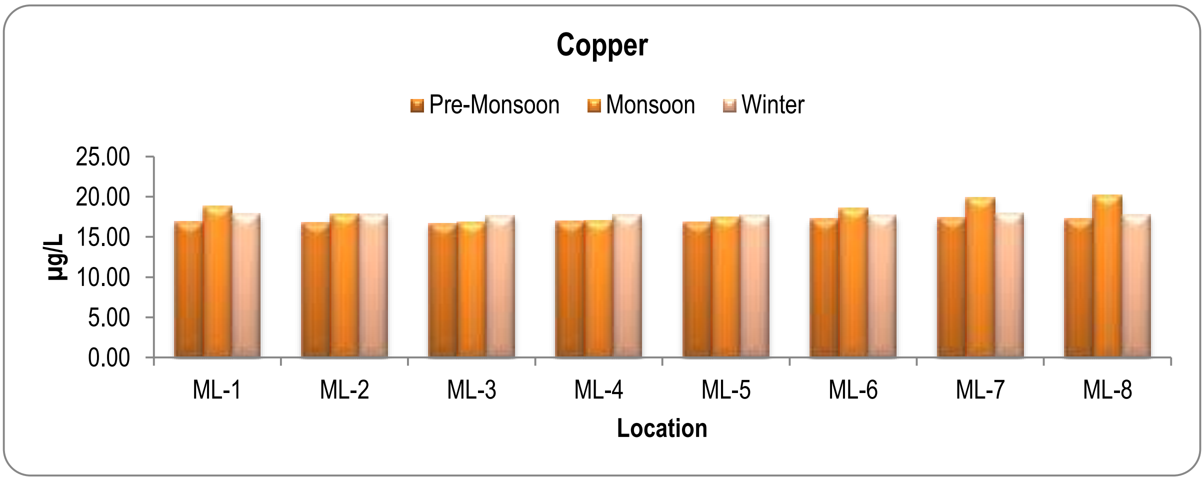


Figure 3-82: Variation of Copper Concentration

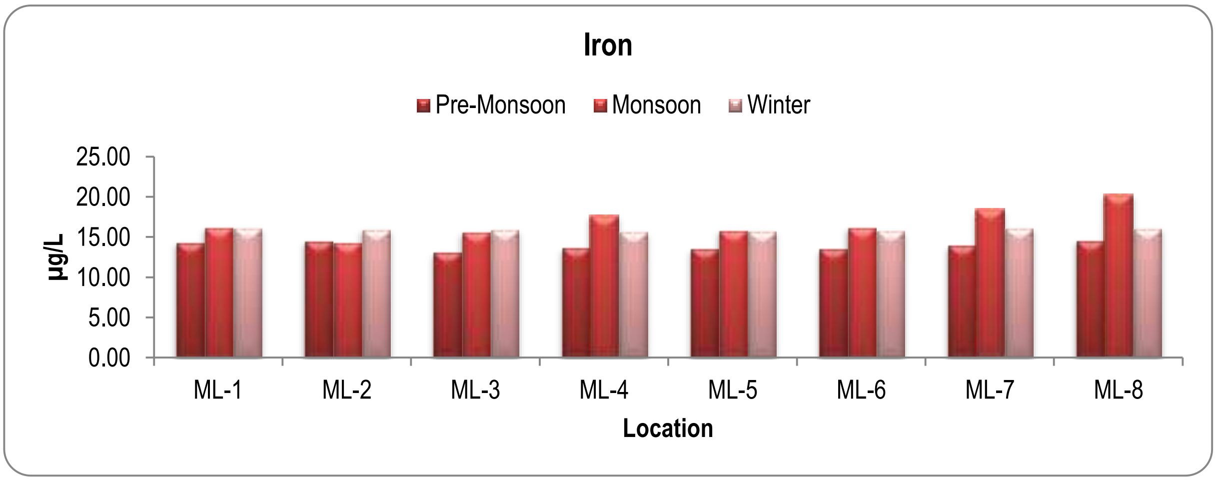


Figure 3-83: Variation of Iron Concentration

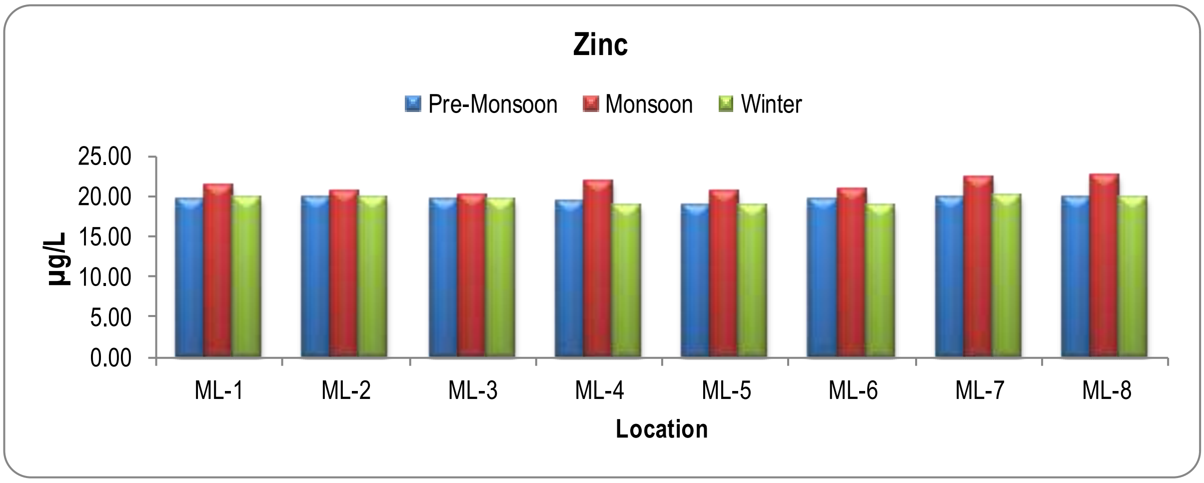


Figure 3-84: Variation of Zinc Concentration

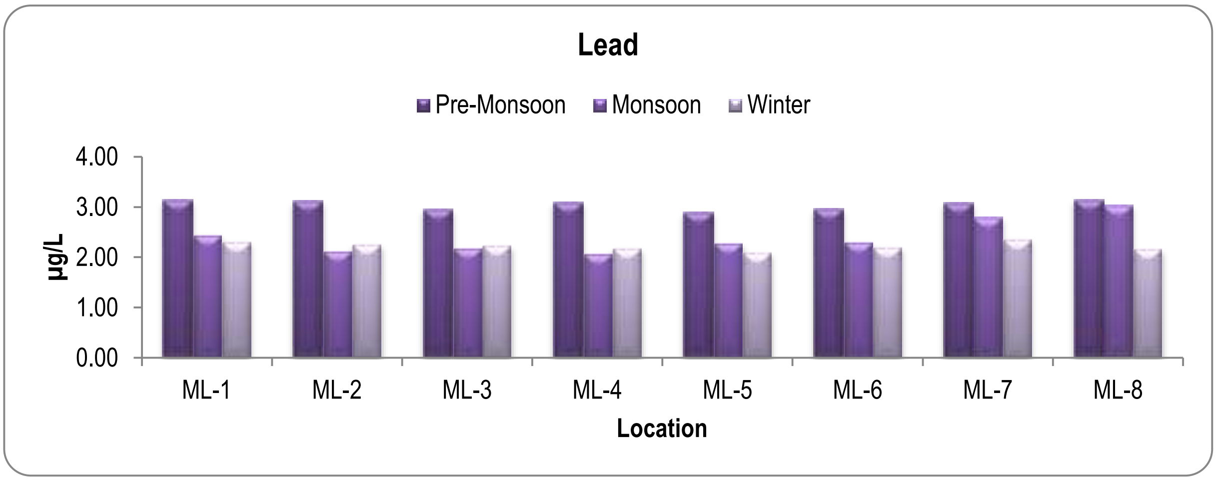


Figure 3-85: Variation of Lead Concentration

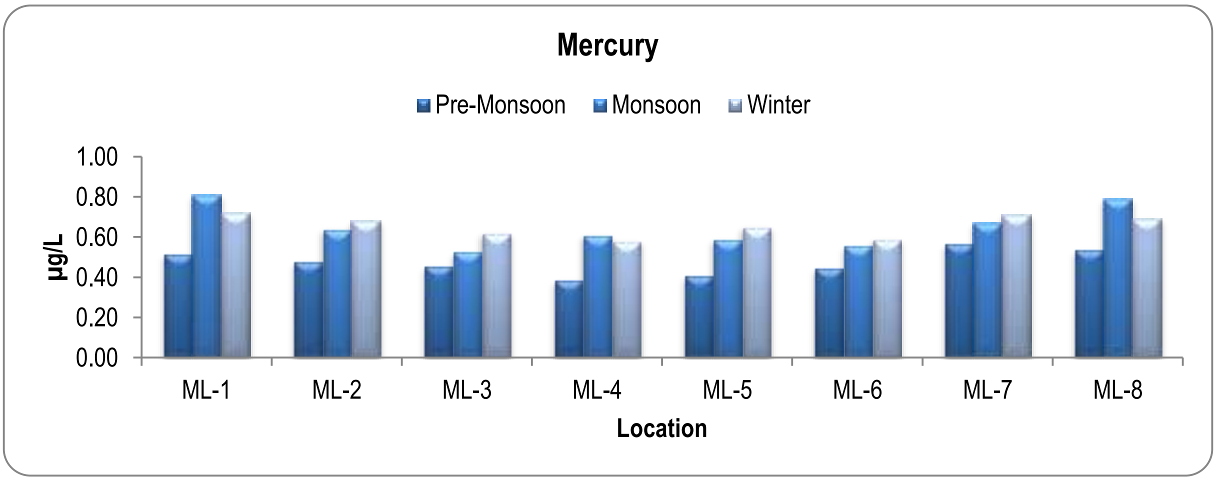


Figure 3-86: Variation of Mercury Concentration

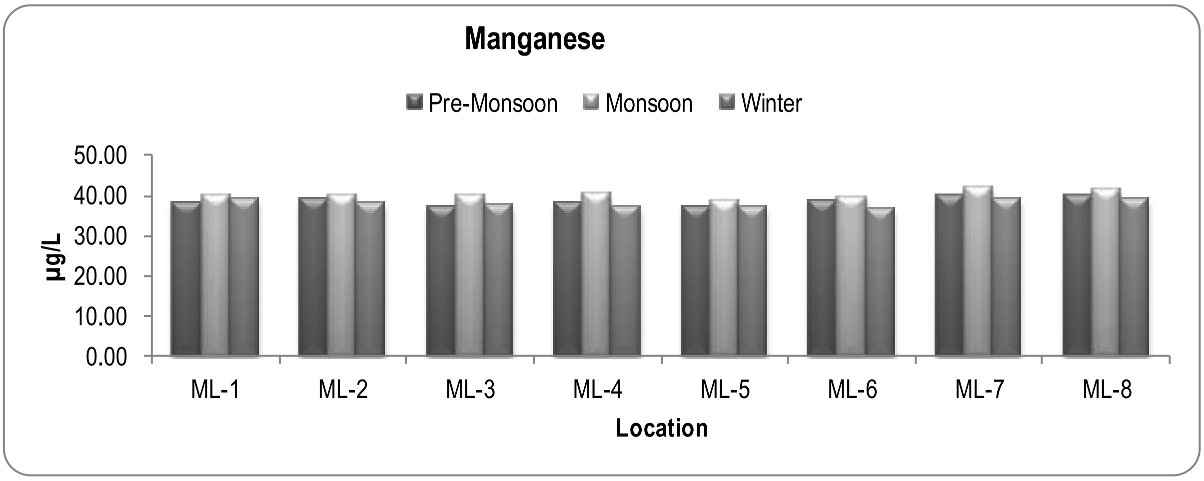


Figure 3-87: Variation of Manganese Concentration

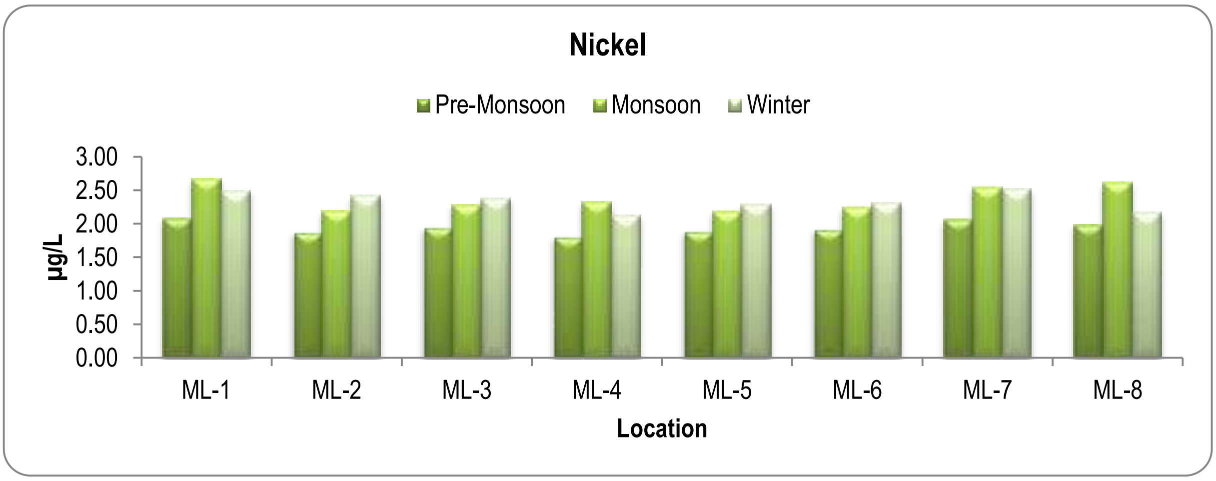


Figure 3-88: Variation of Nickel Concentration

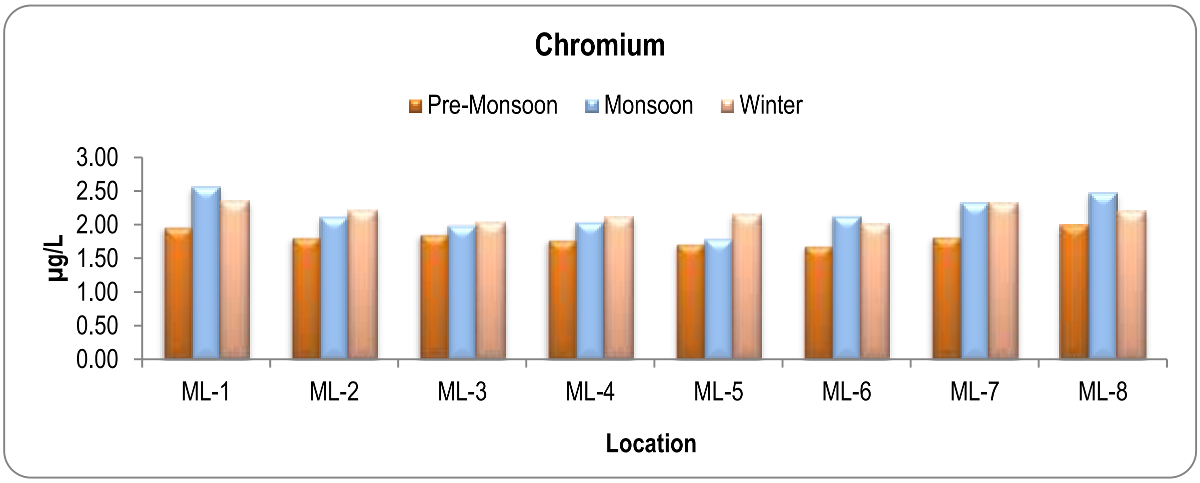


Figure 3-89: Variation of Chromium Concentration

3.8.2.4 Sediment Physical Parameters

The sediment texture

Sand: The percentage of sand ranged between 8% at ML-6 during Monsoon season and 47% at ML-8 during Pre-Monsoon season.

Silt: The silt percentage ranged between 10% at ML-7 during Pre-Monsoon season and 52% at ML-3 during Monsoon season.

Clay: The Clay percentage ranged between 19% at ML-2 and 60% at ML-7 both during Pre-Monsoon season.

pH: The sediment pH is alkaline in nature and varied from 7.8 at ML-1 during Pre-Monsoon season to 8.38 at ML-1 during Monsoon Season.

Total Organic Carbon: The Sediment TOC ranged between 5.72 mg C/g at ML-8 and 10.58 mg C/g at ML-7 both during Winter season.

The Details of sediment Composition, Total organic carbon and pH are shown in the **Table 3-25** and graphically represented in **Figure 3-90** to **Figure 3-94**.

Table 3-25: Variations in sediment physicochemical parameters

Parameters	Units		Value
Sand	%	Max.	47
		Min.	8
Silt		Max.	52
		Min.	10
Clay		Max.	60
		Min.	19
pH		Max.	8.38
		Min.	7.8
TOC	mgC/g	Max.	10.58
		Min.	5.72

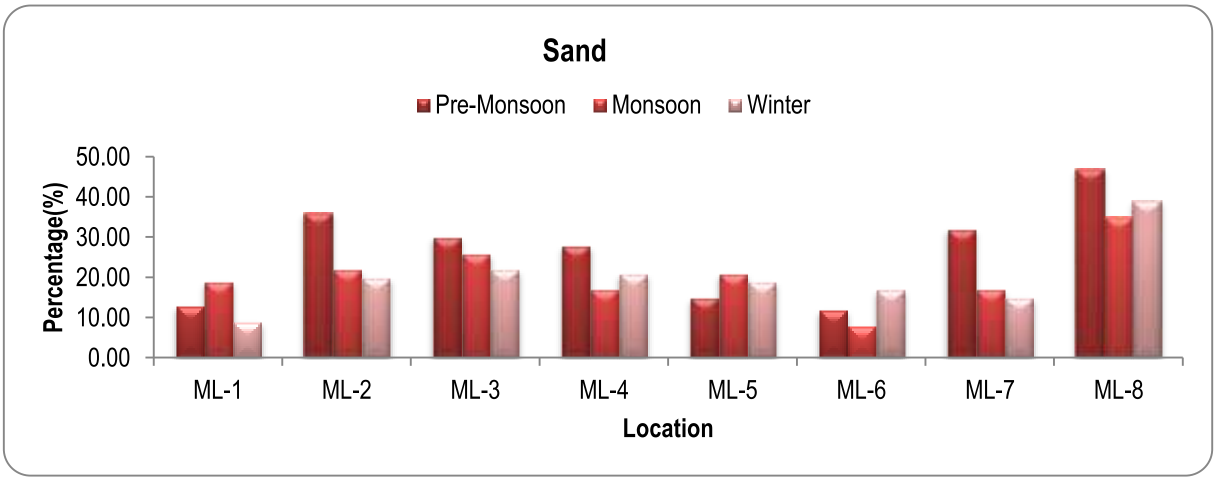


Figure 3-90: Variations in Percentage of Sand

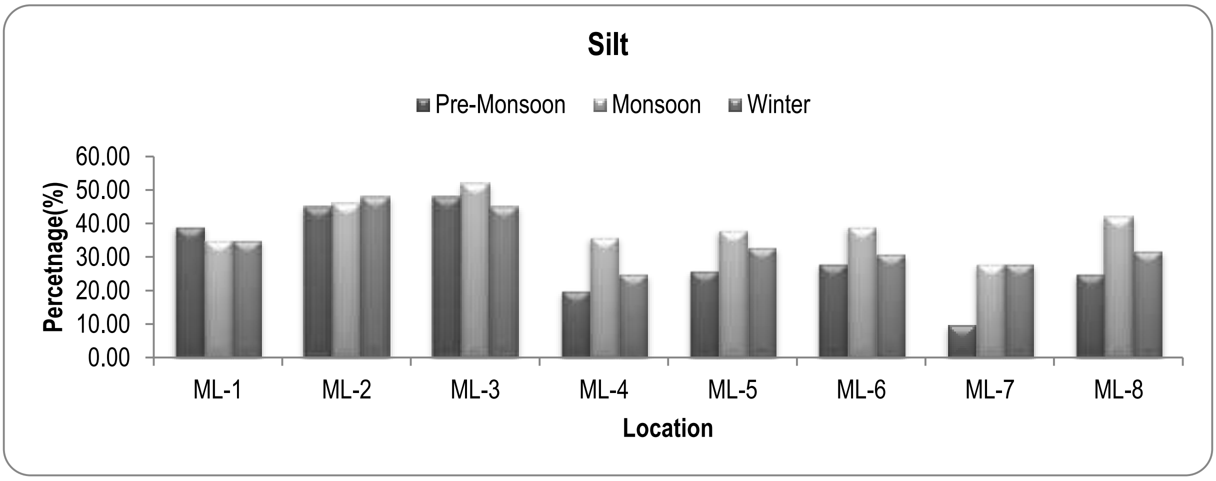


Figure 3-91: Variations in Percentage of Silt

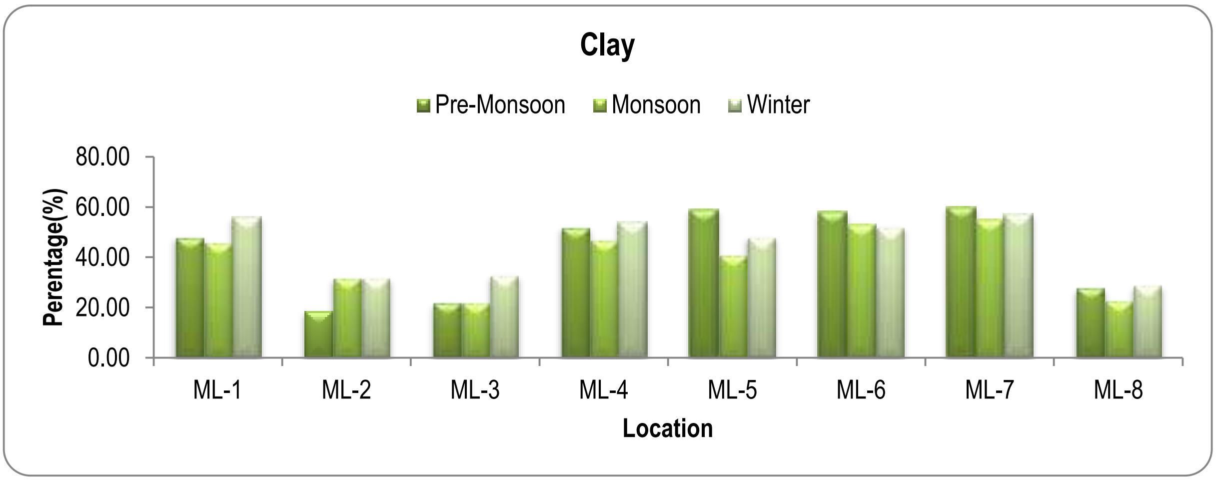


Figure 3-92: Variations in Percentage of Clay

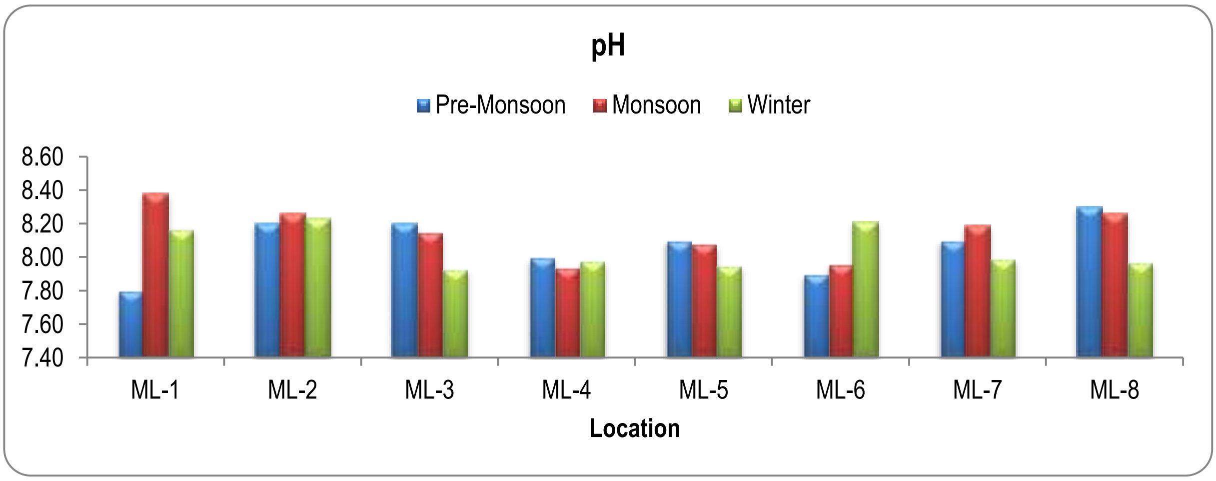


Figure 3-93: Variations in Percentage of pH

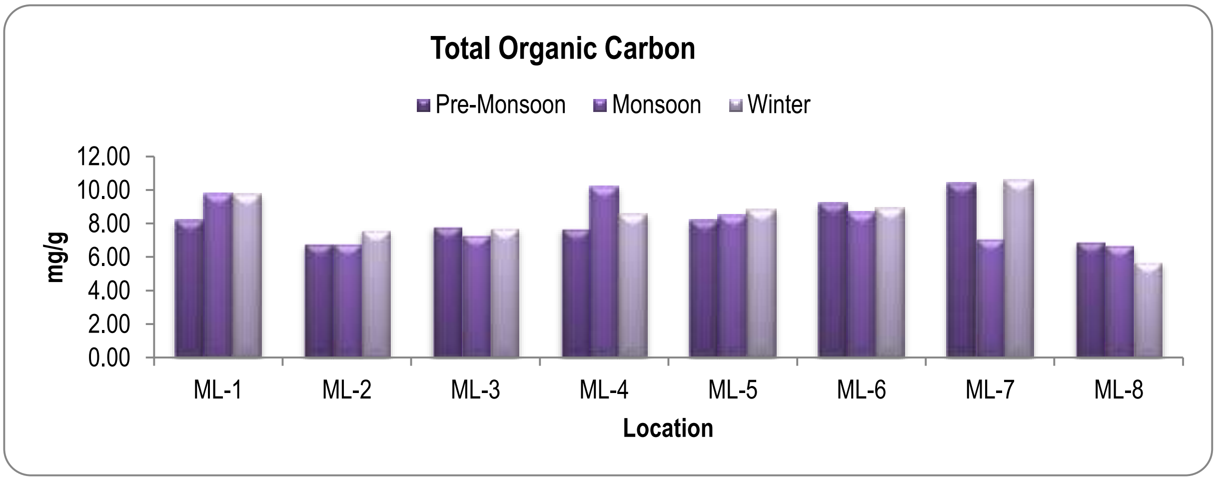


Figure 3-94: Variations in Total Organic Carbon

3.8.2.5 Heavy Metals - Sediment

Cadmium: The Cadmium values for sediment sample ranged from 6.17 µg/g to 10.42 µg/g minimum at ML-4 during Pre-Monsoon season and maximum at ML-8 during Monsoon season.

Copper: The Copper concentration ranged between 21.17 µg/g to 24.98 µg/g minimum at ML-3 and maximum at ML-8 during both during Monsoon season respectively.

Iron: The Iron concentration ranged between 1456.5 µg/g to 3873.1 µg/g minimum at ML-3 during Pre-Monsoon season and maximum at ML-7 during Monsoon season.

Lead: The Lead concentration ranged between 6.04 µg/g to 8.45 µg/g minimum at ML-3 during Pre-Monsoon season an maximum at ML-1 during Monsoon season.

Zinc: The Zinc concentration ranged between 15.9 µg/g to 23.7 µg/g minimum at ML-5 during Monsoon season and maximum at ML-1 during Monsoon season.

Mercury: The Mercury concentration ranged between 0.52 µg/g 0.87 µg/g at ML-2 and ML-6 during Pre-Monsoon season respectively to at ML-8 during Monsoon season.

Nickel: The Nickel concentration ranged between 7.67 µg/g to 13.76 µg/g minimum at ML-4 during Pre-Monsoon season and maximum at ML-1 during Monsoon season.

Manganese: The Manganese concentration ranged between 58.5 µg/g to 72.5 µg/g minimum at ML-5 during Pre-Monsoon season and maximum at ML-8 during Monsoon season.

Chromium: The Chromium concentration ranged between 6.49 µg/g to 8.75 µg/g minimum at ML-3 during Pre-Monsoon season and maximum at ML-8 during Monsoon season.

The details of sediment heavy metals are given in the **Table 3-26** and graphically shown in the **Figure 3-95** to **Figure 3-103**.

Table 3-26: Variations in sediment heavy metals

Parameters	Units		Value
Cadmium	µg/g	Max.	10.42
		Min.	6.17
Copper		Max.	24.98
		Min.	21.17
Iron		Max.	3873.1
		Min.	1456.5
Lead		Max.	8.45
		Min.	6.04
Zinc		Max.	23.7
		Min.	15.9
Mercury		Max.	0.87
		Min.	0.52
Nickel		Max.	13.76
		Min.	7.67
Manganese		Max.	72.5
		Min.	58.5
Chromium		Max.	8.75
		Min.	6.49

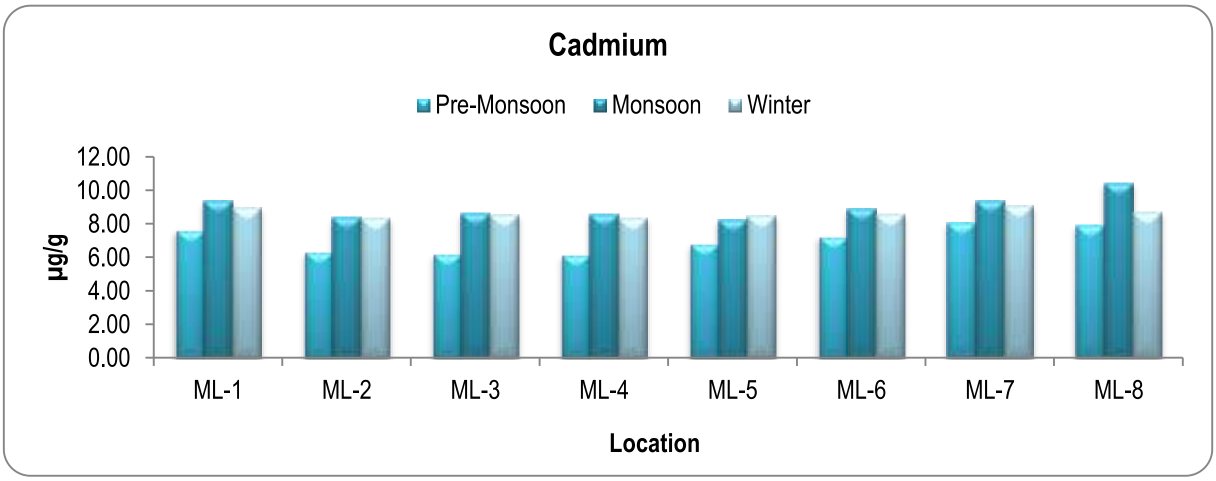


Figure 3-95: Variation of Cadmium Concentration

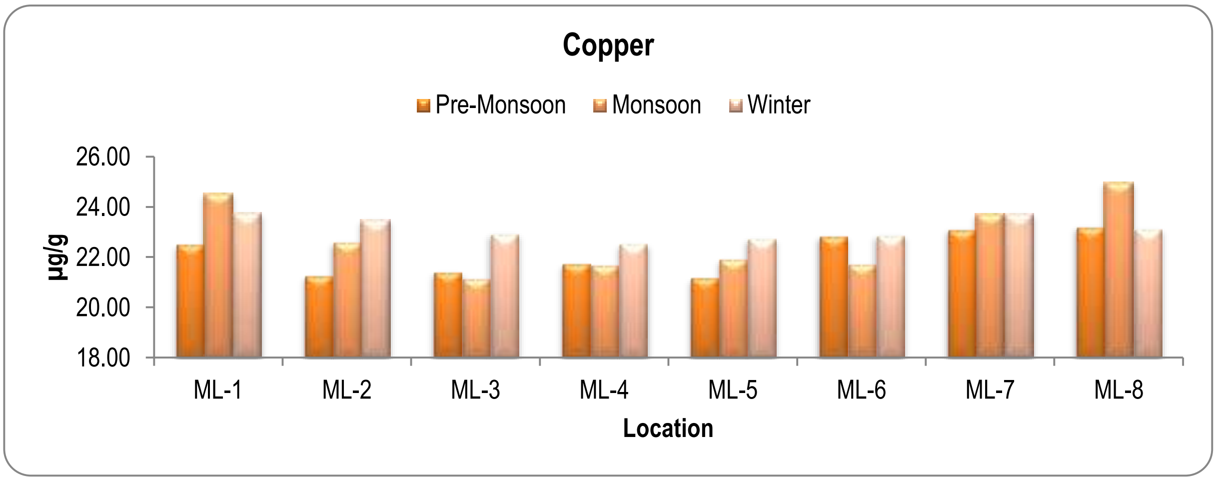


Figure 3-96: Variation of Copper Concentration

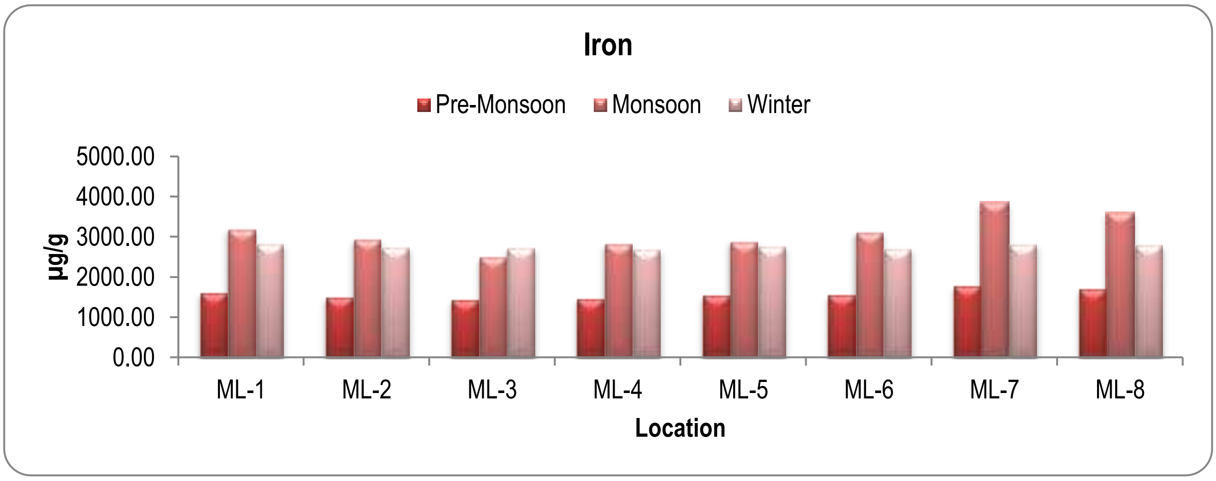


Figure 3-97: Variation of Iron Concentration

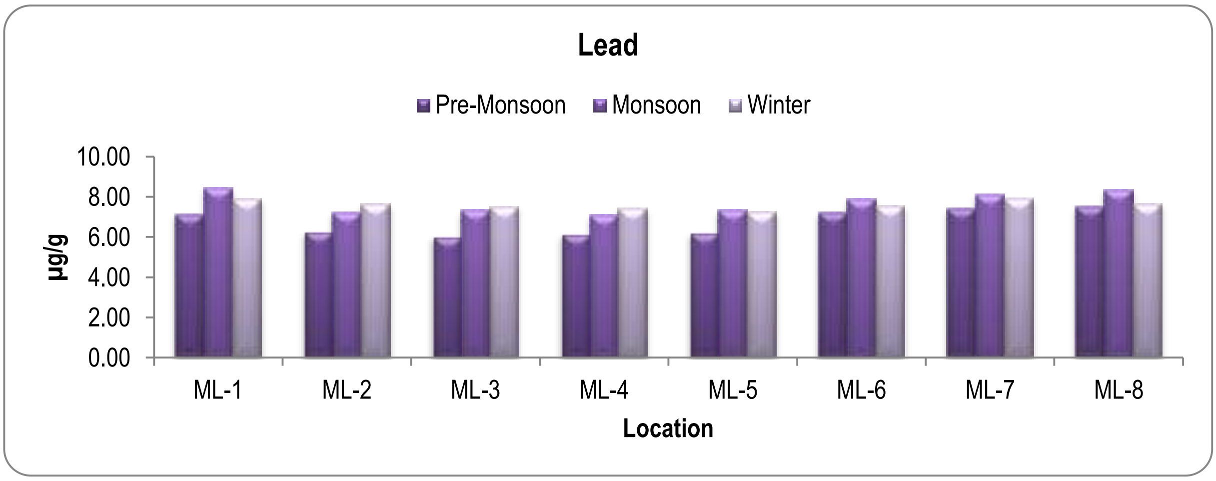


Figure 3-98: Variation of Lead Concentration

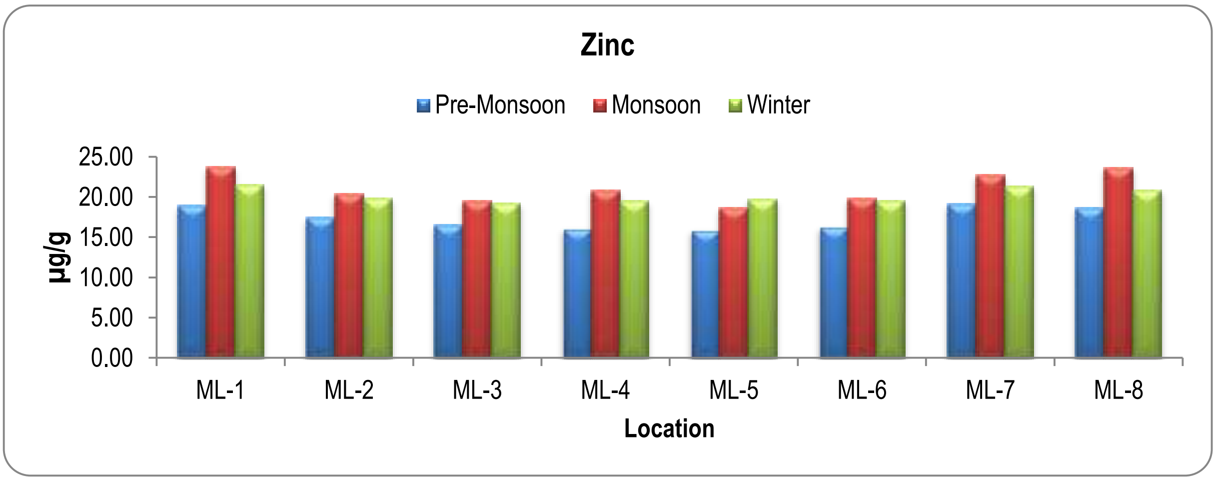


Figure 3-99: Variation of Zinc Concentration

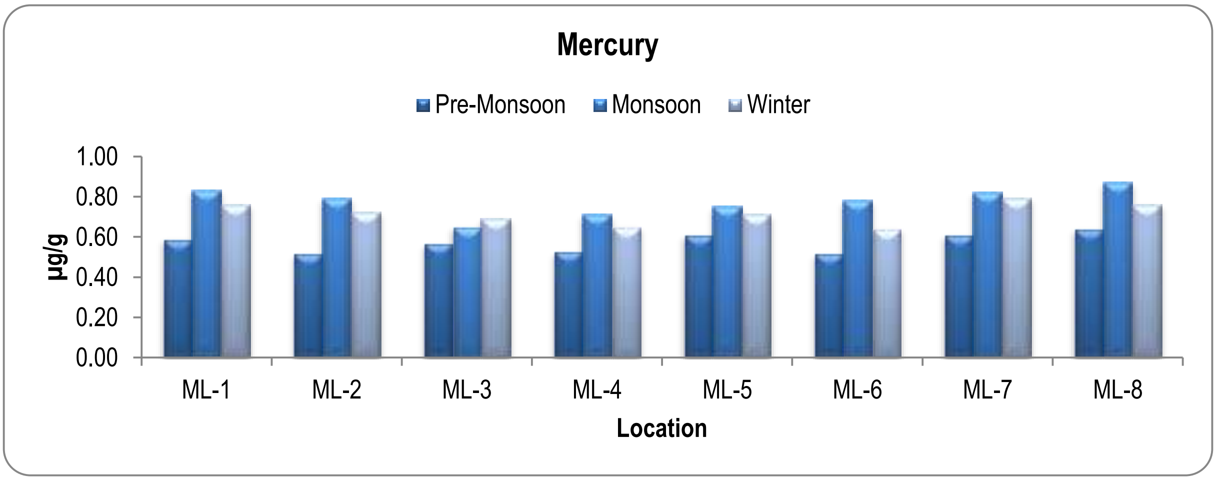


Figure 3-100: Variation of Mercury Concentration

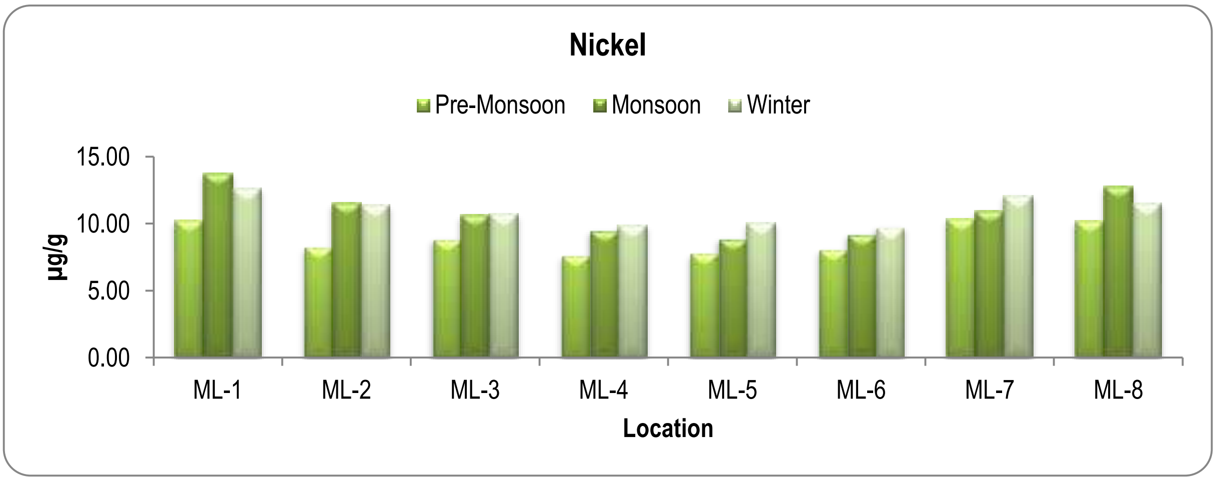


Figure 3-101: Variation of Nickel Concentration

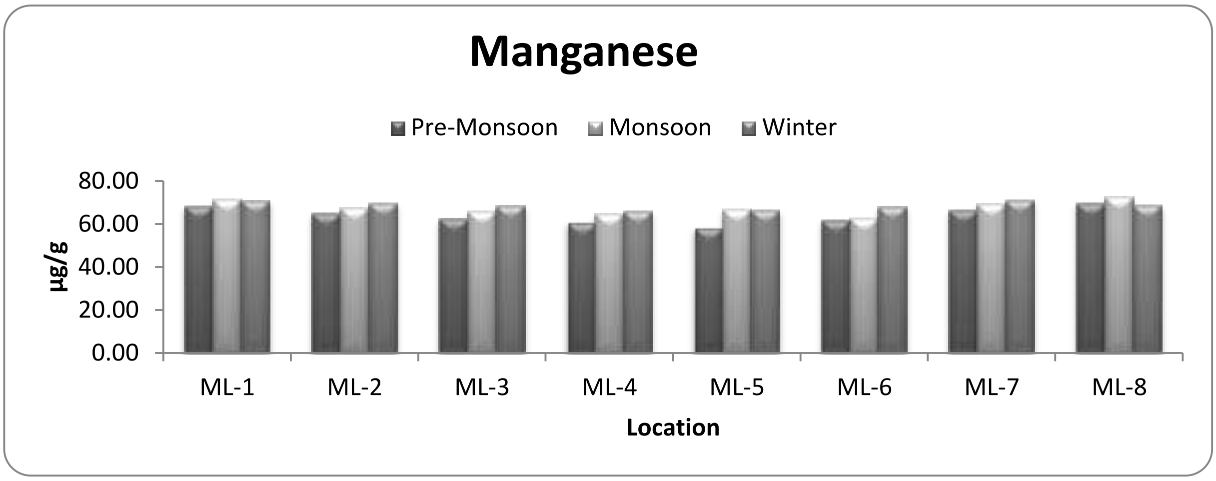


Figure 3-102: Variation of Manganese Concentration

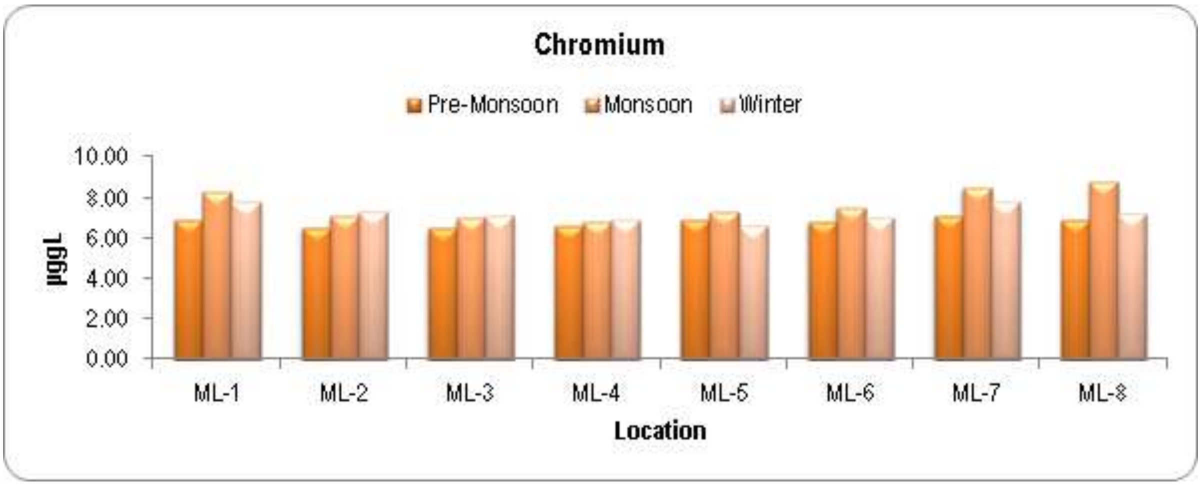


Figure 3-103: Variation of Chromium concentration

3.8.2.6 Productivity

Primary Productivity

The values ranged from 4.683 to 5.849 mgC/m^3hr. The minimum value was recorded at ML-1 during Pre-Monsoon season and maximum value at ML-5 during Winter Season.

Chlorophyll-a

The chlorophyll-a in water sample varied from 0.035 to 1.526 mg/m^3, with minimum value was recorded at ML-8 during Pre-Monsoon season and maximum value at ML-3 during Monsoon season.

Phaeopigment

Phaeopigment ranged between 0.255 mg/m^3 at ML-8 during Pre-Monsoon season and 1.46 mg/m^3 at ML-1 during Winter Season.

Total Biomass

Total Biomass varied between 3.984 ml/100 m^3 at ML-7 during Winter Season and 31.09 ml/100 m^3 at ML-3 during Monsoon season.

Detailed results for the above parameters are given in **Table 3-27** and shown from **Figure 3-104** to **Figure 3-107**.

Table 3-27: Seasonal Variations in Biological Parameters

Parameters	Units		
Primary Productivity (PP)	mg C/m³/hr	Max.	5.849
		Min.	4.683
Chlorophyll-a (Chl a)	mg/m³	Max.	1.526
		Min.	0.035
Phaeopigment		Max.	1.460
		Min.	0.255
Total Biomass	ml/100 m³	Max.	31.090
		Min.	3.984

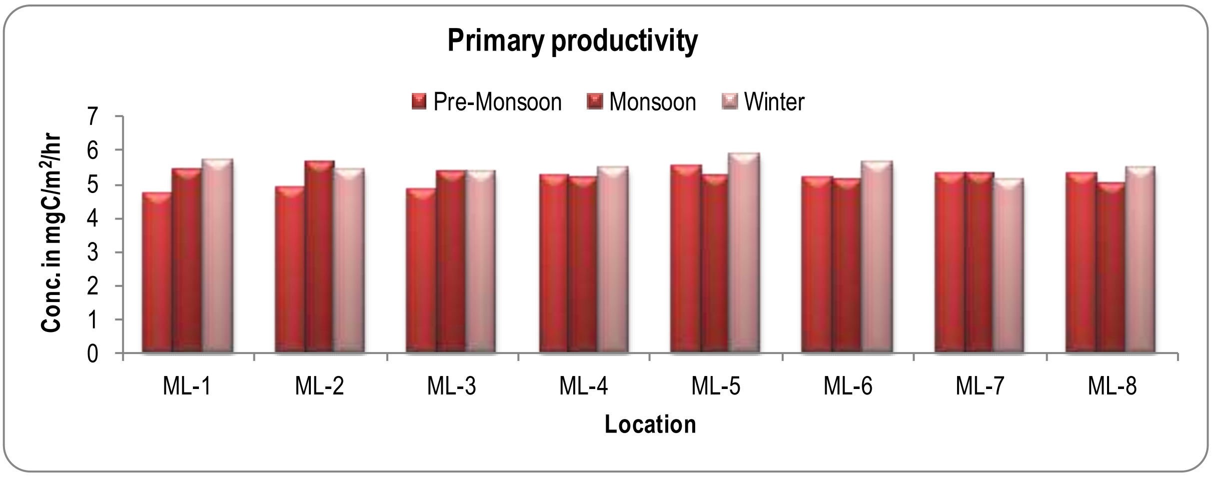


Figure 3-104: Variation in Primary Productivity

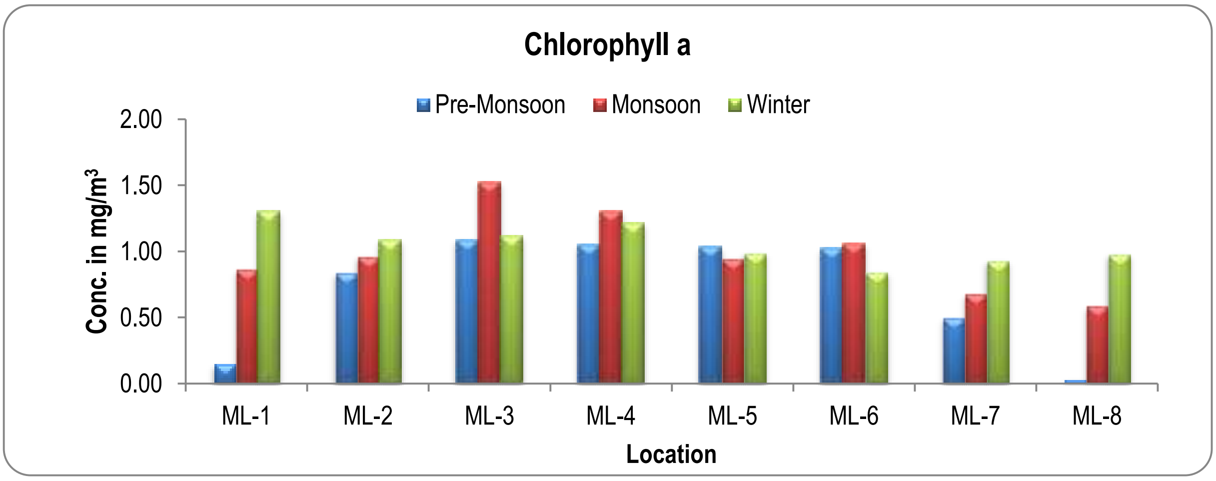


Figure 3-105: Variation in Chlorophyll a

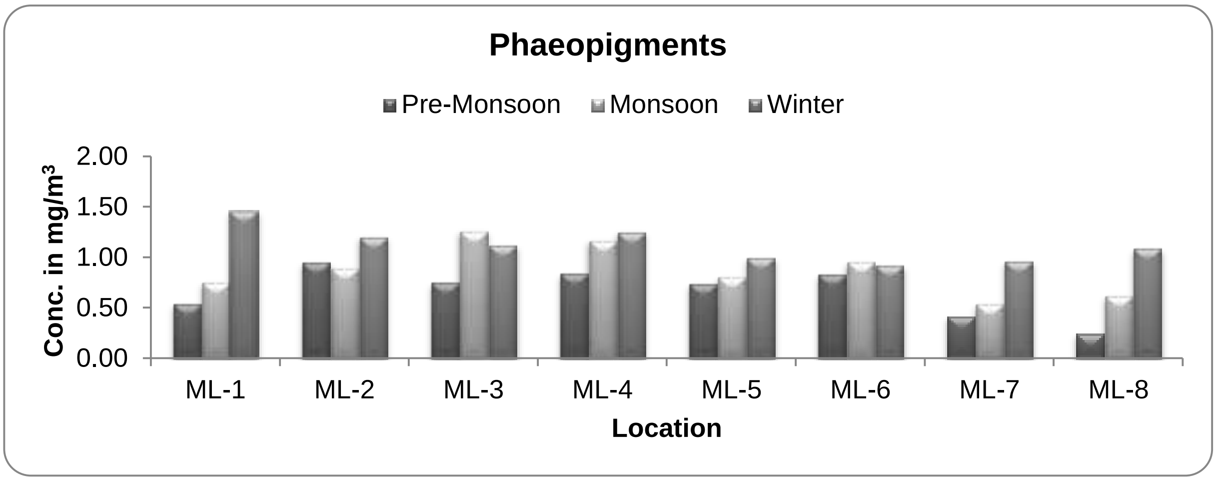


Figure 3-106: Variation in Phaeopigment

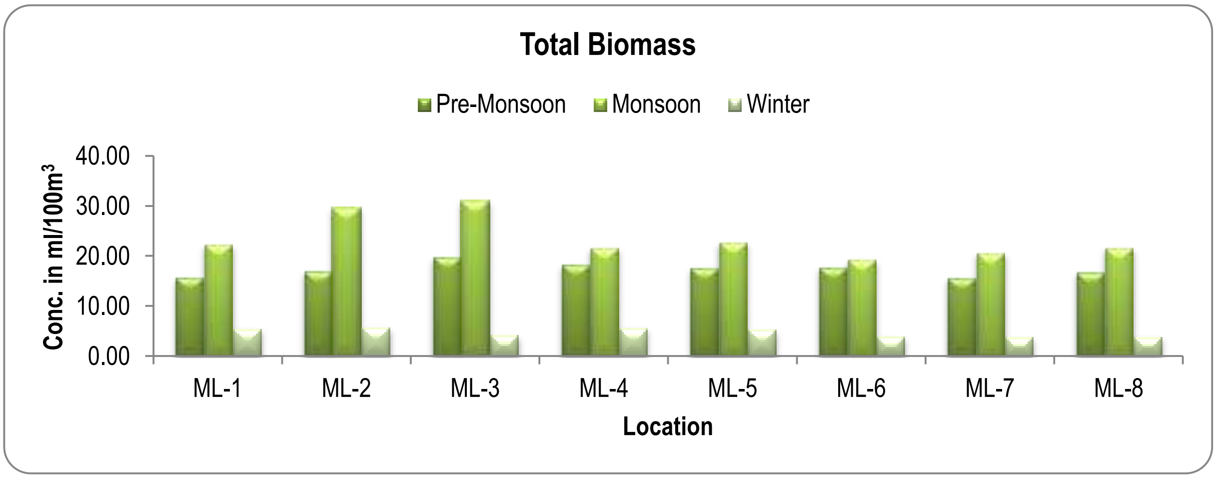


Figure 3-107: Variation in Total Biomass

3.8.2.7 Phytoplankton

Phytoplankton is represented by 3 groups. Out of 86 phytoplankton species, 61 species belongs to Diatoms, 20 sp. belongs to Dinoflagelletes and 5 sp. belongs to Blue-green algae are recorded from sampling locations.

Phytoplankton composition in terms of numbers shows that diatoms (71%) are the most dominant followed by dinoflagelletes (23%) and blue-green algae (6%).

The phytoplankton density varied from 4460 to 11862 Nos/l with minimum at ML-6 during Monsoon season and maximum was at ML-5 during Winter Season.

Maximum diversity of phytoplankton was observed in at ML-8 during Winter Season (57 species). Minimum diversity of zooplankton was recorded in ML-4 during Pre-Monsoon season (18 species).

Among the phytoplankton species *Ditylum brightwellii* was the recorded at only one location and rest of plankton reported at most of the sampling locations.

In terms of numbers Anabaena sp. was the most dominant species while *Ditylum brightwellii* was the submissive species.

The details of phytoplankton species population density are graphically shown in the **Figure 3-108**.

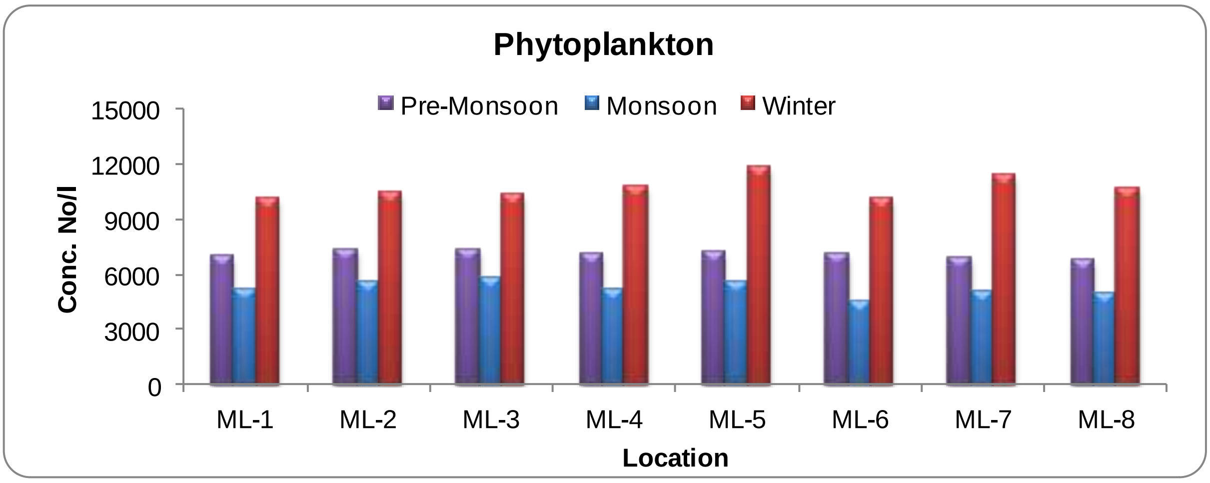


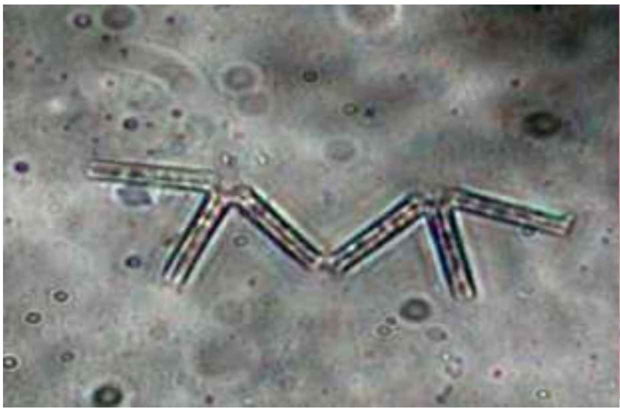
Figure 3-108: Variation in Phytoplankton Density

Phytoplankton Diversity Indices

The phytoplankton species diversity (H') varied from 2.703 to 4.028 minimum at ML-8 during Pre-Monsoon season and maximum at ML-2 during Monsoon season. The species richness (d) ranged between 4.178 and 6.812 minimum at ML-5 during Pre-Monsoon season and maximum at ML-8 during winter season. The species evenness varied from 0.729 to 0.996 minimum at ML-1 during winter season and the maximum at ML-2 during Monsoon season. Representative Phytoplankton recorded during survey are shown in **Exhibit 3-1**

Skeletonema costatum

Eucampia zoodiacus



Thalassionema nitzschioides

Pleurosigma elongatum

Rhizosolenia alata *Odontella mobiliensis*

Exhibit 3-1: Representative Phytoplankton recorded during survey

3.8.2.8 Zooplankton

Zooplankton is represented by 14 groups. Out of 80 Zooplankton species, 24 of them are Calanoida, 12 Spirotrichea species, 10 Cyclopoida and Harpacticoida species each, 5 Larval forms and Protozoans species each, 3 Rotatoria and other form species each, 2 Decapoda and Mollusca species each, Annelida , Cladocera, Coelentrate and Hydroida have 1 specie each are recorded from sampling locations.

Zooplankton composition in terms of numbers shows that Calanoida (30%) are the most dominant followed by Cyclopoida(15%), Harpacticoida (14%), Spirotrichea(13%), Larval forms (7%), Protozoans(6%), Mollusca (4%), other forms (2.7%), Annelida (2%), Rotatoria (1.9%), Coelentrate (1.5%), Decapoda (1.5%), Cladocera (0.7%), and Hydroida (0.7%).

The zooplankton density varied from 4105 to 7794 Nos/m^3 with minimum at ML-8 during Monsoon season and maximum was at ML-5 during Winter Season.

Maximum diversity of zooplankton was observed in at ML-5 during Winter Season (50 species). Minimum diversity of zooplankton was recorded in ML-8 during Monsoon season (21 species).

Among the Zooplankton species *Paracalanus parvus, Doratapsis micropora, Copepod nauplii, Acrocalanus gracilis* and *Nannocalanus minor* was the recorded at least locations and rest of Zooplankton reported at most of the sampling locations.

In terms of numbers *Favella brevis* was the most dominant species while *Doratapsis micropora* was the submissive species.

The details of Zooplankton species population density are graphically shown in the **Figure 3-109**.

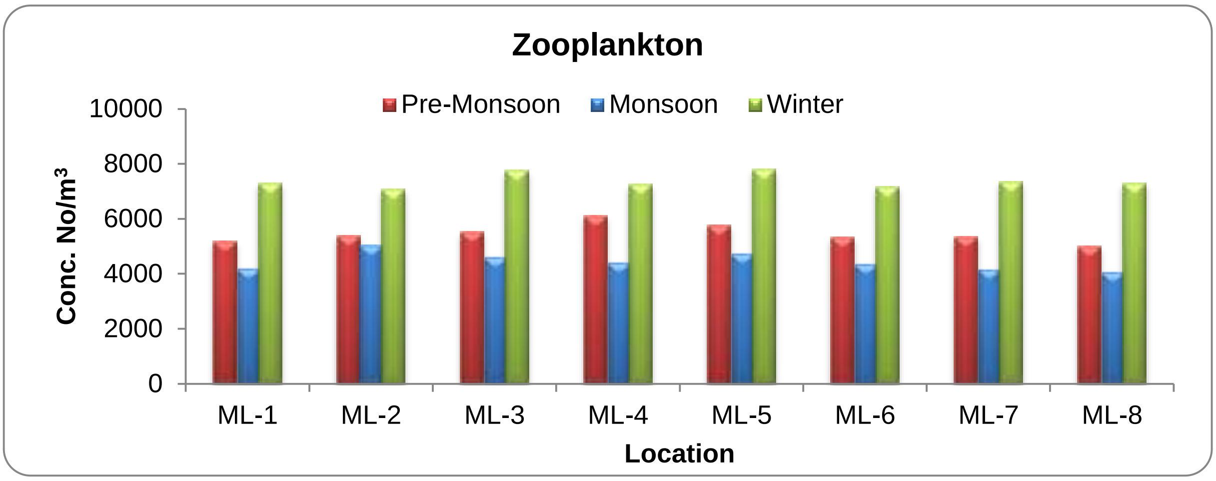


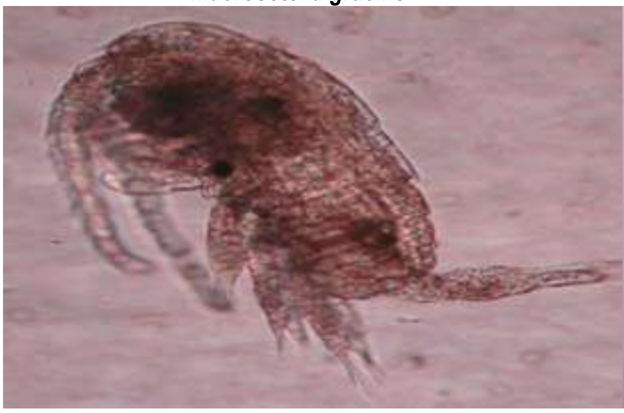
Figure 3-109: Variation in Zooplankton Density

Zooplankton Diversity Indices

The zooplankton species diversity (H') varied from 2.643 to 3.938 minimum at ML-8 during Pre-Monsoon season and maximum at ML-5 during Winter Season. The species richness (d) ranged between 4.392 and 6.933 with minimum at ML-4 and maximum at ML-7 both during Winter Season. The species evenness varied from 0.674 to 0.982 minimum at ML-8 during winter season and maximum at ML-2 during Monsoon season. Representative Zooplankton recorded during survey are shown in **Exhibit 3-2**.

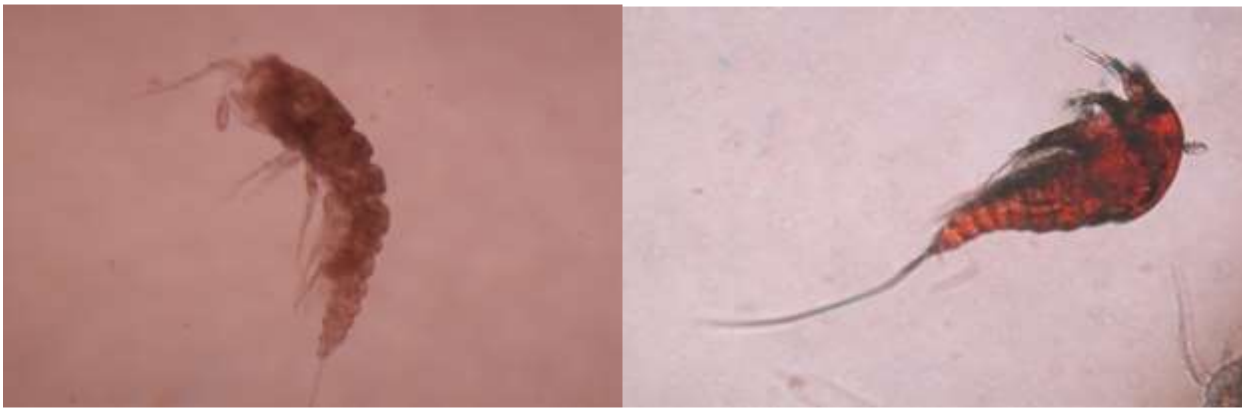
Macrosetella gracilis

Acartia danae



Acrocalanus gibber

Pseudodiaptomus aurivilli



Clytmnestra scutellata ***Metis jousseaumei***

Exhibit 3-2: Representative Zooplankton recorded during survey

3.8.2.9 Macrobenthos

Macrobenthos are represented by five groups. Out of 80 Macrobenthos species, 53 of them are Polychaetes, 10 Bivalves species, 10 Gastropods species, 5 Amphipods species and others have 2 species each.

Macro Benthic composition in terms of numbers shows that polychaetes (59%) are the most dominant followed by Bivalves (17%), Gastropods (10%), Amphipods (9%) and other species (5%).

The macrobenthos density varied from 350 to 950 Nos/m^2 with minimum was at ML-7 during Pre-Monsoon season and maximum at ML-4 during Monsoon season.

Maximum diversity of Macro benthos was observed in ML-2 and ML-5 (reported 27 species each) both during Monsoon season. Minimum diversity was recorded at ML-7 (08 species) during Monsoon season.

Among the macrobenthos species, *Anchistrosyllis sp., Gammarus locusta, Gitanopsis bisponosa* and *Cossura coasta* were found to be present at most of the Locations. *Laonice cirrata, Terebelides stroemi and P.Cirrifera* was recorded at only one location.

In terms of numbers *Cossura coasta* was the most dominant species while *Laonice cirrata, Terebelides stroemi and P.Cirrifera* was the submissive species.

The variation in macrobenthos population is graphically shown in **Figure 3-110**.

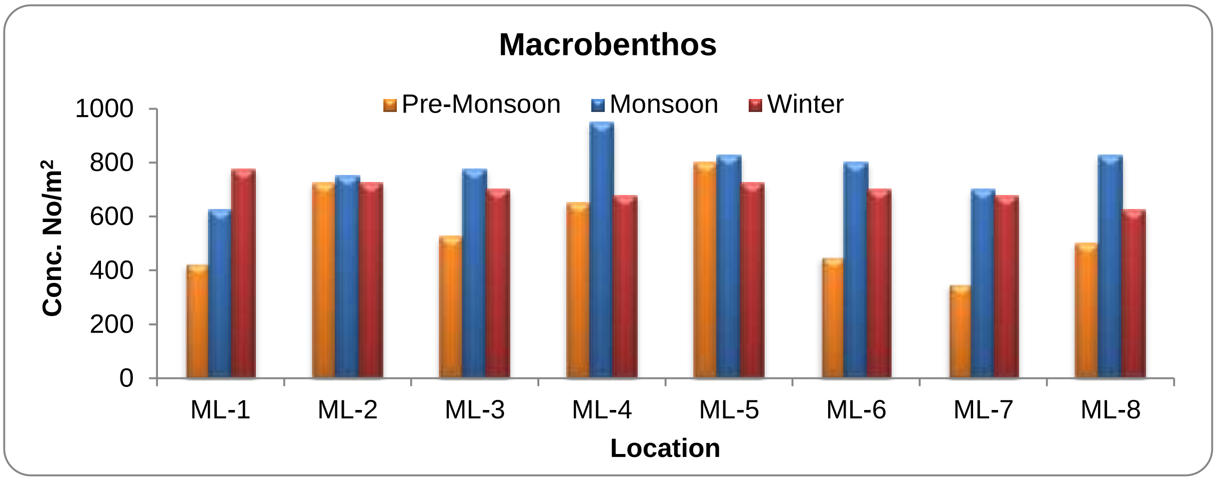
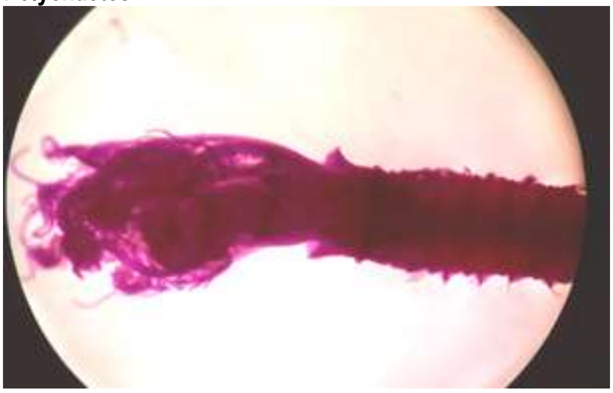


Figure 3-110: Variations in Population Density of Macro benthos

Macro benthos Diversity Indices

The macro-benthic species diversity (H') varied from 1.846 to 3.468 minimum at ML-7 during Pre-Monsoon season with maximum at ML-2 during Monsoon season and the species richness (d) ranged between 1.194 and 6.071 minimum at ML-4 during Pre-Monsoon season and maximum at ML-7 during Winter Season. The species evenness varied from 0.728 to 0.992 minimum at ML-8 during Winter Season and maximum at ML-5 during Pre-Monsoon season. Representative Macrobenthos recorded during sampling are shown in **Exhibit 3-3**.

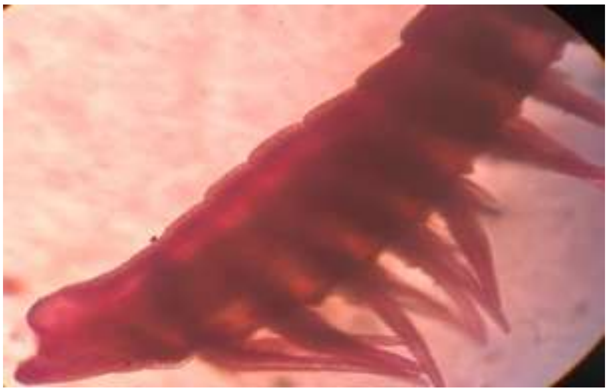
Polychaetes



Megalomma vesiculosum

Armandia intermedia

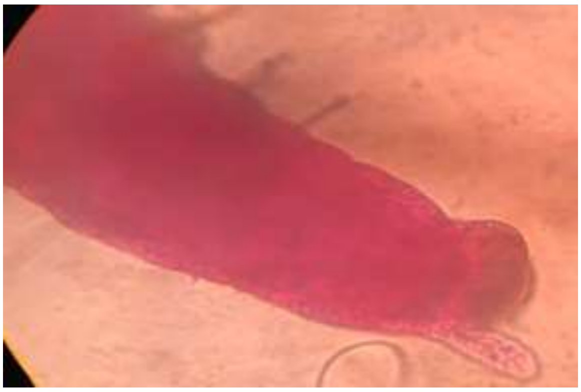
Diopatra Petaloproctus sp.



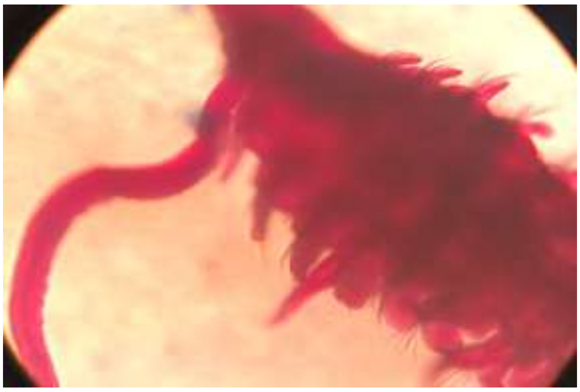
Prionospio sp.

Malacoceros indicus

Orbinid sp.



Pulliella armata



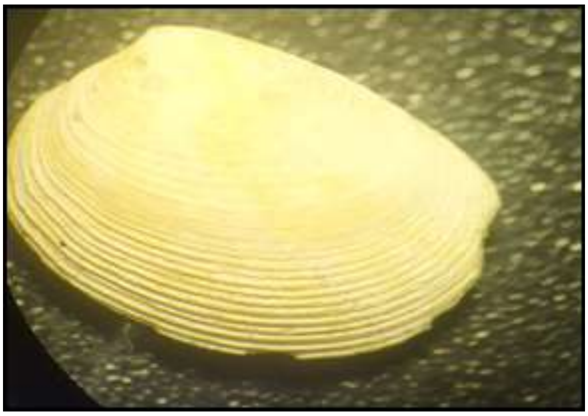
Boccardia proboscidea

Glycera longipinnis

Pygospio sp.

Bivalves

Meretrix casta



Paphia malabarica

Gastropods

Cerithideopsilla conica

Cymatium cingulatum

Lophitoma indica

Duplicaria sp.

Amphipods

Gammarus locusta

Ampithoe ramondi

Exhibit 3-3: Representative Macrobenthos recorded during sampling

3.8.2.10 Meiofauna

Meiofauna are represented by four groups. Out of 75 Meiofauna species, Foraminiferans have 40 species, Nematodes have 17 species, Ostracodes have 12 species and 5 Harpacticoids species are recorded from sampling locations.

Composition of the Meiofauna family, in terms of numbers shows that Foraminiferans (70%) was the most dominant followed by Nematodes (14%), Ostracodes (11%) and Harpacticoids (5%).

Meiofauna density varied from 186 to 254 Nos/m^2 with minimum Density at ML-5 during Monsoon season and the Maximum at ML-1(winter) and ML-5(pre-Monsoon).

Maximum diversity of Meiofauna was observed in ML-2 (34 species) during Winter Season, minimum diversity of meifauna was recorded in ML-3 and ML-5 (24 species) during Monsoon season.

Theristus acer, *Ammonia beccarii*, *Ammonia tepida, Discorbis orbicularis, Desmodora cambelli, Discorbinella bertheloti, Quinqueloculina granulocostata, Pseudononion japonicum Bolivina limbata, Pseudononion japonicum, Quinqueloculina sp., Quadricoma sp., Spirillina limbata, Bairdoppilata scaura, Oxystomina clavicauda* and *Leptastacus mocronyx* was found to be present at most of the locations. *Operculina ammonoides, Elphidium subevolutum, Thurammina cariosa, Pararotalia ozawai Mychostomina revertens, Lagena lacunata and Cylindropsyllus laevis* was recorded at least number of locations.

In terms of numbers *Ammonia becarii* was the most dominant species while *Operculina ammonoides* was the submissive species. Variation in meiofauna population is graphically shown in **Figure 3-111**.

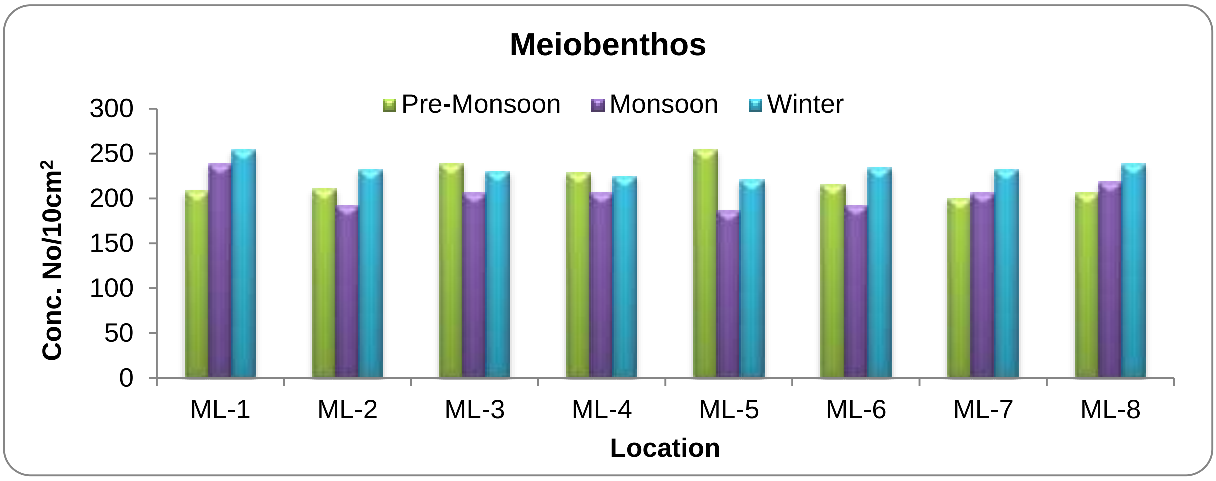


Figure 3-111: Variations in Population Density of Meiofauna

Meio banthos Diversity Indices

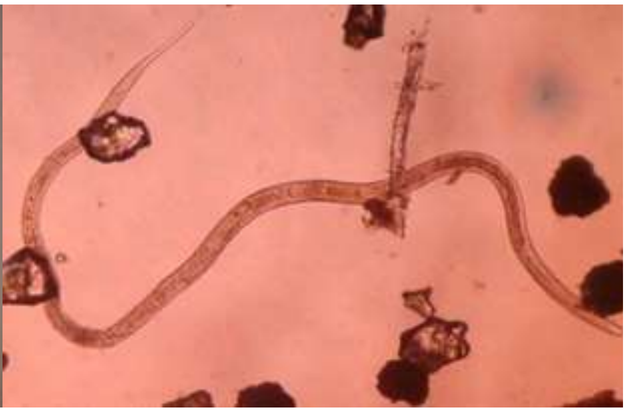
The Meio-benthos species diversity (H') varied from 2.517 to 3.584 with maximum was in ML-5 and minimum in ML-7 both during Pre-Monsoon season and similarly the species richness (d) ranged between 4.242 and 6.635 with maximum in ML-7 and minimum in ML-6 both during Pre-Monsoon season. The species evenness varied from 0.648 to 0.973 with the maximum in ML-1 and minimum in ML-6 both during Monsoon season. Representative Meiobenthos recorded during sampling are shown in **Exhibit 3-4**.

Nematodes

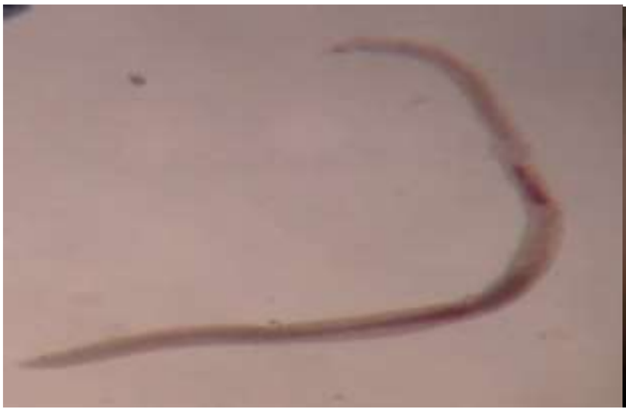
Dracograllus chiloensis

Halalaimus filum

Gonionchus arabica



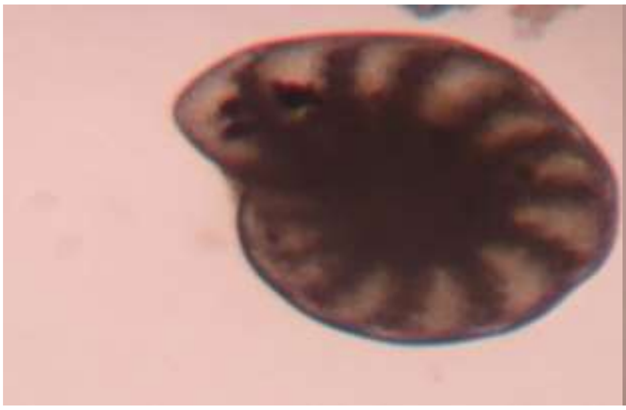
Astomonema jenneri



Oncholaimus sp.

Theristus acer

Foraminiferans



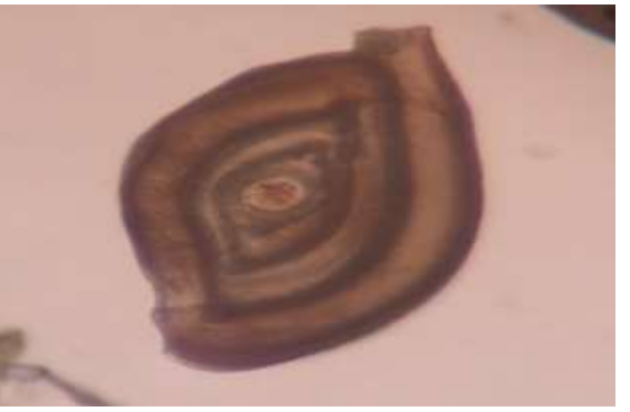
Ammonia aberdoveyensis

Quinqueloculina bicarinata

Nonion depressulus

Lagena semistriata

Rosalina orbicularis



Spiroloculina angulosa

Ostracodes

Paracytherideis sp.

Bairdoppilata scaura

Paijenborchella cymbula

Echinocythereis sp

Bradleya sp.

Basslerites sp.

Harpacticoid copepods

Leptastacus mocronyx

Euterpina acutifrons

Macrosetella gracilis

Cylindropsyllus laevis

Exhibit 3-4: Representative Meiobenthos recorded during sampling

3.8.2.11 Water Microbial Parameters

The indicator and pathogenic bacteria isolated from water samples collected from the marine monitoring locations are described below.

Escherichia Coli (ECLO)

The *E. coli* like organisms ranged from 12 x10^2 to 29 x10^4 CFU/ml with a minimum at ML-4 during Monsoon season and the maximum at ML-1 during Pre-monsoon..

Faecal Coliform (FCLO)

The Faecal Coliform like organism ranged from 28 x10^1 to 27 x10^3 CFU/ml with a minimum at ML-7 during Pre-Monsoon season and the maximum at ML-1 during Winter Season.

Pseudomonas aeurginosa (PALO)

The *Pseudomonas aeurginosa* like organism ranged from 14 x10^2 to 20 x10^4 CFU/ml with a minimum at ML-4 during Winter Season and the maximum at ML-5 during Pre-Monsoon season.

Streptococcus faecalis (SFLO)

The *Streptococcus faecalis* like organisms ranged from 10 x10^2 to 16 x10^4 CFU/ml with a minimum at ML-5 during Winter Season and the maximum at ML-3 during Pre-Monsoon season.

Shigella (SHLO)

The Shigella like organisms ranged from 10 x10^2 to 19 x10^4 CFU/ml with a minimum at ML-6 and the maximum at ML-7 both during winter season respectively.

Salmonella (SLO)

The Salmonella like organisms ranged from 15 $x10^2$ to 19 $x10^4$ CFU/ml with a minimum at ML-7 during monsoon and the maximum at ML-1 both during winter season respectively.

Total Coliform (TC)

The Total coliform in the samples varied from 22 $x10^2$ to 28 $x10^4$ CFU/ml with a minimum at ML-5 during Monsoon season and Winter seasons respectively. Maximumat ML-3 during Monsoon season.

Total Viable Count -Total Heterotrophic Bacteria (TVC)

The Total Viable Count in the samples varied from 28 $x10^3$ to $48x10^4$ CFU/ml with a minimum at ML-8 and the maximum at ML-1 both during Monsoon season respectively.

Vibrio Cholera (VCLO)

The *Vibrio cholera* like organisms was found to fluctuate from 10 $x10^2$ to 23 $x10^3$ CFU/ml with a minimum and the maximum was observed at ML-3 during Pre-monsoon and minimum at ML-3 during monsoon season respectively.

Vibrio Parahaemolyticus (VPLO)

The *Vibrio parahaemolyticus* like organisms found to fluctuate from 80 $x10^1$ to 13 $x10^4$ CFU/ml. minimum was observed at ML-2 and the maximum was recorded at ML-3 during monsoon season respectively.

The Details of the microbial variations in water were shown below in the **Table 3-28**.

Table 3-28: Seasonal Variations in water microbial populations (CFU/ml)

S. No	Microbial Indicator(CFU/ml)	CFU/ml	
		Minimum	Maximum
1.	*Escherichia coli* (ECLO)	$12x10^2$	$29x10^4$
2.	*Faecal Coliform (FCLO)*	$28x10^1$	$29x10^3$
3.	*Pseudomonas aeruginosa (PALO)*	$14x10^2$	$20x10^4$
4.	*Streptococcus faecalis (SFLO)*	$10x10^2$	$16x10^4$
5.	*Shigella (SHLO)*	$15x10^2$	$19x10^4$
6.	*Salmonella (SLO)*	$15x10^2$	$19x10^4$
7.	*Total Coliform (TC)*	$22x10^2$	$28x10^4$
8.	*Total Viable Count (TVC)*	$28x10^3$	$48x10^4$
9.	*Vibrio cholera (VCLO)*	$10x10^2$	$23x10^3$
10.	*Vibrio parahaemolyticus (VPLO)*	$80x10^1$	$13x10^4$

Mangroves: A patchy occurrence of mangrove species, *Avicennia marina* was observed in the surveyed stations.

Coastal vegetation: The survey conducted in the project region revealed the sporadic occurrence of some plants such as Palm tree, Neem tree, Coconut tree, Cashew nut tree, Eucalyptus tree, *Solanum aculeatissimum*, *Prosopis juliflora*, *Borassus flabellifer*, Giant calotrope, *Avicennia marina* and *Phoenix pusilla* are the common type of species found in the study area. Common flora recorded was shown in **Exhibit 3-5**.

Solanum aculeatissimum ***Prosopis juliflora***

Borassus flabellifer **Giant calotrope**

Phoenix pusilla ***Avicennia marina***

Exhibit 3-5: Commonly recorded flora in the study area

Fisheries: *Sillago sihama, Sardinella longiceps, Scatophagus argus, Upeneus sp., Gerres filamentosus and Leiognathus sp.* were the commonly landed fishes using gill nets, purse-seines & bag nets in the nearby landing centre (**Exhibit 3-6**). The crustacean resources like prawns, lobsters & crabs also formed an important commercial catch for the local fishing community.


Sillago sihama


Sardinella longiceps


Scatophagus argus


Upeneus sp.


Gerres filamentosus


Leiognathus sp.

Exhibit 3-6: Commercially Important Fishes

3.8.3 Statistical Analysis

3.8.3.1 Principle Component Analysis for Environmental Parameters

The data on physico-chemical parameters collected in water and sediment samples were subjected to Principle component analysis so as to set a well-defined relation between the environmental parameters against the surveyed stations. The PCA indicated that water parameters such as Depth, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO_2, NO_3, TN, TP, IP, SIO_4, POC, PHC, Cu, TOC, sand and Cr showed significant correlation with the surveyed stations. The stations ML3, ML-4, ML-6 and ML-5 got highly correlated with parameters such as Depth, Temperature, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO_2, NO_3, TN, TP, IP, SIO_4, POC, PHC, Cu, TOC, Silt and Clay during Winter and Pre-Monsoon seasons while the stations ML-2, ML-8, ML-7 and ML-1 significantly correlated with other parameters during monsoon season.

3.8.3.2 Cluster Analysis for Plankton

The abundance data of phytoplankton and zooplankton were amalgamated and subjected to classification and ordination methods. The results revealed that the stations near to the Pulicat lake such as ML-1, ML-2, ML-3 and ML-4 formed a separate cluster based on species composition and abundance and the remaining stations (ML-8, ML-6, ML-5, and ML-7), which were fixed near Ennore creek formed a separate cluster. This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.15) was also found to be low indicating the good ordination pattern of the samples.

3.8.3.3 BIO-ENV (Biota-Environment matching) for Plankton

The BIO-ENV procedure was adopted to measure the agreement between the rank correlations of the biological (Bray-Curtis similarity) and environmental (Euclidean distance) matrices. To achieve this, twelve environmental variables (Primary productivity, Total nitrogen, Nitrite, Nitrate, Dissolved oxygen, Salinity, Chlorophyll ‘a’, Silicate, Inorganic phosphate, Total phosphate, ammonia, pH and Temperature) were allowed to match the plankton data.

In this case, the Primary productivity, Total Nitrogen, Dissolved Oxygen, Silicate, Total phosphate, Total biomass and Chlorophyll ‘a’ were emerged as the major variables explaining the best match (rw= 0.968) with plankton (both phytoplankton and zooplankton) distribution. The other parameters such as Silicate, Inorganic phosphate, Chlorophyll ‘a’, Dissolved Oxygen, Primary productivity, Salinity and Temperature also got manifested in the next best variable combinations in determining the plankton distribution in Ennore creek and Pulicat lake.

3.8.3.4 Cluster Analysis for Benthos

The benthic faunal abundance data (macrofauna and meiofauna) were amalgamated and subjected to classification and ordination methods. The results revealed that the stations near Pulicat (ML-2, ML-1 and ML-3) formed a separate cluster and stations near Ennore creek (ML-4, ML-7, ML-8, ML-6 and ML-5) were forming another cluster based on the species composition and abundance. This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.14) was also found to be low signifying the good ordination pattern of the samples.

3.8.3.5 BIO-ENV (Biota-Environment matching) for Benthos

The BIO-ENV matching was employed to measure the rank correlations of the benthic faunal abundance (Bray-Curtis similarity) and environmental (Euclidean distance) matrices as well. For this, eight environmental variables (Temperature, Salinity, DO, Silt, Sand, Clay, TOC and Soil pH) were allowed to match the biota. The results revealed that, a combination of six environmental parameters ($p\omega$ = 0.973) namely Salinity, Slit, pH, Clay and TOC got manifested as best match in influencing the benthic faunal distribution followed by Silt, Clay, pH, TOC, (pω = 0.948) which also got manifested as second best variable combinations, in determining the faunal distribution in the Ennore creek and Pulicat lake back waters.

3.8.3.6 Observations

The results of the Primary and secondary surveys indicated that the physico-chemical and biological parameters did not vary much except a few parameters which showed only marginal variations. The surface water temperature, salinity, pH, TSS and turbidity were within the permissible level as suggested by Dept. of Oceanography, SOEST, Hawaii (2012). The variation noticed between the stations was only marginal and it might be due to seasonal changes, geographical location and sampling time. The range of ecologically sensitive chemical parameters such as Oxygen, BOD, nutrients was also at the optimal concentration corresponding to the seasonal variation as suggested by Khadanga (2012). The sand, silt and clay fraction at each of the stations along with their textural classification indicated that the sand and silt percentage was higher during this survey. The microbial population showed general trend in water and sediment samples during this survey with maximum colony count in sediment samples compared to the water samples.

With regard to biological entities, the phytoplankton species predominantly belonging to three groups namely diatoms, dinoflagellates and blue-green algae and seven groups of macro zooplankton namely, *Calanoid copepod*, *Cyclopoid copepod*, *Harpacticoid copepod*, Spirotricha, Protozoans, Other Crustacean forms, Rotatoria and five groups of micro zooplankton namely, Mollusca, Larvacean, Hydroida, Coelentrate and Annelida were recorded from the surveyed stations.

Among the macro benthic organisms, five taxa were recorded and among these polychaetes topped the list followed by bivalves and other groups. Meio-benthic organisms belonging to four groups were recorded and it was dominated by foraminiferans followed by nematodes, ostracodes and harpacticoids.

More importantly, the project site is not falling in the ecologically sensitive areas like Biosphere Reserves, National Parks, Wildlife Sanctuaries and other protected areas (PA). However, Ecological sensitive area and marine protected area in Pulicat Lake are located away from the project site. The primary data collected during comprehensive survey period as well the secondary data collected did not reflect the existence of any critical flora and fauna in the study area.

The careful perusal of the available information suggests that the water quality parameters are within the safe level and did not indicate any alarming impact on the existing biological components. Further, the results of physico-chemical and biological parameters indicate that the water is well oxygenated and nutrients are adequate supporting fairly good plankton population, the base in the food chain. The other biological parameters like benthos and fisheries are also appeared to be at the normal level.

3.9 Biodiversity of Marine, Brackish Water and Fresh Water Ecosystems

MoEF&CC ToR recommendation suggested study the following

- ***To prepare a detailed biodiversity impact assessment report and management plan through the NIO or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. The report shall study the impact on the***

rivers, estuary and the sea and include the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, subtidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standard survey methods

- ***Biodiversity of the area, viz., estuary and coastal region, should be studied.***
- ***Measures for protection of general ecosystem of Kosattalaiyar estuary including mangroves.***
- ***Study the impact of dredging and dumping on marine ecology and draw up a management plan through the NIO or any other institute specializing in marine ecology***

In line with above ToR requirement, Marine Biodiversity Assessment study was conducted by Suganthi Devadason Marine Research Institute (SDMRI) (Recognized by Manonmaniam Sundaranar University and U.G.C. & Recognized Scientific and Industrial Research Organization by the DSIR, GOI), Tuticorin, Tamil Nadu during November, 2019- January, 2020.

3.9.1 Methodology

Study Locations

- Underwater Assessment: 92 locations within 10 km radius in Bay of Bengal (marine zone)
- Marine Water: 86 Locations within 10 km radius towards marine zone
- Marine Sediment: 86 Locations within 10 km radius towards marine zone
- Benthic Assemblages: within 10 km radius towards marine zone
- Fishery and Fish landing: within 10 km radius towards marine zone & landing site

Study Locations (including the river mouths)

- Water & Sediment: 13 Locations in Kosasthalaiyar River within 10 km radius
- Water & sediment: 12 Locations in Buckingham canal within 10 km radius
- Water & sediment: 11 Locations in Kosasthalaiyar River Mouths, outside 10 km radius (6 near Pulicat lake & 5 near Ennore)
- Mangroves: 11 Locations are fixed
- Others: Within 10 km radius

Underwater biodiversity assessment, Biological parameters assessment locations for marine zone and brackish & fresh water zones and Biological parameters assessment locations along the coastal area between Ennore creek and Pulicat lake in the 10 km radius of the Kattupalli study area were shown from **Figure 3-112** to **Figure 3-114**.

Standard methods were employed for Marine zone underwater assessment. All sites were marked with GPS and all underwater monitoring was executed involving SCUBA diving upto 30 m and the grids with more than 30 m depth were assessed by using remotely operated vehicle (ROV). Fish community was estimated separately in sandy and clay sea floors using belt transect method (50 X 5 m) by following English et al. (1997). Diversity community indices was performed to measure ecosystem health (Pillans *et al.,* 2007).

Standard methods were employed for Mangrove habitat assessment. Prepared mangrove cover mapping with the help of recent imageries (Horvart, 2013; Dowling & Stephens, 2001) for the study area. Line transect plot method (English *et al.,* 1994) was used to assess mangroves quantitatively. Along transects across vegetation types, 5m x 5m plots were examined. In each plot mangroves were identified to species level and counted (Wagner *et* *al.,* 2004). Benthic epi-macrofaunas were assessed by placing a quadrat (1 x 1 m) in 3 random locations at each site on the substratum and counting fauna by species. Mangrove associated fish were identified through visual observation along the mangrove habitat area. Transect survey was done to record and photo document the avifauna (SNH, 2005) at the study site.

Random survey was conducted, inorder to identify the plant species available in the coastal vegetation (Gillison and Brewer, 1985). The meiobenthic sediment samples were collected (Platt and Warwick, 1983). The core samples were collected and using standard identification keys (Day 1967; Gosner, 1971).

Diversity community indices was performed to measure ecosystem health (Pillans *et al.,* 2007). Phytoplankton identification up to species level was done by following morphological identification keys (Tomas 1997, Sahu 2013) and identification guide by University of California, Santa Cruz. The chlorophyll a and b concentration Primary productivity estimations by Strictland and Parsons, 1972 method. Zooplankton analysis and biomass was calculated by Varghese 2015 method.

Microbial community estimation from surface water and sediment samples were done by employing standard methods.

Transect survey was done to record and photo document the avifauna (SNH, 2005) at the study site. Fish landing data was collected by following the method of Srinath *et al.,* (2005)

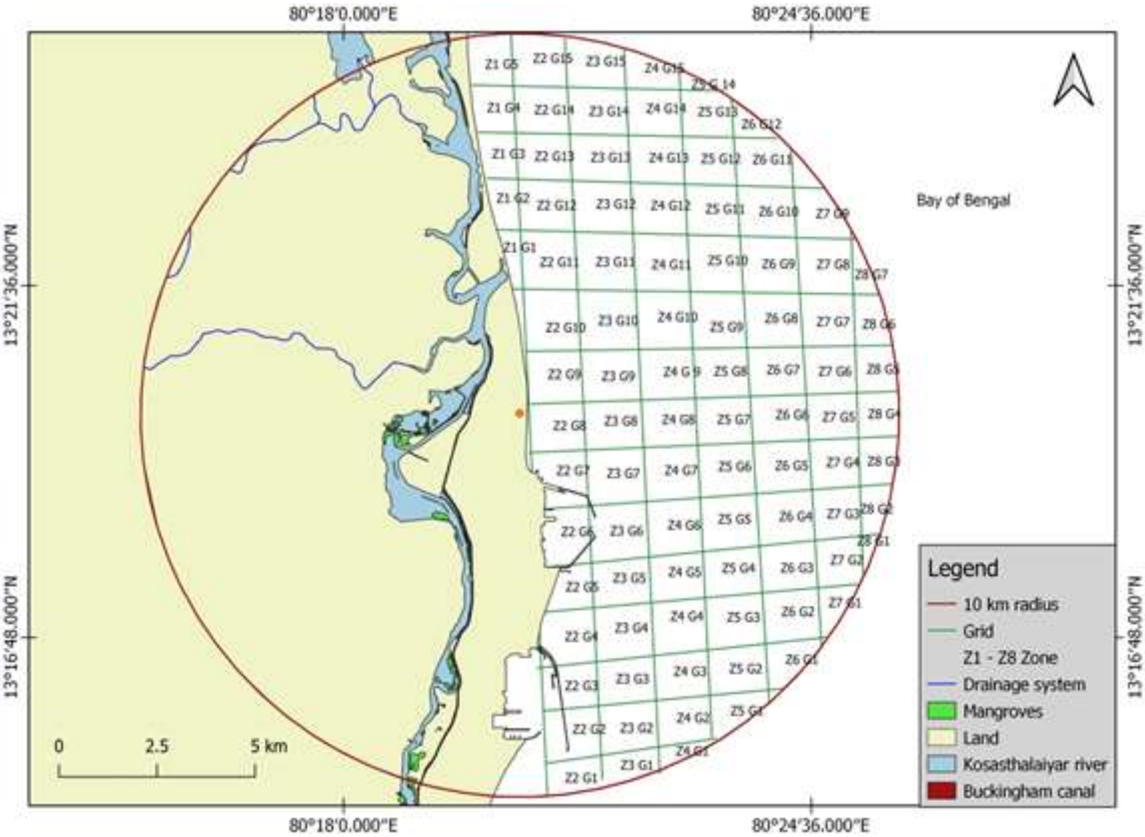


Figure 3-112: Map showing the underwater assessment locations in the 10 km radius of the Kattupalli study area

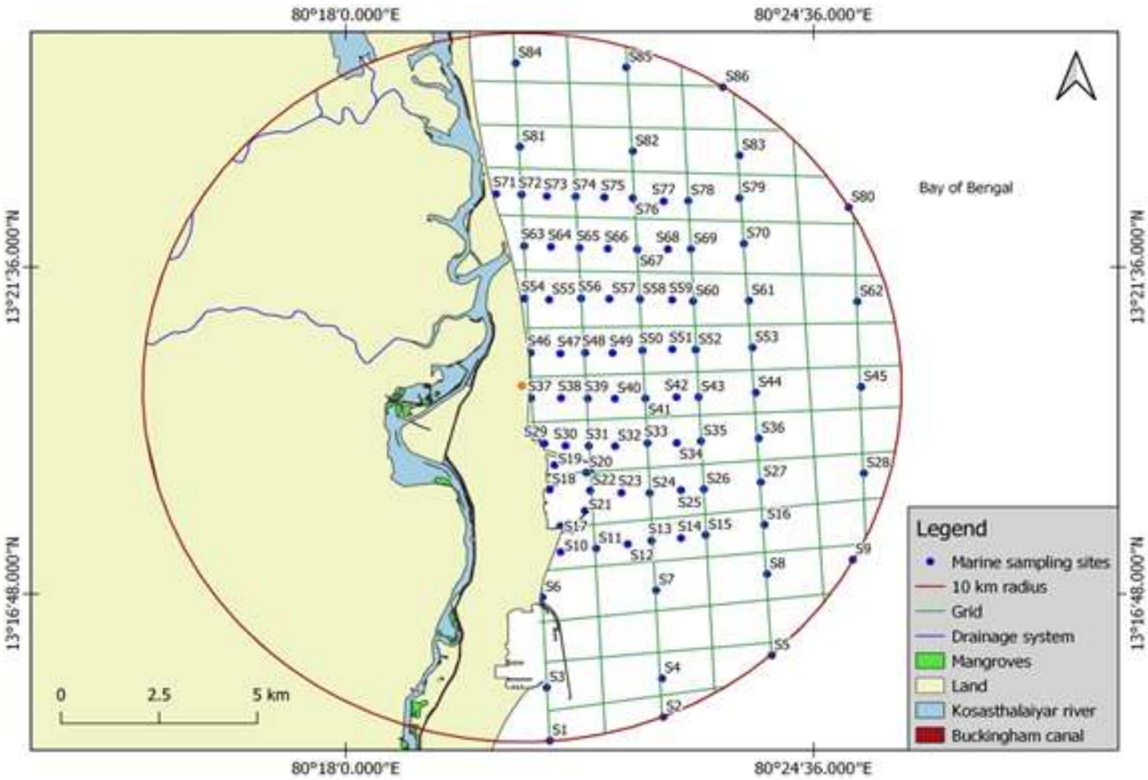


Figure 3-113: Map showing the biological parameters assessment locations in the 10 km radius of Bay of Bengal region of the Kattupalli study area

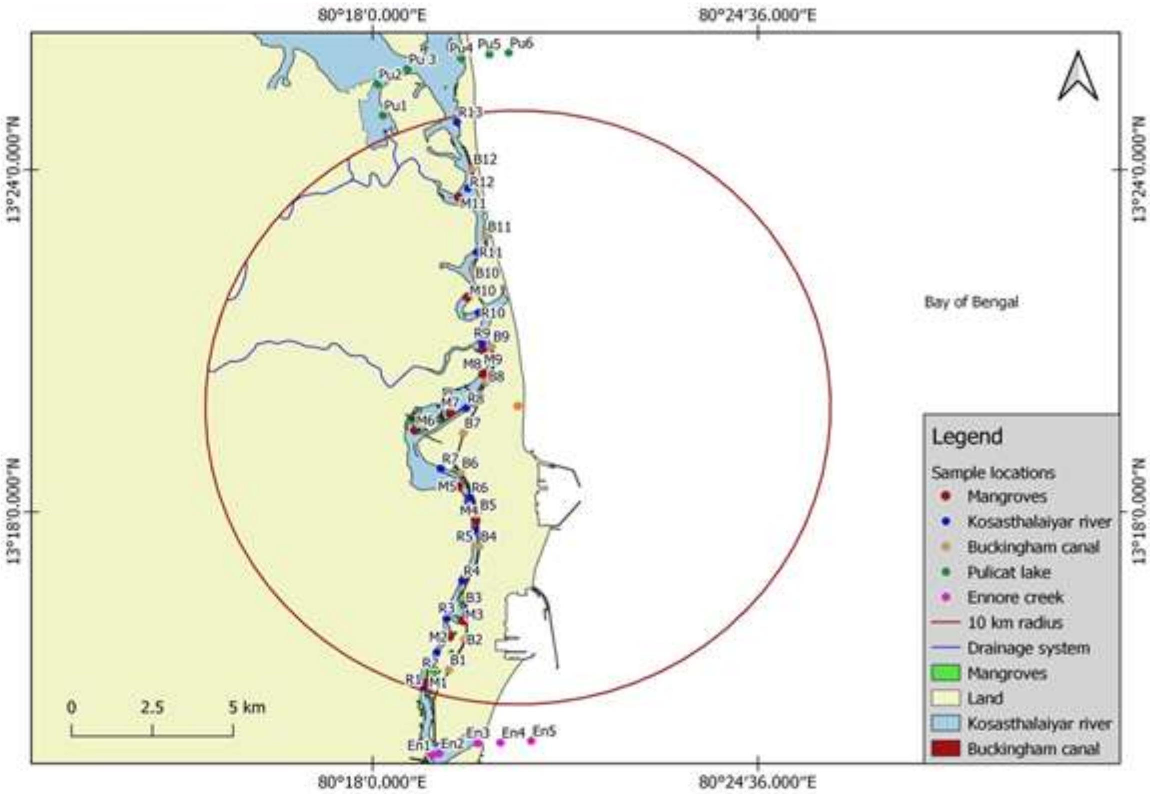


Figure 3-114: Map showing the biological parameters assessment locations along the coastal area between Ennore creek and Pulicat lake

3.9.2 Results

3.9.2.1 Marine zone underwater assessment - Macro faunal community structure

Molluscan diversity with fair distribution comprising of 38 species were observed. Species richness was varied from 21 to 38 among the zones. *Babylonia zeylanica*, *Babylonia spirata*, *Cerithium columna* and *Ficus gracilis* were the most sighted species accounted during the survey. Mean density was 8.80±0.50 (no/5 m^2), it was ranged between 4.00±0.14 and 13.20±0.34 (no/5 m^2) among the stations. The Shannon diversity index value was ranged from 2.9 to 3.6, whereas evenness exhibited lesser variation their values between 0.91 and 0.99.

Very low population of Marine sponges has been reported. Only 10 species were observed, of theses, *Clathria microciona*, *Echinodyctium* sp. and *Chalinula* sp. were the common species. The species richness varied among the zones it was ranged between 2 and 10. Zone 4 had the highest species richness with 10 followed by Zone 3 with 9 no. Diversity index value had ranged between 0.69 and 2.12, while evenness value exhibited that between 0.90 and 1.0 in the study area. Mean density was 1.80±0.58 (no/5 m^2), highest density was in Zone 4 with 4.40±1.24 (no/5 m^2) and lowest had found at Zone 2 with 0.40±0.34 (no/5 m^2) respectively.

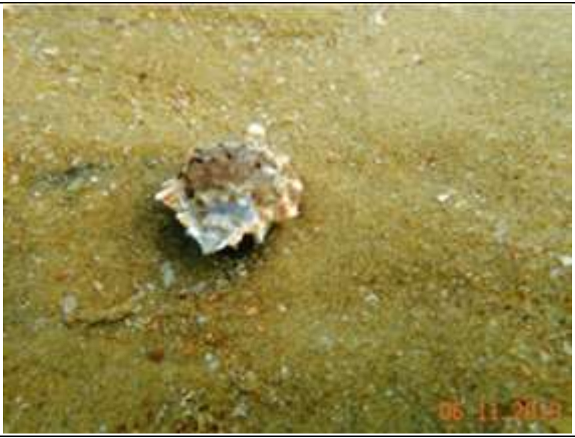
Sparse occurrence of soft coral communities had found in the study area. Only 5 species were observed, of theses, *Carijoa* sp., *Virgularia* sp. and *Cavernulina* sp. were the common species. The species richness varied among the zones it was ranged between 1 and 4. Zone 4 had the highest species richness with 5 followed by Zone 3 and 4 with4 no. Diversity index value had ranged between 0.69 and 2.12, while evenness value exhibited that between 0.90 and 1.0 in the study area. Mean density was 0.88±0.26 (no/5 m^2), highest density was in Zone 4 with 1.8±0.58 (no/5 m^2) and lowest had found at Zone 7 and 8 with 0.2±0.20 (no/5 m^2) respectively.

Relatively poor occurrence of other fauna was observed in the marine zone. Totally 9 species were recorded, among them *Astropecten indicus* was the dominant species. Sand dollars comprised three species which were *Clypeaster* sp., *Clypeaster* sp1. and *Echinodiscus auritus*. Two species from sea urchin includes *Salmacis bicolor* and *Salmacis* sp., two species from star fish which are *Astropecten indicus* and *Astropecten* sp. Anemone species are *Paracondylactis sinensis* and *Paracondylactis* sp. was recorded during the assessment. Sea snakes were also observed during the survey.

3.9.2.2 Marine zone underwater assessment - Fish community structure

Fish communities in terms of diversity and abundance were comparatively low. 50 fish species were recorded in the study area. Species richness varied from 12 to 50, while total fish individuals counted between 69 and 542. In fish density, significantly varied among the zones it was varied between 13.18 (no/250 m^2) and 38.71 (no/250 m^2) Details are given in the. *Rastrelliger kanagurta*, *Rhabdosargus sarba*, *Sphyraena jello*, *Alepes melanoptera* and *Selaroides leptolepis* were the most abundant fishes in the study area. Reef fishes are poorly occurs in the marine zone.

Underwater assessment carried in the study area revealed that the seascape is dominated by sandy and clayey bottom. Because of the bottom topography and prevailing strong currents, benthic communities were very less in amount. Dynamic and ecologically sensitive marine habitats such as coral reefs and seagrasses were not observed in any of the assessed grids. Because of the absence of critical habitats, density and diversity of fish and other biodiversity were comparatively low. Mollusc species and Other faunal community recorded in Marine zone are shown from **Exhibit 3-7** to **Exhibit 3-13**.

	
Bufonaria albovaricosa	*Ficus variegata*
	
Oliva vidua	*Sunetta donacina*
	
Turritella acutangula	*Glyphepithema alapapilionis*

Calliostoma tranquebaricum

Conus sp.

Cardites bicolor

Chicoreus virgineus

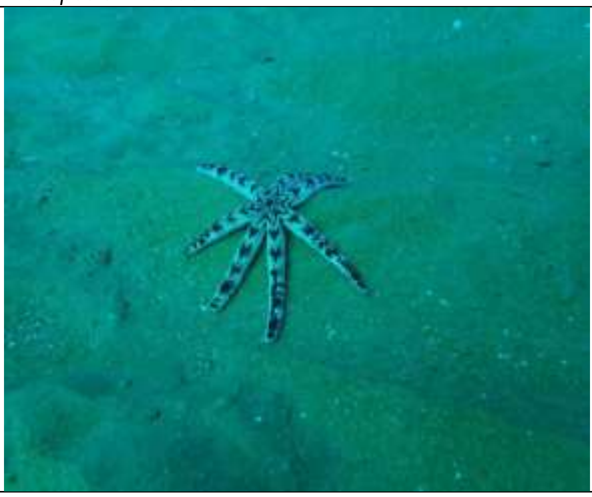
Sunetta donacina

Turbinella pyrum

Chicoreus virgineus	*Neverita didyma*
	
Chicoreus virgineus	*Meretrix casta*
	
Babylonia zeylanica	*Goniobranchus trimarginatus*
	
Phalium areola	*Murex carbonnieri*

	
Armina sp.	*Chelidonura hirundinina*

Exhibit 3-7: Mollusc species recorded in Marine zone

	
Luidia hardwicki	*Astropecten indicus*
	
Luidia maculate	*Luidia maculata*

	
Astropecten indicus	*Luidia maculata var. ceylonica*

Exhibit 3-8: Other faunal community recorded in Marine zone –Echinoderms

Exhibit 3-9: Other faunal community recorded in Marine zone –Sea anemone

Cavernularia sp.

Cavernularia sp

Retracted Cavernularia sp.

Virgularia sp 1.

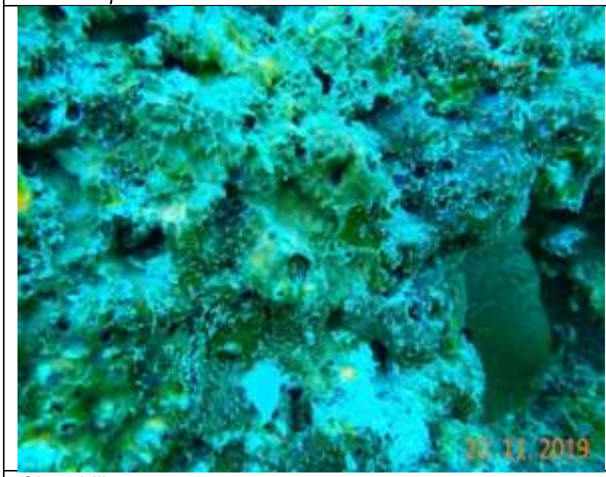
Virgularia sp 2.

Virgularia sp 3.

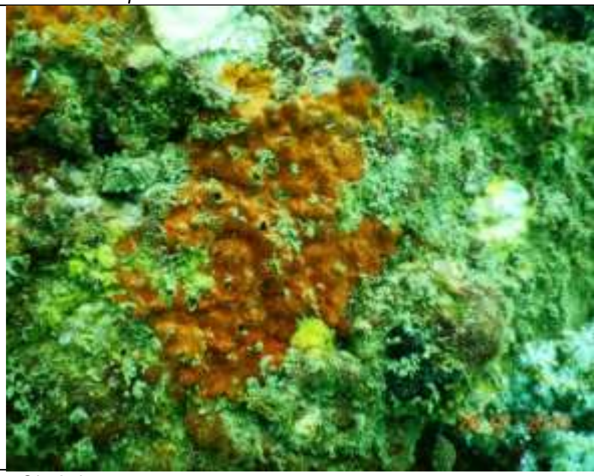
Exhibit 3-10: Other faunal community recorded in Marine zone – Soft coral community

Clathria sp.

Chondrilla sp.

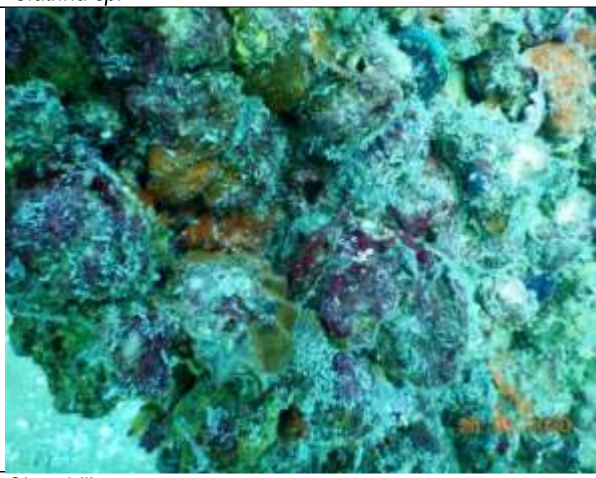


Chondrilla sp.



Clathria sp.

Chalinula sp.



Chondrilla sp.

Exhibit 3-11: Other faunal community recorded in Marine zone – Sponge community

Selaroides sp.

Epinephelus malabaricus

Rastrelliger kanagurta

Lutjanus sp. and Caranx sp.

Scomberoides sp.

Lutjanus sp.

Trichonotus sp.

Sphyraena jello and Caranx sp.

Rhabdosargus sarba

Scarus ghobban

Rastrelliger kanagurta

Sphyraena jello

Exhibit 3-12: Other faunal community recorded in Marine zone – Fish community

Exhibit 3-13: Other faunal community recorded in Marine zone - Sea Snake

In the study area, aquatic mammals were sighted seldom as dolphins were the only aquatic mammal sighted within the study area whereas aquatic birds were sighted abundantly. In the study area opposite to the Koraikuppam at about 5 km from the shore, few individuals of dolphins were sighted. Being mammals, dolphins have to come to surface for breathing and thus were sighted from the boat. However, none of the mammals were sighted during the underwater assessment.

3.9.2.3 Mangrove habitat assessment

Mostly mangroves are observed as small and large patches, totally thirteen large patches were observed in the study area, which are seen in the mudflat on the river banks and few inside the Kosasthalaiyar river. Well grown healthy mangrove vegetation is seen in most of the patches, whereas stunted and degraded mangroves are also seen in few patches particularly were flushing of water is absent. Three species of mangroves are observed in the study area. *Avicennia marina*, *Avicennia* sp. and *Rhizophora mucronata* belonging to two family Avicenniaceae and Rhizophoraceae. The study area is dominated by *Avicennia marina*, whereas *Avicennia* sp. and *Rhizophora mucronata* are very fewer in number and limited to the northern side of the study area near Pulicat.

The mangrove vegetation density in the study area varied between 1.3 and 11.3 plants per 5 square meters. For *Avicennia marina*, it varied between 4.6 and 11.3 plants per 5 square meters, for *Avincennia* sp. it varied between 1.3 and 9.3 plants per 5 square meters. *Rhizophora mucronata*, it varied between 1 and 2 plants per 5 square meters. High density of mangroves are recorded at M8 and M9 followed by M4, while low density was recorded at M10 and M11. It is observed that huge patch exhibits less density, while small patch along the river banks exhibits higher density. The less mangrove density observed at M 10 and M 11 is due to the plantation of mangrove at these sites.

The mangrove tree stem circumference ranged between 4 and 69 cm in the study area. For *Avicennia marina*, it ranged between 4 and 52 cm, for *Avicennia* sp., it varied between 27 and 69 cm and for *Rhizophora mucronata*, it varied between 10 and 20 cm. Both *Avincennia marina* and *Avincennia* sp. exhibits larger circumference than the *Rhizophora mucronata* and the stem thickness of *Avicennia* sp. is higher than other species of mangroves in the study site.

A large range of variation was observed among the seed and sapling abundance in the study area. *Avicennia marina* and *Avicennia* sp. are dominant than the *Rhizophora mucronata.* The length and width of *Rhizopora mucronata* leaves is larger than *Avicennia marina* and *Avicennia sp.*

As far as the mangrove height canopy is concerned, the height of different species of mangroves in the study area ranged from 0.8 to 5 m for *Avicennia marina*, 2.6 to 5.2 m for *Avicennia* sp. and 3 to 3.3 m for *Rhizophora mucronata*.

Number of mangrove species at different sites in the study area are given in **Figure 3-115**.

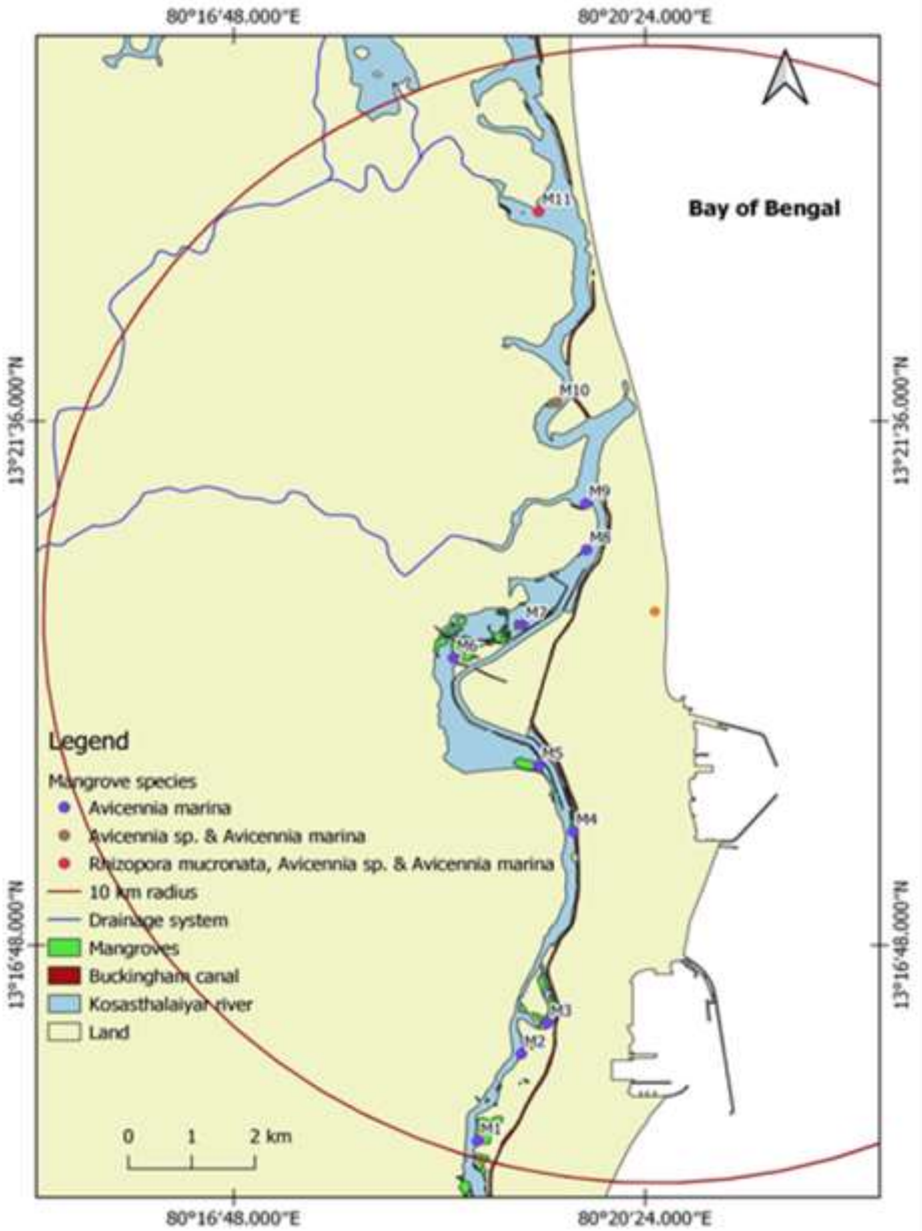


Figure 3-115: Map showing location of mangrove species in the study area

3.9.2.4 Mangrove associated vegetation

Mangroves ecosystem is a reservoir of salt tolerant halophytic plants. They are also called as associate mangroves (Selvam *et al.,* 2004). Five types of halophytic plants were observed in the study area. They are *Sesuvium portulacastrum, Suaeda monoica, Suaeda sp., Suadea* *nudifolra Moq*. and *Salicornia brachiate* Roxb. They are seen in the periphery of mangrove patches and also with mangrove along the banks of the river. On the other hand halophytic plants are also seen as mono-specific in the mudflat, were mangroves are absent and regions of no flushing of water where hypersaline condition exists. *Suaeda monoica* and *Sesuvium portulacastrum* were dominant halophytic plants in the study area. Assessment details are shown in **Exhibit 3-14**.

Avicennia marina

Avicennia sp.

Rhizophora mucronata

Mangrove density


Mangrove stem circumference


Mangrove seedling


Mangrove height

Suadea nudiflora Moq.

Sesuvium portulacastrum

Salicornia brachiate

Suaeda monoica

Suaeda sp.

Exhibit 3-14: Mangrove species in the study area

3.9.2.5 Macro and meio benthic species in All Zones

Density and diversity of both macro and meiofaunal communities were reasonably good in the study area. In the mangrove waters, the macrobenthic organisms were represented by six groups viz., polychaetes, gastropods, bivalves, amphipods, isopods and others. Among them, polychaetes were the dominant group followed by gastropods. A total of 40 species from 29 genera comprised with 24 families were found in the mangrove waters. Density and diversity of meiofauna were comparatively less with six major groups such as nematodes, Foraminifera, cumaceans, Harpacticoids, Ostrocods, and others groups and of the nematodes were the dominant group. A total of 75 species of meiofauna from 58 genera belonging to 45 families were observed in the mangrove waters.

In Kosasthalaiyar River, a total of 34 macrofaunal species from 28 genera belonging to 22 families were observed. Polychaetes were the dominantly represented group in Kosasthalaiyar River. Among the meiofauna in the river, nematodes and Foraminifera, were the dominant groups. A total of 66 meiofaunal species from 50 genera belonging to 41 families were observed in the river samples.

In the samples collected from Buckingham canal, a total of 27 macrofaunal species from 19 genera belonging to 17 families were observed. Polychaetes were the dominant macrofaunal category in the canal samples. In the case of meiofauna from river samples, a total of 58 species from 48 genera belonging to 38 families were recorded. Nematodes and Foraminifera were the dominant meiofaunal groups in the canal.

Samples from Pulicat Lake and Ennore Creek revealed 42 macrofaunal species from 35 genera belonging to 27 families. As in other cases, polychaetes were the dominant macrofaunal group. A total of 58 meiofaunal species from 49 genera belonging to 42 families were also observed in the canal samples. From the marine samples, a total of 118 species of macrofauna were observed and among them polychaetes were the dominant group. A total of 66 species of meiofauna were also observed in the marine samples where nematodes and Foraminifera were dominant. Macro and meio benthic species in Mangrove waters are shown in **Exhibit 3-15**. Macro and meio benthic species in Kosasthalaiyar River are shown in **Exhibit 3-16** and Macro and meio benthic species in Buckingham canal are shown in **Exhibit 3-17**. Macro and meio benthic species in Pulicat lake and Ennore creek are shown in **Exhibit 3-18**. Macro and meio benthic species in Marine zone are shown in **Exhibit 3-19**.


Nereis capensis
Nereis sp.
Prionospio pinnata
Prionospio sp.
Scololepis squamata
Glycera sp.
Lumbrineris sp.
Orbinia angrapequensis
Cerithedia cingulata
Umbonium vestiarum
Epitonium sp.
Nassarius sp.
Capitella capitata
Spiophanes sp.
Armandia sp.
Ancistrosyllis sp.
Amphithoe sp.
Asellota sp.
Gammarus sp.
Cumacean sp.
Discorbinella montereyensis
Ammonium tepida
Eliphidium crispum
Calcarina sp.
Triloculina sp.
Spiroloculina depressa
Edentostomina sp.
Milionella sp.
Rosalina bradyi
Asterorotalia trispinosa
Ammonium beccarii
Nanion sp.

Exhibit 3-15: Macro and meio benthic species in Mangrove waters

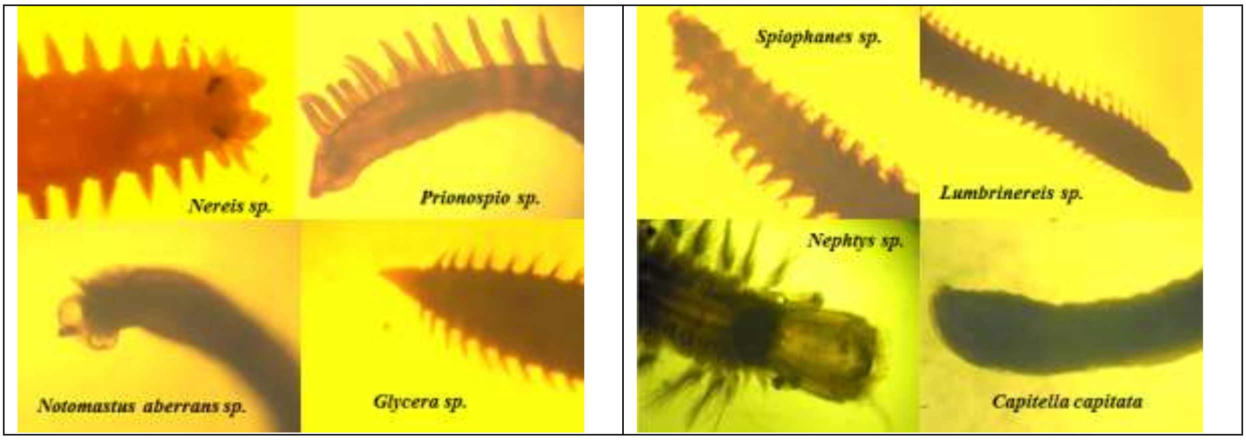
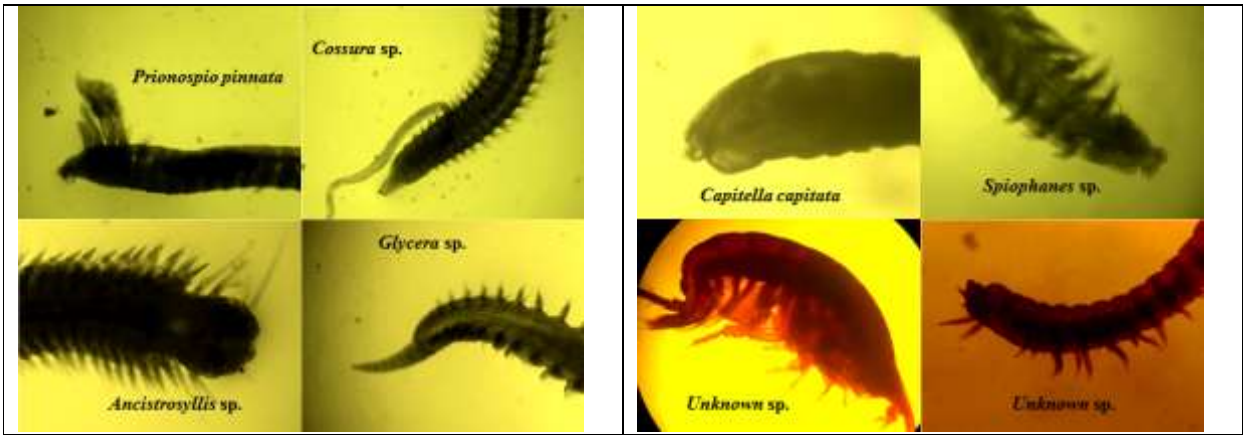


Exhibit 3-16: Macro and meio benthic species in Kosasthalaiyar River



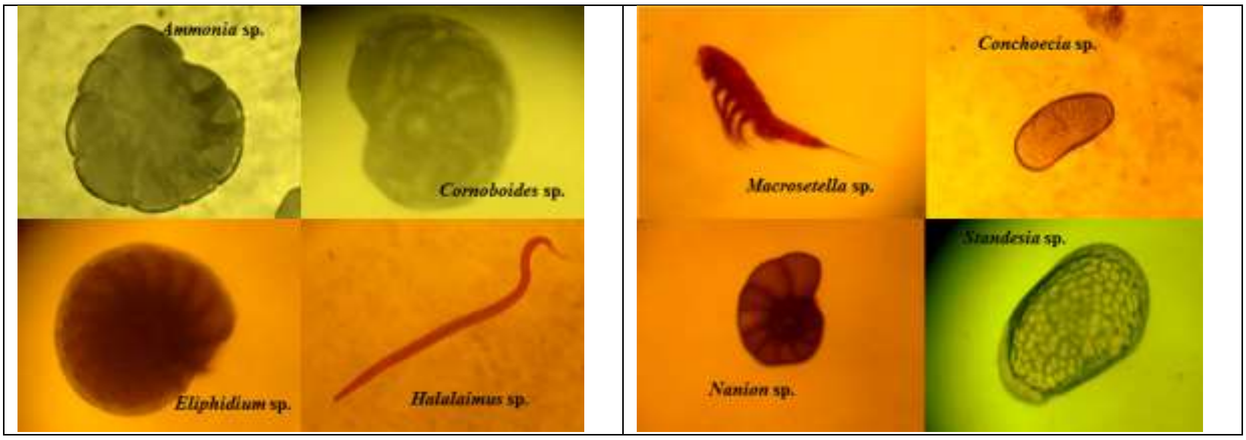


Exhibit 3-17: Macro and meio benthic species in Buckingham canal

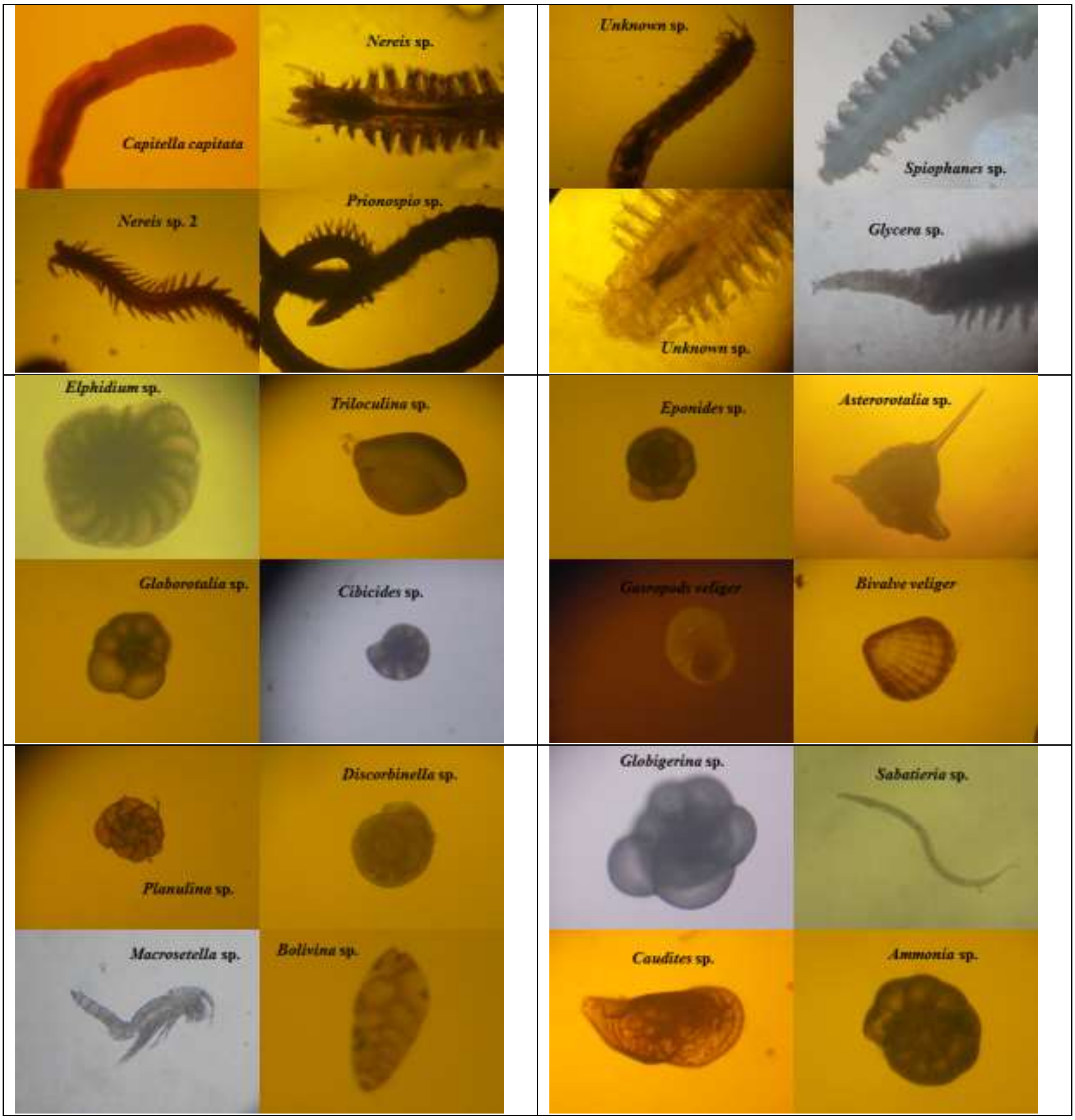


Exhibit 3-18: Macro and meio benthic species in Pulicat lake and Ennore creek

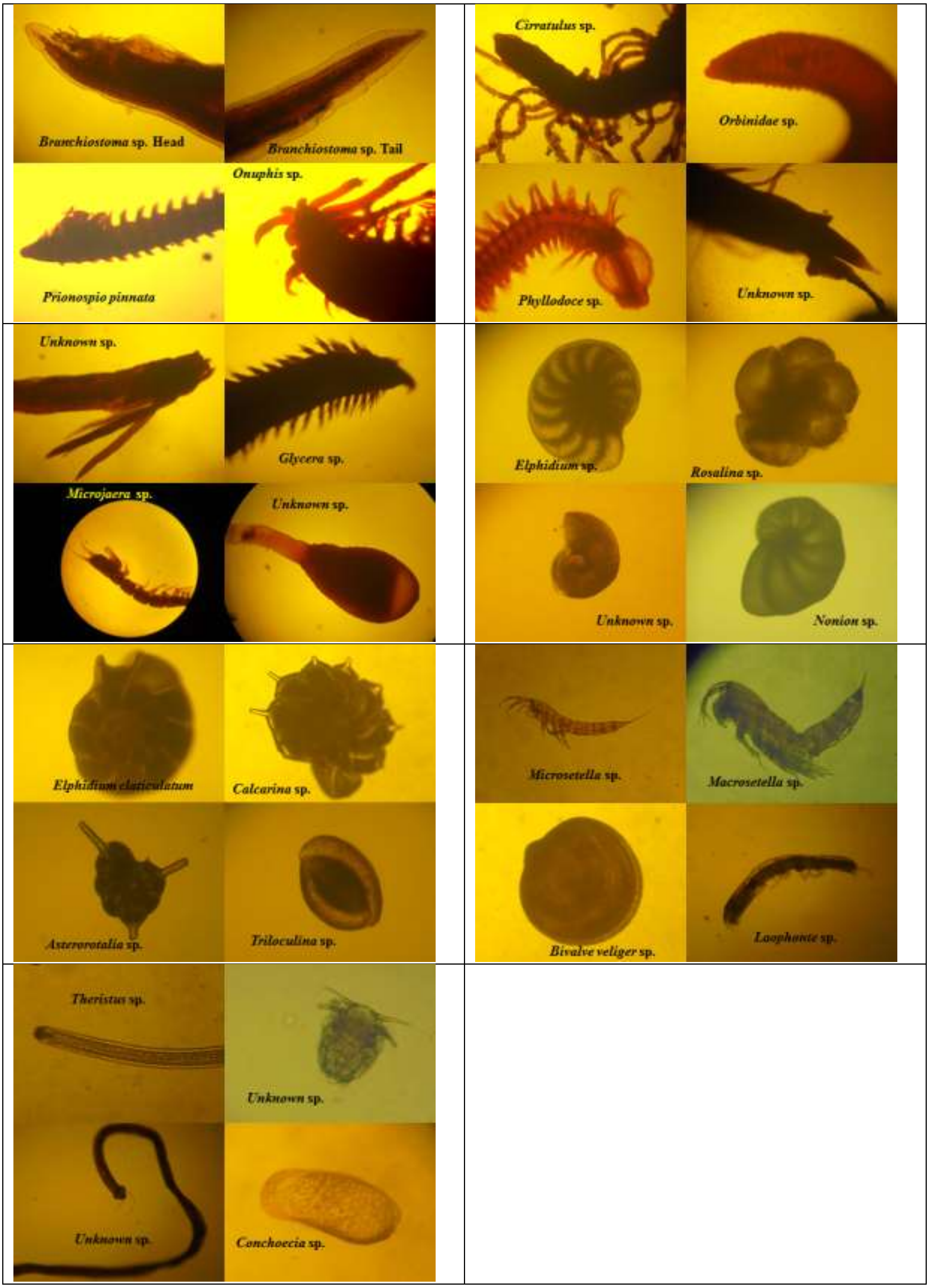


Exhibit 3-19: Macro and meio benthic species in Marine zone

3.9.2.6 Phyto and zooplankton species in all the Zones

Density and diversity of phyto and zooplankton in the study areas were fair. From the samples collected from Buckingham canal, a total of 12 phytoplankton species belonging to three groups such as diatoms, dinoflagellates and cyanophyceae were observed. Phytoplankton density in the canal samples ranged from 600-5000 cells/l. Chlorophyll ‘a’ in varied from 0.22 to 2.70 mg/m^3 and chlorophyll ‘b’ varied from 0.10 to 0.91 mg/m^3 while primary productivity varied from 100.13 to 270.23 mgCm^{-3}d^{-1}. A total of 14 zooplankton species were recorded from the canal samples. Zooplankton density ranged from 120-3240 Nos/m^3.

A total of 16 phytoplankton species belonging to diatoms and dinoflagellates were recorded from the samples from Ennore Creek. Phytoplankton density ranged between 3400-5500 cells/l. Chlorophyll ‘a’ in ranged from 2.07 to 5.28 mg/m^3 and chlorophyll ‘b’ ranged from 0.3 to 2.51mg/m^3 while primary productivity ranged from 203.26 to 275.41mgCm^{-3}d^{-1}. A total of 7 zooplankton species were recorded from Ennore Creek where zooplankton density ranged from 360-1320 Nos/m^3.

A total of 8 phytoplankton species belonging to the diatoms were observed in the mangrove region. Phytoplankton density in the samples showed a range of 1500-10300 cells/l. The chlorophyll ‘a’ content in the mangrove region ranged 4.59 to 8.28 mg/m3 and chlorophyll ‘b’ content varied from 1.01 to 2.42 mg/m^3 while primary productivity ranged from 420.33 to 500.88 mgCm^{-3}d^{-1}. A total of 12 zooplankton species were recorded from the mangrove region where zooplankton density was 360-4200 Nos/m^3.

Samples from Pulicat Lake revealed 13 species of phytoplankton belonging to diatoms, dinoflagellates and cyanophyceae. Phytoplankton density in the lake samples showed a range of 8700-14500 cells/l. Chlorophyll ‘a’ varied from 2.29 to 3.86 mg/m^3 and chlorophyll ‘b’ varied from 0.74 to 1.32 mg/m^3 while primary productivity varied from 310.21 to 460.18 mgCm^{-3}d^{-1}. A total of 8 zooplankton species were recorded from the Pulicat Lake where zooplankton density was 2760-6480 Nos/m^3.

From the samples collected from Kosathalaiyar River, a total of 7 phytoplankton species belonging to the diatoms and cyanophyceae group were observed. Phytoplankton density showed a range of 900-4400 cells/l. Chlorophyll ‘a’content ranged from 2.01 to 4.32 mg/m^3 and chlorophyll ‘b’ content ranged 0.53 to 1.97 mg/m^3 while primary productivity varied from 390.12 to 240.01 mgCm^{-3}d^{-1}. A total of 9 zooplankton species were recorded from Kosathaliayar River. Zooplankton density showed a range of 360-2760 Nos/m^3.

In the marine zone, a total of 57 phytoplankton species belonging to diatoms, dinoflagellates and cyanophyceae were recorded where phytoplankton density ranged from 200-46900 cells/l. Chlorophyll ‘a’ in marine samples varied from 1.03 to 12.73 mg/m^3 and chlorophyll ‘b’ content varied from 0.58 to 10.45 mg/m^3 while primary productivity varied from 220.16 to 490.35 mgCm^{-3}d^{-1}. A total of 34 zooplankton species were recorded from the marine zone where zooplankton density ranged from 120-4680 Nos/m^3.

3.10 Terrestrial Biodiversity Assessment

An attempt has been made to understand the distribution pattern of flora and fauna in different habitat types of core and buffer area for Biodiversity assessment in and around

Kattupalli Port, Chennai, Tamil Nadu. During the survey period all the seasons were covered for the present status of flora and fauna.

3.10.1 General Description of the Study Area

For better understanding of the habitat setup and identification of influences/impacts, the study was carried in both core zone and buffer zone.

Core Zone (Project area) study: Quantification has been done for the trees, shrubs, herbs, grasses and terrestrial & arboreal fauna in the core area. Status of natural vegetation, Green belt plantation type, soil type, and associated services were also recorded. Maximum effort has been taken to assess the damage to be caused by the activity (if any) in the core zone and suggest appropriate implementable conservation action plan (if any).

Buffer zone/PIA (Study area) study:

The following habitats are investigated in the study area:

- Vegetation type (Agriculture, Plantation types, Avenue plantations, Mangroves and Reserve Forests)
- Terrain type (Plain & Undulating)
- Aquatic Habitat (lentic and lotic)

3.10.2 Methodology for Ecological Survey

The methodology we adopted for the present study was divided into data collection and data analysis.

3.10.2.1 Data Collection

Secondary data is collected from Tamil Nadu Forest Office/Tamil Nadu Biodiversity Board, Forest Survey of India reports, ENVIS, Avibase portals, Reserve/Protected forest boundary are extracted from Survey of India toposheets, Bhuvan portal and relevant scientific publications.

The primary data was collected by visual observational sampling as well as by discussion with local villagers. These observations were supplemented by published literature and data including the reports, records and working plans of the forest department.

Flora & Fauna assessment methodology consists of detailing taxonomic accounts based on direct visual enumeration of plant species. For fauna, circumstantial evidence based on foot prints, feathers, skin, hair, hooves etc. Moreover, habitat features and information from locals, especially the local residents were considered as secondary data.

Flora: Phytosociological aspects of the study were carried out by perambulating and sampling through quadrat sampling method. Sample plots were selected in such a way to get maximum representation of different types of vegetation and plots were laid out in different parts of the areas. Accordingly, quadrats of 20 m x 20 m for the trees, 5 m x 5 m for shrubs and 1 m x 1 m for herbs were selected. The plants were identified using state floras (Books published by research and academic institutions on plants in a particular area) and also by using updated check list from www.theplantlist.org

Fauna: Surveys were conducted by using transect method of 500 to 1000 m in all major habitats and recorded the species through direct and indirect evidences. Species were identified using standard field guides like mammals by Vivek Menon (2003), Reptiles by

Whitaker and Captain (2004), Amphibians by Daniel (2005), Birds by Grimmet *et.al.,* (1998) and Butterflies by Isaac Kehimkar (2008). Scheduling of species is made as per the Indian Wildlife Protection Act (1972) and IUCN to check the Rare Endangered Endemic and Threatened (REET) species. For fauna no quantitative assessment is made as it can be done through a detailed species specific and seasonal survey. Migratory paths for the birds and mammals were discussed with locals and forest department and habitats used for foraging, nesting, breeding and other ecological parameters were found.

3.10.2.2 Data Analysis for Flora

The primary data recorded on number of individuals of a species and girth was analysed for secondary attributes like density and frequency following standard phytosociological methods of *Mishra (1968)*. Relative values were calculated by following *Philips (1959)*. Important Value Index (IVI) was calculated by adding up the three relative values of relative frequency, relative density and relative dominance (Curtis, 1959).

Species Diversity Index: The species indices were calculated to know variations of flora in different areas. The species diversity indices were calculated by using Shannon-Wiener Index (H`) & Simpson Index (l) (Kerbs, 1972 and Magurran, 1988)

The authenticity of field observations are confirmed through discussions with local people and based on secondary data collected from different Government offices like Forest Department, Wildlife Department and Fisheries Department etc.

3.10.3 Status of Flora

The field investigation and satellite imagery data show that the study area is an flat to undulating terrain with mixture of open scrub land.

3.10.3.1 Core Area

The core area is mostly with infrastructure development however considerable amount of open spaces with natural vegetation, Green belt/Avenue plantation, few water logged areas, small steams and few patches of mangrove associates were noticed. Trees such as *Acacia auriculiformis*, *Anacardium occidentale*, *Azadirachta indica*, *Borassus flabellifer*, *Calophyllum inophyllum*, *Ficus benghalensis*, *Pongamia pinnata*, *Peltophorum pterocarpum*, *Syzygium cumini*, *Terminalia catappa* and *Prosopis chilensis* are the common species visible in the core area.

The plant resources in core area consist of 93 species belonging to 42 families. The life forms include trees with 29 sp. followed by Shrubs with 21 sp., Herbs 36 sp., and Climbers 5 sp. and Hydrophyte 2 species. Detailed checklist for flora was presented/observed in the Core Area is shown in **Appendix F.**

Habitat Assessment

Habitat features present in the core area include Open land with scrub vegetation, Dense scrub with Calamus, Open scrub dominated with proposis, Low laying area with marginal mangrove associates and plantations such as Eucalptus, Casurina and Cashew.

Open land with scrub vegetation: This habitat is common along the sea coast along the Kalanji coast. Species visible in this habitat are *Borassus flabellifer*, *Phoenix sylvestris*, *Ziziphus jujube*, *Catunaregam spinose*, *Dodonaea viscosa, Opuntia dillenii* and *Dodonaea viscosa*.

Dense scrub with Calamus: This prominent habitat is noticed beside the Kalanji colony. Species visible in the habitat Calamus rotang associated with *Ficus benghalensis*, *Alangium salviifolium*, *Acacia nilotica* and *Morinda pubescens*.

Low laying area with marginal mangrove associates: Few land parcels near to the Ooranambedu is noticed with marginal mangrove associates such as Suaeda maritima, Suaeda monoica, Sesuvium portulacastrum and Halosarcia indica.

Open scrub dominated with proposis: Area adjacent to the buckingham canal and kosasthalaiyar river is dominated with Prosopis juliflora

Other vegetation includes plantations such as Eucalptus, Casurina and Cashew

3.10.3.2 Phytosociological studies in Core Zone

Among trees species *Azadirachta indica* showed highest IVI (21.62) followed by *Acacia nilotica* (18.11), *Acacia auriculiformis* (17.60) and *Anacardium occidentale* (15.30). These four tree species were significant in occupying majority of space and resources representing sampled area. Among shrub species *Catunaregam spinose* showed highest IVI (27.47) followed by *Calamus rotang* (23.04) and *Hyptis suaveolens* (22.51). Among herbaceous species, *Sesuvium portulacastrum* (24.94), *Sida cordifolia* (24.94), *Ageratum conyzoides* (24.79) and *Ocimum tenuifolium* (24.36) showed highest IVI in the core area.

3.10.3.3 Species Diversity Index in Core area

There are two important indices to denote the diversity such as Shannon Wiener Index (H') and Simpson Index (λ). The trees in core area showed Shannon Wiener Index (H') value as 1.61 and Simpson Index (λ) values as 0.82. The shrubs in core area showed Shannon Wiener Index (H') value as 1.28 and Simpson Index (λ) values as 0.12. The herbs in core area showed Shannon Wiener Index (H') value as 1.23 and Simpson Index (λ) values as 0.91. Majority portion of the proposed site is open area with scrub vegetation followed by built-up area and water logged areas. The species diversity values interpret less diversity in plant composition as to the major portion of the vegetation is occupied by Cashew and *Euclayptus* plantation interspersed with scrub vegetation.

Natural vegetation present in the core area is *Azadirachta indica, Borassus flabellifer, Calophyllum inophyllum, Pithecellobium dulce, Prosopis chilensis, Thespesia populnea and Ochna obtusata* along with associated mangrove species such as *Suaeda maritima, Suaeda monoica, Sesuvium portulacastrum* and *Halosarcia indica.*

The proposed site does not encounter with any kind of forest types like Reserve Forest, Protected forest or un-classed Forest (declared Protected under “The Indian Forest Act, 1927”) and “Forest (Conservation) Act, 1980 with Amendments Made in 1988”).

Core area habitat features, vegetation type are shown in **Exhibit 3-20** to **Exhibit 3-25.**

Exhibit 3-20: Low-lying area with mangrove associates in the core area

Exhibit 3-21: Scrub vegetation with phoenix in the core area

Exhibit 3-22: Open land with borassus in the core area

Exhibit 3-23: Scrub land with *Calamus rotang* in the core area

Exhibit 3-24: Open land with scanty vegetation in the core area

Exhibit 3-25: *Euclayptus* plantation in the core area

3.10.3.4 Buffer Area/PIA Area

The buffer area, i.e. 15 km radial distance around the project site, comprises of marine and terrestrial habitat in equal folds. Most of the terrestrial habitat is occupied by urban built-up area, followed by agriculture habitat, inland water bodies of both lentic and lotic. Protected areas such as Mangrove are distributed along the Ennore creek.

The plant resources of the buffer area account about 235 plants species belonging to 91families. The predominant life forms includes Trees (69 sp.), Shrubs (43 sp.), Herbs (93 sp.), Climbers (19 sp.) and Hydrophytes (11 sp.) Detailed checklist of flora represented in both core and buffer area are enclosed as **Appendix F**. Among the families Leguminosae (37 sp.) showed the dominance in species occurrence family followed by Malvaceae (15 sp.), Apocynaceae (12), Poaceae (12 sp.) and Acanthaceae (10 sp.). Species rich families (more species with in same family of flowering plants) in the buffer area are shown in **Figure 3-116**.

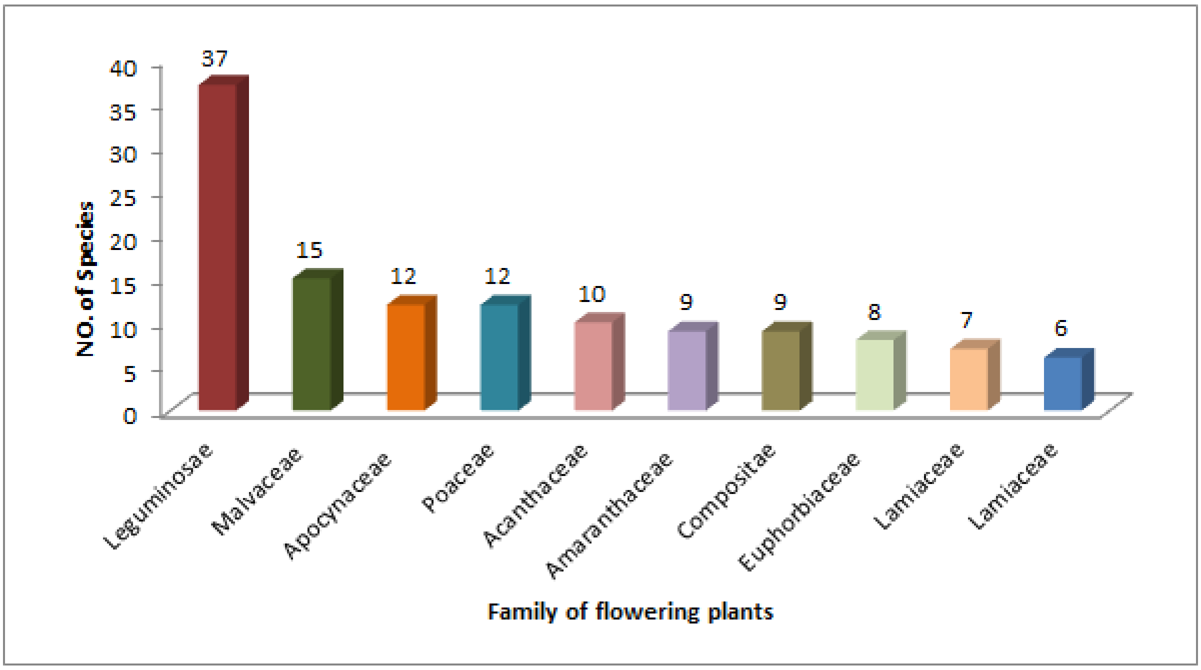


Figure 3-116: Species rich plant families in the buffer area

Buffer area habitat features, vegetation type are shown in **Exhibit 3-26** to **Exhibit 3-31**

	
Exhibit 3-26: Vegetation in the buffer area	**Exhibit 3-27: Ennore creek in the buffer area**

	
Exhibit 3-28: Open scrub land in the buffer area	**Exhibit 3-29: Marsh land in the buffer area**
	
Exhibit 3-30: Inland waterbody marattoor in the buffer area	**Exhibit 3-31: Kosasthalaiyar River in the buffer area**

3.10.3.5 Phytosociological studies in Buffer Zone

Among trees species *Casuarina equisetifolia* showed highest IVI (14.38) followed by *Ficus benghalensis* (14.24) and *Ochna obtusata* (14.17), *Terminalia arjuna* (12.64) & *Samanea saman* (10.90). These five tree species were significant in occupying majority of space and resources representing sampled area. Among shrub species *Catunaregam spinosa* showed highest IVI (18.19) followed by *Senna occidentalis* (15.41) and *Chromolaena odorata* (14.22). Among herbaceous species, *Commelina benghalensis* (18.62), *Evolvulus alsinoides* (17.21), *Cyanotis tuberosa* (15.16) and *Tridax procumbens* (15.12) showed highest IVI in the buffer area. Details of other species are presented in **Appendix F**.

3.10.3.6 Species Diversity Index in Buffer area

The trees in Buffer area showed Shannon Wiener Index (H') value as 1.54 and Simpson Index (λ) values as 0.034. The shrubs in Buffer area showed Shannon Wiener Index (H') value as 1.46 and Simpson Index (λ) values as 0.043. The herbs in Buffer area showed Shannon Wiener Index (H') value as 1.40 and Simpson Index (λ) values as 0.04. The species diversity in the buffer area interprets low diversity in plant composition as majority of the portion is occupied by built-up area followed by agricultural farm lands, sparse mangroves and coastal belt plantation. Zone wise number of plant species recorded in the study area shown in **Figure 3-117** and Zone wise plant species diversity index in the study area are shown in **Figure 3-118.**

Photographs of the flora captured in the buffer area are shown in **Exhibit 3-32**.

	
Calotropis gigantea	***Cochlospermum religiosum***
	
Anacardium occidentale	***Capparis divaricata***
	
Calophyllum inophyllum	***Ficus benghalensis***
	
Azadirachta indica	***Nelumbo nucifera***

Exhibit 3-32: Photographs of the Flora recorded in the Buffer Area

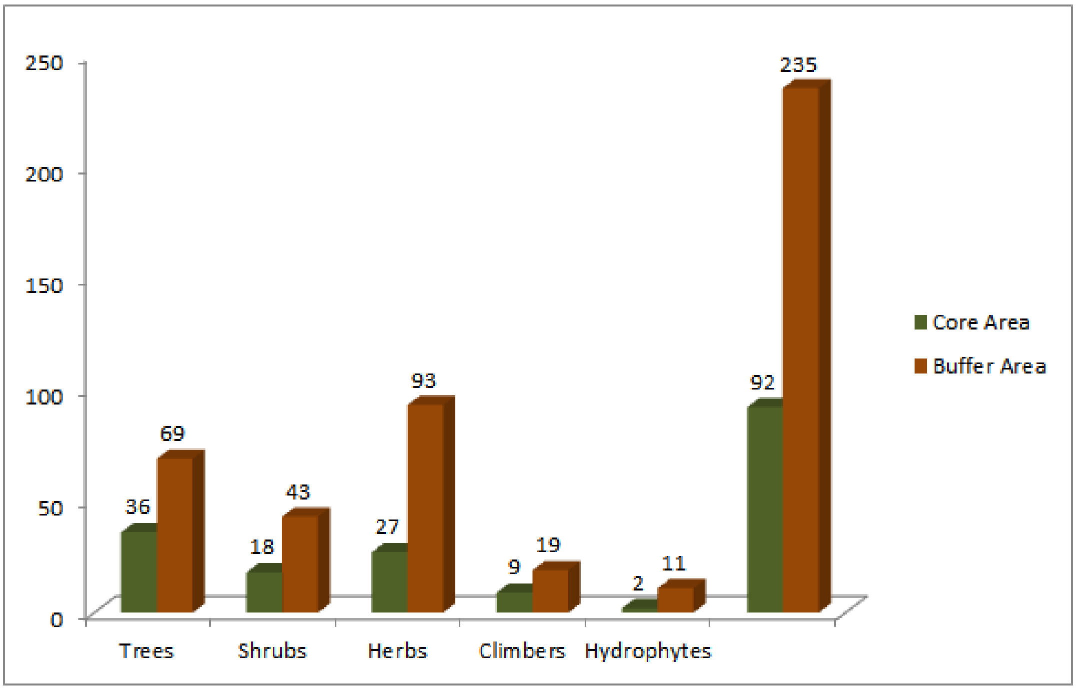


Figure 3-117: Zone wise number of plant species recorded in the study area

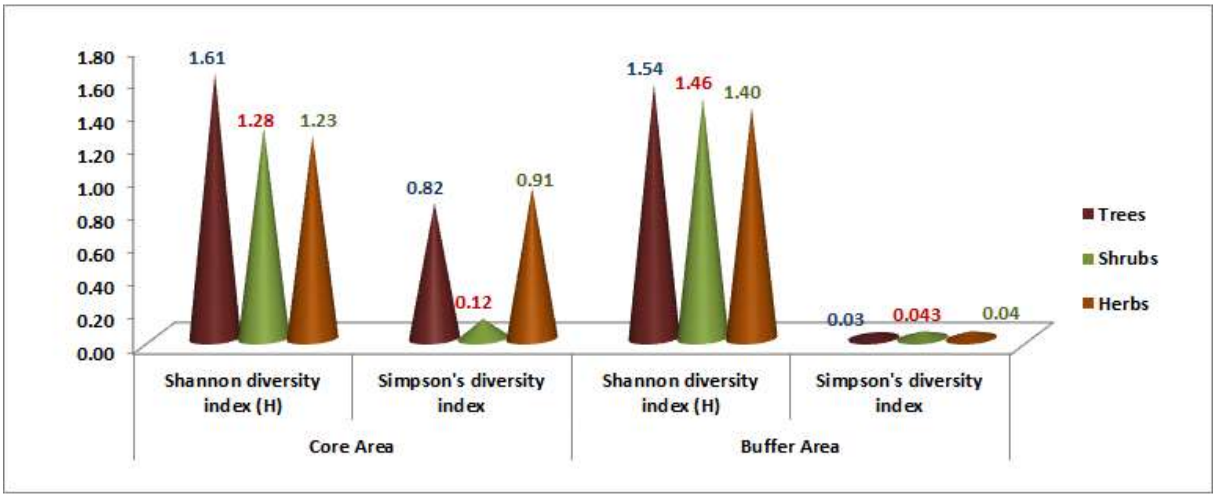


Figure 3-118: Zone Wise Plant Species Diversity in the Study Area

3.10.3.7 Coastal Vegetation

The vegetation along the coast is dominated by Casuarina, Eucalyptus, Coconut plantation followed by soil binding herbaceous flora like *Alternanthera sessilis*, *Boerhavia diffusa*, *Chloris barbata*, *Glinus oppositifolius*, *Ipomoea pes-caprae*, *Launaea sarmentosa*, *Leucas aspera* and *Spinifex littoreus* etc.

3.10.4 Status of Faunal Diversity

Core Zone:

During the study period a total of 40 species of fauna were recorded in the study area. Details of each group are as follows.

Mammals: In the core zone six species of mammals were recorded namely Black-naped Hare (*Lepus nigricollis*), Common Indian Mongoose (*Herpestes javanicus*), Little Indian Field mouse (*Mus booduga*), House rat (*Rattus rattus*)and three striped palm squirrel (*Funambulus palmarum*) are commonly sighted.

Birds: In birds 19 species were recorded, species such as Cattle Egret (*Bubulcus ibis*), White-breasted Kingfisher (*Halcyon smyrnensis*), Spotted Dove (*Streptopelia chinensis*), Common Babbler (*Turdoides caudatus*), Red vented bulbul (*Pycnonotus cafer*), Purple rumped Sun bird (*Nectarinia zeylonica*) are the common species which are encountered during the survey period.

Herpetofauna: In Herpetofauna 5 species were recorded namely Fan throated lizard (*Citana ponticeriana),* Common skink (*Mabuya carinata*), Indian rat snake (*Ptyas mucosa*), Common Indian cobra (*Naja naja*), Common Indian Toad (*Bufo melanostictus*) and Common Tree Frog (*Polypedates maculatus*).

Invertebrates: Invertebrates include only 10 species, common species includes Danaid egg fly (*Hypolimnas misippus*), Tawny Coster (*Acraea violae*), Common Mormon (*Papilio polytes*) and Common Club tail (*Ictinogomphus rapax*) are the common species.

Detailed check list of fauna in the study area is enclosed as **Appendix F.**

Buffer Zone

As the study area is mostly influenced by urban settlement habitat there is no direct evidence of major wild animal observed except few pug marks of Indian wild boar near the coastal areas.

Mammals: A total of 9 species of mammals belonging to 7 families were recorded. The species includes Black-naped hare (*Lepus nigricollis*), Common Indian Mongoose (*Herpestes javanicus*) and Indian Wild Boar (*Sus scrofa cristatus*).

Birds: Among the birds, 52 species belonging to 44 families were recorded. The common bird species of the area include *Pavo cristatus* (Indian peafowl), *Mycteria leucocephala* (Painted stork), *Pelecanus philippensis* (Spot-billed pelican), *Anhinga melanogaster* (Oriental Darter), Little Egret (*Egretta garzetta*), Spotted Dove (*Streptopelia chinensis*), Rose ringed Parakeet (*Psittacula krameri*), Red vented bulbul (*Pycnonotus cafer*), Purple rumped Sun bird (*Nectarinia zeylonica*), White breasted kingfisher (*Halcyon smyrnensis*), Small green bee-eater (*Merops orientalis*) and Black Kite (*Milvus migrans*).

Herpetofauna: The herpetofauna represented with 12 species belonging to 7 families. Species includes Indian Monitor Lizard, Fan throated lizard, Common Indian cobra, Indian rat snake and Russell 's viper.

Invertebrates: 29 species of invertebrates belonging to 18 families. Peacock Pansy, Common castor, Common Mormon and Lemon pansy are common to the area.

Among the fauna in study area the Species richness was high in birds (51 sp.) followed by Mammals (10 sp.), Herpetofauna (12sp.), Invertebrates (29sp) and Fishes (8 sp). This clearly indicates the moderate representation of species composition with moderate levels of energy transfer, predation, composition and niche availability.

3.10.5 Endangered/Threatened/Protected species

Flora: Among the 235 plant species reported from the study area no species is listed in IUCN (International Union for Conservation of Nature) threatened category.

Fauna: Among the 111-fauna species reported. The four species were listed in the IUCN/IWPA (Wildlife Protection Act, 1972). Indian peafowl is listed as schedule I species reported near the sea shore of pulicat lake which is 7 km aerial distance from the project boundary. Management Plan will be prepared for conserving Indian peafowl during the construction phase.

Table 3-29: IUCN/IWPA listed Fauna species reported in 10 km buffer area

S. No	Scientific Name	Common Name	IUCN	IWPA Schedule
1	*Pavo cristatus*	Indian peafowl	Least concern	I (Part III)
2	*Mycteria leucocephala*	Painted stork	Near Threatened	IV
3	*Pelecanus philippensis*	Spot-billed pelican	Near Threatened	IV
4	*Anhinga melanogaster*	Oriental Darter	Near Threatened	IV

3.11 Air Environment

3.11.1 General Meteorological scenario based on IMD Data

The nearest Indian Meteorological Department (IMD) station located to project site is Chennai (Nungambakkam). The Climatological data for Chennai (13°04’N and 80°15’E), published by the IMD, based on daily observations at 08:30 and 17:30 hour IST for a period from 1981-2010 is given in **Table 3-30** for some important meteorological parameters.

Table 3-30: Climatological data Summary – Chennai (Nungambakkam) (1981-2010)

Month	Temp (^{o}C)		Rainfall (mm)		Relative Humidity (%)		Station Level Pressure hPa		Mean Wind Speed (km/h)	Predominant Wind Directions (From)*	
	Daily Max.	Daily Min.	Total	No. of days	08:30	17:30	08:30	17:30		08:30	17:30
Jan	29.3	**21.2**	25.9	1.4	81	67	1014.3	1011.2	5.3	N, NE	NE, E
Feb	30.9	22.0	**3.4**	0.8	80	66	1013.1	1009.8	5.1	W, SW,NW	E, SE
Mar	32.9	24.2	3.5	**0.3**	78	67	1011.4	1007.7	5.5	SW, W	SE, E
Apr	34.5	26.6	14.4	0.8	74	70	1009.0	1005.1	6.4	SW, S	SE, S
May	**37.1**	28	34.2	1.8	67	68	1005.8	1002.2	7.4	SW, W	SE, S
Jun	37.0	27.5	55.8	4.0	64	**63**	1004.5	1001.1	**7.9**	W, SW	SE, S
Jul	35.3	26.4	103.8	6.5	70	65	1005.2	1001.9	7.0	W, SW	SE, S
Aug	34.7	25.9	126.8	7.7	73	66	1006.0	1002.5	6.7	W, SW	SE, S
Sep	34.2	25.6	147.7	7.3	77	71	1007.4	1003.9	5.8	W, SW	SE, E,S
Oct	32.1	24.6	315.6	10.9	82	76	1009.5	1006.3	**4.7**	W, SW	NE,E,SE
Nov	29.9	23.1	**374.4**	11.5	**83**	76	1011.8	1008.9	5.7	N, NE,NW	NE, N
Dec	28.9	21.9	177.4	5.8	81	71	1013.9	1011.0	6.4	N, NE	NE, N

(Source: IMD Climatological Data for Chennai (Nungambakkam))

As per the above Climatological table the observations drawn for the study area for different seasons are as follows

- Daily maximum temperature is 37.1^{o}C and the daily minimum temperature is 21.2^{o}C
- Maximum and minimum relative humidity of 83% and 63% were recorded at 08:30 hours and 17:30 hours respectively.
- Maximum and minimum rainfall of 374.4 mm and 3.4 mm was recorded.
- Maximum Mean wind speed is 7.9 km/h

3.11.2 Meteorological Scenario

Site-specific meteorological data was generated during the study period. Automatic weather station was installed at project site to record the meteorological parameters during the study period. Meteorological parameters recorded include temperature, wind speed, wind direction, relative humidity and rainfall.

Also, Project site specific meteorological data for the year 2019 to 2020 (March 01, 2019 - February 29, 2020) was obtained from Lakes Environment, Canada to understand the prevailing surface and upper air conditions for air quality modelling. The parameters like wind speed, wind direction, relative humidity, station pressure, cloud cover, ceiling height, precipitation and temperature etc. have been considered as a meteorological input to the model.

Rainfall: The annual total rainfall recorded during the study period is 1837 mm. Total numbers of rainy days (rainfall <2.5 mm/day) during the study period is observed as 85 Days.

Wind speed and Wind Direction: The daily-recorded meteorological data was processed and wind roses were drawn on a sixteen-point compass (N, NNE, NE, ENE; E, ESE, SE, SSE; S, SSW, SW, WSW; W, WNW, NW, and NNW).

Wind pattern representing 00-23 hours for the year 2019-2020 is considered. The frequency occurrence of wind at various speeds was calculated on the basis of total number of observations recorded in the respective wind speed category.

3.11.3 Ambient Air Quality

The selection criteria for monitoring locations are based on the following:

- Topography/Terrain
- Meteorological conditions
- Residential and sensitive areas within the study area
- Representatives of regional background air quality/pollution levels and
- Representation of likely impacted areas.

3.11.3.1 Ambient Air Quality Monitoring Stations

To evaluate the baseline air quality of the study area, seven (07) monitoring locations have been identified. Map showing the air monitoring locations are given as **Figure FD0301** and the details of the locations are given in **Table 3-31**

Table 3-31: Details of Ambient Air Quality Monitoring Locations

Station Code	Location	Distance (km) from Project boundary	Azimuth Directions	Environmental Setting
AAQ1	Attipattu	2.3	SW	Residential
AAQ2	Kattupalli	Within the project site		Industrial
AAQ3	Kalanji	Within the project site		
AAQ4	Karungalikuppam	0.6	N	Residential
AAQ5	Neidavayal	3.2	W	
AAQ6	Uranambedu	Within the project site		Industrial
AAQ7	Kattur	1.5	NW	Residential

3.11.3.2 Ambient Air Quality Monitoring Techniques and Frequency

Ambient air quality was monitored twice in a week for complete three (03) seasons. All the 12 parameters (Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}), Carbon Monoxide (CO), Ozone (O_3), Lead (Pb), Ammonia (NH_3), Benzene (C_6H_6), Benzo (a) Pyrene (BaP) – Particulate phase only, Arsenic (As) and Nickel

(Ni)) are monitored as per NAAQS. The monitoring and analysis were carried out as per CPCB standard methods of measurements.

3.11.3.3 Results and Discussions

The variations of PM_{10}, $PM_{2.5}$, SO_2, and NO_2 levels are compared with National ambient air quality standards (NAAQS), MoEF&CC Notification, November, 2009. The minimum and maximum values in different seasons for PM_{10}, $PM_{2.5}$, SO_2, and NO_2 are presented below.

- PM_{10} concentration ranged between 37 µg/m^3 and 86µg/m^3 at Kattur (during summer and winter seasons) and Uranambedu (during summer season) respectively. NAAQ stipulated standard for PM_{10} for 24 hr average is 100 µg/m^3.
- $PM_{2.5}$ concentration ranged between 12 µg/m^3 and 40 µg/m^3 at Kattupalli (during Winter season) and Uranambedu (during Summer season) respectively. NAAQ stipulated standard for $PM_{2.5}$ for 24 hr average is 60 µg/m^3.
- SO_2 concentration ranged between 3.5 µg/m^3 and 9 µg/m^3 at Karungalikuppam (during winter season) and Attipattu (during Summer season) respectively. NAAQ stipulated standard for SO_2 for 24 hr average is 80 µg/m^3.
- NO_2 concentration ranged between 9.4 µg/m^3 and 17.9 µg/m^3 at Karungalikuppam (during winter season) and Attipattu (during Winter and summer seasons) respectively. NAAQ stipulated standard for NO_2 for 24 hr average is 80 µg/m^3.
- O_3 concentration observed was below 10 µg/m^3 at all locations during entire study period.

Variations in PM_{10}, $PM_{2.5}$, SO_2, and NO_2 were given in **Appendix F** and graphically presented in **Figure 3-119** to **Figure 3-122**.

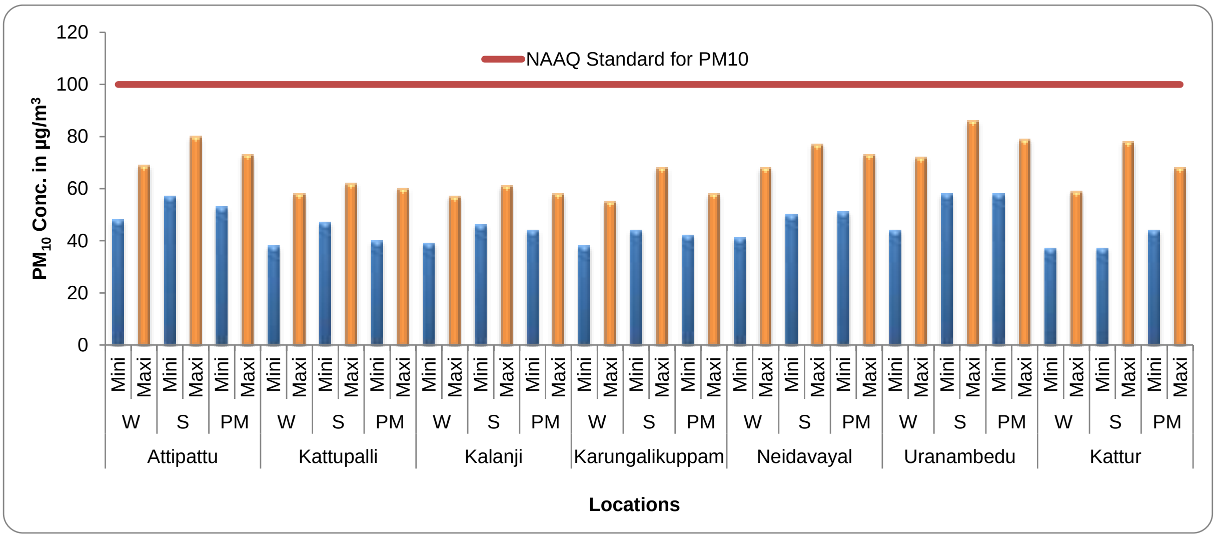


Figure 3-119: Seasonal variations in PM_{10}

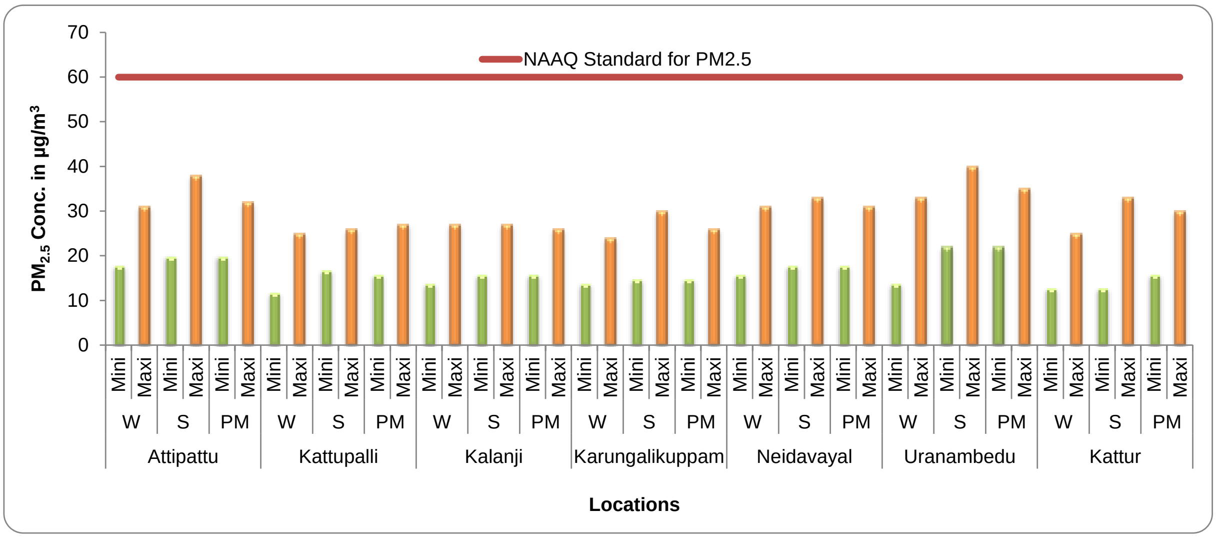


Figure 3-120: Seasonal variations in $PM_{2.5}$

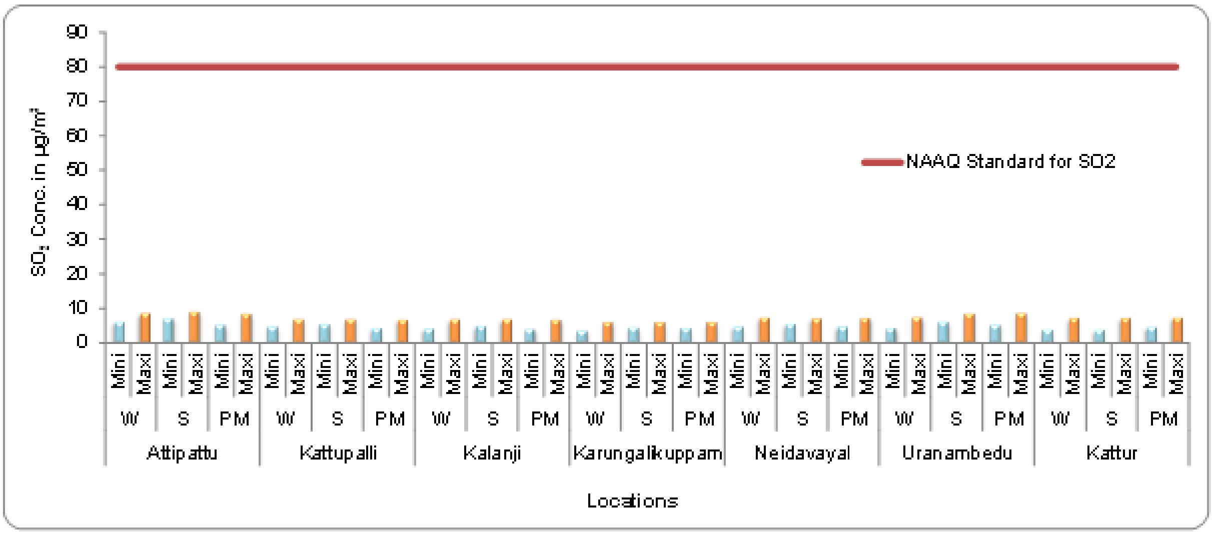


Figure 3-121: Seasonal variations in SO_2

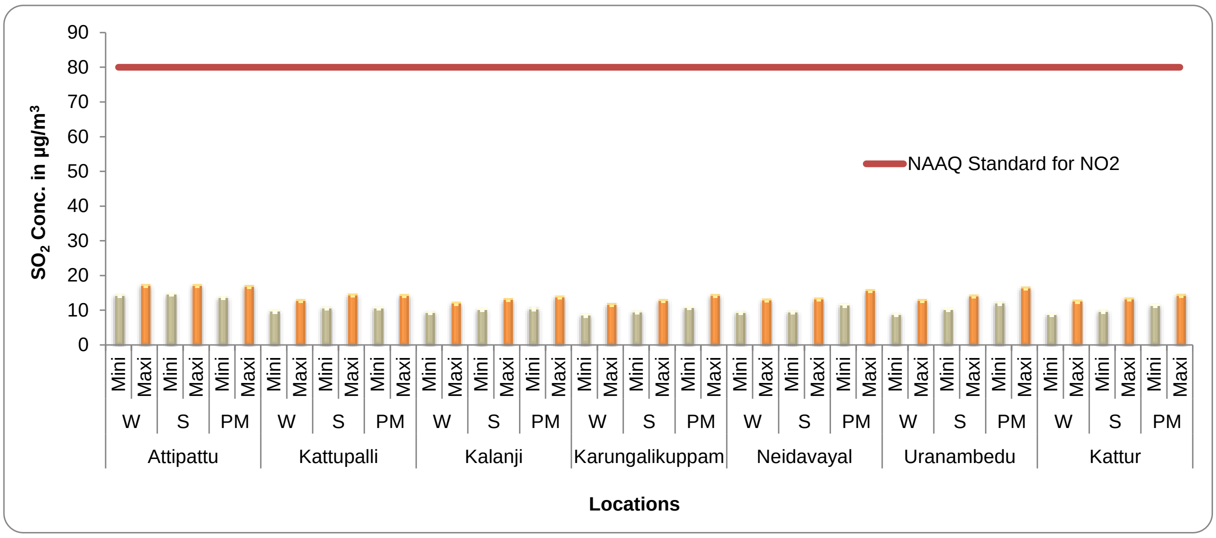


Figure 3-122: Seasonal variations in NO_2

3.11.3.4 Secondary Data

Secondary data are data collected indirectly from published records or documents such as project documents, village proflie, maps, photos, internet sources etc. This data is used to understand the existing environmental scenario of the project area. In this case, the secondary data for Ambient Air Quality was collected from Marine Infrastructure Developer Private Limited (MIDPL) for the period, October 2018 to March 2020 (The monitoring locations are shown in **Figure 3-63**.

- PM_{10} concentration ranged between 34 µg/m^3 at Kalanji village and 83 µg/m^3 at Port Main gate location during the monitoring period.
- $PM_{2.5}$ concentration ranged between 13 µg/m^3 and 35 µg/m^3 at Port Main gate location during the monitoring period.
- SO_2 concentration ranged between 3.5 µg/m^3 at Kalanji village and 9.6 µg/m^3 at Port Main gate location during the monitoring period.
- NO_2 concentration ranged between 8.8 µg/m^3 at Kalanji village and 19.5 µg/m^3 at Port Main gate location during the monitoring period.
- Pb concentration was found below 0.1 µg/m^3.
- CO concentration was found below 1 mg/m^3
- O_3 concentration was found below 10 µg/m^3
- NH_3 concentration was found below 2 µg/m^3
- As, Ni concentrations was found below 2 ng/m^3
- C_6H_6 concentration was found below 1 µg/m^3
- BaP concentration was found below 0.1 ng/m^3

3.12 Ambient Noise

Ambient noise levels have been established by monitoring noise levels at Seven (07) locations in the study area during study period using precision noise level meter. The noise monitoring locations in the study area were selected after giving due consideration to the various land use categories like residential, industrial, etc. Noise levels were recorded on an hourly basis for one complete day at each location using pre- calibrated noise levels. Map showing Noise monitoring locations is given as **Figure FD0301** and the details of the sampling locations are given in **Table 3-32.**

Table 3-32: Day and Night Equivalent Noise Levels

S. No	Location	Distance (km) from Project boundary	Azimuth Directions	Environmental Setting
1.	Attipattu	2.3	SW	Industrial
2.	Kattupalli	Within the project site		
3.	Kalanji	Within the project site		
4.	Karungalikuppam	0.6	N	Residential
5.	Neidavayal	3.2	W	
6.	Uranambedu	Within the project site		Industrial
7.	Kattur	1.5	NW	Residential

3.12.1 Results and Discussions

The day equivalent noise levels (L_d) and night equivalent noise levels (L_n) are compared with the respective CPCB stipulated noise standards for observed land use categories. The map showing the noise monitoring locations is given as **Figure FD0301**.

Based on the recorded hourly noise levels at each monitoring location, the day equivalent (Ld) and night equivalent (Ln) were calculated considering the following;

- Ld: Average noise levels between 6:00 hours to 22.00 hours.
- Ln: Average noise levels between 22:00 hours to 6.00 hours.

The Day-Night (L_{dn}) equivalent noise levels were calculated using the US Environmental Protection Agency formula:

L_{dn} = 10 Log [0.0416 {16 ($10^{Ld/10}$) + 8 ($10^{Ln+10/10}$)}]

3.12.1.1 Day Equivalent Noise Levels (L_d)

For Residential areas L_d ranged between 55.98 dB(A) at Karungalikuppam during Winter to 65.38 dB(A) at Kattur during winter season and for Industrial areas, L_d ranged from 58.13 dB(A) at Kalanji during Summer season to 67.8 dB(A) at Attipattu during Winter season. Day equivalent noise levels for all the three seasons are graphically presented in **Figure 3-123**. Seasonal variations were given in **Appendix F**.

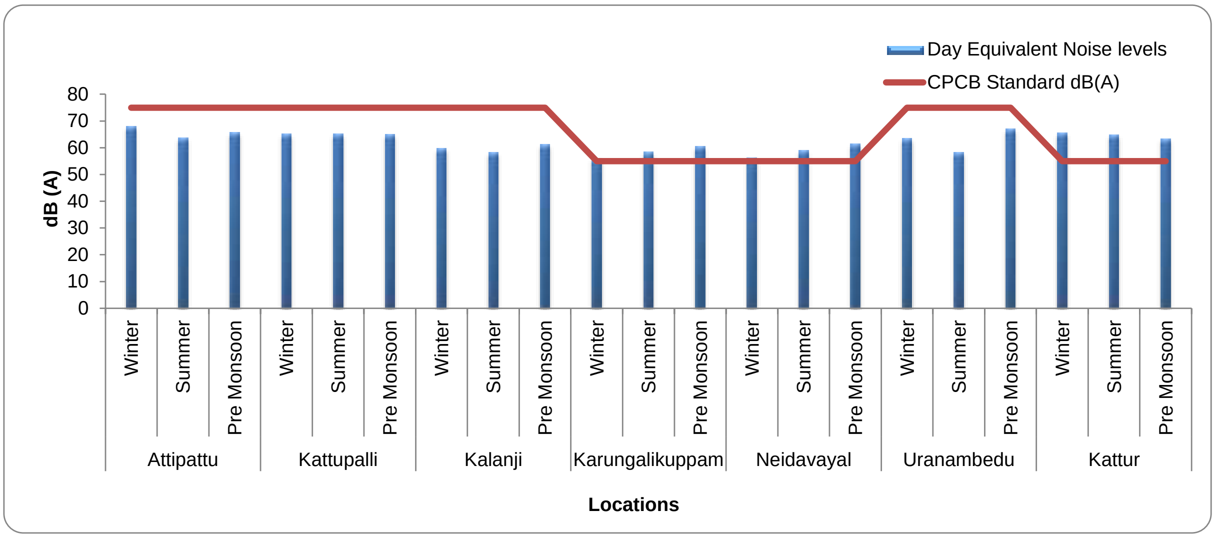


Figure 3-123: Variation in Day Equivalent Noise levels

3.12.1.2 Night Equivalent Noise Levels

For Residential areas, L_n ranged between 50.05 dB(A) at Karungalikuppam during Summer season to 56.05 dB(A) at Karungalikuppam during winter season and for Industrial areas , L_n ranged from 53.21 dB(A) at Kalanji to 63.21 dB(A) at Kattupalli both during Winter season. Night equivalent noise levels for all the three seasons are graphically presented in **Figure 3-124**. Seasonal variations were given in **Appendix F**. It is observed that the day and night equivalent noise levels at most of the monitoring locations except Karungalikuppam, Neidhavoyal and Kattur where both the day and night noise levels are exceeding. Intense vehicular movements were observed in these areas and rest of the of the locations noise limits are well within the prescribed CPCB standards.

Figure 3-124: Variation in Night Equivalent Noise levels

3.12.1.3 Secondary Data

Secondary data are data collected indirectly from published records or documents such as project documents, village proflie, maps, photos, internet sources etc. This data is used to understand the existing environmental scenario of the project area. In this case, the secondary data for Ambient Noise Level Quality was collected from Marine Infrastructure Developer Private Limited (MIDPL) for the period, October 2018 to March 2020 (The monitoring locations are shown in **Figure 3-63**.

- L_{eq} (day) ranges between 50.06 dB(A) to 69.76 dB(A) at Kalanji village and marine control area respectively.
- L_{eq} (night) ranges between 50.67 dB(A) to 69.89 dB(A) at Kalanji village and Port main Gate respectively

3.13 Other Natural Hazards

3.13.1 Cyclones and Depressions[14]

The cyclones in India are seasonal phenomena and most places have a maximum frequency of cyclone formation that takes place during the late summer and early fall period, which coincides with the period of maximum sea temperature that is idea for cyclone formation. Both the east and west Coast of India is affected by cyclones that are formed in the Arabian Sea and Bay of Bengal.

The number of cyclones that have occurred within the vicinity of 100 km of the proposed project location for the period of 1970 to 2018 from (Cyclone eAtlas) India Meteorological Department (IMD, India) are shown in the **Figure 3-125**.

December 2016 Vardah cyclone made severe impact at the study area. At Kattupalli Port location, the Vardah cyclone has caused a maximum surge height of 0.78m and a maximum current speed of 2.74 m/s.

[14] *Source: Maps of India, Vulnerability Atlas of India series*

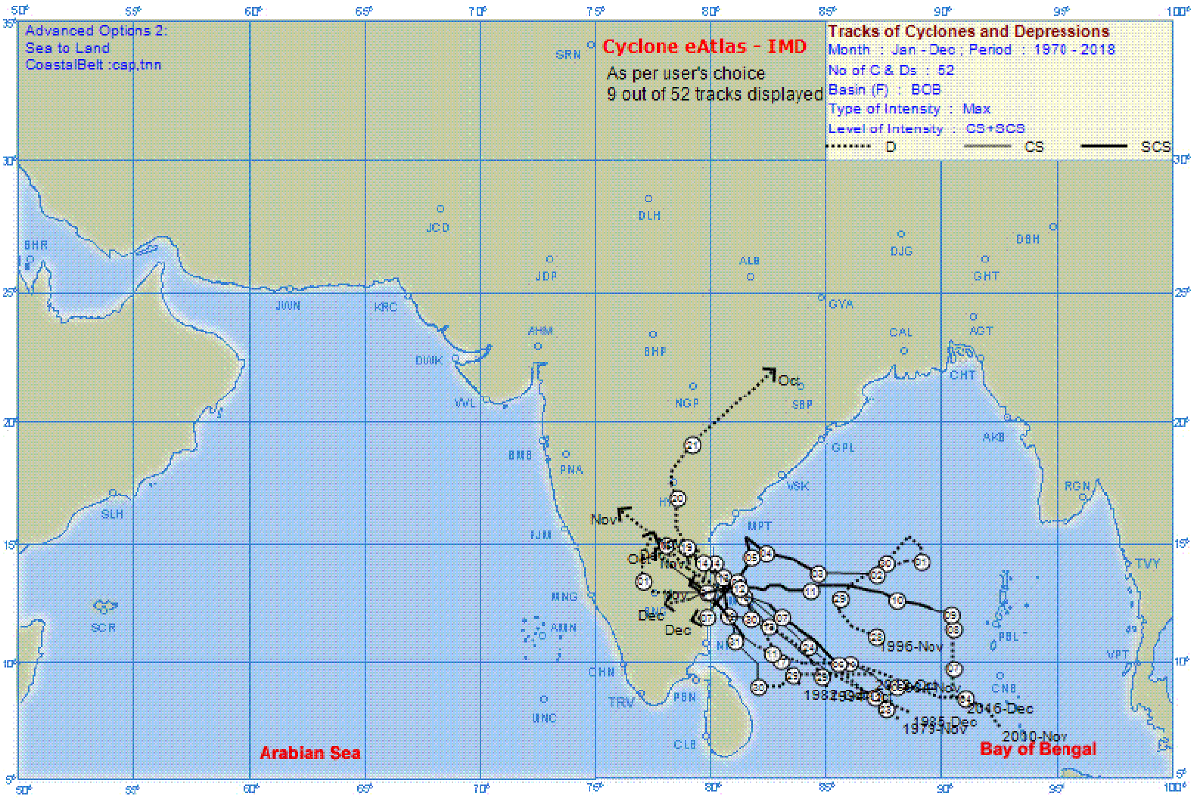


Figure 3-125: Tracks of the cyclones in vicinity of study area

3.13.2 Seismicity

As per the IS: 1893 (Part 1) 2002 of Bureau of Indian Standards (BIS), the project area and study area fall in Zone III which is a moderate risk zone. The seismic zoning map of Tamil Nadu region is shown in **Figure 3-126**. From the figure, it is observed that the location of port falls under Seismic zone III (Moderate risk zone).

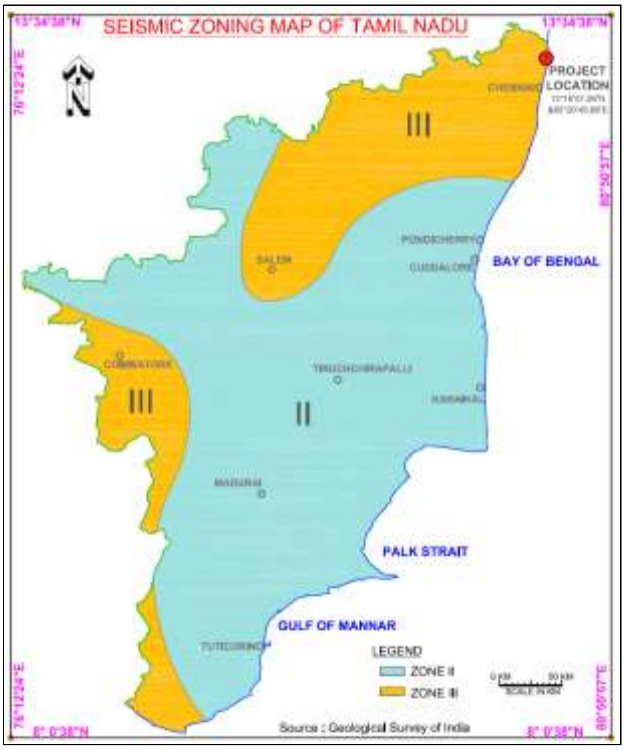


Figure 3-126: Seismic Zoning Map of Tamil Nadu

For the present study for calculating the initial vertical displacement due to the earthquake various earthquake parameters was considered such as the initial rupture time, dip angle, strike angle, slip angle, latitude and longitude and most importantly the moment magnitude of the earthquake and the type of fault mechanism.

For the current study, the fault parameters of the earthquakes considered for the generation of 2004 Sumatra Tsunami is from the journal “Source Constraints and Model Simulation of the December 26, 2004, Indian Ocean Tsunami”, Similarly fault parameters for 1881 and 1941 earthquakes are from the journal “Tsunami vulnerability assessment in urban areas using numerical model and GIS” respectively. The fault parameters are listed in **Table 3-33**.

Table 3-33: Fault parameters for 1881, 1941 and 2004 Earthquakes in the Bay of Bengal

Parameters	1881 Car Nicobar	1941 Andaman	2004 Sumatra				
			Fault-1	Fault-2	Fault-3	Fault-4	Fault-5
Longitude [Deg]	92.43	92.5	95.10	93.90	93.41	92.10	92
Latitude [Deg]	8.52	12.1	2.50	4.33	5.80	9.10	10.50
Magnitude [Mw]	7.9	7.7	9.3				
Slip [m]	5	5	18	23	12	12	12
Fault length [km]	200	200	220	150	390	150	350
Fault width [km]	80	80	130	130	120	95	95
Strike angle [Deg]	350	20	323	348	338	356	10
Dip angle [Deg]	25	20	12	12	12	12	12
Rake angle [Deg]	90	90	90	90	90	90	90
Focal depth [km]	15	30	25	25	25	25	25

3.13.3 Tsunami[15]

A tsunami is a natural coastal hazard generated in the deep ocean as a result of an earthquake, volcanic activity, submarine landslide or meteoritic impact.

[15] Source: CURRENT SCIENCE, VOL. 88, NO. 11, 10 JUNE 2005

In general, the extent of vertical run-up of sea water during tsunamis depends on earthquake parameters, geographical location, velocity of tsunami waves and their frequency, nearshore bathymetry, beach profile and land topography. Due to these parametric variations, along Tamil Nadu coast, the run-up levels and landward penetration characteristics of sea water were location-specific and varied within a location and even in an island.

The run-up level and seawater inundation due to tsunami in 2004 near the project region is given in the **Table 3-34.**

Table 3-34: Run-up Level and Seawater Inundation Inland Details

S. No.	Location	Maximum Run-up Level (m)	Distance of Seawater inundation inland (m)
1.	Kattupalli	1.8	190
2.	Kalanji	1.4	45
3.	Pulicat	3.5	80

3.14 Socio-Economic Profile of Project Study Area

3.14.1 Demographic Profile of the Study Area

The socio-economic profile of the 15.0 km and 108 census villages secondary data for Kattupalli Port expansion is studied and analysed based on the Census of India 2011. The total households are 1,74,745 and total population within the study area is 6,79,695. In the 15.0 km project area is falling in Thiruvallur District of Tamil Nadu. The total of 108 villages including hamlets is falling in three talukas viz. Gummidipoondi, Ponneri and Mathavaram talukas of Thiruvallur District. The brief profile is discussed in the following sections.

3.14.2 Talukas in the study area

The village talukas falling in the study area are Gummidipoondi, Ponneri and Mathavaram talukas of Thiruvallur District. The census summary of the State, District and Talukas are summarized in **Table 3-35**.

3.14.3 Villages Falling in the Study Area

In the study area of 15.0 km radius, 108 census villages are falling which includes hamlets and settlement within the census villages of three talukas of Thiruvallur Districts of Tamil Nadu. **Table 3-36** represents the villages falling in the study area. However, project area falls under notified revenue villages (i.e. Kalanji, Kattupalli, Kattur-II, Ebrahampuram, Puzhudivakkam, Voyalur) out of which only four villagers are inhabited and two villages are un-inhabited (viz. Ebrahampuram, Puzhudivakkam[16]).

[16] *Demographic profile is not presented as these are uninhabited villages*

Table 3-35: Census Statistic Status of State, District and Project influenced Talukas

Name	Tamil Nadu State			Thiruvallur District			Gummidipoondi Taluk			Ponneri Taluk			Mathavaram Taluk		
TRU	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
No of Household	18524982	9528495	8996487	946949	331697	615252	50144	42148	7996	100866	64051	36815	150990	7597	143393
Total Population	72147030	37229590	34917440	3728104	1299709	2428395	190541	159356	31185	389862	243676	146186	596156	29360	566796
Total Male	36137975	50.17	50.00	50.32	50.05	50.47	50.28	50.23	50.51	50.06	49.98	50.20	50.54	50.25	50.56
Total Female	36009055	49.83	50.00	49.68	49.95	49.53	49.72	49.77	49.49	49.94	50.02	49.80	49.46	49.75	49.44
Below 6 yrs	7423832	10.51	10.06	10.88	10.92	10.86	11.33	11.21	11.92	10.99	11.10	10.80	11.00	11.01	11.00
<6 Male	3820276	51.66	51.24	51.38	51.37	51.39	50.74	50.88	50.08	51.13	50.91	51.50	51.70	51.08	51.73
<6 Female	3603556	48.34	48.76	48.62	48.63	48.61	49.26	49.12	49.92	48.87	49.09	48.50	48.30	48.92	48.27
SC Population	14438445	25.45	14.21	22.04	34.78	15.22	26.16	29.33	9.97	31.83	37.89	21.72	17.99	44.37	16.62
SC Male	7204687	49.98	49.74	49.96	49.86	50.10	49.78	49.76	50.14	49.81	49.84	49.74	50.20	49.72	50.26
SC Female	7233758	50.02	50.26	50.04	50.14	49.90	50.22	50.24	49.86	50.19	50.16	50.26	49.80	50.28	49.74
ST Population	794697	1.77	0.38	1.27	2.70	0.50	2.68	2.92	1.41	2.04	2.64	1.03	0.29	1.27	0.23
ST Male	401068	50.46	50.51	50.15	50.00	50.59	49.37	49.50	48.07	49.69	49.66	49.80	47.94	49.73	47.44
ST Female	393629	49.54	49.49	49.85	50.00	49.41	50.63	50.50	51.93	50.31	50.34	50.20	52.06	50.27	52.56
Literacy Population	51837507	65.81	78.29	74.88	66.15	79.56	63.72	61.80	73.53	70.73	66.97	76.99	78.63	74.72	78.83
Male Literacy	28040491	55.77	52.59	53.58	55.39	52.77	55.93	56.33	54.21	54.09	54.64	53.29	52.81	53.90	52.76
Female Literacy	23797016	44.23	47.41	46.42	44.61	47.23	44.07	43.67	45.79	45.91	45.36	46.71	47.19	46.10	47.24
Illiterate Pop	20309523	34.19	21.71	25.12	33.85	20.44	36.28	38.20	26.47	29.27	33.03	23.01	21.37	25.28	21.17
Male Illiterate	8097484	39.39	40.68	40.62	39.60	41.52	40.36	40.37	40.26	40.34	40.54	39.87	42.18	39.44	42.35
Female Illiterate	12212039	60.61	59.32	59.38	60.40	58.48	59.64	59.63	59.74	59.66	59.46	60.13	57.82	60.56	57.65
TOT_WORK_P	32884681	50.66	40.16	41.26	46.72	38.33	44.82	46.48	36.39	42.08	44.12	38.66	37.41	39.44	37.30
TOT_WORK_M	21434978	59.46	72.88	71.75	64.06	76.77	67.52	65.60	80.04	71.90	69.29	76.86	79.49	75.02	79.74
TOT_WORK_F	11449703	40.54	27.12	28.25	35.94	23.23	32.48	34.40	19.96	28.10	30.71	23.14	20.51	24.98	20.26
MAINWORK_P	27942181	81.33	89.87	81.14	72.43	86.82	76.60	74.99	87.12	77.39	75.08	81.80	85.11	76.60	85.58
MAINWORK_M	18961194	85.18	92.06	85.66	78.32	89.65	82.02	80.76	88.77	83.29	81.90	85.67	87.71	80.36	88.08
MAINWORK_F	8980987	75.67	84.00	69.65	61.93	77.45	65.33	63.98	80.49	62.30	59.67	68.94	75.05	65.30	75.71
MAIN_CL_P	3855375	22.99	2.61	4.84	11.95	0.98	11.31	12.71	3.42	6.02	8.78	1.19	0.82	7.78	0.48
MAIN_AL_P	7234101	40.76	7.79	13.88	36.40	1.62	35.11	39.70	9.33	20.38	30.29	3.09	1.25	12.29	0.71
MAIN_HH_P	1119458	3.62	4.47	3.34	3.61	3.20	2.11	2.02	2.59	2.45	2.27	2.75	1.94	3.35	1.87
MAIN_OT_P	15733247	32.62	85.13	77.94	48.04	94.21	51.48	45.57	84.67	71.16	58.66	92.97	95.99	76.59	96.94
MARGWORK_P	4942500	18.67	10.13	18.86	27.57	13.18	23.40	25.01	12.88	22.61	24.92	18.20	14.89	23.40	14.42
MARGWORK_M	2473784	47.19	57.15	54.56	50.38	60.25	51.88	50.46	69.77	53.14	50.31	60.51	65.64	62.95	65.88
MARGWORK_F	2468716	52.81	42.85	45.44	49.62	39.75	48.12	49.54	30.23	46.86	49.69	39.49	34.36	37.05	34.12
MARG_CL_P	393082	10.20	2.38	4.48	6.42	1.84	6.96	7.16	4.45	3.34	4.16	1.21	1.79	7.97	1.25
MARG_AL_P	2372446	61.19	15.30	33.58	54.34	5.27	59.54	61.96	28.93	34.22	44.61	7.14	2.31	8.41	1.77

Name	Tamil Nadu State			Thiruvallur District			Gummidipoondi Taluk			Ponneri Taluk			Mathavaram Taluk		
TRU	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
MARG_HH_P	245435	4.15	7.00	5.69	4.74	6.98	2.48	2.38	3.83	7.46	3.44	17.92	5.26	6.20	5.18
MARG_OT_P	1931537	24.46	75.33	56.25	34.50	85.91	31.02	28.51	62.79	54.99	47.79	73.74	90.63	77.42	91.81
NON_WORK_P	39262349	49.34	59.84	58.74	53.28	61.67	55.18	53.52	63.61	57.92	55.88	61.34	62.59	60.56	62.70
NON_WORK_M	14702997	40.64	34.64	35.27	37.76	34.13	36.27	36.89	33.62	34.20	34.74	33.39	33.24	34.11	33.20
NON_WORK_F	24559352	59.36	65.36	64.73	62.24	65.87	63.73	63.11	66.38	65.80	65.26	66.61	66.76	65.89	66.80

Note: (Source: Census 2011 Data and Government Websites)

1.	MARG_AL	Marginal Agriculture Labourers	15.	MAIN_CL_P	Main Working Cultivating Population
2.	MARG_CL	Marginal Cultivator Population	16.	MAIN_AL_P	Main Working Agriculture Population
3.	MARG_HH_P	Marginal Household Industries Population Person	17.	MAIN_HH_P	Main Working Household Industry Population
4.	MARG_OT_P	Marginal Other Workers Population Person	18.	MAIN_OT_P	Main Other Workers Population
5.	MAIN_AL	Main Agriculture Labourers	19.	MARGWORK_P	Marginal Working Population
6.	MAIN_CL	Main Cultivator Population	20.	MARGWORK_M	Marginal Working Male
7.	MAIN_HH_P	Main Household Industries Population Person	21.	MARGWORK_F	Marginal Working Female
8.	MAIN_OT_P	Main Other Workers Population Person	22.	MARG_CL_P	Marginal Working Female
9.	TOT_WORK_P	Total Working Population	23.	MARG_AL_P	Marginal Working Cultivating Population
10.	TOT_WORK_M	Total Working Male	24.	MARG_HH_P	Marginal Working Agriculture Population
11.	TOT_WORK_F	Total Working Female	25.	MARG_OT_P	Marginal Working Household Industry Population
12.	MAINWORK_P	Main Working Population	26.	NON_WORK_P	Non-Working Population
13.	MAINWORK_M	Main Working Male	27.	NON_WORK_M	Non-Working Male
14.	MAINWORK_F	Main Working Female	28.	NON_WORK_F	Non-Working Female

Table 3-36: Village and settlements falling in the Study Area as per SoI, Topo-sheet

Project Villages		0 to 1km		1 to 5km		5 to 10km		10 to 15Km	
Ponneri Taluk		Ponneri Taluk		Ponneri Taluk		Ponneri Taluk		Ponneri Taluk	
1	Kattupalli	5	Karungali	6	Andarmadam	25	Sirulapakkam	58	Kallur
2	Kattoor			7	Thangalperumbalam	26	Avurivakkam	59	Annamalaicheri
3	Voyalur			8	Sirupazhaverkadu	27	Kanavanthurai	60	Periaveppathur
4	Kalanji			9	Kadapakkam	28	Pakkam	61	Uppunelvoyal
				10	Thathamanji	29	Thirupalaivanam	62	Agaram
				11	Somanjeri	30	Poovami	63	Devambattu
				12	Athamanjeri	31	Vembedu	64	Periakarumbur
				13	Sirulapooncheri	32	Medur	65	Panapakkam
				14	Thiruvellavoyal	33	Asanabudur	66	Kumaranjeri
				15	Eripillaikuppam	34	Vanjivakkam	67	Ilupakkam
				16	Velur	35	Pralayambakkam	68	Kolur
				17	Kadamanjeri	36	Pulicut	69	Avoor
				18	Thinaipakkam	37	Perumbedu	70	Vidathandalam
				19	Marattoor	38	Lingapayampettai	71	Arasur
				20	Kalpakkam	39	Aladu	72	Appalavaram
				21	Neithavayal	40	Kumarasirulapakkam	73	Andavoyal
				22	Nandiambakkam	41	Kaniambakkam	74	Sombattu
				23	Vallur	42	Devadanam	75	Kattavur
				24	Athipattu (CT)	43	Vairavankuppam	76	Chinnakavanam
						44	Anuppampattu	77	Kanagavallipuram
						45	Vellambakkam	78	Elaimbedu
						46	Thottakadu	79	Thadaperumbakkam
						47	Nalur	80	Madhavaram
						48	Seemapuram	81	Vannipakkam
						49	Madiyur	82	Amoor
						50	Valuthigaimedu	83	Jaganathapuram
						51	Chinnamullaivoyal	84	Nayur
						52	Thirunilai	85	Nerkundram
						53	Vichoor	86	Sekkanjeri
						54	Vellivoyal	87	Soorapattu
						55	Minjur (TP)	88	Orakkadu
						56	Edayanchavadi (CT)	89	Budur
						Mathavaram Taluk		90	Kandigai
						57	Kattivakkam (M)	91	Mafaskanpet
								92	Pudupakkam
								93	Periyamullaivoyal
								94	Kodipallam
								95	Arumandai
								96	Marambedu
								97	Kummamur
								98	Angadu
								99	Perungavoor
								100	Ponneri (TP)
								Mathavaram Taluk	
								101	Kadapakkam
								102	Sadayankuppam
								103	Elandancheri
								104	Tiruvottiyur (M)
								105	Manali (M)
								Gummidipindi Taluk	
								106	Kuriviagaram
								107	Ayanallur
								Chennai M.Corp	
								108	Chennai (M Corp.) WARD NO.-0001

Source: Census 2011 Data and Government Websites

3.14.4 Secondary Census Data Analysis of the Project Study Area

Socio-economic assessment of the study area villages was carried out by interpreting the Census of India by using District Hand Book of Thiruvallur District[17] data along with various other statistical sources of Tamil Nadu governments. The study covers around 108 villages within 15km radius from the proposed project site. The details of the assessment are provided below.

3.14.4.1 Census Profile of Study Area

The census stsudy has been carried out for the 15 kmR, were, there are 1,74,745 households and population are 6,79,695 out of which **males** population is 50.21% and **females** population is 49.79%. The sex ratio of the study area is 992 females over 1000 males. In the 0-1 KmR sex ratio is the highest and in Project, villages in the least. The detailed population, households, gender-wise data and sex ratio is presented in **Table 3-37**.

Table 3-37: Households and Population of Study Area

Boundary (in Km)	No. of HH	Total Pop.	Male	%	Female	%	Sex Ratio
Project Villages	3194	11676	5965	51.09	5711	48.91	957
0 to 1 KmR	58	203	97	47.78	106	52.22	1093
1 to 5 KmR	12218	47722	24090	50.48	23632	49.52	981
5 to 10 KmR	38439	148807	74343	49.96	74464	50.04	1002
10 to 15 KmR	120836	471287	236780	50.24	234507	49.76	990
Total	**174745**	**679695**	**341275**	**50.21**	**338420**	**49.79**	**992**

3.14.4.2 Profile of Below 6 years Children

In the study area, the total Child population which is 74,307 that is around 10.93% of the total population in the study area. The child sex ratio of the study area is 947 females over 1000 males. In 0-1 KmR sex ratio is highest and in project villages, sex ratio is least. Gender wise population and sex ratios are shown in **Table 3-38**.

Table 3-38: Population of <6 Years Children

Boundary (in Km)	No. of HH	Total Pop.	< 6 yrs Pop	%	< 6 yrs Male	%	< 6 yrs Female	%	Ratio
Project Villages	3194	11676	1270	10.88	663	52.20	607	47.80	916
0 to 1 KmR	58	203	34	16.75	14	41.18	20	58.82	1429
1 to 5 KmR	12218	47722	5415	11.35	2775	51.25	2640	48.75	951
5 to 10 KmR	38439	148807	16396	11.02	8397	51.21	7999	48.79	953
10 to 15 KmR	120836	471287	51192	10.86	26307	51.39	24885	48.61	946
Total	**174745**	**679695**	**74307**	**10.93**	**38156**	**51.35**	**36151**	**48.65**	**947**

3.14.4.3 Profile of Scheduled Caste

The Scheduled Caste population of the study area is 1,59,037 which constitute to be 23.40% of the total population in the study area. The SC male population is 49.91% and the female population is 50.09%. The sex ratio of the SC population is 1004 females over 1000 males. In the 0-1 KmR villages' sex ratio is highest and in 1-5 KmR sex ratios are least. The schedule caste details are shown in **Table 3-39**.

Table 3-39: Population of Scheduled Caste

[17] *PCA3301_2011_MDSS; 3301_PART_A_DCHB_THIRUVALLUR.pdf and 3301_PART_B_DCHB_THIRUVALLUR.pdf,*

Boundary (in Km)	No. of HH	Total Pop.	SC Pop.	Total SC%	SC Male	%	SC Female	%	Ratio
Project Villages	3194	11676	4687	40.14	2338	49.88	2349	50.12	1005
0 to 1 KmR	58	203	22	10.84	8	36.36	14	63.64	1750
1 to 5 KmR	12218	47722	24519	51.38	12285	50.10	12234	49.90	996
5 to 10 KmR	38439	148807	42583	28.62	21197	49.78	21386	50.22	1009
10 to 15 KmR	120836	471287	87226	18.51	43544	49.92	43682	50.08	1003
Total	**174745**	**679695**	**159037**	**23.40**	**79372**	**49.91**	**79665**	**50.09**	**1004**

3.14.4.4 Profile of Scheduled Tribe

The Scheduled Tribe Population is 6,788 which aggregate to 1% of the total population in the study area. The sex ratio of the ST Population is 1014 females over 1000 males. In 0-1 KmR village sex ratio is highest and in Project villages, sex ratios are least. The ST Population, gender-wise data and ratio are shown in **Table 3-40**.

Table 3-40: Population of Scheduled Tribe

Boundary (in Km)	No. of HH	Total Pop.	ST Pop.	Total ST%	ST Male	%	ST Female	%	Sex Ratio
Project Villages	3194	11676	208	1.78	117	56.25	91	43.75	778
0 to 1 KmR	58	203	101	49.75	48	47.52	53	52.48	1104
1 to 5 KmR	12218	47722	1324	2.77	662	50.00	662	50.00	1000
5 to 10 KmR	38439	148807	2543	1.71	1235	48.56	1308	51.44	1059
10 to 15 KmR	120836	471287	2612	0.55	1308	50.08	1304	49.92	997
Total	**174745**	**679695**	**6788**	**1.00**	**3370**	**49.65**	**3418**	**50.35**	**1014**

3.14.4.5 Literacy & Illiteracy Profile of Study Area

The literate population in the study area is 5,11,558 which constitute to be 75.26% of the total population. The total percentage of the male literate population accounts for 53.16% and total female percentage of the literate population is 46.84%. The sex ratio of the Literacy population is 881 females over 1000 males. Detailed literacy population and percentages are shown in **Table 3-41**.

Table 3-41: Population of Literate in the Study Area

Boundary (in Km)	No. of HH	Total Pop.	Total Literacy	%	Male Lit.	%	Female Lit.	%	Ratio
Project Villages	3194	11676	7492	64.17	4308	57.50	3184	42.50	739
0 to 1 KmR	58	203	102	50.25	51	50.00	51	50.00	1000
1 to 5 KmR	12218	47722	33991	71.23	18534	54.53	15457	45.47	834
5 to 10 KmR	38439	148807	106102	71.30	57156	53.87	48946	46.13	856
10 to 15 KmR	120836	471287	363871	77.21	191877	52.73	171994	47.27	896
Total	**174745**	**679695**	**511558**	**75.26**	**271926**	**53.16**	**239632**	**46.84**	**881**

The illiterate population in the study area is 1,68,137 which constitute to be 24.74% of the total population of the study area. Total percentages of male Illiterates are 41.25% and total female percentage of illiterate population is 58.75%. The sex ratio of the Illiteracy is 1425.

The illiteracy is included of children below 6 years and old age people, dependents and others. The detailed illiteracy data is shown in **Table 3-42**.

Table 3-42: Population of Illiterate in the Study Area

Boundary (in Km)	No. of HH	Total Pop.	Total Ill	%	Male Ill	%	Female Ill	%	Ratio
Project Villages	3194	11676	4184	35.83	1657	39.60	2527	60.40	1525
0 to 1 KmR	58	203	101	49.75	46	45.54	55	54.46	1196
1 to 5 KmR	12218	47722	13731	28.77	5556	40.46	8175	59.54	1471

Boundary (in Km)	No. of HH	Total Pop.	Total Ill	%	Male Ill	%	Female Ill	%	Ratio
5 to 10 KmR	38439	148807	42705	28.70	17187	40.25	25518	59.75	1485
10 to 15 KmR	120836	471287	107416	22.79	44903	41.80	62513	58.20	1392
Total	**174745**	**679695**	**168137**	**24.74**	**69349**	**41.25**	**98788**	**58.75**	**1425**

3.14.4.6 Working & Non-Working Population

The Working population in the project study area is 2,67,917 which are around 39.42%; and non-working population in the 4,11,778 which is 60.58% of study area Population. The working ratio of the study area is very low and this should be raised by providing opportunities and skill development programs to the educated and non-educated locales.

The working and non-working profile studied and population are provided in **Table 3-43**. The non-working population includes children, old age people, dependents, and other disabled persons/ physical and mentally challenged and unemployed.

Table 3-43: Working & Non-Working Population Profile

Boundary (in Km)	No. of HH	Total Pop.	Total Worker	%	Total Non-Workers	%	Ratio
Project Villages	3194	11676	5061	43.35	6615	56.65	1307
0 to 1 KmR	58	203	81	39.90	122	60.10	1506
1 to 5 KmR	12218	47722	19324	40.49	28398	59.51	1470
5 to 10 KmR	38439	148807	60306	40.53	88501	59.47	1468
10 to 15 KmR	120836	471287	183145	38.86	288142	61.14	1573
Total	**174745**	**679695**	**267917**	**39.42**	**411778**	**60.58**	**1537**

The working male population is 76.08% and working female population is 23.92% and nonworking female population is 66.62% given in **Table 3-44**.

During the study, it was found that the female working population is very low which can be portrayed as a major drawback considering employment opportunities in the study area. The working population is provided below in details by gender-wise and ratio. The working ratio is high in 0-1 KmR villages and low in 10-15 KmR villages.

Table 3-44: Working & Non-Working (Male and Female) Population Profile

Boundary (in Km)	Male Worker	%	Female Worker	%	Ratio	Male Non-Workers	%	Female Non-Workers	%	Ratio
Project Villages	3677	72.65	1384	27.35	376	2288	34.59	4327	65.41	1891
0 to 1 KmR	53	65.43	28	34.57	528	44	36.07	78	63.93	1773
1 to 5 KmR	14340	74.21	4984	25.79	348	9750	34.33	18648	65.67	1913
5 to 10 KmR	44543	73.86	15763	26.14	354	29800	33.67	58701	66.33	1970
10 to 15 KmR	141229	77.11	41916	22.89	297	95551	33.16	192591	66.84	2016
Total	**203842**	**76.08**	**64075**	**23.92**	**314**	**137433**	**33.38**	**274345**	**66.62**	**1996**

3.14.4.7 Main & Marginal Workforce

Main-Working population in the study area are 2,18,199 which accounts to be 81.44% and the sex ratio is 245 females for 1000 males and Marginal-Working population in the study area is 49,718 which accounts to 18.56% and the sex ratio is 743 females for 1000 males. The details relative to distance are presented in **Table 3-45** & **Table 3-46**.

Table 3-45: Main & Marginal Working Population Profile

Boundary (in Km)	Total Main Workers	%	Total Mar. Workers	%
Project Villages	3492	69.00	1569	31.00
0 to 1 KmR	23	28.40	58	71.60
1 to 5 KmR	15052	77.89	4272	22.11

Boundary (in Km)	Total Main Workers	%	Total Mar. Workers	%
5 to 10 KmR	46603	77.28	13703	22.72
10 to 15 KmR	153029	83.56	30116	16.44
Total	**218199**	**81.44**	**49718**	**18.56**

Table 3-46: Main & Marginal (Male & Female) Working Population Profile

Boundary (in Km)	Main Work					Marginal Work				
	Male	%	Female	%	Ratio	Male	%	Female	%	Ratio
Project Villages	2780	79.61	712	20.39	256	897	57.17	672	42.83	749
0 to 1 KmR	14	60.87	9	39.13	643	39	67.24	19	32.76	487
1 to 5 KmR	11935	79.29	3117	20.71	261	2405	56.30	1867	43.70	776
5 to 10 KmR	36803	78.97	9800	21.03	266	7740	56.48	5963	43.52	770
10 to 15 KmR	123785	80.89	29244	19.11	236	17444	57.92	12672	42.08	726
Total	**175317**	**80.35**	**42882**	**19.65**	**245**	**28525**	**57.37**	**21193**	**42.63**	**743**

3.14.4.8 Main & Marginal Working Population Profile

Two types of working population i.e. 1) Main Working Population - in which a person works for more than 6 months and 2) Marginal Working Population - in which a person works for less than 6 months.

3.14.4.8.1 Main Working Population Profile

To understand the working force, the main working population is again categorised into four types i.e. Cultivating Workers, Agriculture workers, Household Industries workers and Other Workers.

The main working population in the project study area is 2,18,199 (81.44%) out of which main cultivators are 2.89%, agriculture workers are 9.42%, household Industries workers are 1.88% and other workers are 85.82%. The detailed given in the following **Table 3-47**.

Table 3-47: Category of Main Working Population

Boundary (in Km)	Total Main Workers	MAIN_CL_P	%	MAIN_AL_P	%	MAIN_HH_P	%	MAIN_OT_P	%
Project Villages	3492	289	8.28	911	26.09	87	2.49	2205	63.14
0 to 1 KmR	23	7	30.43	1	4.35	0	0.00	15	65.22
1 to 5 KmR	15052	509	3.38	2502	16.62	371	2.46	11670	77.53
5 to 10 KmR	46603	2349	5.04	6271	13.46	868	1.86	37115	79.64
10 to 15 KmR	153029	3154	2.06	10862	7.10	2770	1.81	136243	89.03
Total	**218199**	**6308**	**2.89**	**20547**	**9.42**	**4096**	**1.88**	**187248**	**85.82**

3.14.4.8.2 Marginal Working Population Profile

The marginal working population is also categorised into four types i.e. Cultivating Workers, Agriculture Workers, Household Industries Workers and Other Workers.

The marginal working population in the project study area is 49,718 (18.56%) out of which marginal cultivators are 2.53%, agriculture workers are 23.07%, household Industries workers are 5.52% and other workers are 68.89%. The detailed are given in the following **Table 3-48**.

Table 3-48: Category of Marginal Working Population

Boundary (in Km)	Total Mar. Workers	MARG_CL_P	%	MARG_AL_P	%	MARG_HH_P	%	MARG_OT_P	%
Project Villages	1569	68	4.33	629	40.09	20	1.27	852	54.30
0 to 1 KmR	58	4	6.90	44	75.86	0	0.00	10	17.24
1 to 5 KmR	4272	163	3.82	1102	25.80	125	2.93	2882	67.46

Boundary (in Km)	Total Mar. Workers	MARG_ CL_P	%	MARG_ AL_P	%	MARG_ HH_P	%	MARG_ OT_P	%
5 to 10 KmR	13703	386	2.82	3512	25.63	1147	8.37	8658	63.18
10 to 15 KmR	30116	636	2.11	6183	20.53	1450	4.81	21847	72.54
Total	**49718**	**1257**	**2.53**	**11470**	**23.07**	**2742**	**5.52**	**34249**	**68.89**

3.14.5 Primary Data Analysis of the Project Study Area

The primary socio-economic assessment of the study area villages was carried out by the MIDPL along with collecting various statistical information and data of the residents. The study covers around 28 villages of 15km radius from the proposed project site. The details of the assessment villages and respondent numbers are provided in following **Table 3-49**.

Table 3-49: Village wise Respondents Details

S No.	Respondent Villages	Respondent No's	%
1	Thangal Perungkulam	168	5.6
2	Kattupalli	206	6.9
4	Kaalanji	105	3.5
5	R&R Kuppam	150	5.0
6	Kattur Village	250	8.4
8	Voyalur	161	5.4
9	Voyalur Colony	46	1.5
10	Sengazhanimedu Village	113	3.8
11	Ornambedu Village	49	1.6
12	Kokkumedu	100	3.4
13	Ramanathapuram	111	3.7
14	Rajan Thoppu	100	3.4
15	Neidhavayal Village	100	3.4
16	Saanarkuppam	100	3.4
17	Mouthambedu	100	3.4
18	Thiruvellavoyal Village	100	3.4
19	Thiruvellavoyal Colony	100	3.4
20	Aandi Kuppam	151	5.1
21	Koraikuppam	123	4.1
22	Karungali Village	60	2.0
23	Kadal Kanniyur	40	1.3
24	Nandiyambakkam Village	100	3.4
25	Kattupalli Kuppam	92	3.1
26	Madhakoil Street	48	1.6
27	Athipattu Village	100	3.4
28	Velur	206	6.9
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.5.1 Age-Wise Category of the Respondents

The **Table 3-50** and **Figure 3-127** indicates that 32 per cent of the respondents belong to the age group of 36-45 years, 28% of the respondents belong to the age group of 22-35 years and very meagre numbers of respondents are from the age brackets of 18-21 (10%) years and above 56 years (7%).

Table 3-50: Age-Wise Category of the Respondents

S No	Age Group of Respondents	%
1	18-21 age	10
2	22-35 age	28
3	36-45 age	32

S No	Age Group of Respondents	%
4	46-59 age	23
5	Above 59 age	7
	Total	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

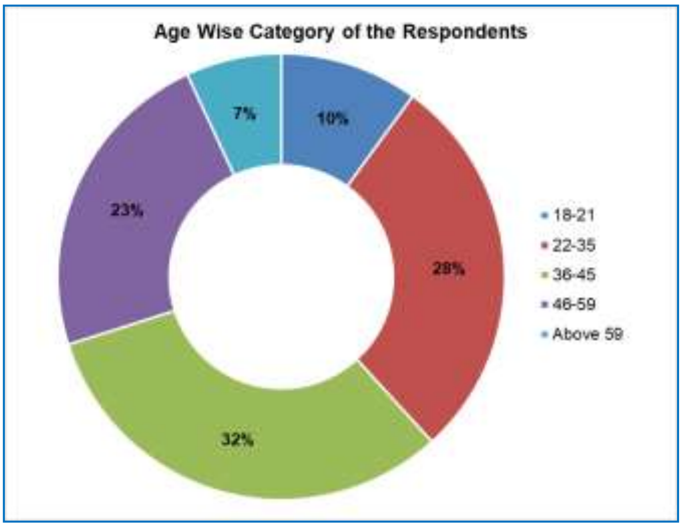


Figure 3-127: Age-Wise Category of the Respondents

3.14.5.2 Gender-Wise Category of the Respondents

Table 3-51 and **Figure 3-128** shows that there is an almost equal number of respondents, in terms of gender i.e., male and female.

Table 3-51: Gender-Wise Category of the Respondents

S No	Gender	%
1	Male	51
2	Female	49
3	Transgender	0
	Total	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

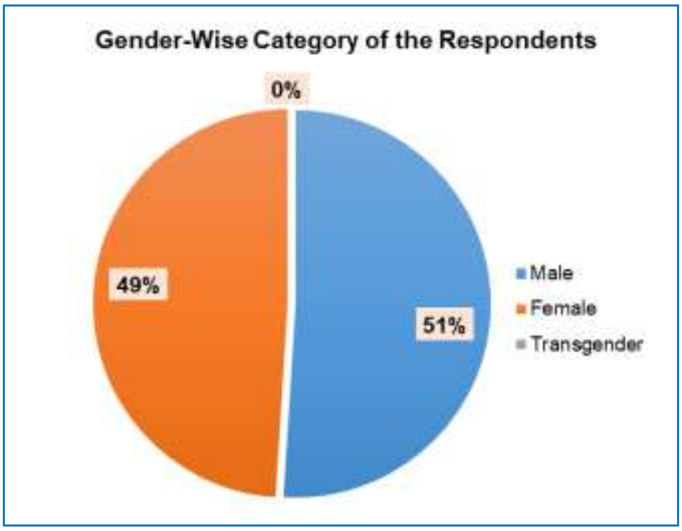


Figure 3-128: Gender-Wise Category of the Respondents

3.14.5.3 Marital, Religion and Social Category Status of the Respondents

It is observed from **Table 3-52, Table 3-53** and **Table 3-54** that the majority (82%) of the respondents are married. Likewise, a vast majority (92.5%) of the respondents are Hindus and only 0.4% falls under the “others” category.

Under community-wise categorisation, nearly half (43.3%) of the respondents are from the most backward community and 15.1% of the respondents are from a scheduled caste.

Table 3-52: Marital Status of the Respondents

Sl. No.	Marital Status	No’s	%
1	Married	2444	82.0
2	Divorcee	51	1.7
3	Unmarried	227	7.6
4	Widow	236	7.9
5	Others	21	0.7
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

Table 3-53: Religion Status of the Respondents

Sl. No.	Religion Status	No’s	%
1	Hindus	2756	92.5
2	Islam	40	1.3
3	Christians	172	5.8
4	Others	11	0.4
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

Table 3-54: Social Category Status of the Respondents

Sl. No.	Social Category Status	No’s	%
1	Forward caste	95	3.2
2	Backward caste	713	23.9
3	Most Backward caste	1290	43.3
4	Scheduled Caste	450	15.1
5	Scheduled Tribes	362	12.2
6	Others caste	69	2.3
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.5.4 Educational Status of the Respondents

It is inferred that over a quarter (28.9%) of the respondents are uneducated, 23.8% have completed primary education and 22.3% of them have completed higher secondary education. The details are provided in the following **Table 3-55** and **Figure 3-129**.

Table 3-55: Educational Status of the Respondents

Sl. No.	Educational Status	No’s	%
1	Uneducated	862	28.9
2	Primary Education	709	23.8
3	Middle School	520	17.5
4	High School	223	7.5
5	Hr. Sec. Education	665	22.3
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

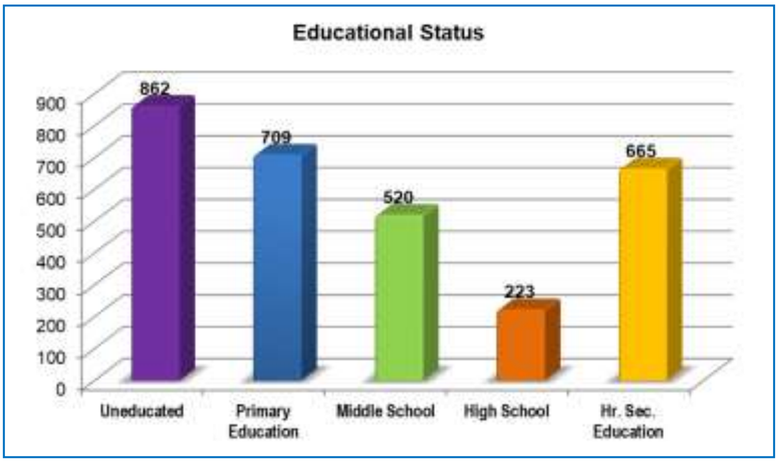


Figure 3-129: Educational Status of the Respondents

3.14.5.5 Employment Status of the Respondents

It is noted from the above table that 28.9% of the respondents are unemployed and as for the rest, 23.8% of the respondents are self-employed, 17.5% work in the private sector, and 7.5% are government employees. The employment status of the remaining 22.3% is listed under the “others” category. The details are given in the following **Table 3-56** and **Figure 3-130**.

Table 3-56: Employment Status of the Respondents

Sl. No.	Employment Status	No’s	%
1	Unemployed	862	28.9
2	Self-Employed	709	23.8
3	Private Job	520	17.5
4	Govt. Job	223	7.5
5	Others	665	22.3
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

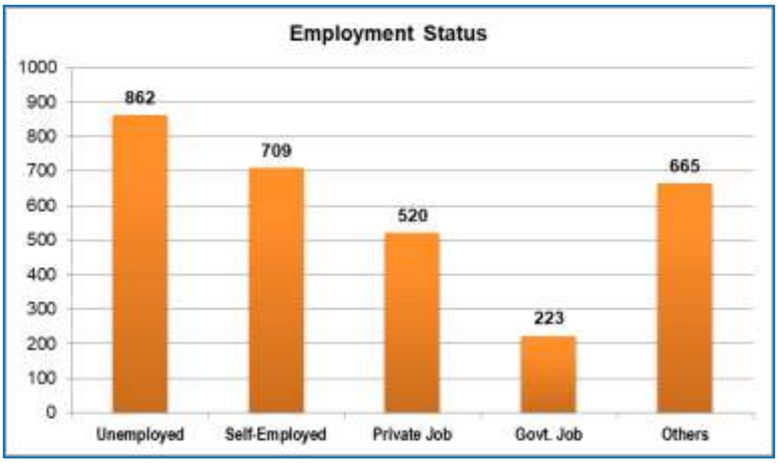


Figure 3-130: Employment Status of the Respondents

3.14.5.6 Place of Employment

It is found from the above table that the nearly half (46.5%) of the respondents are working far away from their homes and 26.3% of the respondents are employed in places nearby.

Table 3-57: Place of Employment.

Sl. No.	Place of Employment	No's	%
1	Nearby	783	26.30
2	Distant	1384	46.50
3	Not applicable	638	21.40
4	Others	174	5.80
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

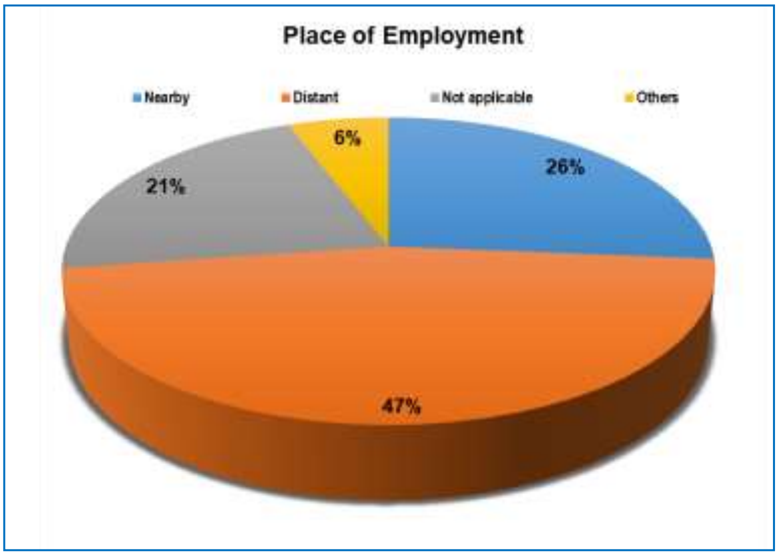


Figure 3-131: Place of Employment

3.14.5.7 Type of Employment of the Respondents

It is proved from the above figure that half (50.8%) of the respondents are unskilled employees and 19.8% of the respondents are into agriculture.

Table 3-58: Type of Employment of the Respondents

Sl. No.	Type of Employment	No's	%
1	Skilled	294	10%
2	Unskilled	1512	51%
3	Business	71	2%
4	Self-Employed	32	1%
5	Fishing Industry	243	8%
6	No Job	237	8%
7	Agriculture	590	20%
	Total	**2979**	**100%**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

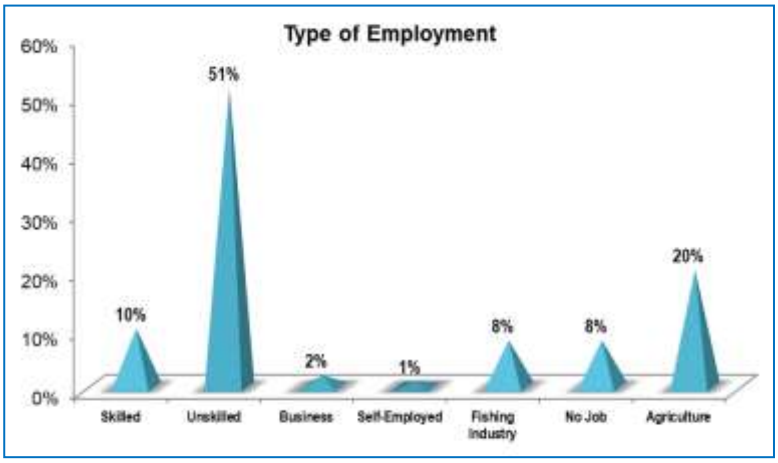


Figure 3-132: Type of Employment of the Respondents

3.14.5.8 Employment Offered by the Local Companies / Organization

It is proved from the **Table 3-59** that 27.7% of the respondents said that they get employment in Adani port, while 25.5% of the respondents said that they get employment in L&T. It is noted that when compared with eight other organizations in the vicinity, Adani and L&T give more employment opportunity to the surrounding people.

Table 3-59: Employment Offered by the Local Companies / Organization

Name of the Companies	No's	%
Adani Port	794	27.7
Cement Factory	292	9.8
CPCL	463	15.5
L&T	764	25.6
Harbor	68	2.3
Kamaraj Port	222	7.5
NTR	28	0.9
Power Plant	36	1.2
EB	179	6.0
Jambo Bag	68	2.3
No Idea	101	3.4
Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.5.9 Family Income of the Respondents

It is noted from the above data that a vast majority (82%) of the respondents' monthly income falls below Rs.5000 and only 7.9% of the respondents' income lies between Rs.10000 to 15000. Hence, it is proved from this finding that the problem of poverty is highly prevalent among the village population.

Table 3-60: Income of the Respondents

Sl. No.	Income Status	No's	%
1	No Earning	51	1.71
2	Below 5000	2444	82.04
3	5001-10000	227	7.62
4	10001-15000	236	7.92
5	15001-20000	21	0.70
	Total	**2979**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

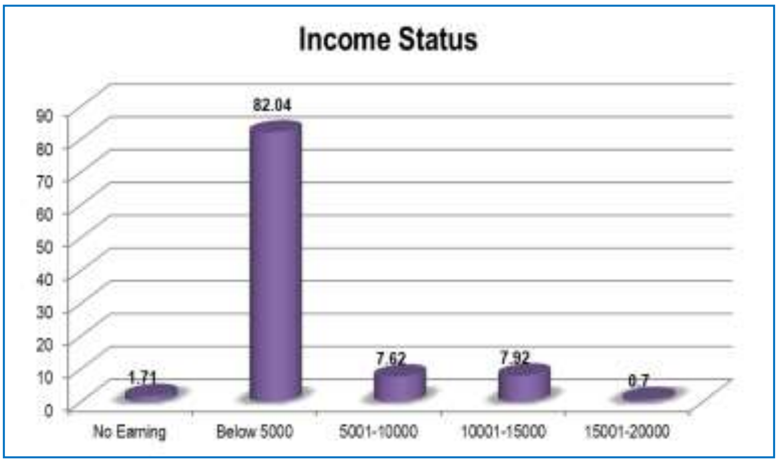


Figure 3-133: Income of the Respondents

3.14.5.10 Family Expenditure Status of the Respondents

Table 3-61 explains the expenditure pattern of the respondents. It is found that

- The majority (75.9%) of the respondents spend Rs. 901-1100 on transport and it is a really unfortunate situation for them since the majority belongs under the poverty line.
- In the case of food expense, the majority (86.2%) of the respondents spend around Rs. 3000.
- 97% of the respondents spend Rs. 500/- on Recreation.
- 34.9% of the respondents spend around Rs. 1000/- on medical expenses.

Based on the above findings, it is suggested that the organization can conduct medical camps and also set up a hospital at least for their acute diseases, and recommendations can be given to the government to provide better public transport facility. Both of these problems have been discussed in qualitative methods as well.

Table 3-61: Family Expenditure status of the Respondents

Particulars	Options	
	Highest %	Lowest %
Transport		
Rs. 901-1100	75.9	
Rs.500-700	-	5.5
Food Expenses		
Around Rs. 3000	86.2	
Below Rs. 2000	-	13.8
Expenses for Recreation		
Around Rs. 500	97.8	
Nothing	-	2.2
Medical Expenses		
Around Rs. 1000	34.9	
Around Rs. 3000		7.3

**Only the highest and the lowest values are mentioned.*
Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.5.11 Infrastructure Facility of the Respondents

It is proved from the above table that a vast majority (89.5%) of the respondents do not have toilet facility and more than half (66.9%) of the respondents do not have bathroom facility. Another significant finding is that a large number of respondents (87.5%) reported having problems in getting clean drinking water, which is one of the basic needs of human life. To substantiate this, the UN has also included ensuring the availability of drinking water in its Sustainable Development Goals.

Table 3-62: Status of Common Infrastructure Facility

Infrastructures	Own House*	Thatched House*	Two Rooms*	No*	Yes*	Public Taps*	Common Wells*
Ownership of the House	73.3%	-	-	-	-	-	-
Type of House	-	55.3%	-	-	-	-	-
Number of Rooms at Home	-	-	70.3%	-	-	-	-
Toilet Facility at Home	-	-	-	89.5%	-	-	-
Bathroom Facility	-	-	-	-	66.9%	-	-
Source for Drinking water	-	-	-	-	-	87.5%	-
Water Source for household purposes	-	-	-	-	-	-	89.5%

**Majority of the per cent has been taken into consideration*
Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

The key findings of the infrastructure facility are given below:

- The majority (66.6%) of the respondents recorded that there is no open sewage water in their villages.
- It is found that a vast majority (85.1%) of the respondents have access only to the intermittent power supply and the alternate power supply facelities to be made availiable for the people of project area.
- A vast majority (84.3%) of the respondents said that there are no trash boxes to collect the waste from every household.

Table 3-63: Infrastructure Facility of the Respondents

Infrastructure Facility	No's	%
Open Sewage		
Yes	994	33.4
No	1985	66.6
Total	2979	100.0
Electricity Facility at Home		
Electricity connection*	2536	85.1
No Electricity Connection	443	14.9
Total	2979	100.0
Trash Box is available nearby		
Yes	466	15.6
No	2513	84.3
Total	2979	100.0
Disposal of Household Waste		
Trash Box	1191	40.0
Using Fuel	1788	60.0
Total	2979	100.0

**Electricity connection is provided but the power supply is available only 2 to 5 hours per day*
Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.5.12 Health & Sanitation Facilities of the Respondents

It is inferred from **Table 3-64** that the majority of the respondents have opted for family planning and a vast majority (98.3%) of the respondents' families expect the female members to undergo family planning and not the men. This finding substantiates that in India till date the conservative behaviour of the people has not changed.

Concerning physical health problems, 44.8% of the respondents have faced only acute diseases. A vast majority (99.5%) of the respondents expressed that they have not faced any mental health issues.

Table 3-64: Health & Sanitation facilities of the Respondents

S. No.	Particulars	No's	%
	Family Planning		
1	Yes	2359	79.2
2	No	620	20.8
	Total	**2979**	**100.0**
1	Male	39	1.3
2	Female	2940	98.7
	Total	**2979**	**100.0**
	Physical Health Problems		
1	Acute Diseases	1335	44.8
2	Blood Pressure	415	13.9
3	BP & Diabetic	633	21.2
4	Breathing Problem	173	5.8
5	Diabetics	133	4.5
6	Thyroid	290	9.7

S. No.	Particulars	No's	%
	Total	**2979**	**100.0**
	Mental Illness		
1	Yes	14	0.5
2	No	2965	99.5
3	**Total**	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

Table 3-65: Required Health Development of the Respondents

S No	Health Facilities Requirement from Respondents	No's	%
1	Clean Drinking Water	41	1.4
2	Proper Waste Management	162	5.4
3	Health Awareness Programs	75	2.5
4	Health Food	100	3.4
5	Health & Hygiene Program	83	2.8
6	Health Camps & Hospital Facility	1001	33.6
7	No Ideas	354	11.9
8	Toilet Facility	1163	39.0
	Total	**2979**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.6 Fishery Villages' Secondary Census Data Analysis of the Project Study Area

3.14.6.1 Fishery Census of Tamil Nadu State

The State has marine fishermen population of 10.07 lakh from 608 marine fishing villages scattered along with the 13 coastal districts. In the inshore waters, the fishery potential is exploited by 38,779 traditional crafts and 5893 mechanized boats. The infrastructure facilities include 6 major fishing harbours, 3 medium fishing harbours, 36 fish landing centres and 254 fish landing points.

The export of marine products from the state during 2017-18 amounted to 88,257 metres valued at Rs.4341.78 Crore. The per capita consumption of fish in Tamil Nadu is 9.83 Kg as against the recommended requirement of 11.60 kg.[18]

3.14.6.2 Fishery Census Villages and Population of Project Study Area

The details of the fishing community/households and fish landing centre, marine fishing village census, population details, activity details, education details, occupation details, craft owned details and fishing craft details of 15 kmR study area are given in **Table 3-66** to **Table 3-73**.

Table 3-66: List of Landing Centres and Marine Fishing Villages[19]

Landing Centres			Fishing Villages		
Talukas	**Sl No**	**Villages**	**Talukas**	**Sl No**	**Villages**
Ponneri	1	Ennore Kuppam	**Ponneri**	1	Ernavoor Kupam
	2	Ernavoor Kuppam		2	Indira Gandhi Kuppam
	3	Indira Gandhi Kuppam		3	Kattupallikuppam
	4	Kasikoil Kuppam		4	Light House Nadu Kuppam
	5	Kathivakkam Chinna Kuppam		5	Pasiyavaram
	6	Kathivakkam Peria Kuppam		6	Thirumalai Nagar
	7	Kattupalli Kuppam		7	Varivan Kuppam
	8	Light House Kuppam			

[18] https://www.fisheries.tn.gov.in/MarineFisheries
[19] http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf

Landing Centres			Fishing Villages		
Talukas	Sl No	Villages	Talukas	Sl No	Villages
	9	Nettukuppam			
	10	Pasivarakuppam (Rajiv Gandhi Kuppam)			
	11	Thirumalainagar Kuppam			
	12	Vairavan Kuppam			

Source: ***http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf*** *and CMFR Report, 2010*

Table 3-67: Fishermen Household Details

Fishing Villages	Fishermen Households and Family Details			
Villages	Fishermen Families	Traditional fishermen families	BPL families	Fisherfolk population
Ernavoor Kupam	135	135	135	466
Indira Gandhi Kuppam	70	70	70	253
Kattupallikuppam	97	97	97	319
Light House Nadu Kuppam	88	88	88	288
Pasiyavaram	125	125	103	424
Thirumalai Nagar	324	324	293	1036
Varivan Kuppam	226	226	226	799
Total	**1065**	**1065**	**1012**	**3585**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-68: Fishermen Population Details

	Population								
	Male			Female			Total	Others	
Fishing Villages	Adults	up to 5	above 5	Adults	up to 5	above 5		Average family size	Sex Ratio
Ernavoor Kupam	169	7	70	156	9	55	**466**	3.45	894
Indira Gandhi Kuppam	89	8	32	83	8	33	**253**	3.61	961
Kattupallikuppam	118	14	29	117	18	23	**319**	3.29	981
Light House Nadu Kuppam	97	20	23	109	15	24	**288**	3.27	1057
Pasiyavaram	108	13	86	123	21	73	**424**	3.39	1048
Thirumalai Nagar	365	53	97	378	50	93	**1036**	3.20	1012
Varivan Kuppam	193	41	166	225	37	137	**799**	3.54	998
Total	**1139**	**156**	**503**	**1191**	**158**	**438**	**3585**	**3.37**	**994**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-69: Fishermen Education Profile

	Education					
Fishing Villages	Primary		Higher Secondary		Above Higher Secondary	
	Male	Female	Male	Female	Male	Female
Ernavoor Kupam	103	93	122	107	8	6
Indira Gandhi Kuppam	65	81	50	30	3	3
Kattupallikuppam	40	29	53	60	4	1
Light House Nadu Kuppam	56	71	41	40	18	7
Pasiyavaram	93	118	75	50	8	12
Thirumalai Nagar	268	295	175	161	13	5
Varivan Kuppam	191	206	114	109	18	10
Total	**816**	**893**	**630**	**557**	**72**	**44**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-70: Fishermen Activity Profile

Fishing Villages	Actual fishing		Fish seed collection				Total
	Full time	Part-time	Full time		Part-time		
			Male	Female	Male	Female	
Ernavoor Kupam	129	10	0	0	0	0	**139**
Indira Gandhi Kuppam	75	0	0	0	0	0	**75**
Kattupallikuppam	0	0	0	0	0	0	**0**
Light House Nadu Kuppam	89	0	0	0	0	0	**89**

Fishing Villages	Actual fishing		Fish seed collection				Total
	Full time	Part-time	Full time		Part-time		
			Male	Female	Male	Female	
Pasiyavaram	111	0	0	0	0	0	**111**
Thirumalai Nagar	327	30	0	0	0	0	**357**
Varivan Kuppam	200	0	0	0	0	0	**200**
Total	**931**	**40**	**0**	**0**	**0**	**0**	**971**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-71: Fishermen Occupation Profile

Occupation Profile									
Fishing Villages	Active fishermen	Marketing of fish	Making/ Repairing Net	Curing/ Processing	Peeling	Labourer	Others	Other than fishing	Total occupied
Ernavoor Kupam	139	68	0	0	0	0	0	8	**215**
Indira Gandhi Kuppam	75	19	0	0	0	0	0	3	**97**
Kattupallikuppam	0	6	0	0	0	0	0	88	**94**
Light House Nadu Kuppam	89	8	0	0	0	2	0	0	**99**
Pasiyavaram	111	42	0	0	0	11	3	0	**167**
Thirumalai Nagar	357	60	0	0	0	0	0	9	**426**
Varivan Kuppam	200	22	0	0	1	6	1	12	**242**
Total	**971**	**225**	**0**	**0**	**1**	**19**	**4**	**120**	**1340**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-72: Fishermen Craft Owned and Fishing Profile[20]

Fishing Villages	CRAFT OWNED BY FISHERFOLK		
	Mechanized	Outboard	Non-motorized
Ernavoor Kupam	3	20	22
Indira Gandhi Kuppam	0	15	10
Kattupallikuppam	0	0	1
Light House Nadu Kuppam	0	14	0
Pasiyavaram	0	32	0
Thirumalai Nagar	0	43	1
Varivan Kuppam	0	56	2
Total	**3**	**180**	**36**

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

Table 3-73: Fishing Craft in Fishery Profile

Fishing Craft in The Fishery							
Fishing Villages	Trawlers	Gillnetters	Ring seiners	Total Mechanized	Motorized	Non-motorized	Total
Ennore Kuppam	0	0	0	0	37	0	37
Ernavoor Kuppam	0	0	0	0	29	0	29
Indira Gandhi Kuppam	0	0	0	0	44	10	54
Kasikoil Kuppam	0	0	0	0	79	20	99
Kathivakkam Chinna Kuppam	0	0	0	0	36	0	36
Kathivakkam Peria Kuppam	0	0	0	0	49	0	49
Kattupalli Kuppam	0	0	0	0	0	2	2
Light House Kuppam	0	0	0	0	35	0	35
Nettukuppam	0	0	0	0	75	30	105
Pasivarakuppam (Rajiv Gandhi Kuppam)	0	0	0	0	59	0	59
Thirumalainagar Kuppam	0	0	0	0	140	0	140
Vairavan Kuppam	0	0	0	0	140	20	160

[20] *http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf and CMFR Report, 2010*

Fishing Craft in The Fishery							
Fishing Villages	Trawlers	Gillnetters	Ring seiners	Total Mechanized	Motorized	Non-motorized	Total
Total	0	0	0	0	723	82	805

Source: **http://eprints.cmfri.org.in/9002/1/TN_report_full.pdf** *and CMFR Report, 2010*

3.14.7 Fishery Villages' Primary Census Data Analysis of the Project Study Area

The Socio-economic survey and impact study was conducted among 8 villages of fishermen communities to explore the socio-economic conditions and to know the impact. The main purpose of the study report is to identify the problem areas and develop new strategies to improve the present conditions of the people. For a deeper understanding, the study adopted both qualitative and quantitative methods for fishermen communities. The quantitative method results have been discussed below.

Table 3-74: Respondents Details of Fishery Villages

S. No.	Name of the villages	No's	%
1	Vairavan Kuppam	228	22.33
2	Sattan Kuppam	104	10.19
3	Kottai Kuppam	60	5.88
4	Madha Kuppam	50	4.90
5	Aandi Kuppam	136	13.32
6	Arangan Kuppam	200	19.59
7	Kattupalli	102	9.99
8	Korai Kuppam	141	13.81
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.1 Age-Wise Respondents Details of Fishery Villages

The majority of the respondents (30.50%) belong to the age group of 22-35 years followed by 36-45 years 27.90%, 46-59 years are 23.30%, above 59 years are 10.20% and 18-21 years is 8.10%. The details are provided in **Table 3-75**.

Table 3-75: Age-Wise Respondents Details of Fishery Villages

S No	Age Group of Respondents	No's	%
1	18-21	83	8.10
2	22-35	311	30.50
3	36-45	285	27.90
4	46-59	238	23.30
5	Above 59	104	10.20
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.2 Gender-Wise Respondents Details of Fishery Villages

Table 3-83 shows that there is an almost equal number of respondents, in terms of gender i.e., male and female.

Table 3-76: Gender-Wise Respondents Details

S No	Gender	No's	%
1	Male	552	54.1
2	Female	469	45.9
3	Transgender	0	0
	Total	**1021**	**100.0**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.3 Marital, Religion and Social Category Profile of Fishery Villages' Respondents

It is observed from the below that the majority (83.40%) of the respondents are married. Likewise, 92.0% of the respondents are Hindus and 53.10% falls under the "Most Backward Caste" category. The details are given in **Table 3-77** to **Table 3-79**.

Table 3-77: Marital Status of Respondents

Sl. No.	Marital Status	No's	%
1	Married	852	83.40
2	Divorcee	25	2.40
3	Unmarried	60	5.90
4	Widow	83	8.10
5	Others	1	0.10
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

Table 3-78: Religion Status of Respondents

Sl. No.	Religion Status	%
1	Hindus	92.00
2	Islam	3.00
3	Christians	5.00
4	Others	0.00
	Total	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

Table 3-79: Social Category Status of Respondents

Sl. No.	Social Category Status	No's	%
1	Forward Caste	50	4.90
2	Backward Caste	255	25.00
3	Most Backward Caste	542	53.10
4	Scheduled Caste	69	6.80
5	Scheduled Tribes	14	1.40
6	Others caste	91	8.90
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.4 Education Profile of Fishery Villages' Respondents

It is inferred from **Table 3-80** that 50.20% of the respondents are uneducated, 9.50% have completed primary education and 13.80% of them have completed higher secondary education. The details are provided in the below table.

Table 3-80: Educational Status of Fishery Villages

Sl. No.	Educational Status	No's	%
1	Uneducated	513	50.20
2	Primary Education	97	9.50
3	Middle School	166	16.30
4	High School	141	13.80
5	Hr. Sec. Education	61	6.00
6	UG Degree	43	4.20
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.5 Health & Diseases Status of the Respondents

It is inferred that 50.10% of the respondents have high blood pressure (hypertension) problem; 38.3% of respondents face acute diseases like general fever, cold & cough and body aches. It is found that none of the respondents faced any problem related to mental illness or mental retardation. The details are given in **Table 3-81**.

Table 3-81: Health & Diseases Status of the Respondents

S No	Name of Diseases	No's	%
1	Acute Diseases	391	38.3
2	High Blood Pressure	512	50.1
3	High BP & Diabetic	114	11.2
4	Breathing Problems	4	0.4
	Total	**1021**	**100**

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.6 Government Schemes Availed by the Respondents

It is observed from the below that the majority of the respondents have not availed of many schemes provided by the government such as educational assistance, financial assistance for the differently-abled, vehicle loan, a loan without interest, medical insurance, or career development training. However, around 12.7% of the fishing community have not availed themselves of the free mixer grinder. Therefore, it is worthwhile for nearby industries to create awareness among the general public regarding government schemes and create support systems under their CSR projects.. The scheme benefits are given in **Table 3-82**.

Table 3-82: Government Schemes Availed by the Respondents

Schemes	Variable	No's	%
Educational Assistance	No	1012	99.1
Financial Assistance for Differently Abled	No	661	64.7
Widow Pension	No	639	62.6
Free Cycle	No	950	93.0
Vehicle Loan	No	999	97.8
Loan without Interest	No	997	97.6
Medical Insurance	No	990	97.0
Career Development Training	No	952	93.2
Free Mixer Grinder	No	130	12.7

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

3.14.7.7 Landing Centres and Marine Fishing Villages

The study area includes coastal and fishing villages of the project study area. Among which, they are Vairavankuppam, Koraikuppam, Kadalkannikuppam and Kattupalli, whereas Karungali, which is situated in between Kattupalli and Kadalkannikuppam. And these fishing villages are situated from north to the centre region of the study area. The Marine study was conducted by the ***Suganthi Devadason Marine Research Institute (SDMRI)***, Thoothukkudi as per the requirements of MIDPL. The same data is used for the assessment of the social study of the fishing communities within the project study area and to interpret it in the social and economical cotext as follows:

3.14.7.7.1 Socio-Economic Status of Coastal Communities

The residents of these fishing villages in the study area are engaged in fishing as a primary occupation. Most of them are using the traditional method of fishing. Most of the fishermen do not have their boat and they are working as crew members in the other's boat. The economic conditions of these fishermen are poor. They are not having proper drinking water supply, proper medical and health care facilities. The non-availability of proper transport facilities separates these fishermen from the nearby urban area. Therefore, they have a low standard of living.

3.14.7.7.2 Economic Activities in the Study Area

The exploitation of fishes and other fishery resources in the marine, brackish and freshwater zone has been the occupation of several fishermen families living along the coast. They have been in close proximity with the sea, brackish and freshwaters (such as Kosasthalaiyar River, Mangroves, Buckingham canal, Pulicat Lake and Ennore creek) and, so that, their life-style, culture, community and social life are centred around the sea and brackish water. During the survey, it has been identified that some of the activities of the fishermen residing in the villages are as follows:

a) Fishing in the sea and brackish water zone
b) Hand-picking of prawns
c) Shell collection
d) Polychaetes collection
e) Cooli (Daily wage Labourers)

3.14.7.7.3 Fishing – Primary Economic Activity

Fishing is the primary economic activity of the people of the fishing villages in the study area. About 1810 fishermen are living in a fishing village in the study area. The fishermen employ mostly FRP boats fixed with outboard engine. Nearly 269 motorized fibre boats are operated for fishing from these fishing villages (**Table 3-83**), few small non-motorized fibre boats are also available, which are particularly used for fishing in the brackish and freshwater area (mainly in Kosasthalaiyar river and Buckingham canal). The various fishing gears used by the fishermen for fishing are thread net, shrimp net, mani valai, kanni valai, visuru valai, crab net, hooks, gill net, ayala valai, velamen valai, kattu valai and pomfret net, of which kanni valai and visuru valai are mainly used for fishing in brackish and freshwater area (**Table 3-84** and **Figure 3-134**). Fishing time of the village is morning 3.00 am to 8.00 am in the marine zone, whereas in the brackish water zone, 6.00 am to 11.00 am, whereas it may extend to 3.00 pm some days.

Fish caught was higher in Koraikuppam, followed by Kattupalli, followed by Vairavankuppam, followed by Kadalkannikuppam and Karungali with 1697 kg/day, 1453 kg/day, 1441 kg/day, 1097 kg/day and 206 kg/day respectively (Fig. 3.9.1). The low catch in Karungali is because of only fishing in Kosasthalaiyar River. Totally 58 species of fishes were caught from the region, among the finfishes, Rastrelliger kanagurta was the most landed fish species with 924 kg/day followed by Alepes djedaba with 326 kg/day and Sardinella sp. with 237 kg/day (Table 3.9.3). As far as crab species, Portunus pelagicus recorded highest caught followed by Portunus sanguinolentus with 101 kg/day and 76 kg/day. Koraikuppam recorded higher number of species caught followed by Vairavankuppam, followed by Kattupalli, followed by Kadalkannikuppam and Karungali with 55, 51, 50, 40 and 8 numbers respectively. Fishes caught in this region are widely seasonal and major fishes caught in this region are recorded during the month of April and May. Total commercial fishery resource of this villages includes 58 species and the overall caught was 5,906 kg/day.

Table 3-83: Types of Crafts and Gears Details

Craft & Gears	Vairavan-kuppam	Korai-kuppam	Kadalkanni-kuppam	Karungali	Kattupalli
Types of crafts	FRB	FRB	FRB	FRB	FRB

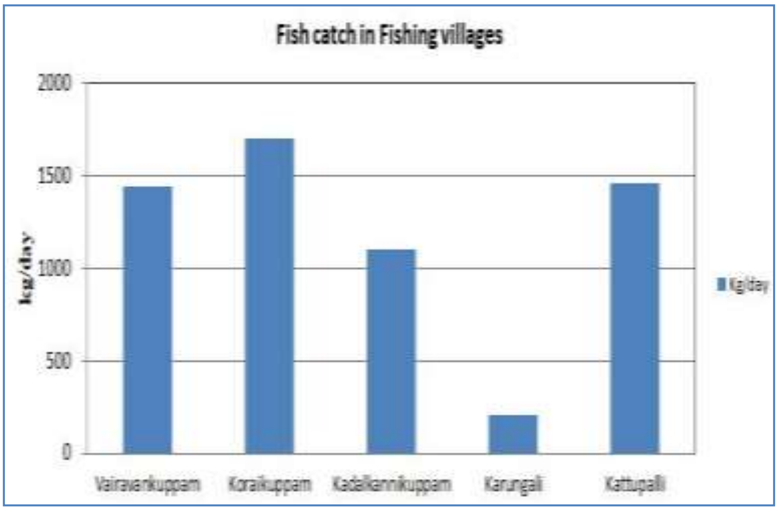
Craft & Gears	Vairavan-kuppam	Korai-kuppam	Kadalkanni-kuppam	Karungali	Kattupalli
No of crafts	150	64	15	10	30
Types of gears	Thread net, Gill net, hooks, kattu valai, mani valai, shrimp net	Hooks, ayala valai, crab net, velameen valai,	Hooks, gillnet, fish net, carb net, pomfret net	Kanni valai, visuru valai	Kanni valai, visuru valai, hooks, velameen valai, ayala valai, hooks
Prefered gears	Hooks	Hooks, ayala valai, velameen valai and crab net	Hooks & gillnet	Kanni valai & visuru valai	Velameen valai & ayala valai

Source: Primary study conducted by Suganthi Devadason Marine Research Institute (SDMRI), Chennai appointed by MIDPL

Table 3-84: Dominant Catch, Peak Seasons and Fishing Ground Details

Fishing activities	Vairavan-kuppam	Korai-kuppam	Kadalkanni-kuppam	Karungali	Kattupalli
Most dominant fish catch	Ayala, iral, seer fish	Ayala, Paarai, Velameen	Shrimph, lutjanus, promfret	Shrimp	Ayala, ooli, lutjanus
Average catch (Kg) per day	1441	1697	1097	206	1453
No of fishing days in a month	20 to 25	25	20 to 25	25	20 to 25
Peak seasons	April, May	April	April, May	All seasons	April
Fishing ground	Sea, lake, canal and river	Sea, lake, canal and river	Sea, lake and river	River and canal	Sea, river and canal

Source: Primary study conducted by Suganthi Devadason Marine Research Institute (SDMRI), Chennai appointed by MIDPL



Source: Primary study conducted by Suganthi Devadason Marine Research Institute (SDMRI), Chennai appointed by MIDPL

Figure 3-134: Fish Catching Details of fishing Villages

Table 3-85: Type of Fishes Landing Details

S. No.	Fish species	Vairavan-kuppam	Koraikuppam	Kadalkanni-kuppam	Karungali	Kattupalli
		kg/day	kg/day	kg/day	kg/day	kg/day
1	*Alepes djedaba*	76	68	102	0	80
2	*Alepes melanoptera*	24	18	13	0	16
3	*Arius jella*	40	24	22	0	19
4	*Brotula* sp.	15	0	0	0	0
5	*Carangoides armatus*	25	12	0	0	20
6	*Carcharhinus limbatus*	5	13	0	0	10
7	*Cephalopholis formosa*	12	10	0	0	8
8	*Chaetodon decussatus*	0	3	5	0	3
9	*Charybdis natator*	19	15	18	0	16
10	*Chirocentrus dorab*	35	17	62	0	30

S. No.	Fish species	Vairavan-kuppam	Koraikuppam	Kadalkanni-kuppam	Karungali	Kattupalli
		kg/day	kg/day	kg/day	kg/day	kg/day
11	*Clarias batrachus*	21	21	16	0	18
12	*Dussumieria acuta*	0	26	33	0	54
13	*Epinephelus malabaricus*	0	16	18	0	19
14	*Epinephelus merra*	2	0	0	0	4
15	*Escualosa thoracata*	15	8	0	0	17
16	*Etroplus suratensis*	0	0	0	0	8
17	*Euthynnus affinis*	19	27	20	0	0
18	*Gerres limbatus*	14	13	10	0	12
19	*Hemiramphus far*	21	8	0	0	17
20	*Heniochus acuminatus*	0	6	5	0	13
21	*Leiognathus dussumieri*	10	20	18	0	20
22	*Liza parsia*	18	19	23	0	18
23	*Liza vaigiensis*	10	13	26	0	12
24	*Loligo* sp.	12	16	23	0	25
25	*Lutjanus fulviflamma*	20	15	0	28	36
26	*Lutjanus rivulatus*	0	6	0	19	18
27	*Megalaspis cordyla*	17	6	13	39	6
28	*Mugil* sp.	16	23	39	17	40
29	*Narcine brunnea*	14	24	16	0	39
30	*Nemipterus* sp.	28	38	35	0	47
31	*Nibea maculata*	9	18	0	0	19
32	*Pelates quadrilineatus*	23	20	0	0	36
33	*Platax orbicularis*	21	18	15	0	36
34	*Rastrelliger kanagurta*	267	295	202	0	160
35	*Sardinella* sp.	85	68	36	0	48
36	*Scarus ghobban*	20	20	0	0	19
37	*Scatophagus argus*	8	11	0	0	13
38	*Scomberoides commersonianus*	30	48	23	0	38
39	*Selaroides leptolepis*	42	26	15	0	0
40	*Siganus javus*	16	20	13	0	0
41	*Siganus lineatus*	8	10	8	0	15
42	*Sillago sihama*	16	23	3	0	15
43	*Sphyraena jello*	35	60	13	0	47
44	*Sphyraena* sp.	59	68	23	0	32
45	*Synaptura commersonnii*	60	45	20	0	28
46	*Tenualosa ilisha*	35	15	0	0	19
47	*Thryssa malabarica*	15	16	0	0	0
48	*Trachinocephalus myops*	3	8	4	0	0
49	*Triacanthus biaculeatus*	6	3	6	0	0
50	*Trichonotus* sp.	8	10	8	0	14
51	*Portunus pelagicus*	16	35	20	0	30
52	*Portunus sanguinolentus*	15	20	23	0	18
53	*Scylla serrata*	0	8	5	0	4
54	*Penaeus monodon*	38	105	55	11	82
55	*Penaeus japonicus*	15	45	20	25	19
56	*Metapenaeus* sp.	65	136	68	0	111
57	*Penaeus canaliculatus*	23	38	0	40	26
58	*Penaeus latisulcatus*	15	23	0	27	11

Source: Primary study conducted by Suganthi Devadason Marine Research Institute (SDMRI), Chennai appointed by MIDPL

3.14.7.7.4 Hand-Picking of Prawns and Shell Collection

Fishermen use hand picking method to catch the prawns from the brackish water zone (Kosasthalaiyar River, Buckingham canal, Pulicat Lake and Ennore creek). Mostly women were involved in handpicking. Similarly they also collect shells from the brackish water zone by handpicking method. The usual fishing time in the brackish water zone extends from morning 6.00 am to forenoon at 11.00 am, whereas it extends to 3.00 pm in some days. They usually sell their catch in the Kamaraj Port roadside near Athipattu Pudunagar and some time to the nearby landing centre Pulicat and Thazhakuppam.

3.14.7.7.5 Polychaetes collection

Few fishermen also involved in collection of Polychaetes from the brackish water zone, particularly in the mudflats in the Kosasthalaiyar River. They involved in the collection during the low tide time when most of the mudflat is exposed above water. The collections of Polychaetes are one of the secondary fishing activities for a few fishermen. Both fishermen and fisherwomen are involved in the collection.

3.14.7.7.6 Cooli or Daily wage Labourers

The main secondary way of income for the local fishermen is through cooli. They are getting fishing related and non-fishing jobs in the nearby area, mostly in aquafarm, salt pan, L & T and Power plant. Mostly they are getting wages on daily basis.

3.14.7.7.7 Summary Results and Remarks

The study area which covers the Vairavankuppam, Koraikuppam, Kadalkannikuppam, Kattupalli and Karungali where the fishery survey was conducted. The residents of these fishing villages have fishing as the primary occupation. Most of the fishermen do not have their boat and are working as crew members others' boats. They fish in the sea, lake, river and canal. The villages do not have proper drinking water supply, transportation, proper medical and health care facilities. The exploitation of fishery resources in the marine and brackish water zones by the fishermen is significant. Some of the fishing related activities of the villagers include fishing in the sea and brackish waters, handpicking of prawns, shell collection, polychaetes collection and working as coolies in aqua forms and other agencies. There are about 1810 fishermen live in the study area. The fishermen employ mostly FRP boats fixed with outboard engine. There are about 269 motorized fibre boats are being operated from the study area. Various fishing gears used by the fishermen include thread net, shrimp net, mani valai, kanni valai, visuru valai, crab net, hooks and lines, gill net, ayala valai, velamen valai, kattu valai and pomfret net, of which kanni valai and visuru valai are mainly used for fishing in brackish water area. Fish catch was higher in Koraikuppam, followed by Kattupalli and Vairavankuppam with 1697, 1453 and 1441 kg/day respectively. Among the 58 landed species, *Rastrelliger kanagurta* was the dominantly caught species followed by *Alepes djedaba* and *Sardinella* sp. In the case of shellfish, *Portunus pelagicus* and *P. sanguinolentus* were the dominantly landed fishes in this region. Fishermen use hand picking method to catch the prawns from the brackish water zone. Mostly women were involved in handpicking. Few fishermen are also involved in collection of polychaetes from the brackish water zone, particularly in the mudflats in the Kosasthalaiyar River.

Exhibit 3-33: Fishing Activities

Exhibit 3-34: Fishing and Marketing Activities

3.14.8 Archaeological Sites in the Study area

This region was under a chain of regimes commencing from the Pallavas during 7th century CE ending with the Nawabs of Arcot during the early part of 19th century CE when it came under the British rule. The town of Pulicat was the earliest Dutch possession in India founded in 1609 CE which was ceded to the British in 1825 CE.[21]

It was studied that there are no Archaeological Monuments as per the Archaeological Survey of India and State Archaeological department observed in the project area.

Pulicat or Pazhaverkadu is a historic seashore town on the southern periphery of the Pulicat Lake. In Pulicat town Dutch Cemeteries are observed and ASI identified these as monuments and it is situated around 6.7 km from the project site (northeast of the project)[22]. The picture of the Dutch cemetery is given in **Exhibit 3-35**. And the location of the moument is given in **Figure 3-135**.

Exhibit 3-35: Dutch Cemetery ***©Lucifer House Inc.***

[21] *http://164.100.232.37/departments/archaeology.htm* *and* *https://www.tnarch.gov.in/pre-historic-site-museum-tiruvallur*

[22] *https://www.asichennai.gov.in/monuments_full_list.html*

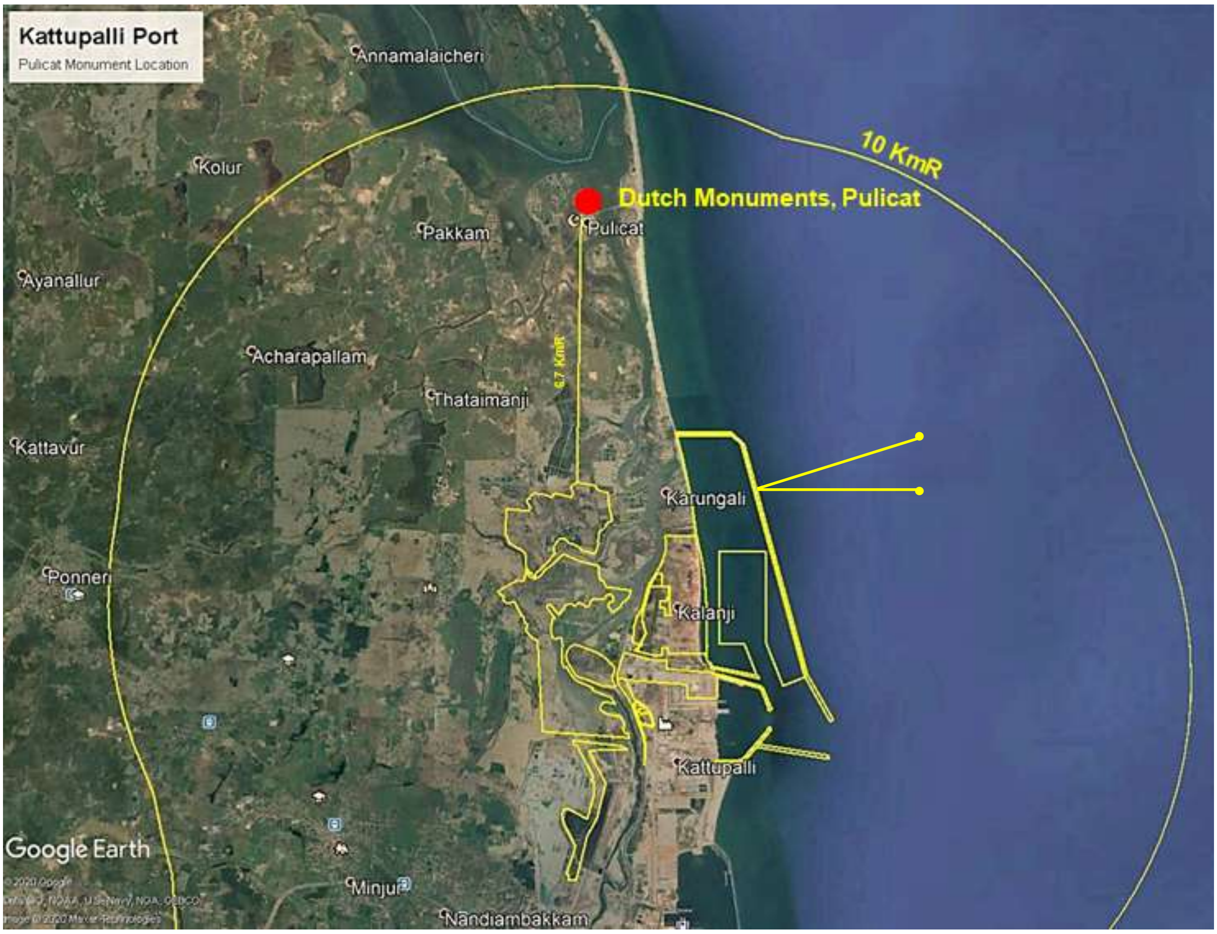


Figure 3-135: Location of the Monument from the Project Site

3.14.9 General Amenities of the Study Area

3.14.9.1 Infrastructure Facilities

Infrastructure facilities status in the study area can be interpreted as developed to the well-developed stage. The education system, hospitals for health care and general amenities are available and in good condition.

3.14.9.2 Public Health Institution

Health Amenities: Health is the most important and part of human life. It is to be taken care of by self and government. Keeping this in view, a study was done to assess the health infrastructure in the project study area. The study follows health facilities range from small clinics and doctor's offices to emergency care centres and large hospitals with elaborate emergency rooms and trauma centres. The number and quality of health facilities in a country, region, State, Mandal, village, is one common measure of that area's prosperity and quality of life. Medical facilities may be owned and operated by various organizations for-profit businesses, non-profit organizations, governments, and in some cases by individuals, with proportions varying. The government medical facilities available in the study area are given in **Table 3-86**.

Table 3-86: List of Medical Facilities of Study Area

S. No	Particulars	No of Hospitals	No. of Doctors	No. of Beds

S. No	Particulars	No of Hospitals	No. of Doctors	No. of Beds
1	Community Healthcare Centre	1	2	0
2	Primary Healthcare Centre	17	20	0
3	Primary Health Sub Centre	55	56	0
4	Maternity and Child Welfare Centre	32	35	31
5	TB Clinic	20	21	21
6	Allopathic Hospitals	1	4	32
7	Dispensary Health Centre	22	28	31
8	Veterinary Hospital	11	11	1
9	Mobile Health Clinic	1	1	0
10	Family Welfare Centre	20	24	0
11	Non-Govt. Hospitals	44	29	0
12	Medical Shops	58	0	0

Source: Census 2011 Handbook of Thiruvallur District

3.14.9.3 Educational Institution

Educational Amenities: Education is important in human life, especially for the children of any area/locality. Therefore, keeping this in view, a study is done by assessing the educational institutes available in the project study. The study follows the type of different educational facilities available (government & Private) in the study area is given in numbers. If there are composite schools like Middle schools with Primary classes, or Secondary schools with middle classes, these are included in the number of Primary and Middle schools respectively. The lists of educational institutes are given in **Table 3-87**.

Table 3-87: List of Educational Institutes of Study Area

S. No	Particulars	No of Schools/Colleges in Study area
1	Government Primary Schools	177
2	Government Middle Schools	60
3	Government Secondary Schools	26
4	Government Senior Secondary Schools	8
5	Private Primary Schools	34
6	Private Middle Schools	20
7	Private Secondary Schools	13
8	Private Senior Secondary Schools	7
9	Government Colleges	1
10	Private Colleges	3

Source: Census 2011 Handbook of Thiruvallur District

Figures

Loc Name	Distance (km)	Direction
Kattupalli	-	-
Urnamedu	-	-
Kalanji	-	-
Ramanatha puram	-	-
Karungali kuppam	0.6	N
Kattur	1.5	NW
Attipattu	2.3	SW
Neidavayal	3.2	W

LEGEND:

- AIR, NOISE & SOIL MONITORING LOCATION
- GROUNDWATER SAMPLING LOCATION
- SURFACE WATER SAMPLING LOCATION

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

PROJECT: CEIA/EMP FOR KATTUPALLI PORT EXPANSION

TITLE: BASELINE TERRESTRIAL SAMPLING LOCATIONS MAP

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

PROJECT NO: C1161303

DATE: 24.10.2020

MADE: BNK

FIGURE NO: FD0301

REV: 0

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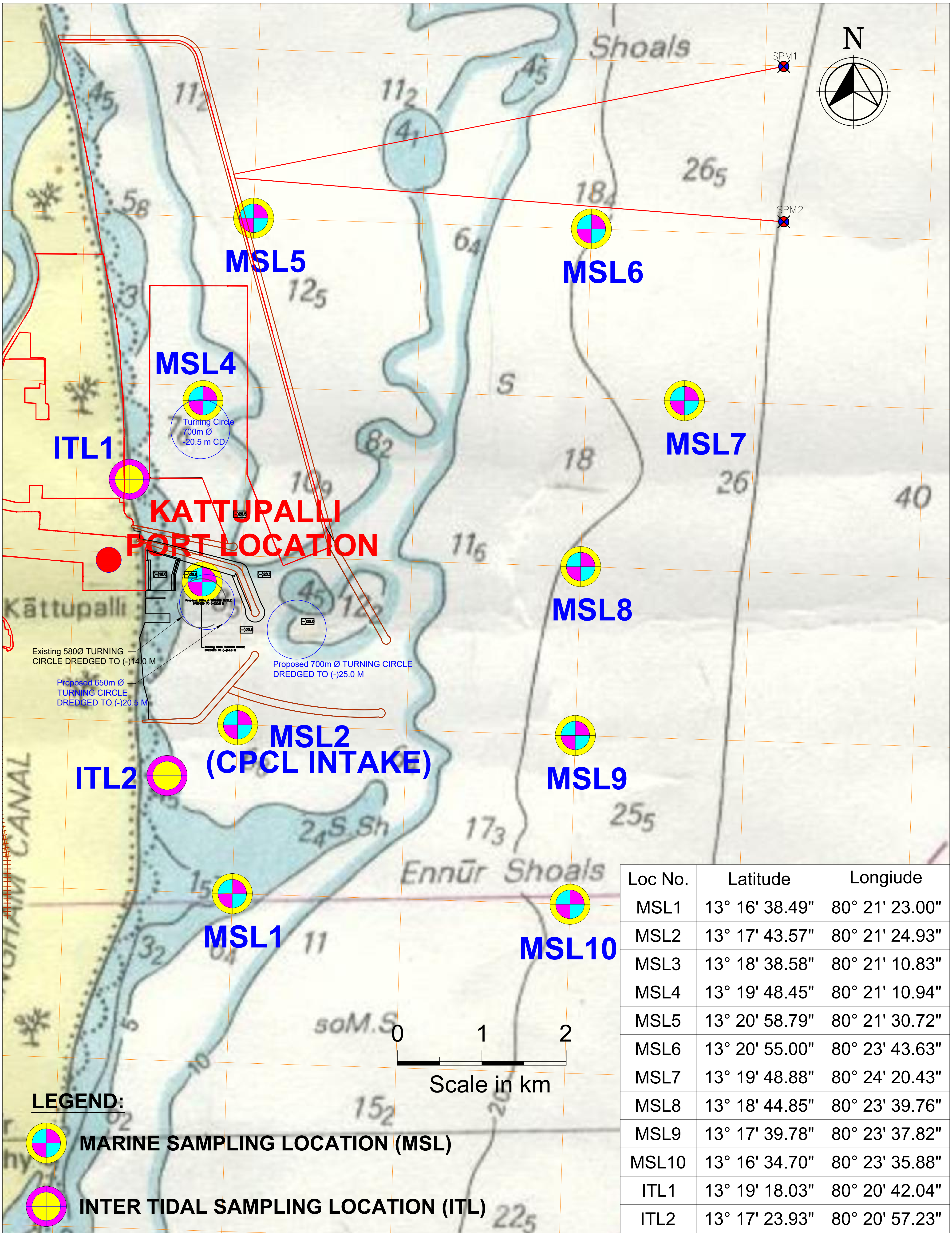

Loc No.	Latitude	Longiude
MSL1	13° 16' 38.49"	80° 21' 23.00"
MSL2	13° 17' 43.57"	80° 21' 24.93"
MSL3	13° 18' 38.58"	80° 21' 10.83"
MSL4	13° 19' 48.45"	80° 21' 10.94"
MSL5	13° 20' 58.79"	80° 21' 30.72"
MSL6	13° 20' 55.00"	80° 23' 43.63"
MSL7	13° 19' 48.88"	80° 24' 20.43"
MSL8	13° 18' 44.85"	80° 23' 39.76"
MSL9	13° 17' 39.78"	80° 23' 37.82"
MSL10	13° 16' 34.70"	80° 23' 35.88"
ITL1	13° 19' 18.03"	80° 20' 42.04"
ITL2	13° 17' 23.93"	80° 20' 57.23"

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

PROJECT: CEIA/EMP FOR KATTUPALLI PORT EXPANSION

PROJECT NO: C1161303

TITLE: MARINE SAMPLING LOCATIONS MAP

DATE: 24.10.2020

MADE: BNK

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

FIGURE NO: FD0302

REV: 0

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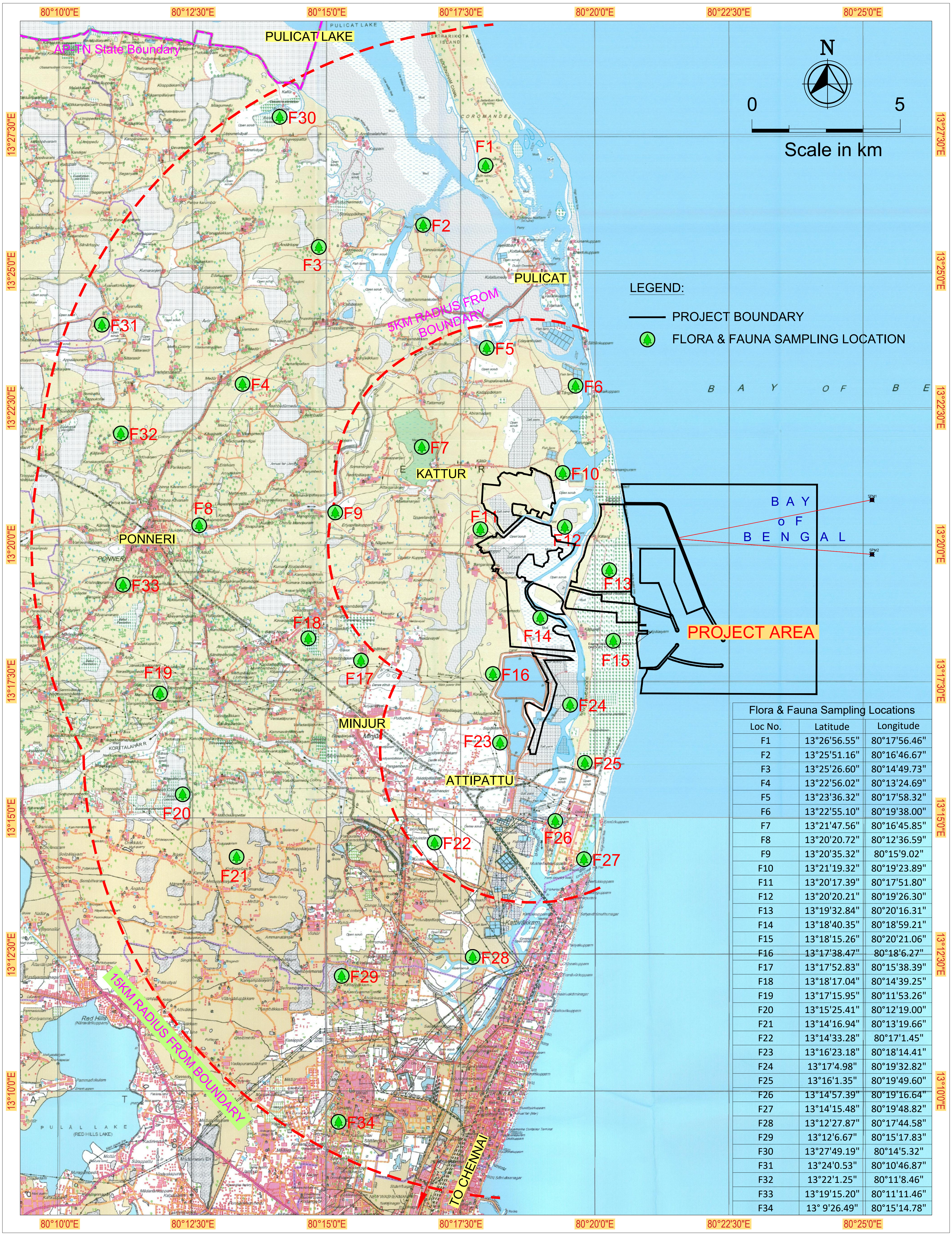

Flora & Fauna Sampling Locations

Loc No.	Latitude	Longitude
F1	13°26'56.55"	80°17'56.46"
F2	13°25'51.16"	80°16'46.67"
F3	13°25'26.60"	80°14'49.73"
F4	13°22'56.02"	80°13'24.69"
F5	13°23'36.32"	80°17'58.32"
F6	13°22'55.10"	80°19'38.00"
F7	13°21'47.56"	80°16'45.85"
F8	13°20'20.72"	80°12'36.59"
F9	13°20'35.32"	80°15'9.02"
F10	13°21'19.32"	80°19'23.89"
F11	13°20'17.39"	80°17'51.80"
F12	13°20'20.21"	80°19'26.30"
F13	13°19'32.84"	80°20'16.31"
F14	13°18'40.35"	80°18'59.21"
F15	13°18'15.26"	80°20'21.06"
F16	13°17'38.47"	80°18'6.27"
F17	13°17'52.83"	80°15'38.39"
F18	13°18'17.04"	80°14'39.25"
F19	13°17'15.95"	80°11'53.26"
F20	13°15'25.41"	80°12'19.00"
F21	13°14'16.94"	80°13'19.66"
F22	13°14'33.28"	80°17'1.45"
F23	13°16'23.18"	80°18'14.41"
F24	13°17'4.98"	80°19'32.82"
F25	13°16'1.35"	80°19'49.60"
F26	13°14'57.39"	80°19'16.64"
F27	13°14'15.48"	80°19'48.82"
F28	13°12'27.87"	80°17'44.58"
F29	13°12'6.67"	80°15'17.83"
F30	13°27'49.19"	80°14'5.32"
F31	13°24'0.53"	80°10'46.87"
F32	13°22'1.25"	80°11'8.46"
F33	13°19'15.20"	80°11'11.46"
F34	13° 9'26.49"	80°15'14.78"

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

PROJECT: CEIA/EMP FOR KATTUPALLI PORT EXPANSION

TITLE: STUDY AREA MAP - 15KM RADIUS

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

PROJECT NO: C1161303

DATE: 24.10.2020

MADE: BNK

FIGURE NO: FD0303

REV: 0

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Chapter 4
Anticipated Environmental Impacts and Mitigation Measures

Chapter 4 Anticipated Environmental Impacts and Mitigation Measures

4.1 General

The development of Kattupalli port revised master plan involves various landside and marine side construction and operational activities. The development activities such as capital dredging, reclamation, dredge spoil disposal, expansion/modification of navigational facilities, breakwater development and extension, offshore structures will impact marine environment. Site grading and development, civil construction and mechanical erection of facilities, onsite infrastructure development, environmental management facilities and backup area development are likely to cause impacts on the terrestrial environment. During the operation phase, activities such as cargo handling/storage, movement of ships and tugs, etc. are also likely to cause certain marine as well as terrestrial environment Impacts.

In this chapter, likely impacts of proposed development on environmental attributes have been identified, assessed and presented. To mitigate likely environmental impacts during construction and operation phases due to landside and marine side activities, suitable mitigation measures are incorporated as a part of planning process itself. The impacts have been assessed both quantitatively and qualitatively for various terrestrial and marine environmental components and impact specific mitigation measures are proposed.

4.2 Land Environment

4.2.1 Potential Impact due to Port Location

4.2.1.1 Impact due to Land Acquisition

Revised Master Plan development of Kattupalli Port will be carried out in total area of 2472.85 ha which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 hectares including basin and all developable area. The revised master plan development area is falling under Six (06) villages namely Kalanji, Kattupalli, Kattur -II, Ebrahampuram, Puzhudivakkam and Voyalur. The RMP area doesn’t involve any Eari/Grassing Land/kullam etc. Land use classification of the proposed project area is sea, Abandoned-Saltpans, Agriculture-Cropland, Builtup-Industrial, Agriculture-Plantation, Waterbody-River, Barren-Scrub land, Agriculture-Aquaculture The land classification of RMP area is as per the VAO’s certificates are Dry/Wet and land use is either Agricultural/Vacant land under the possession of both government and private ownership.

4.2.1.2 Impacts due to Changes in Land Use Pattern

MIDPL Kattupalli port master plan development is planned within the approved port limits. No settlements are present within the land identified for port expansion. The existing land use and the proposed land use are discussed in **Section 3.5** of **Chapter 3**. The change in land use pattern will be as per the requirement of master plan development plan. Land reclamation and change in land use pattern will be limited to the proposed expansion area and will be carried out in such a way that to ensure the proper drainage by providing surface drainage systems including storm water network etc., Approximately 85 MCM of dredged material will be used for reclamation of proposed backup yard and as well as berth area and level rising upto +5 m CD. Natural drainage pattern of Kattupalli and its surrounding area is being maintained through Kosthathaliyar River and Buckinham canal towards west, Ennore creek towards south and discharge to Bay of Bengal. There are few natural drains passing through the project site, therefore, storm water drainage network is planned to facilitate the proper drainage pattern of the area.

The details of the proposed Storm Water Drainage Plan are given in **Section 7.3.4** of **Chapter 7**.

4.2.1.3 Impacts due to Changes in Coastline/Shoreline

The shoreline/coastline changes such as erosion/accretion is usually expected due to the construction of marine structures such as breakwaters, berthing facilities and reclamation etc. Existing Kattupalli port with north western breakwater of 1775 m and south breakwater of 1665 m is under operational since 2013. Historical shoreline changes for the past 20 years i.e., 2000-2020 was estimated[23] by using satellite images.

The transect lines from Ennore to Pulicat creek are demarcated at every 1 Km interval. These transect lines started from 13° 11' 3.19" N, 80° 19' 2.48" E and ended at 13° 32' 33.46" N, 80° 16' 36.38" E. Total 43 transect lines are digitized in GIS and named as T01, T02, … T43 as shown in **Figure 4-1**. These transect lines are used for demarcation of entire study area into 6 zones, as well as erosion / deposition analysis from 2000 to 2020. The transect wise total area of erosion and deposition from 2000 to 2020 (pre-monsoon and post-monsoon) is extracted and analysed for statistics.

Landsat-5 TM (30 m spatial resolution), Landsat-7 ETM+ PAN sharpened imagery (15 m spatial resolution) and Landsat-8 OLI PAN sharpened imagery (15 m spatial resolution) from 2000 to 2020 have been used to obtain information on base mapping, erosion/deposition area mapping, land use/land cover mapping, shoreline change mapping of area from Ennore – Pulicat Creek.

Shorelines have been delineated by on-screen digitization in a GIS platform using ArcGIS 10.7 software. The total area of erosion and deposition from all the unions were calculated using ArcGIS software. Quantitative data generation and thematic maps has been produced outlining hot spots of high erosional reaches of shoreline.

The zone wise shoreline changes are presented in **Figure 4-2** and the observations are as follows:

Zone-A Open Coast: This coastal stretch is mostly protected by seawall and groynes. It is noticed that, the erosion/deposition pattern, and shoreline changes are not showing any trends, because the coast is protected by long seawall parallel to the coastline and series of groynes perpendicular to the coastline.

Zone-B Ennore Creek: Southern side of Ennore Creek is well protected by seawall and groynes. Northern side of the creek, north chennai thermal power station is located, where the seawall and groynes are located, erosion/deposition patterns have not shown any trends. But at Ennore Creek mouth, the erosion/deposition is predominant. In the north of Ennore

[23] *Historical Shoreline Changes: Remote Sensing - Mathematical Modelling studies for Development of Kattupalli Port Master -DHI (India) Water & Environment Private Limited, November 2020*

Creek, shoreline is advancing. Deposition is more predominant at the Ennore port because the port development has caused significant changes in the surrounding regions.

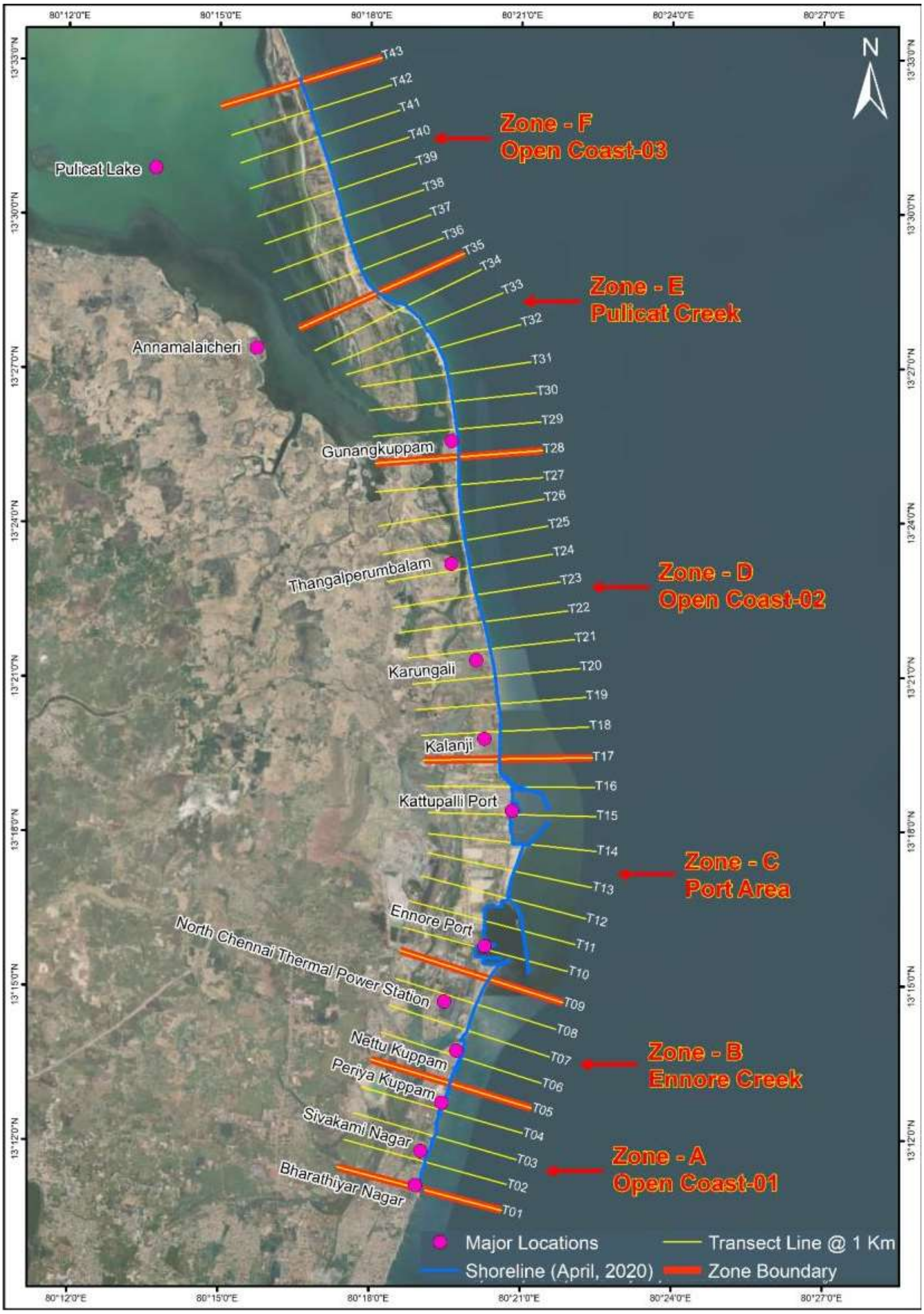


Figure 4-1: Study area with demarcation of zones

Zone-C Port Area: In this stretch of the shoreline, two ports i.e. Ennore Port and Kattupalli Port are situated between two coastal inlets viz. Ennore inlet and the Pulicat inlet. It is noticed that, the south side area of Ennore Port is more predominant for deposition and erosion, and it is active since 2007, and continuous till 2020. The area located between two ports i.e. Ennore and Kattupalli Ports has shown no significant changes, and that area is stable. The north side area of Kattupalli Port, where erosion is more predominant, and it is active after the construction of Kattupalli Port. These changes started during the construction stages of port affecting the area north side of port.

Zone-D Open Coast-02: This area is located, north of Kattupalli Port, which is almost sandy beaches, and where erosion is more predominant, and it is active after the construction of Kattupalli Port. It is clearly seen that, tendency of erosion and deposition is decreasing, while moving from Kattupalli Port towards Pulicat Creek.

Zone-E Pulicat Creek: This coastal stretch is located where Pulicat Creek is situated. The area where mouth of Pulicat Creek is located, there shoreline changes are more predominant, and shoreline is very dynamic due to the inlet migration. In comparison to erosion, the sand deposition is more in this particular stretch of coastline.

Zone-F Open Coast: This coastal stretch consists of mostly sandy beaches. The area just north of Pulicat Creek is more dynamic, because that area is located nearby the mouth of Pulicat Creek. Therefore, shoreline is more-or-less stable.

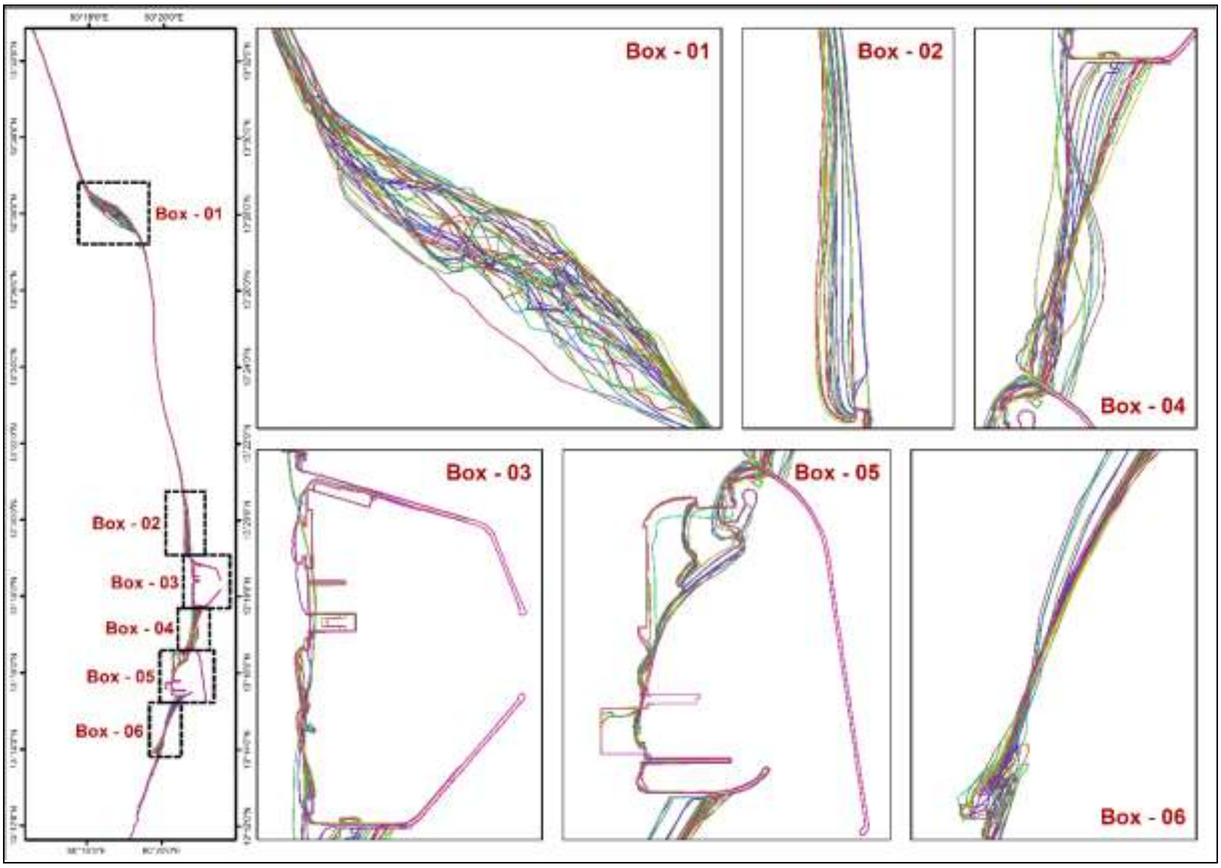


Figure 4-2: Visual interpretation of shorelines on Landsat satellite imageries: 2000 – 2020

The detailed shoreline change analysis for Zone-D is presented in **Figure 4-3**, indicates that the maximum shoreline changes are around 303m for the 1km stretch of shoreline immediate north of Kattupalli port. The maximum shoreline erosion is around 198m at 2km from north of port and around 31m at 3km from north of Kattupalli port breakwater. Thereafter, the shoreline is stable and subjected to no erosion and deposition.

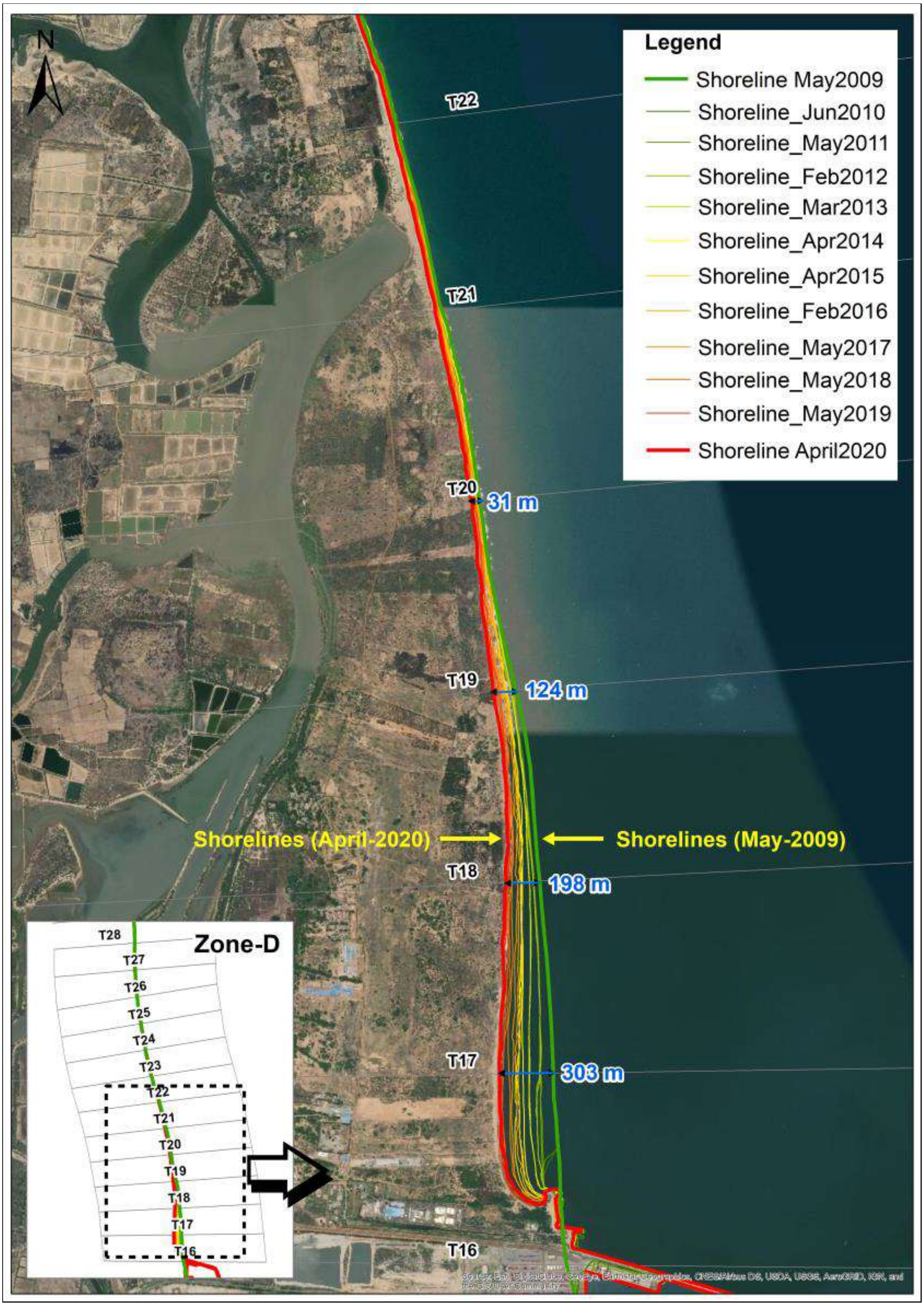


Figure 4-3: Shoreline changes immediate north of Kattupalli Port: 2009-2020

4.2.1.4 Impacts due to Reclamation

Land/Sea/Submerged area reclamation will be carried out within the approved port limits as a part of Kattupalli port master plan development. The dredged material will be used for land reclamation for the proposed backup area and level rising after suitable ground preparation. dredged material will be used for reclamation of proposed backup areas and level-raising of low-lying areas upto approximately + 5 m CD. Total proposed quantity for reclamation including landfilling is estimated about 138 Mm^3 which will be used for reclaiming 1145 Ha area. Additional material will be sourced tentatively from Satyavedu (Chittoor District, Andhra Pradesh) - 65 km from the site, Walajah (Tamil Nadu) - 140 km from the site; Karadipudur (Tamil Nadu) - 80 km from the site. However, other quarry sites will also be explored if need during the execution of the project for which necessary permission from local competent authority will be obtained if required.

Marine sediment quality analysis of the material to be dredged was carried out by MIDPL in terms of its toxic metals: Cadmium, Chromium (VI), Mercury, Manganese, Copper, Lead, Iron, Nickel, and Zinc. Results of the analysis show that the concentrations of the toxic metals are in low level. Hence it is pertinent to mention that the dredge material will be of high volume, low effect material and non-hazardous which will render insignificant impact on the marine environment. Hence, based on this analysis, the dredged material can be suitably used for reclamation and any excess/unused material can be safely disposed in dredge spoil disposal site.

The land proposed to be reclaimed is sea, submerged (intertidal zone) and low lying land and in seaward/intertidal area which is saline in nature and having slope towards sea. Also the proposed expansion area is also close to sea and soil analytical results of the area show higher conductivity and saline nature. Hence, impact due to this activity on land environment will not be significant.

Inter tidal biodiversity assessment has been carried out and found that the Macro benthos was represented by 5 taxonomic groups viz., Polychaetes, Bivalves, Gastropods, Amphipods and others. Around 54 species of macro benthos was recorded during the survey. Minimum Density of 600 Nos/m^2 and the Maximum density of 1000 Nos/m^2 was observed. Meiobenthos was represented by 4 taxonomic group's viz., Nematodes, Foraminiferans, Harpacticoids and Ostrocodes during the study. Around 55 species were recorded. The meiobenthos density ranged between 208 Nos/10 cm^2 and 328 Nos/10 cm^2.

Reclamation would result in the smothering or blanketing of intertidal communities. During Reclamation sessile forms will be covered along with reclamation material and mobile species tend to move away and are likely to increase species diversity in areas adjoining the site. Marine, Estuarine, Creek waters, Backwater and Mangrove habitat baseline biodiversity were assessed and impacts were identified due to proposed development. Impact and mitigations were presented under biodiversity management plan in **Section 9.5** of **Chapter 9**.

4.2.1.5 Mitigation Measures

Reclamation with dredged material is likely to impact the reclamation area with the turbid water. Protective reclamation bunds or containment bunds (rock/boulders) will be constructed around the planned reclamation areas to avoid spreading of dredge material and to reduce turbidity. The dredged material will be pumped into the reclamation area enclosed by reclamation bunds wherein the sand will be allowed to settle and the supernatant water will be directed into sea through appropriate outfall pipelines. Thereafter the reclamation levels within the bunds shall be raised in suitable stages known as cascading, to prevent overloading of underlying subsoil. After completion of the reclamation and hard standing, necessary development shall be carried out. Since majority of the reclamation is proposed mostly into the Sea/Submerged (Inter tidal) partly in the proposed acquired land for level rising which is saline in nature hence, the impact due to this activity will not be significant.

Following are the additional mitigation measures.

- Judicial planning of project facilities will be carried out
- Reclamation will take place within the stipulated project area limits
- Existing drainage pattern around the project site will not be disturbed. Storm water drainage network will be provided within the project development area
- Reclamation bunds shall be constructed. Also minimum required retention time of return water in the reclamation area will be ensured
- Regular monitoring of return water (turbid water) from the reclamation area will be carried out at nearby points in the sea.
- In order to study variations in groundwater quality, regular groundwater quality monitoring shall be carried out.
- Minimum 50 m Buffer shall be maintained near the mangrove areas. In addition due care shall be taken during construction and reclamation.
- Temporary access created during construction if any shall be removed after completion of construction activities.

4.2.2 Potential Impact during Construction

4.2.2.1 Impact on Local Infrastructure

Transportation of Construction Material: Transportation of huge quantities of construction material for construction of berths, jetties, stockyards, operational and administrative buildings etc., results in use of public infrastructure like roads, railways, drainage, water and power supply which in turn results in congestion. Though initially, existing road network near Kattupalli port i.e., connecting from NH-5 to Panchetty and Jaganathapuram will be used for transport of construction material, proposed connectivity of road and rail line from Minjur station will be commenced along with initial phase of Kattupalli port expansion activities and same will be used for completing the master plan development. Thus the strain on existing infrastructure will be minimised. Kattupalli port has already developed with infrastructure facilities such as drainage, water and power supply for existing capacity and these facilities shall be augmented/used during construction phase of proposed expansion.

The basic raw material such as coarse/fine aggregates and stone etc., is required during the construction phase. As mentioned in **Section 2.5.23**, construction material will be sourced from the nearby quarries after obtaining necessary permission from competent authority. Ready mix concrete will be made out of the basic raw material on site itself. Batching plants of respective size and capacity as per requirement will be installed at the site.

Thus transportation of raw materials from nearby areas is likely to result in increased road traffic but only temporary during construction phase.

Construction Workers Camp: During the construction phase of the project there will be employment generation (around 500-1000 workers) in the form of skilled and semiskilled labourers and technical staff. Also, majority of the works will be sub-contracted.

Temporary workers camps is planned to be set up for skilled, semi-skilled labourers and technical staff will be provided housing infrastructure within the project area. There will be impact/strain on local infrastructure, if self-sustained facilities are not provided.

4.2.2.2 Mitigation Measures

- During the construction phase, existing roads shall be used and if required strengthening will be carried out by MIDPL
- Drivers shall be sensitized with respect to need to drive carefully while passing through the villages. Speed is one of the main causes for accidents. So, speed of the trucks shall be controlled especially when they are passing through villages by providing speed breakers, sign boards and other appropriate speed control techniques
- Proper lighting, signboards shall be provided at required locations
- Construction material shall be sourced from Government approved quarries and vendors/agencies
- Transportation management will be adopted for movement of dumpers transporting quarry stones and construction materials and traffic will be regulated
- Vehicles deployed will confirm to emission norms (air/noise) of CPCB and have valid Pollution Under Control (PUC) certificates
- Dumpers and trucks will comply with standards for exhaust emissions and noise levels

To avoid/minimise impact/strain on the existing infrastructure, the worker and technical staff housing areas will be self-sufficient and would not rely on any local resource. This would help to avoid any conflict with the local population. To mitigate impacts from health hazards, sanitation facilities will be provided. Further, worker camps in the project site will be located away from CRZ area. Following additional mitigation measures shall also be considered:

- The camps will be adequately equipped with all the necessary facilities such as water supply, power supply, wastewater collection, solid waste collection and sanitation
- The domestic wastes generated from the camps will be disposed at approved disposal sites
- No bore wells will be made for the drinking water requirements.
- Periodic health check-ups will be undertaken for early detection and control of communicable diseases
- Medical facilities including first aid will be available in the workers camps for attending to injured workers

4.2.2.3 Impact on Existing Port Operations

Construction of Kattupalli master plan development facilities envisages both land side and marine side construction activities such as movement of construction equipment/vehicles, construction material transport/ temporary storage, reclamation, creation of buildings and structures as per land use plan, Dredging at harbour area and channel, construction of offshore structures, movement of barges/dredgers, etc., These activities may hinder the existing port operation if not managed/ planned in a proper manner.

4.2.2.4 Mitigation Measures

- All the construction activities shall be planned judiciously without interrupting the existing operations.
- Construction area shall be earmarked and activities shall be confined within that area.

- Construction activities in the existing port operational areas such as deepening and widening of the channel and harbour basin etc., shall be planned in consultation with harbour master by ensuring safe navigation of the vessel movements for the existing operations.
- All the necessary safety precautions shall be implemented while doing the construction activities near the existing operational area.
- Necessary sign boards and marker buoys shall be installed and shall be communicated to Port employees/Harbour master/Pilot etc., about the marker buoys indicating the areas of construction so that they may avoid those areas.

4.2.3 Potential Impact during Operations

4.2.3.1 Discharges from Ships on Land

Kattupalli Port obtained necessary permissions to provide waste reception facilities. Presently waste being accepted by Kattupalli Port and will extend the waste reception services as per Government/TNPCB guideline. In addition, the ships are expected to discharge sewage in deep seas as per defined procedures for International ship movements (MARPOL). This will ensure the ships have their own storage capacities in their on board sewage receptions to handle wastes generated during the period/days the ship is at the port. The sewage generated in the port area will be treated in the 240 KLD STP which is proposed on Modular basis at various locations within the operational area.

Due to site topography and coastal belt location it is proposed to have a combination of gravity & pressure sewer system to collect and convey sewage/wastewater from toilet blocks and other facilities to STP.

Impacts on marine environment, terrestrial environment, local communities and waste facilities as a result of inappropriate storage, containment and transport of waste.

4.2.3.2 Mitigation Measures

- Management and Disposal of Wastes (Storage, Segregation and Transport of Waste)
- Waste Reception Facility/arrangement with approved vendor
- Develop specific Waste Management Plan (WMP) and manage through project EMS.
- Reduce waste generation and maximise reuse and recycling.
- Waste identification and classification.
- Waste collection, storage and segregation on-board vessels.
- Use of specified waste transport containers only.
- All wastes to be transported in a safe manner, in accordance with Material Safety Data Sheet information and via well maintained, legally compliant and suitable vehicles or vessels, with appropriate documentation and driven/crewed by fully trained operators.
- Waste to be transported by approved waste contractors only.
- Appropriate treatment and disposal routes for different waste streams to be defined as part of the WMP.
- Waste study to identify potential options for medium and long term waste treatment of hazardous wastes where in-country solutions have not been identified.
- Support national efforts to improve waste management standards.

4.2.3.3 Soil Contamination

Soil contamination may be envisaged if proper measures are not taken for the following activity at port

- Used oil/Spent oil & Used Battery, Containers/Barrels/liners Contaminated with HW/Chemicals and Sludge from oil water separator
- Municipal wastes in the form of canteen wastes, domestic wastes, papers, etc.
- Cargo and Other Spills
- Other hazardous and non-hazardous wastes generated from operations

4.2.3.4 Mitigation Measures

Good housekeeping and best practices of waste material handling shall be adopted to eliminate/minimise the risks of soil contamination. The provision for temporary storage of hazardous and other waste will be developed for a period of 90 days. The hazardous wastes generated will be disposed at nearby Treatment, Storage and Disposal Facility (TSDF) or Common Hazardous Waste Incineration facility (CHWIF) and also sent to the approved vendors of TNPCB. The nearest TSDF is located at Gummidipoondi at a distance of ~22 km NW and operational since 2007. TSDF has treatment, storage and disposal facility with current landfill capacity of 100000 TPA and 1.5 Tons/Hour for Incinerator. MIDPL is having agreement with this TSDF for the hazardous waste being generated at existing port and same will be extended for expansion of Kattupalli port.

4.2.3.5 Shoreline Changes/ Shoreline Evolution Study

The shoreline change rate is predicted using numerical model techniques by DHI. Littoral processes FM is a numerical model capable of simulating littoral drift and coastline evolution in areas with non-cohesive sediment and quasi-uniform beaches in which the flow and transport can be assumed to be primarily in the longshore direction. The model has the capacity to simulate the influence of structures like groin, breakwater, jetties etc. on shoreline evolution.

Data Input:

The model predicts variations in shoreline position within a stipulated period of time under the combined action of waves and currents. The input data required for the model are cross-shore profile, initial shoreline position along the coast, sediment size, annual wave climate etc. The required annual wave climate for study area is obtained from the fair weather analysis from spectral wave model. The cross-shore profiles and the shoreline position used in coastline evolution model were derived from bathymetry data used in the hydrodynamic and wave model studies.

Initial coastline and Profiles: The model is simulated for the baseline conditions of the shoreline during 2018 and shoreline changes with the presence of existing features. For this study, starting from south of Ennore creek to Pullicat bar mouth along 26km has been considered as shown in **Figure 4-4.** The initial shoreline is digitised from Google earth for the year 2018. Three cross-shore profiles were derived from the bathymetry and topography information and the coordinates of each cross section is determined from the 11 m contour as shown in **Figure 4-5**. All the cross-shore profile drawn to same length and perpendicular to shore. Since the surf zone bathymetry data and topographic data is not available, it is assumed that dune height of 2 m and interpolated with the existing bathymetry. The 2 m contour has been demarcated in the google image where there is permanent feature like vegetation or changes in land use are appeared.

The model boundary is considered as variable wave climate and is obtained from the spectral wave model at 30 m water depth.

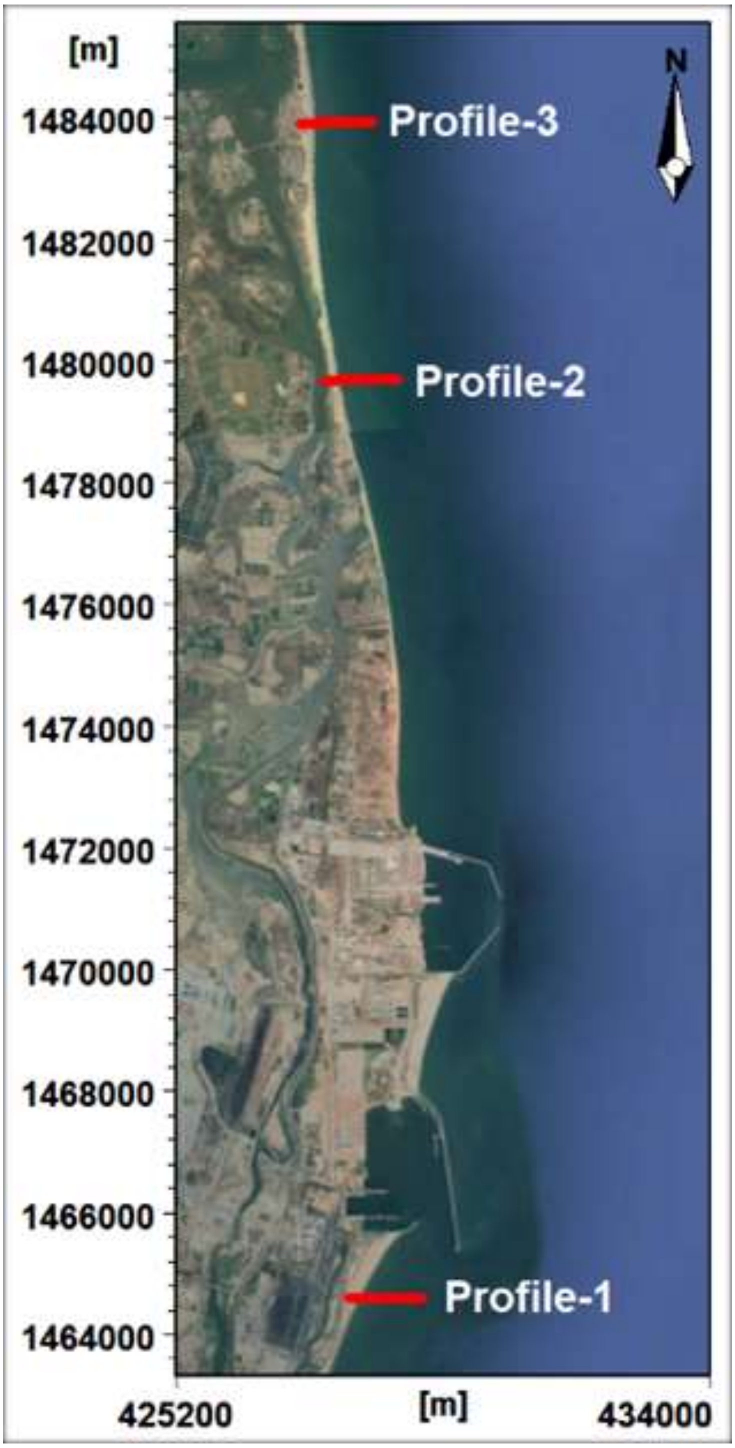


Figure 4-4: Shoreline and location of profiles considered for model studies

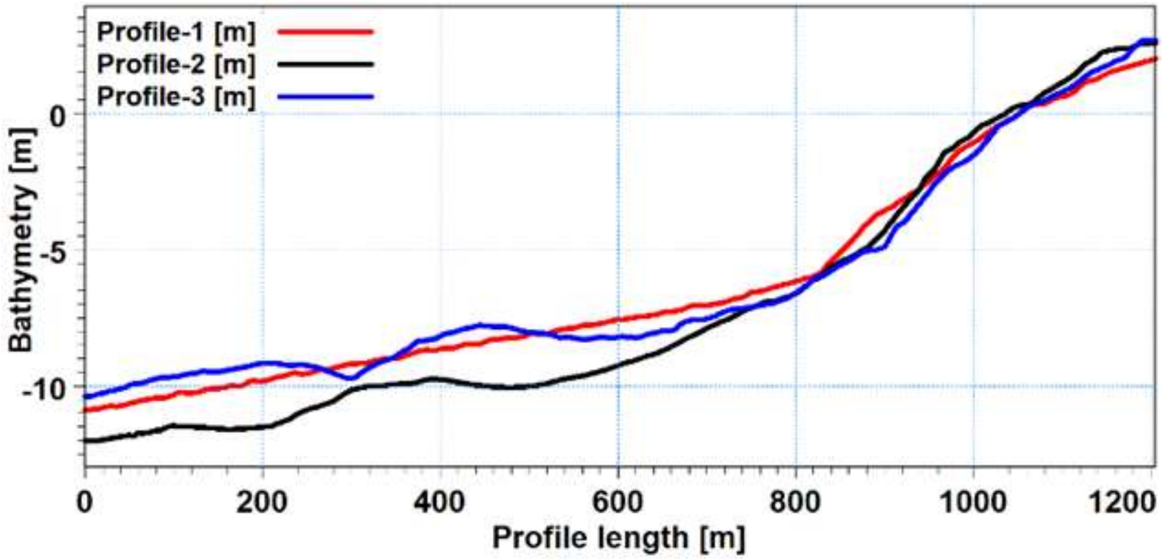


Figure 4-5: Cross section of the three profiles considered for the Littoral Process FM Model

Waves: Swell waves are often relatively long, of moderate height, regular and unidirectional. Swell waves tend to build up the coastal profile to a steep shoreface. Sea waves are referred to as short-crested. Wind waves tend to be destructive for the coastal profile because they generate an offshore movement of sediments, which results in a generally flat shoreface and a steep foreshore. 15years wave data (2018-2032) used for the shoreline change prediction and shoreline management study is depicted in **Figure 4-6**.

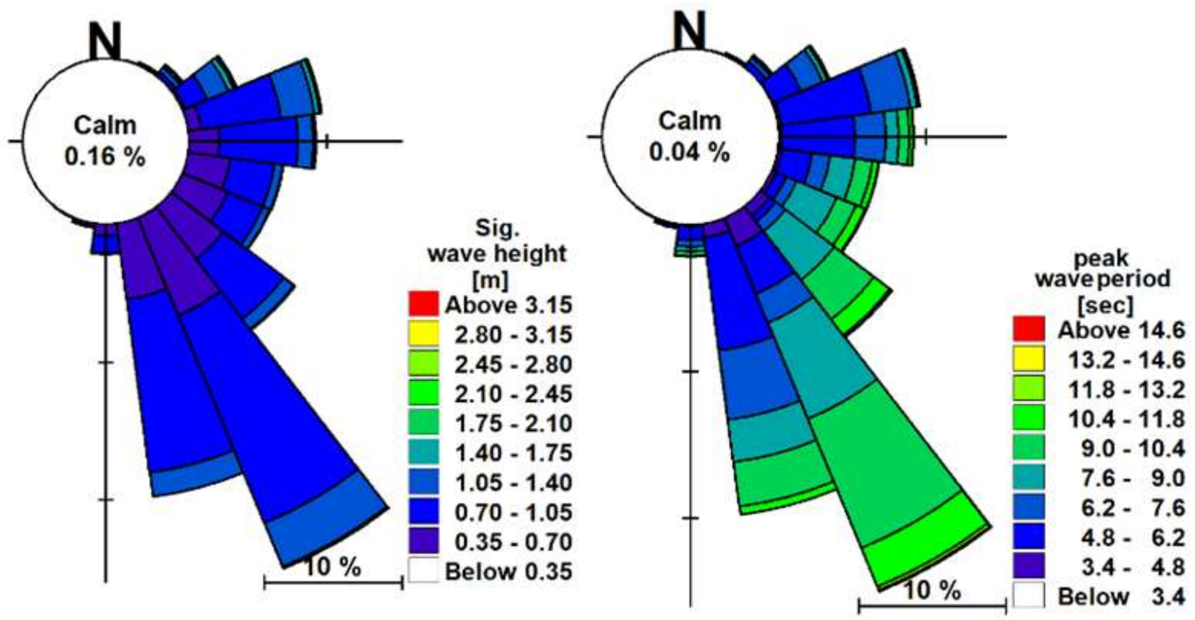


Figure 4-6: 15 years wave data at 30 m depth from NIOT

Sediment Property: The mean grain size for the model input were considered as 0.50 mm. Final EIA report on the development of shipyard cum port complex at Kattupalli indicates that the sub-soil profile of top layer is coarse dense sand overlying a layer of loose fine silty sand. This layer covers a relatively soft clay layer. The underlying layer consists of stiff clay or dense cemented clayey sand layer. There is little difference between the northern and southern parts of the area.

Results:

The model is simulated with the shoreline as base (2018) and shoreline evolution under the presence of Master Plan layout structures. The shoreline changes were predicted for 1- year, 5-years, 10-years and 15-years subjected to the development of Master Plan.

Littoral Drift: The littoral drift along the Ennore-Pulicat coast is calculated as 3000 m^3/year/m for a shoreline orientation of 170-degree N. The cross shore distribution of the littoral transport is shown in **Figure 4-7** to **Figure 4-9** for the considered three cross-shore profiles. It is observed that net movement is always towards north.

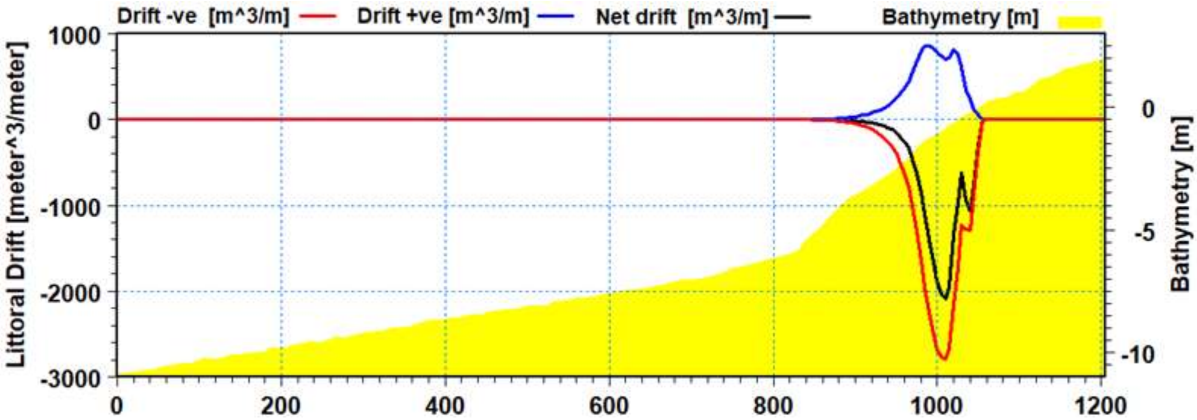


Figure 4-7: Littoral drift along the cross shore profile-1

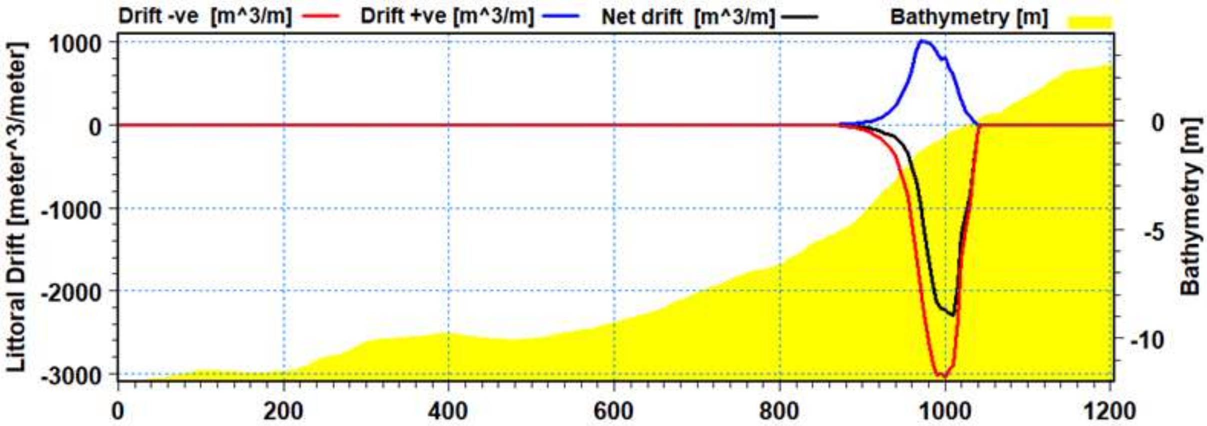


Figure 4-8: Littoral along the cross shore profile-2

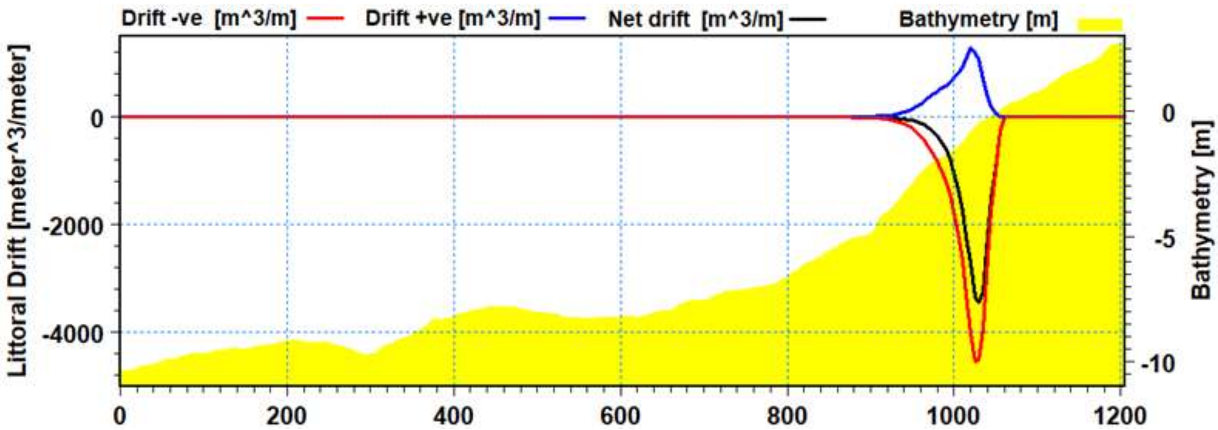


Figure 4-9: Littoral drift along the cross shore profile-3

Longshore sediment transport: Under varying annual wave conditions, the model predicted the littoral drift for one (1) year as shown in **Figure 4-11**. The prediction clearly indicates that the coast will undergo erosion in the immediate north with the proposed Master Plan layout.

The northerly movement of 0.21 million cu.m and southerly movement of 0.03 million cu.m is anticipated for 1-yr with the proposed development. The net drift is towards north with a quantity of 0.18 million cu. m in one year.

For 15 years, it is estimated that northerly movement of 5.1 million cu.m and southerly movement of 0.17 million cu.m. After 15 years the shoreline erosion of the order of 200m is predicted immediate north of the proposed northern breakwater as shown in **Figure 4-10**.

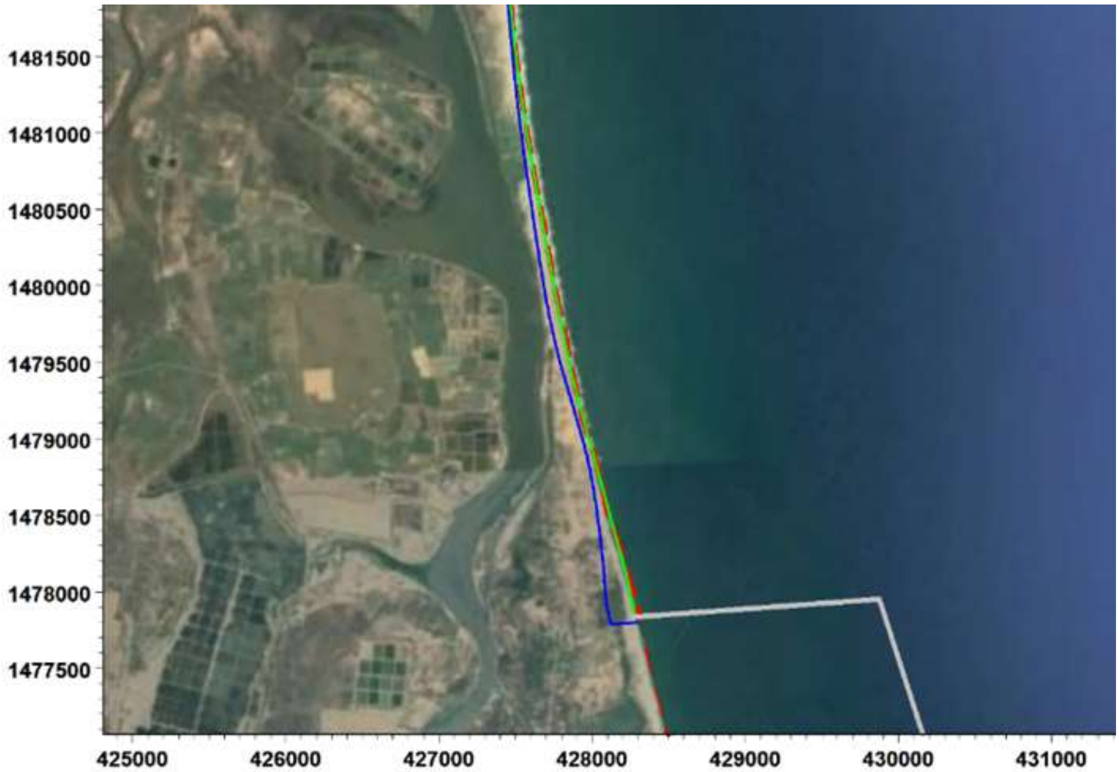


Figure 4-10: Shoreline change prediction at north of proposed northern breakwater [Red line: Initial Shoreline, Green line: after 1yr & Blue line: after 15yrs]

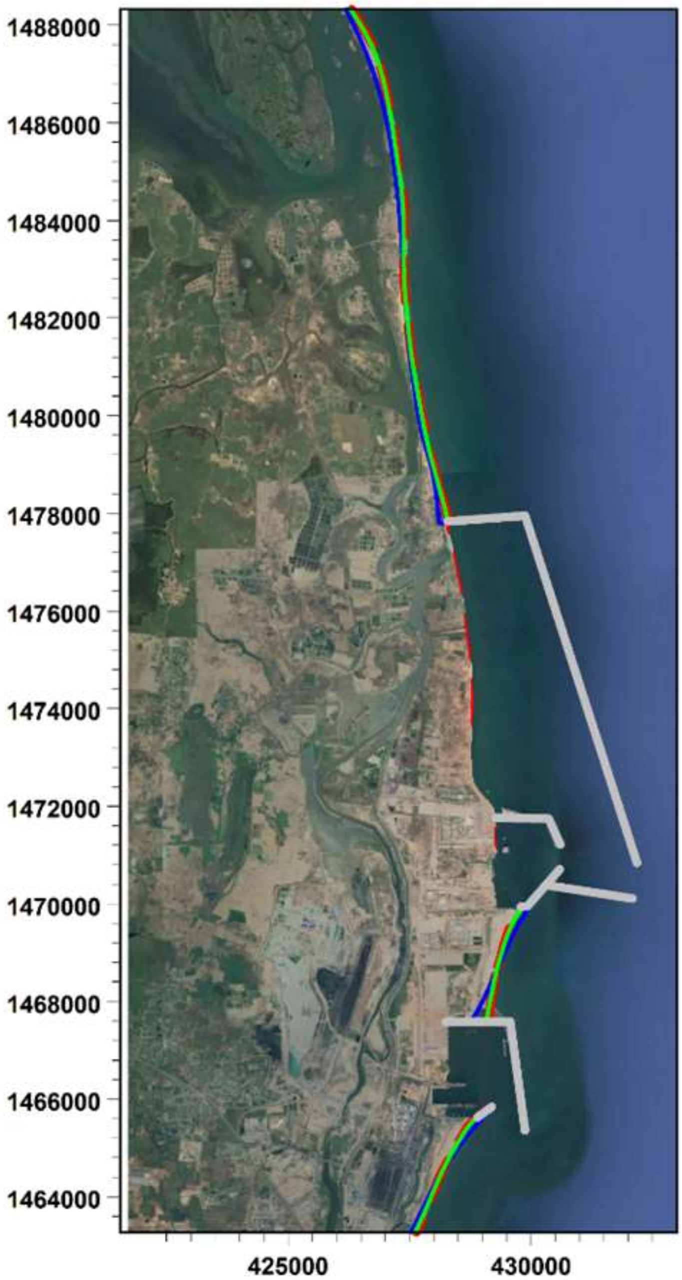


Figure 4-11: Shoreline change prediction for Layout condition [Green Arrow–1 yr & Blue Arrow- 15yrs]

Table 4-1: Longshore Sediment Transport and rate for different scenarios

Scenario	Structure	Longshore sediment Transport (m^3)			Sediment transport rate [$meter^3/sec$]	
		Northerly Drift	Southerly Drift	Net Drift	Northerly	Southerly
1 year	Existing Facilities	213484.3	31668.9	181815.4	0.0536	0.0446
1 year	Proposed Facilities	213178.7	31422.0	181756.7	0.0760	0.0184
5 years	Proposed Facilities	1358018.5	60221.8	1297796.7	0.0760	0.0288
10 years	Proposed Facilities	3063603.2	131301.0	2932302.2	0.1020	0.0662
15 years	Proposed Facilities	5102208.0	170769.3	4931438.7	0.1020	0.0662

The following results have noticed from the shoreline change prediction:

- Northward movement of sand in the order of 213484.3m^3 and southward movement of sand in the order of 31668.9 m^3 is noticed with the baseline conditions for 1 year.

- Northward movement of sand in the order of 213178.7 m^3 and southward movement of sand in the order of 31422.0 m^3 is noticed with proposed port facilities for 1 year.
- Northward movement of sand in the order of 1358018.5 m^3 and southward movement of sand in the order of 60221.8 m^3 is noticed with proposed port facilities for 5 years.
- Northward movement of sand in the order of 3063603.2 m^3 and southward movement of sand in the order of 131301.0 m^3 is noticed with proposed port facilities for 10 years.
- Northward movement of sand in the order of 5102208.0 m^3 and southward movement of sand in the order of 170769.3 m^3 is noticed with proposed port facilities for 15 years.

4.2.3.6 Shoreline Management during port operation

The aim of a SMP is to provide the basis for the implementation of overall sustainable shoreline management policies and strategies-a management strategy-for a well-defined region and to set the framework for the future management of conflicts in the coastal area. The purpose of Shoreline Management Planning (SMP) is to identify the resources and assets in the coastal area now and in the future and through that minimise negative consequences from the interaction between various interests, i.e. coastal protection.

4.2.3.6.1 Parameters influence

Wind: The wind and the variations in atmospheric pressure are responsible for the generation of waves, wind set-up and storm surges as well as wind generated currents. Furthermore, wind has a direct impact on the morphology of coastal areas through Aeolian transport of sand on the beach and in the dunes.

The shift in the wind directions leads to the monsoons or the monsoon wind climate. Monsoons are wind systems that show a pronounced seasonal trend in direction. Southwest monsoon occurs during the summer months and the north-east monsoon during the winter months.

Besides the large-scale atmospheric circulations, local pressure differences are influencing the local wind fields, where the wind speed mainly depends on the gradients of the pressure. Low pressure systems are generating extratropical cyclones.

In addition to larger scale events which, in a statistical sense, occur more or less randomly, the existence of sea breezes and land breezes with daily period are common phenomena. The sea has a higher capacity of heat absorption and storage than the neighbouring land masses. During daytime the surface of the land warms up faster than the surface area. Warm air over the land is rising and causes a local low-pressure area. As a result, we have wind from the sea (sea breeze) with a maximum in the afternoon. During the night, the land masses are cooling down faster than the water masses. If the surface water temperature is higher than the surface temperature of the land, warmer air over the sea is rising and causes a local low. As a consequence, wind from land (land breeze) is blowing during the night with a maximum before sunrise.

The input data required for the model are cross-shore profile, initial shoreline position along the coast, sediment size, annual wave climate etc. are already mentioned in **Section 4.2.3.5**.

Water Levels: Tidal ranges for locations along the Chennai coast are given in **Table 4-2** Mean High High Water (MHHW) at Chennai port is 0.5 m above MSL. Mean High High Water is the average height that the tide reaches on a Spring Tide. Spring tides basically occur when there is a new moon or a full moon. Spring tides rise furthest up the shore at high tide and go out furthest at low tide (i.e. maximum tidal range occurs).

Table 4-2: Tidal levels and datum for Chennai (NHC Chart No. 3039)

Datum	Tidal Level (m) w.r.t CD
Mean High High Water, MHHW	1.1
Mean High Low Water, MHLW	0.8
Mean Sea Level, MSL	0.6
Mean Low High Water, MLHW	0.4
Mean Low Low Water, MLLW	0.1

Current: Currents can be divided in ocean currents and nearshore currents, only the later influence the coastal processes.

4.2.3.6.2 Interventions

The model studies for shoreline changes with the proposed Master Plan indicate that 4km north coast of Kattupalli is eroding at the rate of 16m/yr. In order to prevent the erosion in north coast two types of interventions and the consequent impacts on shoreline management along the coast both soft (sand bypassing) and hard measures (groynes) were tested with appropriate model simulations.

Option-1 Artificial Beach Nourishment:

Soft engineering measures such as beach nourishment are widely used for shore protection due to lack of negative impacts like erosion and also advantage over hard measures (seawalls and groynes) in terms of performance, aesthetics and restoration of natural beach. **Figure 4-12** shows a broad classification based on cross-shore dimension.

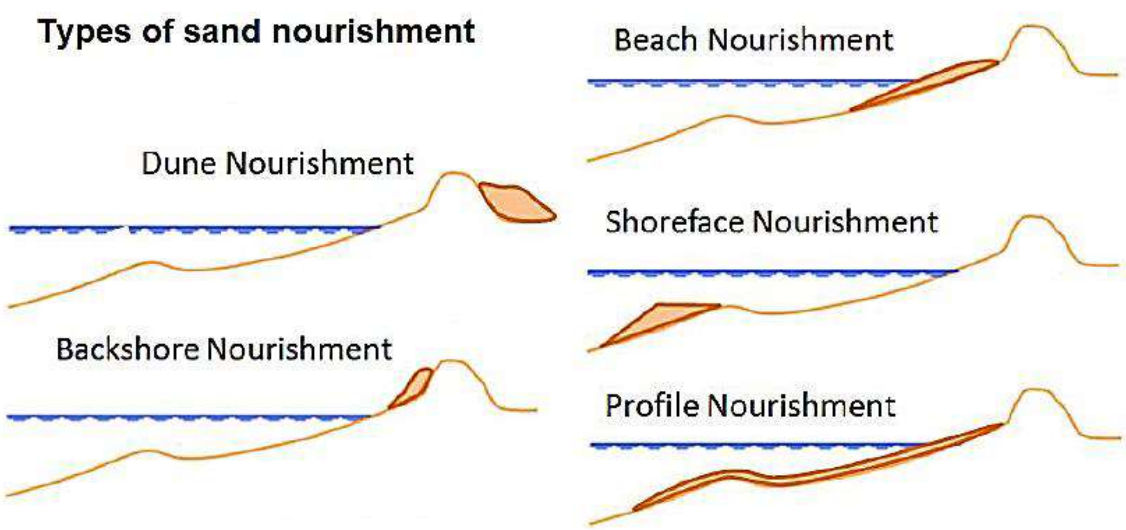


Figure 4-12: Types of sand nourishment

Beach nourishment is not a coastal protection measure, as the beach will normally be flooded during extreme events allowing erosion of the coast, but it will support possible coastal protection measures. When performing beach nourishment, the borrow sand must be similar to the native sand to adjust smoothly to the natural profile. It may be an advantage to use slightly coarser sand than the natural beach sand, as this will enhance the stability of the resulting slightly steeper profile. Finer sand will very quickly be transported to deeper water and will thus not contribute directly to a wider beach.

Another mitigation measure to consider in relation to minimising the impact of nourishment on the port operations is to perform the nourishment during the southwest monsoon so that possibility of material entering into entrance channel can be avoided.

Figure 4-13: Nourishment methods in practice worldwide. 1: Beach nourishment by pipe discharge. 2: Foreshore nourishment by over the bow pumping and 3: Shoreface nourishment by split barge

At Ennore Port, nourishment of backshore nourishment was implemented. The material dredged from Ennore port through capital dredging (3.5M Cu.m) was transported through pipeline to the north of the port. Out of total quantity of dredged material, 0.7 M Cu.m was placed over the existing beach to rise the berm height from 2.5 to 6m above mean sea level and the rest is spread nearshore to widen beach by 500. Filll started supplying material to the downdrift coast from the inception of the project and a 250m wide beach was lost between 2000 and 2004, forming a steep cut at the beach fill location.

In order to find suitability of nourishment at Kattupalli, similar method applied using mathematical models. The overall performance of the beach fill to protect the downdrift coast appears satisfactory at Kattupalli. Two Million Cu.m of the dredged material is used for nourishing 1km of the beach immediate after the northern breakwater of proposed port development for one year.

Figure 4-14 shows the 15 years shoreline changes after one-year nourishment of 2 m Cu.m dredged material. Predictions made using mathematical models indicated that beach fill would be completely lost to sea after 12 years from the time of nourishment and the original coast will be under threat if no intervention is planned. To mitigate the impact of beach nourishments on intertidal sandy beaches and to assure a swift recolonization of the nourished beach by the original sandy beach community, the use of sediment that resembles the initial beach sediment, is therefore strongly recommended.

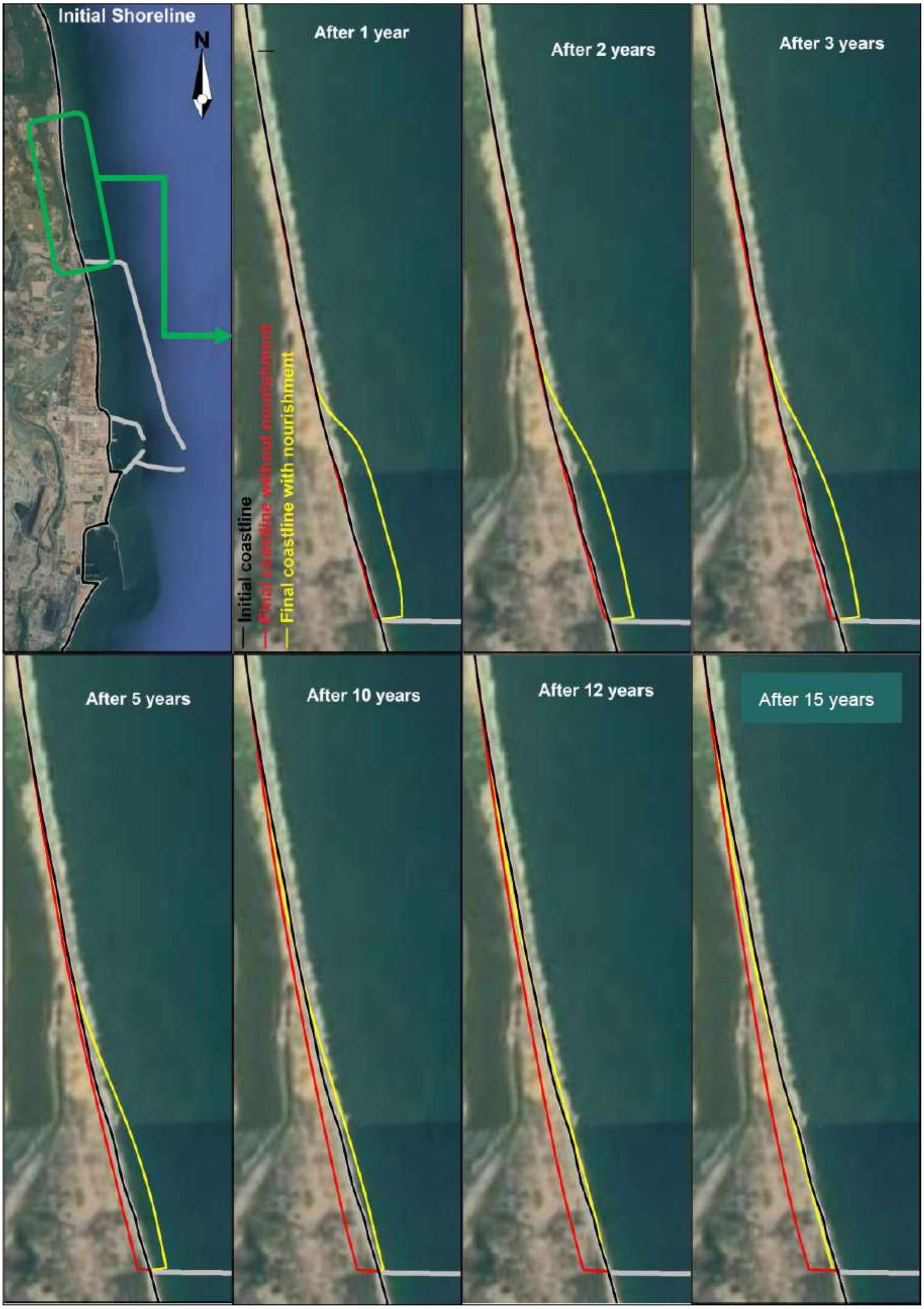


Figure 4-14: Shoreline changes in 15 years (with and without nourishment)

Option-2 Groyne Field:

Groins are coastal structures oriented approximately shore-normal and built of similar material as seawalls. They form a cross-shore barrier that traps sand that moves alongshore, thereby increasing the width of the beach on the upstream side. Thus, they function best on beaches with a predominant alongshore transport direction. Groins are built to serve three purposes. 1) to build or widen beach, by trapping sand, 2) to stabilize a beach, which is subject to excessive storms or periods of episodic erosion and 3) to reduce or prevent the movement of littoral materials out of an area. Along Ennore to Pulicat coast even though there is predominant alongshore sediment transport but at immediate north of port there is considerable onshore/offshore movement of sediment. In order to suitability of groynes to arrest erosion north of port groyne field is considered and their possible response along the shore was studied with the help of models.

Simulations on effectiveness of groyne structure under different wave directions indicate that the groin effect is completely negligible when waves approach the coast from East direction i.e. parallel to coastline. It is evident from the studies that the bypassing of sediment to north of the proposed development is not possible due to presence of entrance channel on southern side of port, which traps the sediment. The model results indicate that the wave heights on the downdrift side were drastically reduced and the wave induced current strength decreased and considerable amount of sediment is accumulated.

Under varying annual wave conditions, predicted shoreline for 15 years north of the proposed development is assessed using three (03) groins of varying size (100 to 150 m length) and the spacing is one km (**Figure 4-15**). 3 km of the shoreline is protected by beach nourishment and groyne field. The predicted shoreline indicated that the coast is undergoing erosion on its northern side of the end groyne in the order of 8m/year even though the beach was built with the groyne field. In order to compensate the loss of north beach of groyne field artificial nourishment of the lost beach is needed. One km coastline immediate after the northern breakwater is nourished with 2 M Cu.m dredged material to overcome the erosion and 0.5 M Cu.m sand from the maintenance dredging should be used for nourishment in alternative years but the main problem regarding groyne construction is downdrift erosion, which is extended further north.

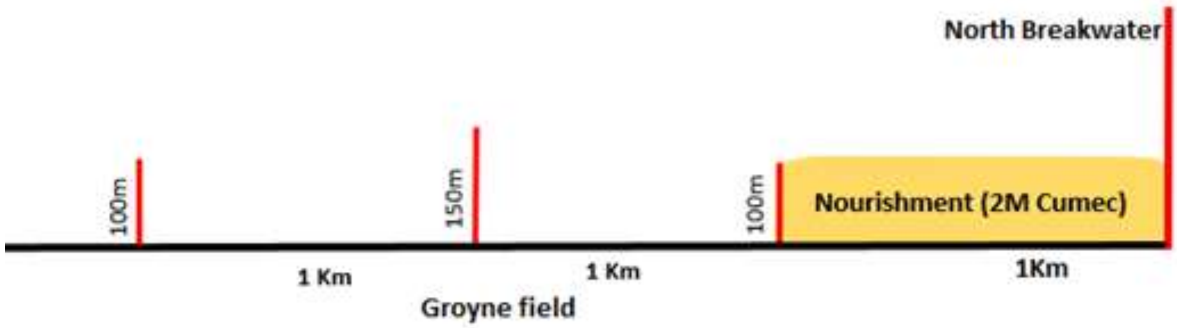


Figure 4-15: Proposed Groyne field to protect the shoreline on the north of proposed port

Figure 4-16 shows the shoreline changes for 15 years after introducing the groyne field and 2 M Cu.m nourishment immediate after north of the proposed port facility along with 0.5M Cu.m. nourishment in alternate years. The shoreline is well protected up to 3km from the north of proposed breakwater, but there is significant shoreline erosion further north of the groyne field in the order of 48 m over 15 years duration.

Figure 4-16: Shoreline changes over 15 years with option-2 (nourishment with groyne field)

Recommendations:

The information on hydrodynamic conditions (tide, wave, current and water level), shoreline changes and sediment characteristics was used to estimate sediment quantity for the coastal stretch from Ennore creek to Pullicat creek.

The model results with the proposed master plan and without any shoreline protection measures indicates shoreline erosion up to 2 km on the northern side of the port with an erosion rate of 16 m/year. To prevent the loss of land, DHI assessed the performance of artificial nourishment combined with groyne field on the northern side of the proposed master plan.

The model analysis indicates that beach fill with a length of 1000 m, width of 200 m with a transition length of 800 m would result in increase in the life of the project and the impact on adjacent coast can also be minimized. Predictions further indicates that this nourished material would be completely lost to sea after 12 years from the time of nourishment and the original coast will be under threat if no intervention is planned. The rate of erosion with the proposed beach fill is in the order of 10m/yr and the zone of erosion is shifting further north.

In order to avoid the quick flow of nourished sand towards north due to littoral transport, implementation of three groins on the northern side of the beach fill is proposed. The length of smaller groin is 100 m and longer groin is 150 m and the distance between the groins as 1 km. Following the implementation of beach fill and groyne field, the rate of erosion is reduced to 8 m/year but the erosion extent shifted further 3 km from the proposed development. This would be minimized with additional nourishment of 0.5 Million Cu.m of sand at every alternate year to protect the area immediate north of the groin filed.

Overall, the erosion of extent is limited to 3 km north of the proposed groyne field along with beach fill. Thereafter the coastline is stable and not subjected to any erosion. The Pulicat lake is further 7 km north from the erosion region hence, it will have no impact either from the proposed Master plan development or from the proposed shoreline protection measures (beach fill and groyne field). The groyne field will also help to keep the nourished material on the beach during extreme weather conditions such as tsunami and cyclones.

Shoreline Trend with various interventions

Scenarios	Erosion Rate in meter/year
Master Plan without any shore protection	16
Master Plan with beach nourishment alone	10
Master Plan with beach nourishment and groyne field	8

4.3 Water Environment

4.3.1 Potential Impact due to Port Location

4.3.1.1 Impact on Existing Water Resource

Based on the land use and land cover studies it was identified that study area (15.0 Km radius) mostly covered with Sea (50.48%), Agriculture-Crop Land (15.31%), Wasteland-Scrub Land (11.5%), Reservoir/Lakes/Ponds (7.74%), Built-up-Industrial (5.03%), Built-up-Rural (3.96%) etc. are observed.

Only 9.42% of the study area is covered with Water bodies such as Rivers/Streams/Canals, Reservoir/Lakes/Ponds. The following are the rivers/canals observed in the study area:

- River Kosisttalaiyar (Tidal influenced)-Adjacent
- Korattalaiyar River-6.3 km, SW
- Aranai River- 4.2 km, W
- Buckingham canal- >0.05 km, W

Water requirement during operation phase of RMP will be 30 MLD, which will be met by proposed desalination plant of total capacity 30 MLD. The source of water for this desalination plant is sea water.

As water requirement is proposed to be met from sea and not relying on existing drinking water facilities/resources, significant impacts are not envisaged.

The reject brine of around 45 MLD from the desalination plant will be discharged into the sea through an outfall arrangement. Marine outfall model studies were conducted for identification suitable outfall location for reject brine. In all the simulations the excess salinity does not exceed 1.5 PSU at the outfalls, and this has further not reached to the intake locations considered outside the proposed Master Plan breakwater. Due to the excess salinity at the outfall, the dense plume is directed downwards to the bottom and maximum spreading can be occur at the bottom.

The edge of the mixing zone is 3.5 km from the discharge point of the outfall location (port entrance). The differences in temperature and salinity are observed to be less than 0.1°C and 0.04 PSU at the edge of mixing zone. The results of the model clearly illustrate that the discharge water from the outfall notation does not mix with water in any intake location.

4.3.1.2 Mitigation Measures

Though the withdrawal of groundwater is not envisaged as a part of proposed development, the following measures are proposed as a part of development to improve the ground water scenario.

- Strategic plans such as implementing following structures for rainwater harvesting and ground water recharging purposes in Project site-
- Roof-top rain water harvesting
- Rainwater storage tanks
- To step up the present level of rain water harvesting and conservation in the study area, the measures such as renovation/revamping of existing rain water harvesting structure
- Proposed to create awareness among farmers in the study area on advanced management methods in utilizing the ground water for irrigation and other purposes
- Monitoring of water quality and ground water level variations in and around the Project site

4.3.1.3 Impact due to Stagnation of Wastewater in Harbour

The construction of marine structures such as protected harbour will change the current patterns and results in tranquil conditions suitable for the operation of the port. In case, the untreated wastewater from the domestic as well as industrial activities in the vicinity of the port flows into the harbour, it results in stagnation of water. This condition may deteriorate through increase of phytoplankton and a decrease of dissolved oxygen, resulting from eutrophication of water, caused by effluents containing nutrient salts (chemical compounds including N and P). Anaerobic water leads to the generation of hydrogen sulphide (H_2S).

The wastewater generated from the port area during construction as well as operational phases will be collected through a wastewater collection network and sent to the Sewage

Treatment Plant and Effluent Treatment Plant for treatment. It is proposed to reuse the treated wastewater for the irrigation of greenbelt within the port.

4.3.1.4 Mitigation Measures

- Sewage generated from port will be treated in STP of 240 KLD during RMP development
- Effluent generated from port will be treated in ETP of 1500 KLD during RMP development
- The waste reception facilities shall be developed as per the Guidelines issued by Government of India (GoI). The collected wastewater will be treated in ETP / sent to approved vendors for further treatment and the bilge water will be collected by authorized waste recycler and taken for further treatment.
- Treated wastewater will be used for greenbelt development

4.3.2 Potential Impact during Construction

4.3.2.1 Impacts due to Land Reclamation/Wastewater Generation

Generally, reclamation of low lying areas with capital dredged material is likely to affect groundwater quality due to intrusion of sea water and based on quality of dredged material. In **Section 3.7.9 Chapter 3**, it is discussed in detail about the quality of marine sediments. The area proposed to be reclaimed is majorly in the sea (Inter tidal) which is saline in nature. The slope of project site is towards the sea and chances of intruding sea water into groundwater are envisaged to be negligible. Hence, no significant impacts are anticipated due to land reclamation on ground/surface water.

Also, as most of the development in the form of dredging and reclamation will be into the sea and small area towards landward side of the port will be developed as backup area. The applied land to be reclaimed will be saline mud and is separated from the adjoining land mass through the salt dyke.

During construction phase of the proposed project, sewage will be generated from construction workers camp and from the project site. Wastewater generation at construction site includes surface runoff also which may contain pollutants and traces of solvents, paints, metal compounds, etc. which may impact the groundwater and nearby surface water resources if not managed properly.

4.3.2.2 Mitigation Measures

- The return sea water quality from the reclaimed area shall be monitored during reclamation phase
- Groundwater quality shall be monitored
- An adequate drainage system will be provided at the site with separate collection streams to segregate the storm run-off from roads, open areas, material storage areas, vehicle wash water and other wastewater streams. Suitable measures will also be taken to prevent the washing away of construction materials into the drainage system.
- Contaminated storm water will be collected and conveyed to sedimentation tank for removing grit.
- Sewage generated at site /construction workers camp will be treated in the existing/proposed STP.
- No wastewater shall be disposed directly on land or on existing surface water resources without appropriate treatment.
- Construction workers camp shall be located outside CRZ area

4.3.2.3 Impact on Existing Drainage Pattern

A watershed boundary defines the drainage or catchment areas that contribute to a specified outlet channel, such as a creek or river (Bhola, 2012). Drainage morphometry provides quantitative description of the drainage system. Natural drainage of the Kattupalli and its surrounding area is being maintained through Kosisttalaiyar River through direct discharge to Bay of Bengal. Kattupalli port back up area falls between Kosisttalaiyar River, Buckingham canal and Bay of Bengal. There are few natural third/fourth order drains are passing through the project site, therefore, storm water drainage network (Detailed in **Section 7.3** of **Chapter 7**) is planned to facilitate the proper drainage pattern of the area.

4.3.2.4 Mitigation Measures

- Existing drainage pattern around the project site will not be disturbed. Storm water drainage network will be provided within the project development area
- An adequate drainage system will be provided at the site with separate collection streams to segregate the storm run-off from roads, open areas, material storage areas, vehicle wash water and other wastewater streams.
- Suitable measures will also be taken to prevent the washing away of construction materials into the drainage system.

4.3.3 Potential Impact during Operation

4.3.3.1 Impact on Water Quality due to Cargo Operations

The Revised Master Plan development of Kattupalli port will handle cargo such as Dry bulk cargo (Coal / Iron ore / limestone / Mines & Minerals & Other dry bulk); Multipurpose & General Cargo (Fertilizers and raw materials for manufacture of fertilizer / food grains / sugar / clinker / cement / Project cargo / timber & wood / machines/ Iron steel products / Break Bulk etc.); Container; Cryogenic Liquids and Gas (LNG, Propane, Butane, LPG, CNG, NG) and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals and other Liquid cargos).

Araniyar river drains into the southern end of Pulicat lake and joins a stream which connects Pulicat Lake with Ennore Creek. The port lies beside Kosisttalaiyar River. Buckingham canal flows parallel to this stream (between the stream and the coast) until Ennore Creek.

Precautionary measures will be taken in case of spillage to reduce the impact on water quality. The proposed cargo is to be handled with specialized handling systems and equipment and hence there will be very little chances of spill. However, in case of accidental spill of cargo during handling, spills will be contained and wash water or surface runoff containing spills will be collected separately and will be treated to avoid any further impact on water quality. Storm water runoff from the cargo storage areas and other areas of the project facilities may contaminate marine water quality if not regulated properly.

The following are the wastewater generation from the Kattupalli Port:

- Estimated sewage for Revised Master Plan development will be around 240 KLD
- Industrial Wastewater/Effluent with Oil presence from the areas such as equipment Workshop, Utility Building, Raw Water Pump House, Fire Water Pump House, fire station and, fuel station for RMP development is estimated to be around 1500 KLD

- Dust Suppression water from cargo stock yard etc., containing mainly suspended particulates
- Rain washed roads and roof tops containing particulates

4.3.3.2 Mitigation Measures/Wastewater Management

It is proposed to develop STP of 240 KLD capacity for RMP development. Similarly, ETP will be developed of 1500 KLD capacity for RMP development.

Sewage treatment Plant will be of compact size with efficient treatment to treat raw sewage of following Inlet Parameter at STP:

S. No.	Parameter	Unit	Design Parameter for Raw Sewage @inlet
1	pH	-	6.0-8.5
2	TSS	ppm	1000
3	BOD	ppm	300-350

Biological treatment is considered for STP and considering recycling in irrigation/horticulture area

The sewage generated from the various sources is collected in the Collection tank through the screen chamber to remove floating material and particle size greater than 20 mm. The Screened sewage from the collection tank is then led to the Fixed Bed Bio Reactor (FBBR) tank through Raw Sewage Transfer Pump and coarse bubble diffusers are provided in the collection tank. In the FBBR tank, air is diffused through special type of diffusers to oxidize the organic matters with the help of air blower & diffuser arrangement. Biological treatment takes place through FBBR media. The FBBR media is introduced in to the aeration system to increase the surface area of the aeration tank, the bacteria will fix in the rough surface of the plastic media, which is submersible in floating conditions will enhance the growth of microorganism and improve the BOD reduction in the aeration tank. Then the overflow from FBBR tank is sent to the Settling tank for settling.

The bioflocs formed in the FBBR tank will be settled at the bottom of the Settling tank and the settled sludge will be pumped to the Filter Press through the return sludge pump. The clarified overflow is collected in the Clarified water tank where sodium hypo chlorite is given with the help of dosing system for disinfection purpose. The disinfected water is then fed to the Pressure Sand Filter and Activated Carbon Filter for the removal of suspended solids, organic matter, odour. The filtered water is stored in Treated water tank to maintain the concentration sludge from secondary clarifier will be recirculated to aeration tank. The microorganisms present in the sludge will digest the organic compounds present in the sewage and thus reduces BOD and COD content of the inlet raw sewage effluent. Oxygen required for the survival of the microorganisms will be supplied through air blower and diffuser arrangements.

The Process Flow Diagram for STP based on MBBR technology is given in **Figure 4-17**.

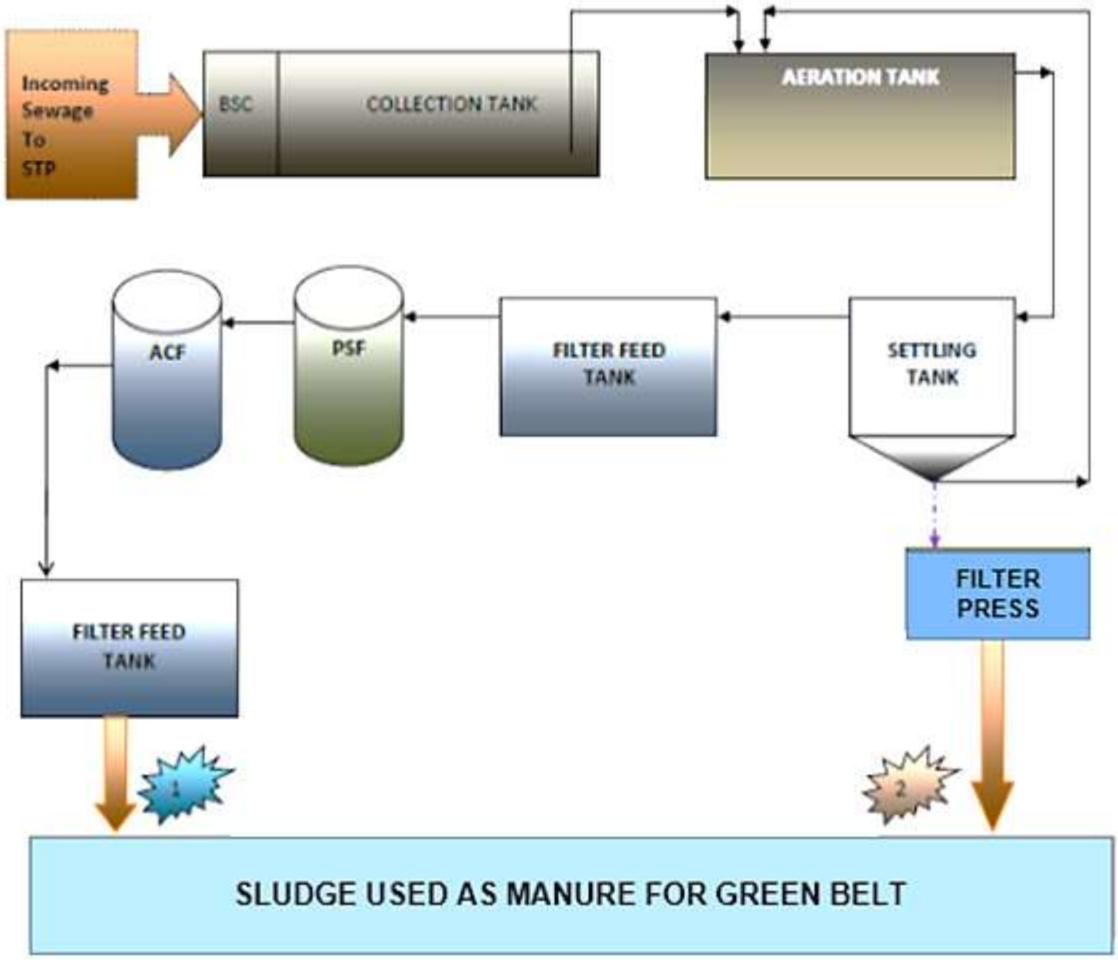


Figure 4-17: Process Flow Diagram for STP

Treated water discharge standards after treatment for sewage treatment plants will be as below:

S. No.	Parameter	Unit	Design Parameter for Treated water @ outlet
1	pH	-	6.5-9.0
2	TSS	ppm	<100
3	BOD	ppm	<30

Sludge cake will be used as compost for agriculture. Treated water will be used for Gardening/Irrigation use within Port premises

Storm water runoff will be directed as per the storm water drainage network planned considering the existing drainage pattern to finally discharge into the sea. Settling ponds are proposed for Dry Bulk Cargos such as Coal and iron ore stack yards etc., to settle coal and iron ore particles or other bulk cargo particles which would otherwise pollute the stream water. The size of the settling pond shall be determined from detention time of 2.5 hours. Supernatant water from settling pond will be reused. During rainy season, the excess water will be discharged into the sea. The runoff from uncontaminated areas will be discharged into the greenbelt area. The oil contaminated water will be sent to ETP and the separated oil will be given to the authorised waste oil recycler. The separated water will be reused. Cargo spill control measures such as Oil Spill Contingency Plan etc., shall be followed the details are given in **Section 7.5** of **Chapter 7**.

4.3.3.3 Oil Spill Assessment

A stochastic oil spill assessment is undertaken to assist with oil spill contingency planning for the proposed Master Plan development at Kattupalli port. The spill events included 08 simulations (each four at turning circle and SPM location) to evaluate potential oil spill impact to the surrounding environmental resources under different weather and met-ocean conditions.

The HD modelling has been carried out using DHI MIKE21 modelling suite. The simulation of the hydrocarbon spills has been carried out using DHI's Oil Spill model MIKE 21 OS. In this model the oil is represented as (Lagrangian) particles being advected with the surrounding water body and exposed to weathering processes. The advection (drift) of the individual particles is determined by the combined effects of current, wind and bed drag. The model provides information on oil slick locations, the amount of oil left on the sea surface, the slick mobility and the evolution of the physiochemical properties of the oil.

4.3.3.3.1 Oil Spill Processes

MIKE 21 OS model describes the spreading and weathering of oil spills in an aquatic environment under the influence of water movements and the associated dispersion processes. The oil itself is defined according to its distillation properties and chemical structure. The processes are considered in the models includes spreading, evaporation, emulsification, vertical dispersion, and dissolution.

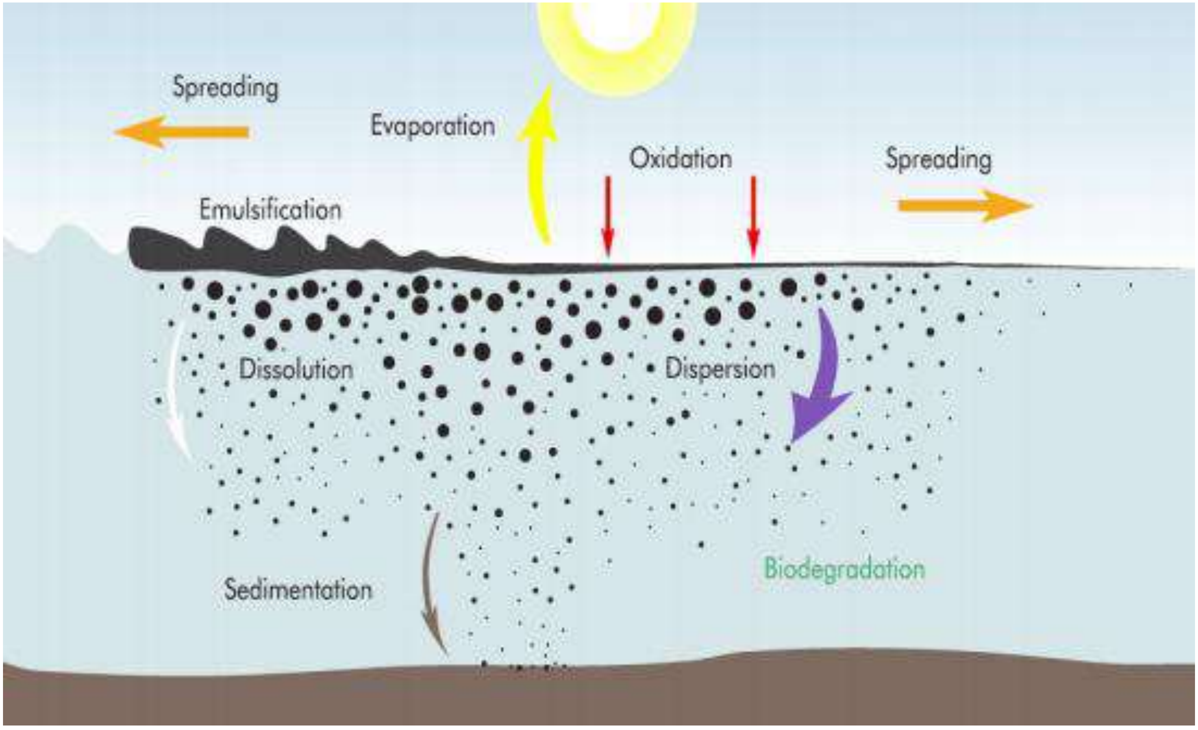


Figure 4-18: Processes acting on spilled oil

The physical and chemical changes that spilled oil undergoes are collectively known as weathering. Although the individual processes causing these changes may act simultaneously, their relative importance varies with time. Together they affect the behaviour of the oil and determine the fate. These processes are illustrated in **Figure 4-19** for a spill of a typical medium crude oil under moderate sea conditions. Sedimentation only occurs for very heavy oils in connection with mineral particles (sand/clay). Biodegradation and photo - oxidation only affect oil spills in the longer term (i.e. weeks to months or years).

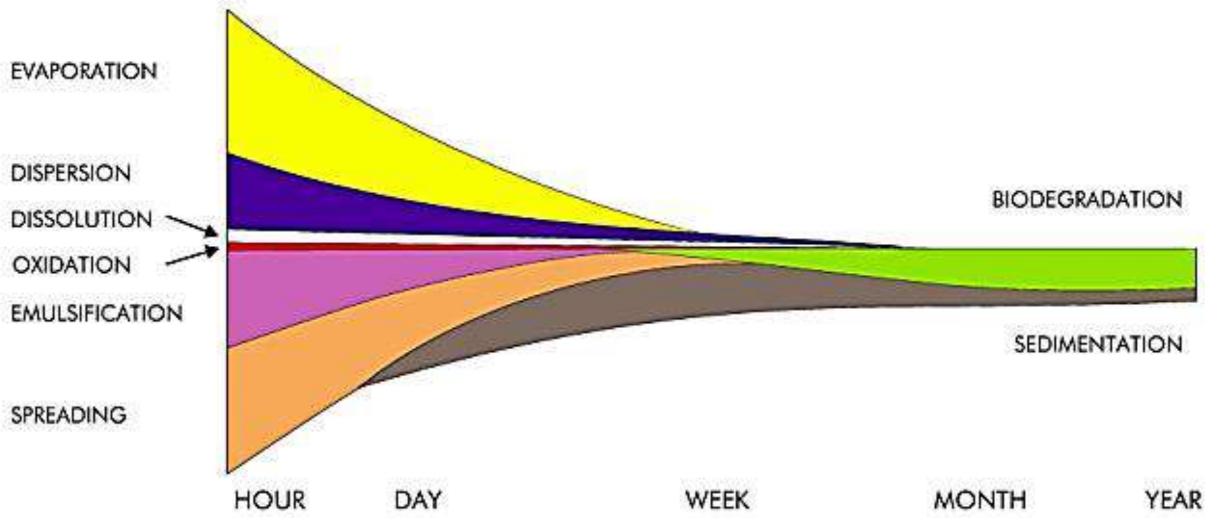


Figure 4-19: A schematic representation of the fate of a crude oil showing changes in the relative importance of weathering processes with time

4.3.3.3.2 Oil spill process and properties

The different parameters applied for the oil spill processes are listed below.

- Spreading: The currents define the water movement (advection) while the dispersion in the OS module is described using three dispersion coefficients that are proportional to the current in the longitudinal, transverse and vertical directions. Proportionality constants of 1.0 [m], 0.1 [m] and 0.01 [m] respectively were applied.
- Evaporation: Evaporation is given as a constant that is proportional to the amount of the evaporated oil. A default value of 0.0292 (dimensionless) has been applied.
- Emulsification: The emulsification process (water uptake) leads to a reduction in concentration, but also diminishes the evaporation of components from an emulsion. For the present study the emulsification is not included.
- Dispersion (called entrainment in MIKE 21 OS): The entrainment of oil (or vertical dispersion) into the water column is simulated using an interfacial tension parameter with a value of 20 dyne/cm valid for nonbreaking waves.
- Dissolution: The volume of oil leaving the slick due to dissolution is calculated via a mass transfer coefficient set to a default value of 2.36·10-6 (dimensionless).

Additionally, the heat transport is considered in MIKE 21 OS with the following parameters used in the balance calculation:

- Albedo value: 0.14
- Emissivity of oil: 0.8
- Emissivity of water: 0.95
- Emissivity of air: 0.82

Additionally, a viscosity of 3.24 and reference temperature of 22°C are included in the spill modelling set up.

4.3.3.3.3 Environmental Data:

Hydrodynamic and wind conditions are key to drive the oil spill model.

Currents: The drift applied in the oil spill simulations is a combination of a traditional bed shear profile (logarithmic from the hydrodynamic model simulation and wind acceleration of particles directly exposed to the wind). The drift profile applied in the model is the sum of these two profiles.

Wind Data: Wind data obtained from the Kattupalli Port wind station is applied in the oil spill model to describe the surface drift.

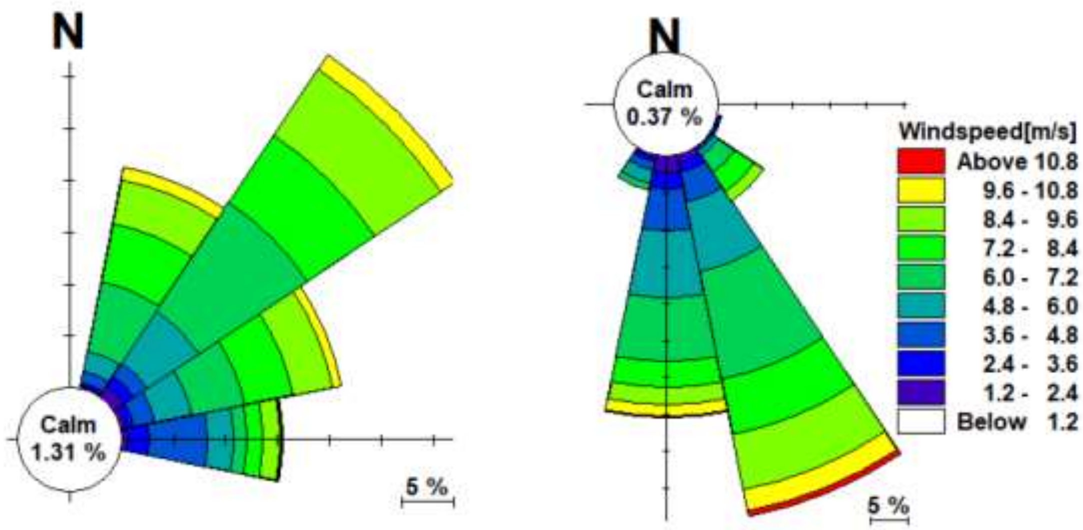


Figure 4-20: Northeast and Southwest Monsoon wind used for the simulations

Oceanographic Data:

A constant salinity of 33 PSU and a constant sea water temperature of 26°C have been considered.

4.3.3.3.4 Spill Scenarios

A single surface spill scenario is defined in terms of the spill location, oil properties, rate, duration, and temperature. The oil is divided into five fractions, each characterized by a vapour pressure, water solubility, viscosity, and density.

Eight oil spill scenarios have been modelled. Each spill event will involve simulation of 6000 (200 particles per 10 minutes for 5 hours) discrete oil spill particles whose advection, dispersion and weathering will be computed over a maximum two-week (14 days) period.

- Scenario 1 to 4: Collision at the turning circle with Gas oil and Heavy oil for NE and SW monsoon.
- Scenario 5 to 8: Collison at SPM location with possible rupture from hale.

Details of the individual oil spill scenarios are given in **Table 4-3** and **Table 4-4**. Each spill simulates Gas oil and Heavy oil as a conservative approach.

Table 4-3: Spill parameter for scenario 1-4

Scenario Number	1	2	3	4
Location	Turning Circle	Turning Circle	Turning Circle	Turning Circle
Case	Collision	Collision	Collision	Collision
Type of oil	Gas Oil	Heavy Oil	Gas Oil	Heavy Oil
Total Spill [m3]	15000	15000	15000	15000
Spill duration [hours]	5	5	5	5
Simulation duration [days]	15	15	15	15
Temperature [°C]	26	26	26	26
Water depth [m w.r.t CD]	25	25	25	25
Monsoon season	North East	North East	South West	South West

Table 4-4: Spill parameter for scenarios 5-8

Scenario Number	5	6	7	8
Location	SPM	SPM	SPM	SPM
Case	Collision	Collision	Collision	Collision
Type of oil	Gas Oil	Heavy Oil	Gas Oil	Heavy Oil
Total Spill [m3]	15000	15000	15000	15000
Spill duration [hours]	5	5	5	5
Simulation duration [days]	15	15	15	15
Temperature [o C]	26	26	26	26
Water depth [m w.r.t CD]	32	32	32	32
Monsoon season	North East	North East	South West	South West

4.3.3.3.4.1 Model Setup

Figure 16-4 shows the model bathymetry used for the oil spill simulations and the oil spill locations considered in the model. The overall flexible mesh set-up for the study area and zoom-in plot of the bathymetry at the area of interest can be seen in the figure. The computational triangular mesh of the model is made with sufficiently small cells to resolve the detailed conditions.

Bathymetry data from different sources were combined to produce a consistent bathymetry dataset covering the entire study area.

The boundaries of the model domain were selected to align with the tidal phase of the study area from hydrodynamic model studies. Tidal level and current predictions were imposed from the hydrodynamic model.

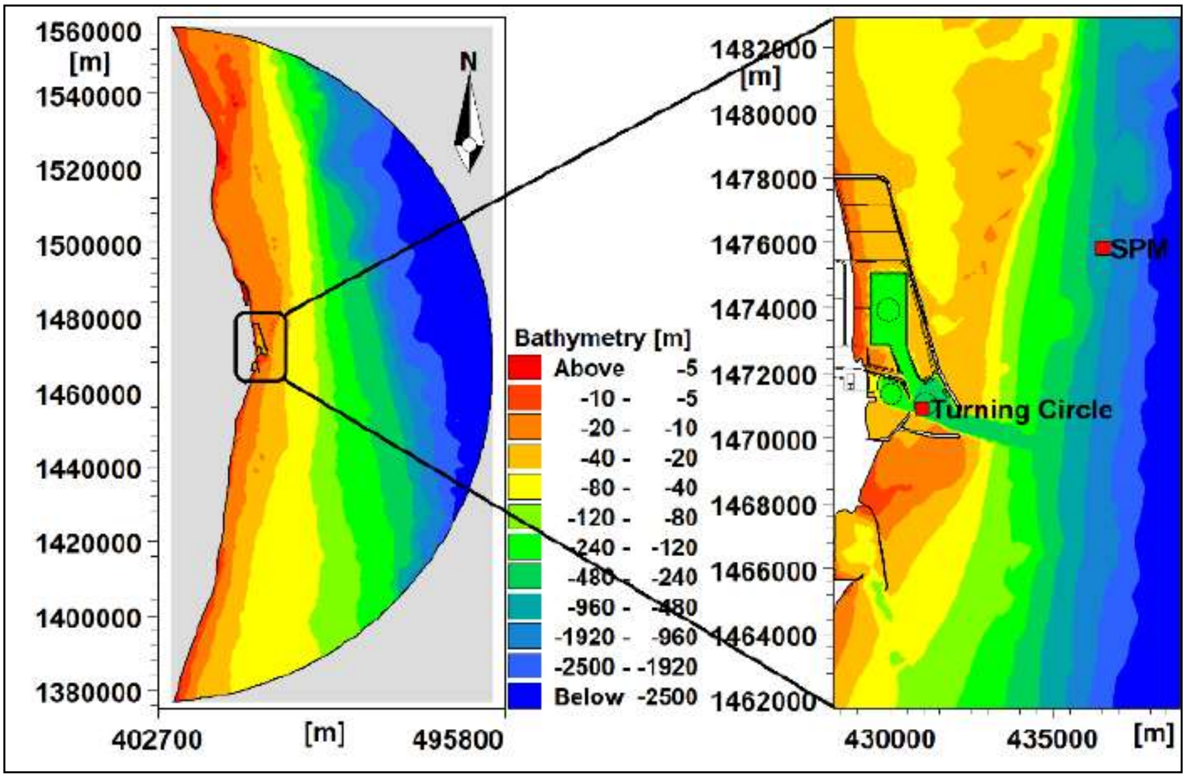


Figure 4-21: Left: Bathymetry used for oil spill model, right: oil spill location considered in the simulations

4.3.3.3.5 Oil Spill Modelling Results

The results from the combination of 8 spill scenarios within the two monsoon seasons are presented in terms of arrival times (Shortest drift time) and oil slick thickness.

Figure 4-22 to **Figure 4-25** show the maximum oil thickness with area of extent and minimum time to exposure at the end of 15 day simulation occurring during NE and SW monsoon for all scenarios at the turning circle.

Similarly, **Figure 4-26** to **Figure 4-29** show the maximum oil thickness with area of extent and minimum time to exposure at the end of 15 day simulation occurring during NE and SW monsoon for all scenarios at SPM location.

Some key observations include:

Spillage occurrence at turning circle is not having any shoreline impact. This is due to the shelter effect of the proposed breakwater and predominant wind direction is from South-East direction. The oil slick is concentrated within the berth area and does not travel far away. For some combination of tide and wind conditions, the oil slick tends to get trapped within the port.

Spillage occurrence at SPM location is having shoreline impact on the northern side of the proposed development. During the southwest monsoon (June to August), winds from south-Easterly is able to move oil very far to the east.

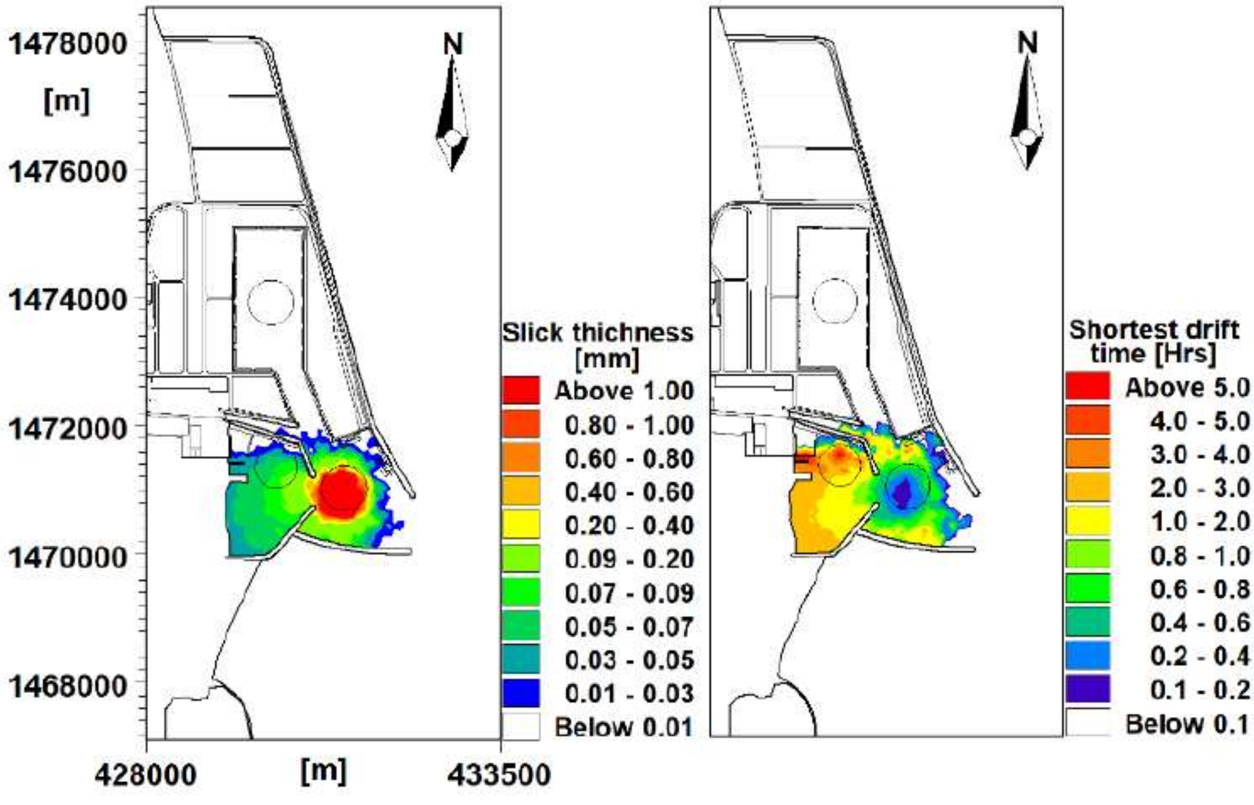


Figure 4-22: Scenario 1- Maximum oil slick thickness and minimum time exposure to oil slick

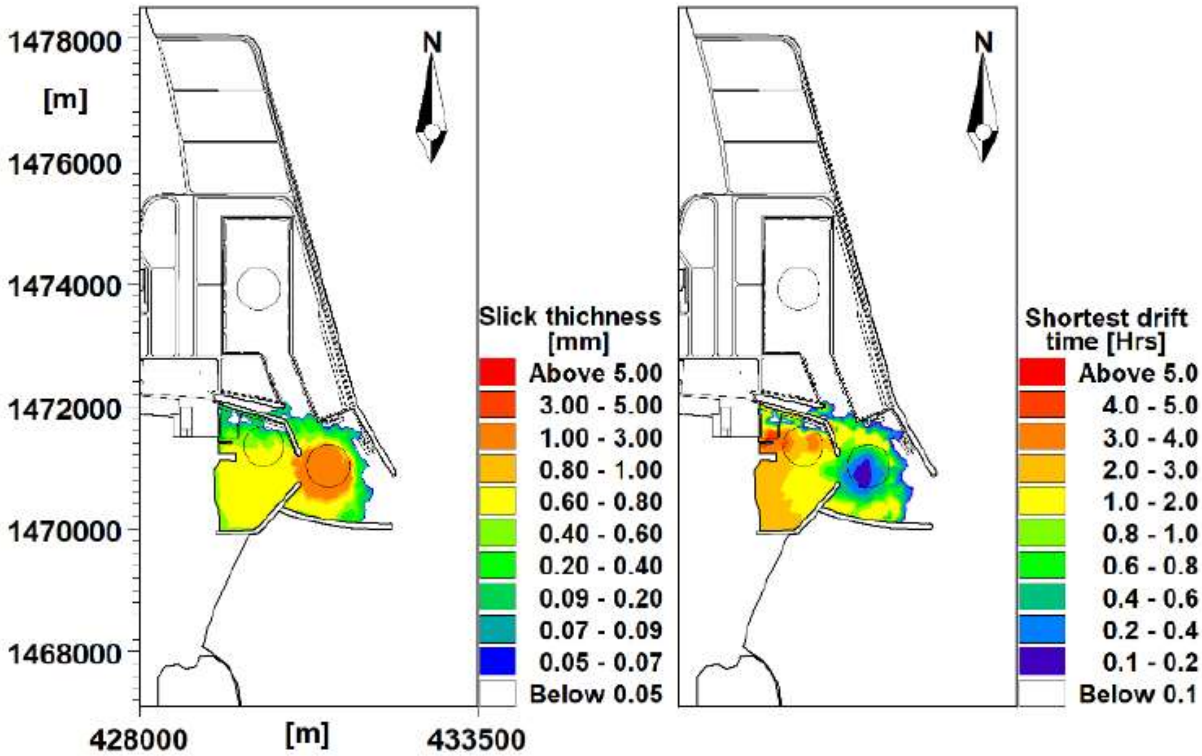


Figure 4-23: Scenario 2- Maximum oil slick thickness and minimum time exposure to oil slick

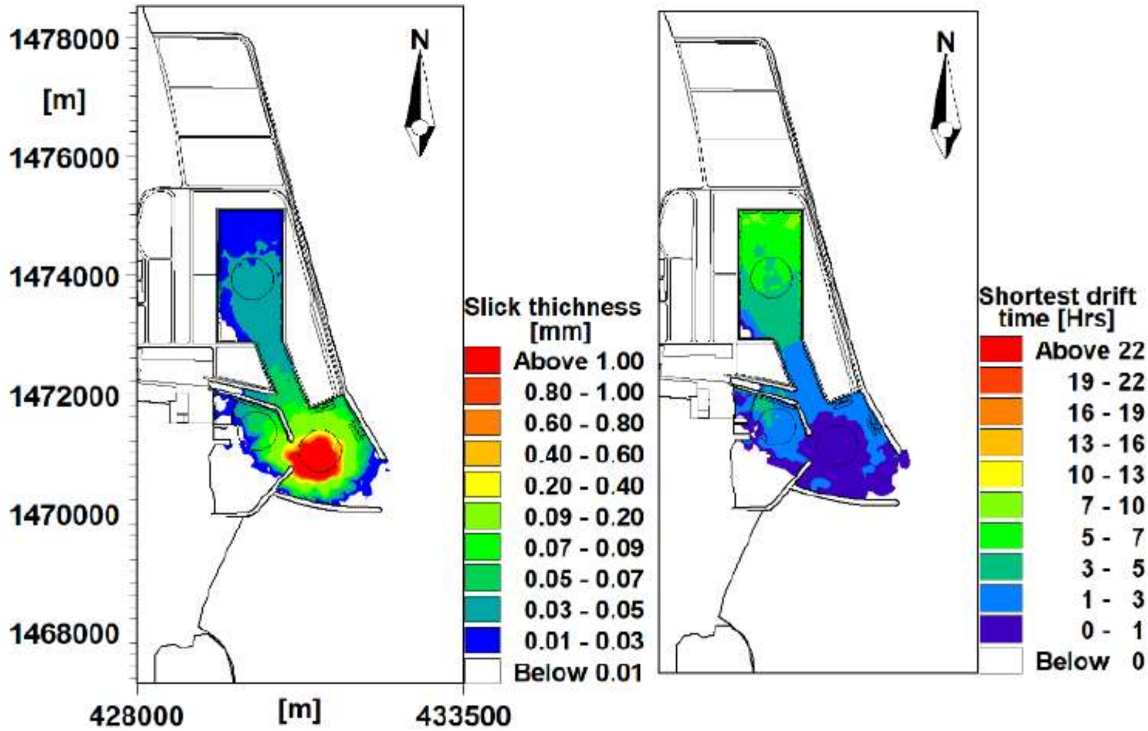


Figure 4-24: Scenario 3- Maximum oil slick thickness and minimum time exposure to oil slick

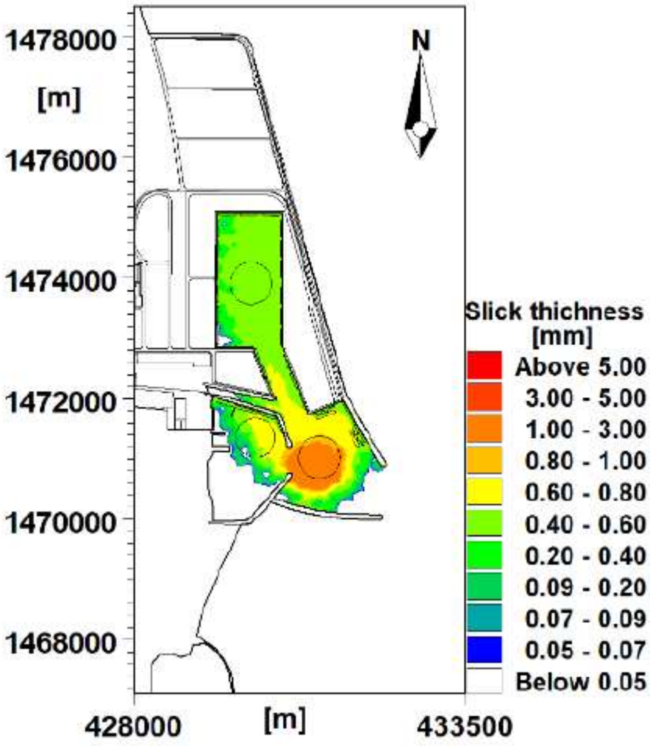


Figure 4-25: Scenario 4- Maximum oil slick thickness and minimum time exposure to oil slick

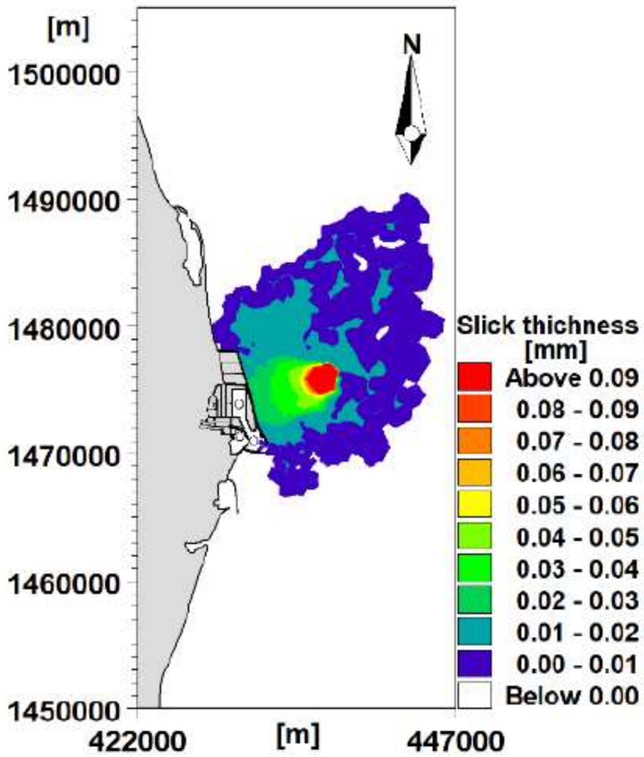


Figure 4-26: Scenario 5- Maximum oil slick thickness and minimum time exposure to oil slick

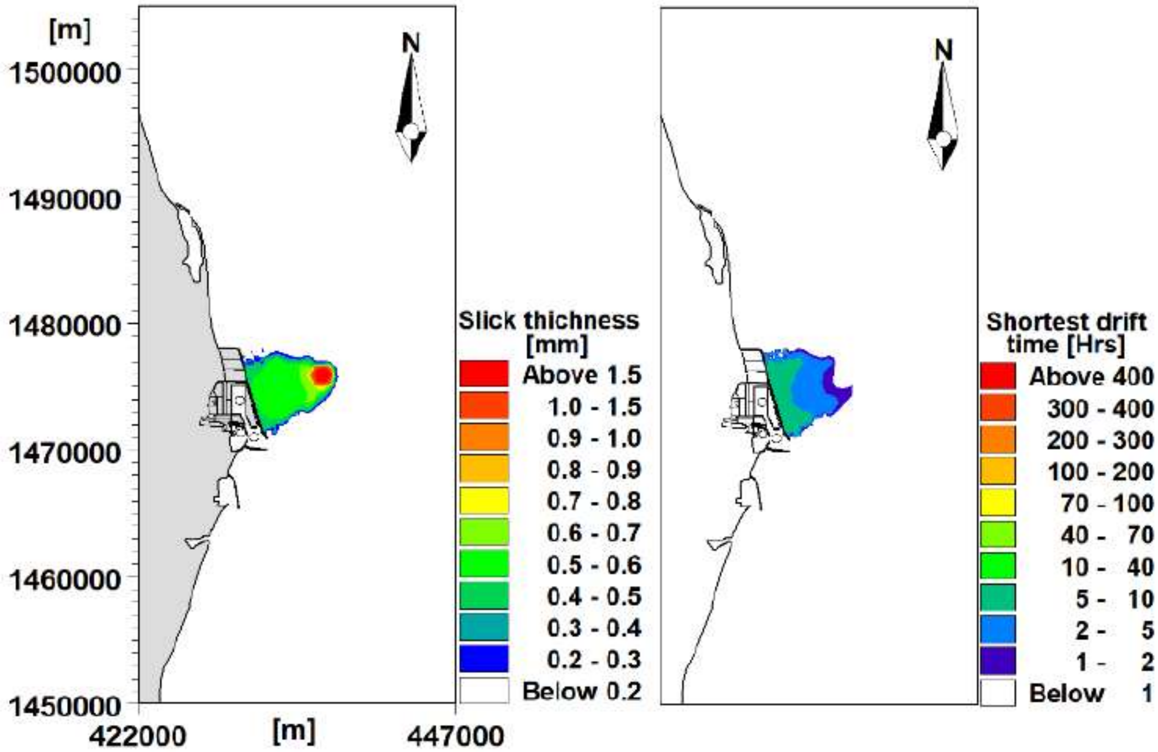


Figure 4-27: Scenario 6- Maximum oil slick thickness and minimum time exposure to oil slick

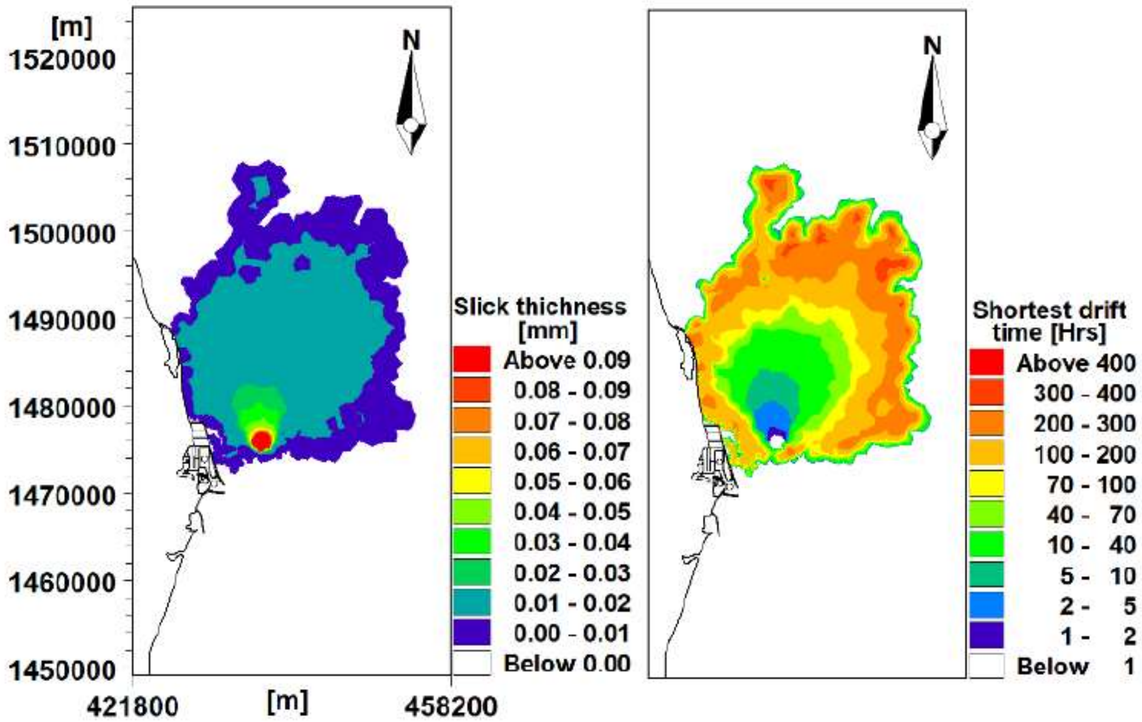


Figure 4-28: Scenario 7- Maximum oil slick thickness and minimum time exposure to oil slick

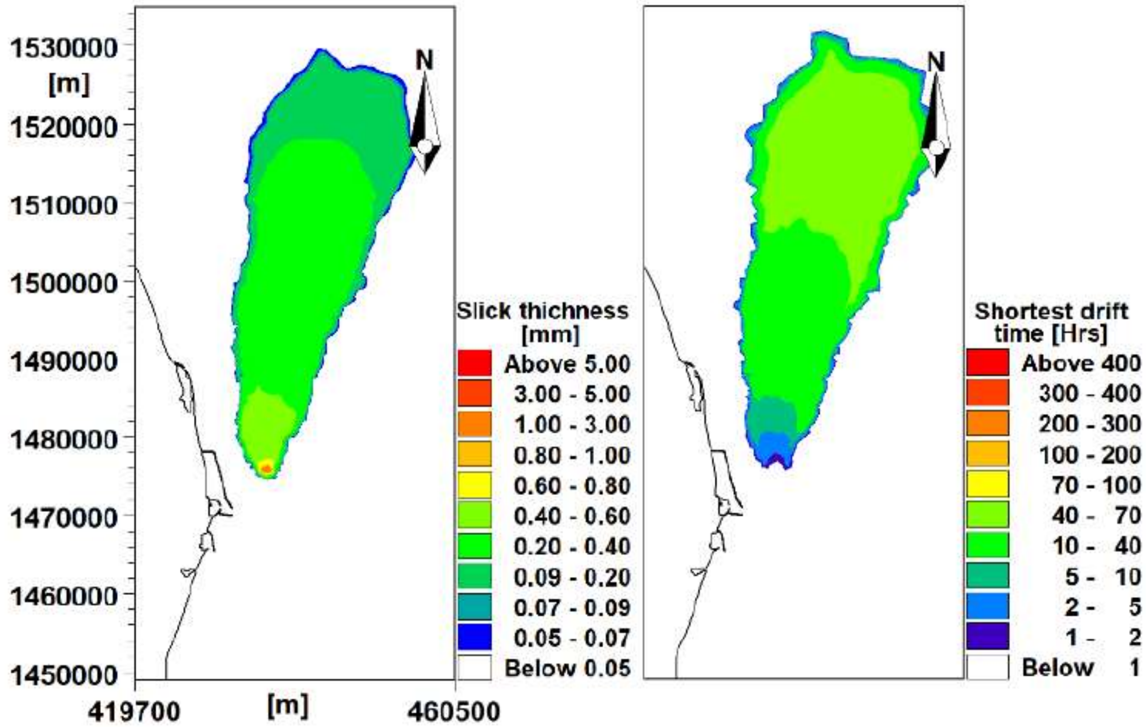


Figure 4-29: Scenario 8- Maximum oil slick thickness and minimum time exposure to oil slick

4.4 Marine Environment (Coastal Hydrology/ Bottom Contamination, Sea/Harbour Water Quality)

4.4.1 Potential Impact due to Port Location

4.4.1.1 Hydrodynamic and Sedimentation Studies

Sedimentation study assesses the annual maintenance dredging quantities with existing and proposed Mater Plan layout at Kattupalli Port. Since, sediment transport is dependent on hydrodynamic conditions; the calibrated hydrodynamic model is extended by sediment transport process calculations. The DHI's MIKE 21 Mud Transport (MT) model is used to assess the sedimentation in the approach channel, turning circle and berth pockets.

DHI's MIKE 21 Mud Transport (MT) module is a state-of-the-art cohesive sediment transport model that simulates the erosion, transport, and deposition of mud or sand/mud mixtures (< 63µm) under the action of currents and waves in marine, brackish or freshwater environments. The model is capable of handling flocculation as well as hindered settling in the water column in addition to sliding and consolidation in the bed.

In the MIKE 21 model complex, the transport of fine-grained material (mud) has been included in the Mud Transport (MT), linked to the Hydrodynamic module (HD) and the Advection-Dispersion (AD) module. The primary input to sediment transport modelling is in the form of characteristics of the bed material as well as material in suspension in addition to the current and wave inputs which are directly embedded from the hydrodynamic simulation results. It considers the following sediment properties:

- Settling velocities
- Critical shear stresses for deposition and erosion
- Bed layer densities
- Several fractions (fine sand, silt, clay)
- Transport of suspended sediment concentrations

4.4.1.1.1 Model Bathymetry

The model extent and bathymetry considered for sedimentation study is shown in **Figure 4-30** for baseline and layout conditions.

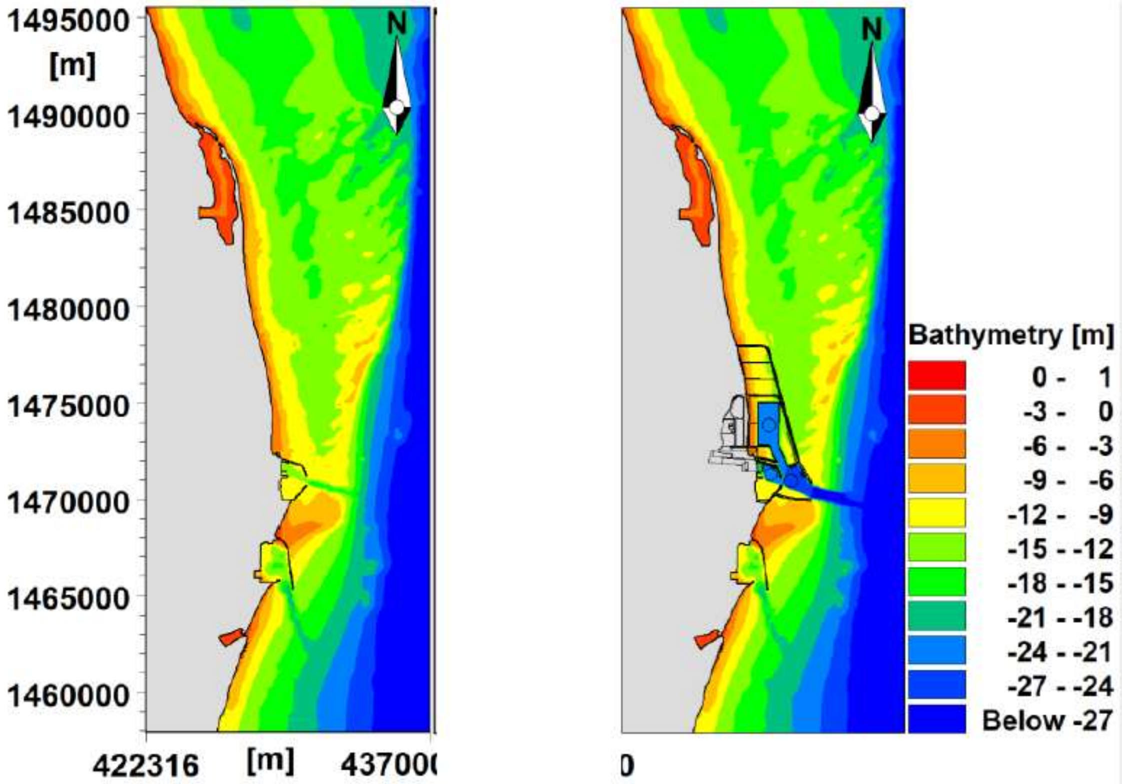


Figure 4-30: Bathymetry data, Left: Baseline conditions; Right: Master Plan Layout

4.4.1.1.2 Simulation Period

The simulation was carried out for a period of 15 days during pre-monsoon (2020) as part of model calibration. Followed by the calibration, the MT model was simulated for layout condition for pre monsoon covers one spring and neap tidal cycle, in order to estimate the annual siltation quantity in the vicinity of the proposed development.

The production period of the mud transport model is given below.

For Calibration: Tide with pre-monsoon wind and wave: 18th February to 06th March 2020.

4.4.1.1.3 Model Parameters

The table below summarizes the sediment transport parameters applied during the simulation period.

Table 4-5: Mud Transport model parameters

Parameter	Value
No. of grain size fractions	2
No. of bed layers	2

Parameter	Value
Dispersion coefficient	1m²/s
Boundary concentration	Zero gradient
Settling velocity	Varying for Silt & Clay
Critical shear stress for deposition	Varying [N/m²]
Power of erosion	soft mud=8.1 and hard mud=1
Erosion coefficient	3e-05 [m²/s]
Critical shear stress for erosion	Varying [N/m²]
Density of bed layer	180 [kg/m³] for layer 1 and 300 [kg/m³] for layer 2
Bed roughness	0.005 [m]
Initial sediment concentration	0.005 kg/m³

4.4.1.1.4 Water Column Parameters

Under the water column parameters, the following sections are included:

- Settling velocity
- Sand fractions
- Deposition

4.4.1.1.4.1 Settling Velocity and Erosion Coefficient

The settling velocity of the fine sediment depends on the particle/floc size, temperature, concentration of suspended matter and content of organic material. Based on the grain size, the approximate settling velocities can be calculated using Stokes law. For sand fraction settling velocity is 0.24m/s and the settling velocity coefficient for the fine sediment is 50.

4.4.1.1.4.2 Critical Shear Stress for Erosion/Deposition

Selection of critical bed shear stress for deposition and bed erosion is important task in sediment transport and morphological modelling. The bed shear stress distribution and sedimentation condition in the study area is strongly related to hydrodynamic characteristics e.g. boundary conditions and characteristics of the tides (semidiurnal and diurnal).

The erosion of a bed layer is the transfer of sediment from bed layer to the water column. Erosion takes place from the active bed layer in areas where the bed shear stress is larger than the critical shear stress for erosion.

The deposition of suspended sediment is the transfer of sediment from the water column to the bed. Deposition takes place where the bed shear stress is smaller than the critical shear stress for deposition.

The critical shear stress of erosion and deposition determines the concentration profile of the water column. The criteria for erosion is that the critical shear stress for erosion is exceeded corresponding to the driving forces exceeding the stabilising forces. **Figure 4-31** shows the critical shear stress for erosion and deposition considered in the mud transport simulations.

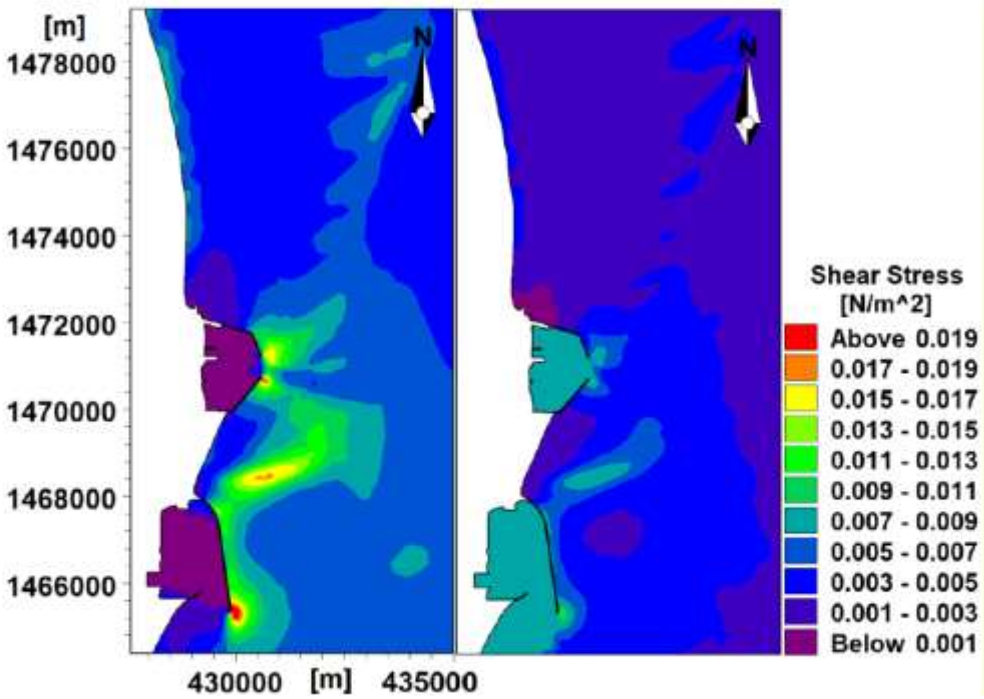


Figure 4-31: Critical shear stress:- Left for erosion Right: for deposition

4.4.1.1.5 Bed Parameters

The bed sediment is defined by the sediment mass contained in the layer and by the dry density and erosion properties of the layer. For Layer 1, the dry density is chosen as 180 kg/m^3 and for layer 2 the dry density is chosen as 300 kg/m^3 in the model. Bed roughness considered in mud transport model is 0.005m.

4.4.1.1.6 Initial Conditions

Values of bed composition and the suspended sediment are specified as initial conditions in the model calculations:

- Initial thickness of bed layers
- Initial concentration of suspended sediment
- Initial grain size distribution of the bed

The initial thickness of the specified bed layer defines the mass of sediment present in the bed at simulation start. The initial concentration defines the amount and distribution of sediment in the water column at the simulation start. The distribution of sediment fraction is specified as percentage of fraction.

4.4.1.1.7 Boundary Conditions

At each open boundary in the model, concentration of suspended sediment matter is specified. Zero sediment gradient is considered along the ocean boundaries.

4.4.1.1.7.1 Model Calibration

The calibration has been performed by comparing the modelled suspended sediment concentration (SSC) with the derived SSC from the measured water samples data. The water samples were collected by the survey consultant at various depths (surface, mid depth and near-bottom) during spring tide at several geographic locations as shown in **Figure 4-32**.

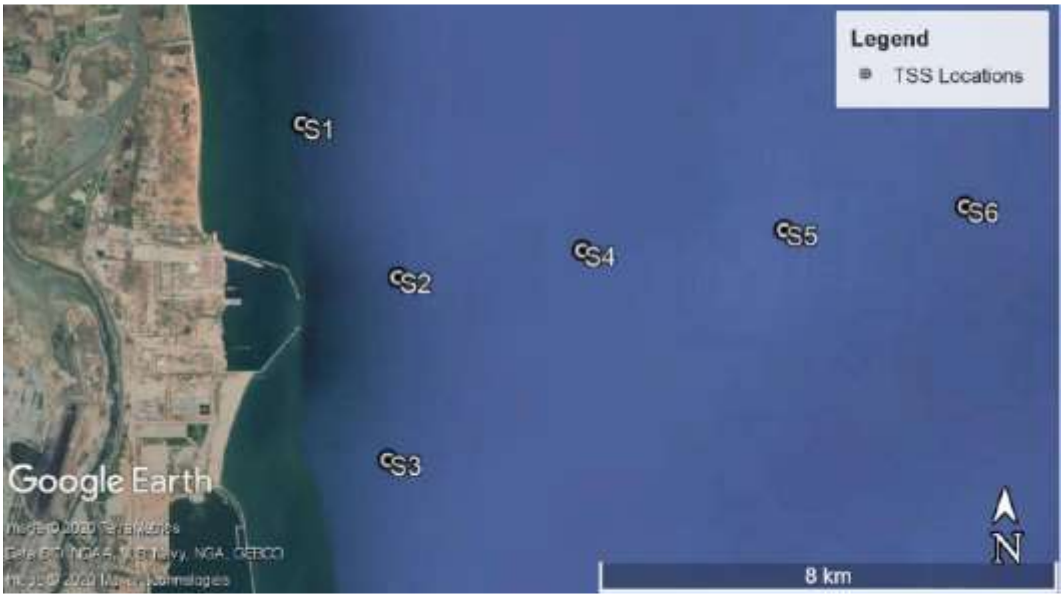


Figure 4-32: Measured TSS locations during pre-monsoon

The periodically varying tidal currents, which increase linearly with tidal range, erode-resuspended material at a rate, which depends on the surface density of the sediment deposits and the bed shear stress. Sediment eroded from the sea bed by the tidal currents is gradually dispersed throughout the depth by the process of vertical turbulent exchange.

A spring-neap tidal cycle has been simulated in order to predict the suspended sediment concentrations at the study area. The measured and simulated suspended sediment concentration during pre-monsoon season at three (03) locations is shown in **Figure 4-33** to **Figure 4-35**.

The continuous lines represent the simulated suspended solids and the dots represent the measured suspended solids. It should be noted that, measured water samples are not as continuous and hence the comparison is shown only for few hours. The maximum suspended solid concentration at location S1, S2 and S3 locations are ranging from 60 mg/l to 70 mg/l.

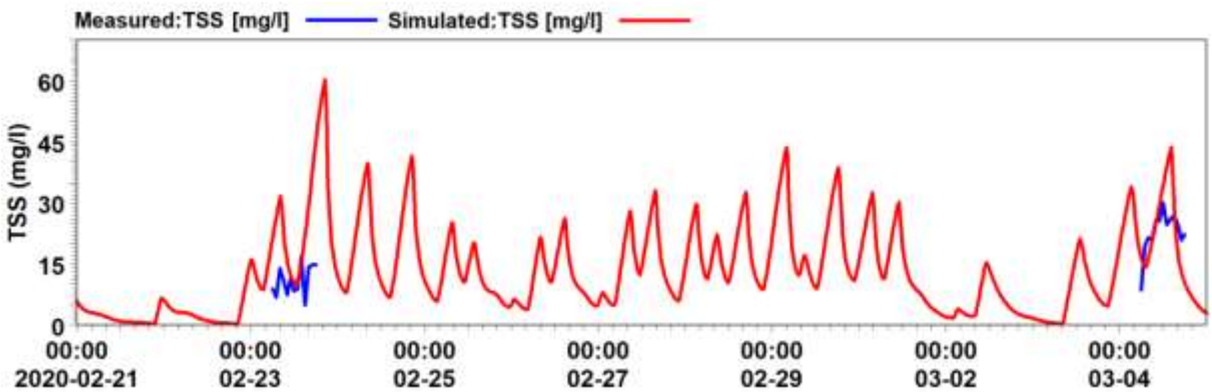


Figure 4-33: Comparison of measured and simulated suspended solid concentration at S1

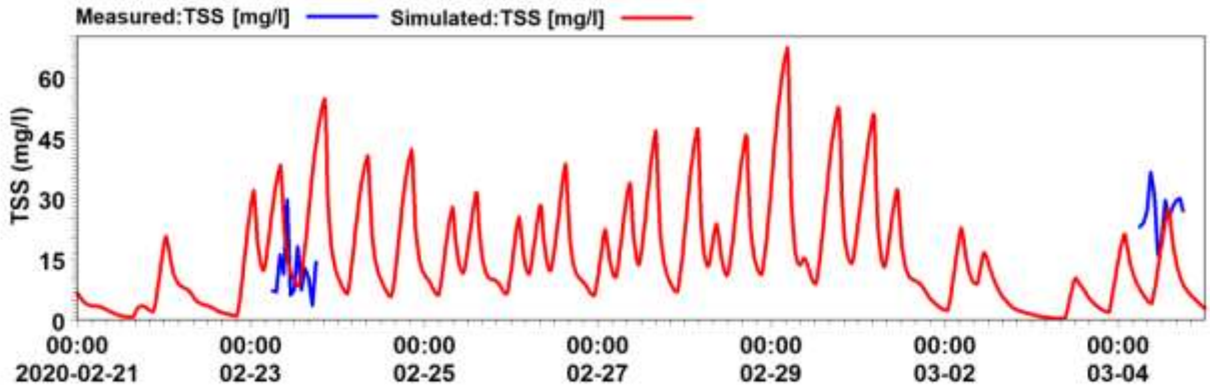


Figure 4-34: Comparison of measured and simulated suspended solid concentration at S2

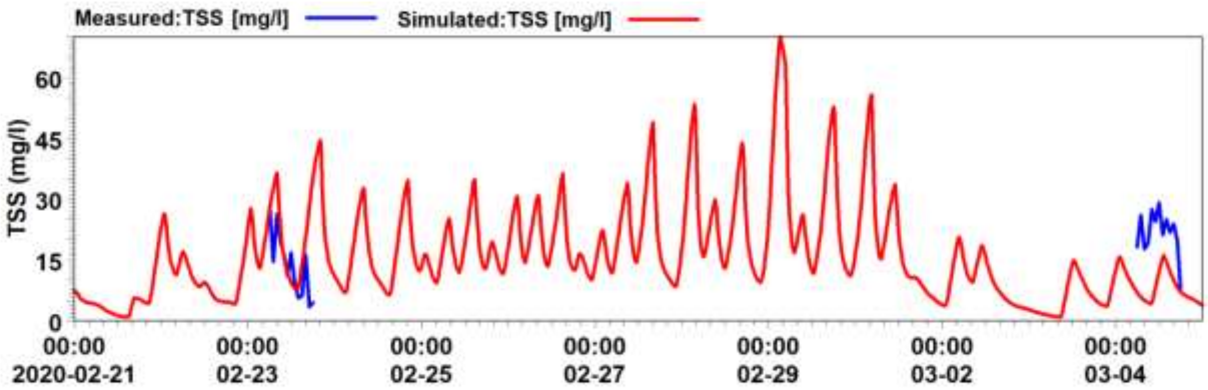


Figure 4-35: Comparison of measured and simulated suspended solid concentration at S3

Further, the model bed level changes in the approach channel are compared with actual dredging quantity information shared by MIDPL in existing approach channel. As per MIDPL records, the annual maintenance dredging quantity with the existing approach channel, turning circle and berthing area is around 450000 m^3. One-year average siltation quantity obtained from the mud transport model is around 455621 m^3.

Table 4-6 lists the measured and modelled suspended solid concentration and siltation quantity, which indicates the model is replicating the bed level changes with a good amount of agreement.

4.4.1.1.7.2 Model Results

The calibrated mud transport model presented in the previous section is further applied to predict the bed level changes in the approach channel, turning circle and basin area (**Figure 4-36**) with proposed Master Plan configuration.

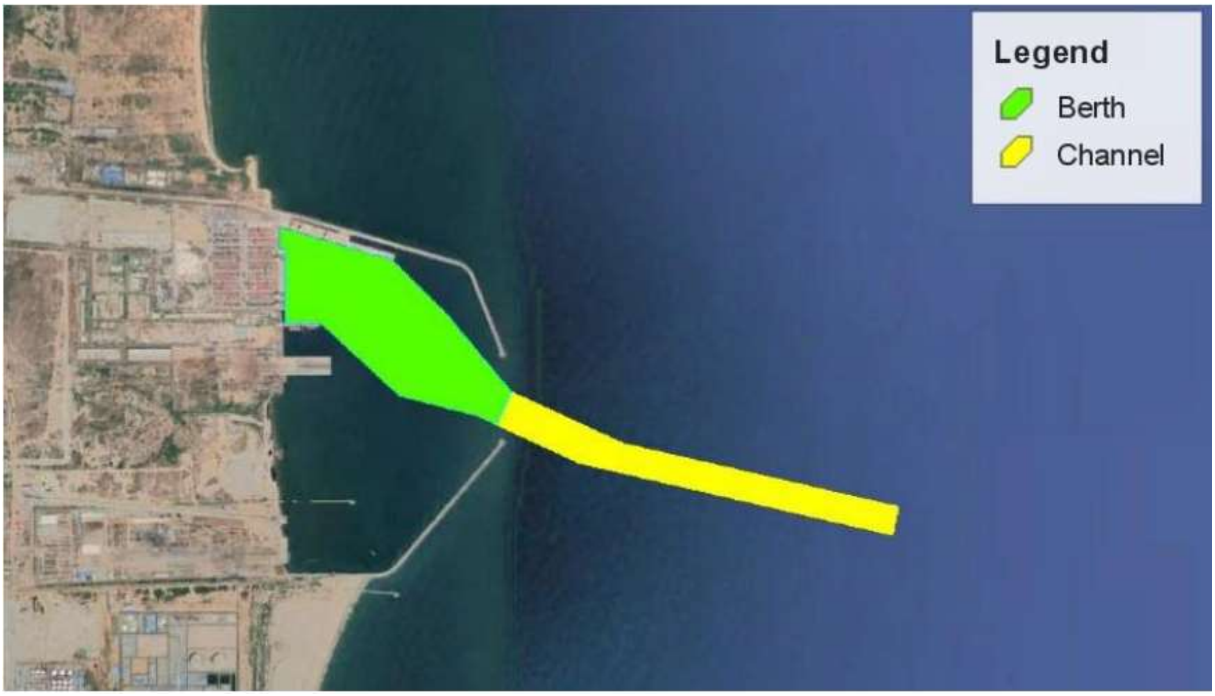


Figure 4-36: Existing dredging layout for kattupalli port

Model results indicates that the maximum deposition of 0.055m is taking place during 15day cycle (spring and neap) in the basin area with the baseline and proposed development. Bed level changes during pre-monsoon season with baseline & Master plan layouts are shown in **Figure 4-37**.

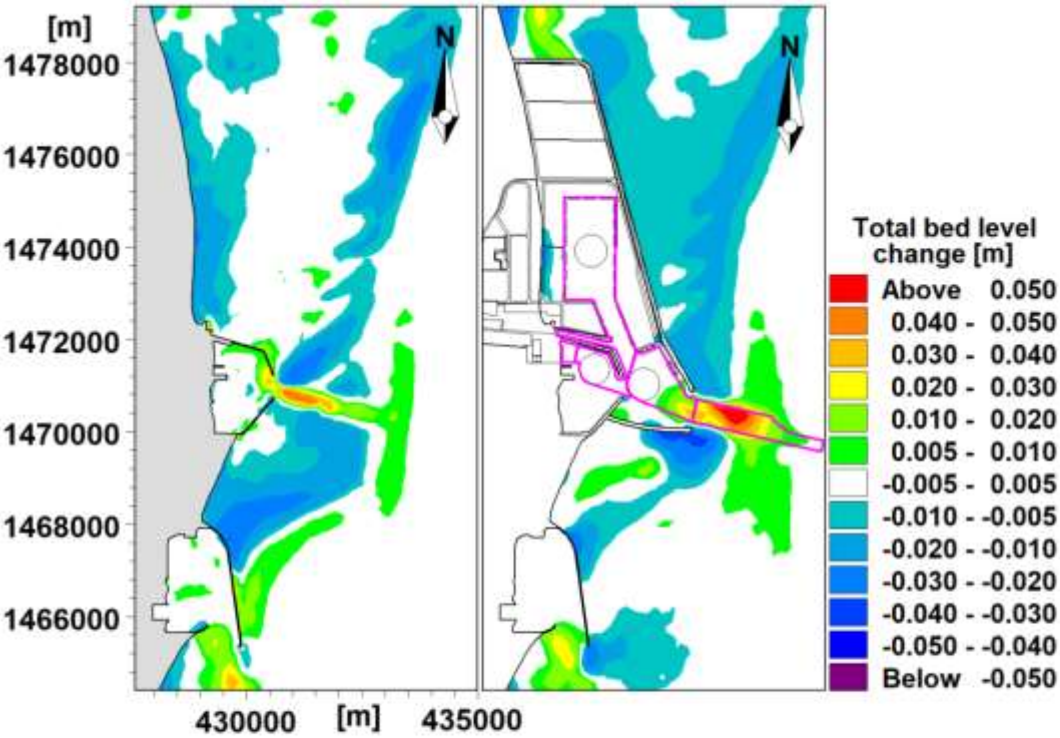


Figure 4-37: Bed level changes during pre-monsoon season with baseline & Master plan layouts

Table 4-6: Annual siltation quantity with existing port facilities from model and dredging records

Section	Area (sq.m)	Annual Siltation (m³) from MT model		Annual Siltation (m³) from dredging records
		Average	Maximum	
Turning circle & berth	718067	137869	689344	450000
440823	317393	528988	440823	

4.4.1.2 Maintenance Dredging

Based on the siltation rates predicted using mud transport model, the annual maintenance dredging quantities are estimated at different sections of the proposed development (section-A, B, C and D) as shown in **Figure 4-38**. **Table 4-7** lists the average/maximum bed level changes and siltation quantities in one-year (January to December 2020) at different sections (section-A, section-B, section-C and section-D) of proposed layout.

The analysis has set out that maximum sediment rates of between 0.91 and 1.85 m per year in the outer channel (Section A) and inner channel (Section B) respectively and up to 0.12m per year in the berthing area.

Figure 4-38: Proposed dredging layout plan cross-sections in the Kattupalli proposed layout

Table 4-7: Annual bed level change and siltation quantity with Kattupalli proposed layout

Section	Area (sq.m)	Annual Bed Level (m) Model: Layout		Annual Siltation (m³) Model: layout	
		Average	Maximum	Average	Maximum
Section-A	1186174	0.72	1.85	854045	1565750
Section-B	1329543	0.17	0.91	223363	1212543
Section-C	3757130	0.05	0.12	180342	450856
Section-D	129948	0.02	0.02	3119	3119

From the **Table 4-7** following inferences were made with regard to annual maintenance dredging quantities:

- To maintain a water depth of 27m w.r.t CD in the approach channel (Section-A) of the proposed Master Plan, the predicted average and maximum dredging quantities are 8,54,045 m^3/year and 1,56,5750 m^3/year respectively.
- To maintain a water depth of 25m w.r.t CD in the basin area (Section-B) of the proposed Master Plan, the predicted average and maximum dredging quantities are 2,23,363 m^3/year and 1,21,2543 m^3/year respectively.
- To maintain a water depth of 20.5m w.r.t CD in the basin area (Section-C) of the proposed Master Plan, the predicted average and maximum dredging quantities are 1,80,342 m^3/year and 4,50,856 m^3/year respectively.
- To maintain a water depth of 16m w.r.t CD in the basin area (Section-D) of the proposed Master Plan, the predicted average and maximum dredging quantities are 3119 m^3/year and 3119 m^3/year respectively.
- For the given Master Plan consisting of approach channel, turning circle and berthing area, the total predicted average and maximum dredging quantities are 12,60,869 m^3/year and 32,32,267 m^3/year respectively.

The effects of deepening of the access channel has been analysed through certain hydraulic quantities which provide an understanding of the response of the flow to the channel deepening and thus the effect of channel deepening on the ability to retain sediment in suspension. It is stressed that the changes in the hydraulic regime, from deepening the channel, relies entirely on the channel being dredged to a constant depth over the entire length and to the width to be maintained.

4.4.2 Potential Impact due to Construction

Developmental activities such as capital dredging, dredged material disposal and construction of cargo berths will result in disturbance to marine environment. During these activities, particularly dredging, localised and short term impacts on marine water quality are likely to occur due to increased turbidity from suspended sediment. Further, marine sediment quality indicates that it is free from any significant pollution.

4.4.2.1 Impact due to dredging and disposal of dredge material

Dredge disposal sites should be selected on the basis of non-interference with navigation and also based on the nearshore circulation phenomena and hydrodynamic characteristics of the sea. Economic and environmental considerations should be covered before the selection of the dumping site. The selection of dumping ground for dredged material should be such that the dredged material disposed at the dumping ground should not come back into the port channel. Further, the material shall be disposed off evenly spread at the dumping ground to see that the depths should not get reduced unevenly.

Deepening the approach channel will most likely increase the amount of deposition in the channel there by increasing the needed maintenance dredging. The predicted quantities of maintenance dredging with the proposed Master Plan is around 1.25 (Avg) -3.2 (Max) Million cu.m/yr of predominantly fine material from the approach channel, turning circle and berth area.

The fine material will be dredged using Trailer Suction Hooper Dredger and will be bottom disposed at the designated spoil ground of 2 sq. miles as shown in **Figure 4-38**.

In this section, the following two aspects were assessed with regard to dredge spoil disposal and dispersion:

- Stability of the spoil ground to make sure the disposed sediment stays at the spoil ground.
- In case the disposed sediment is not stable, in which quantities can be expected to leave the spoil ground and where does the sediment move. Does it return to approach channel where it will need to be removed again.

In this study, two spoil grounds are considered, both the spoil ground having an area of 1716264m^2 and approx.4.5km away from the proposed port location (**Figure 4-38**). Rectangles in red and yellow colours in **Figure 4-38** represent existing and proposed extended spoil grounds. Spill rate and dredger trips details are provided in **Table 4-8**.

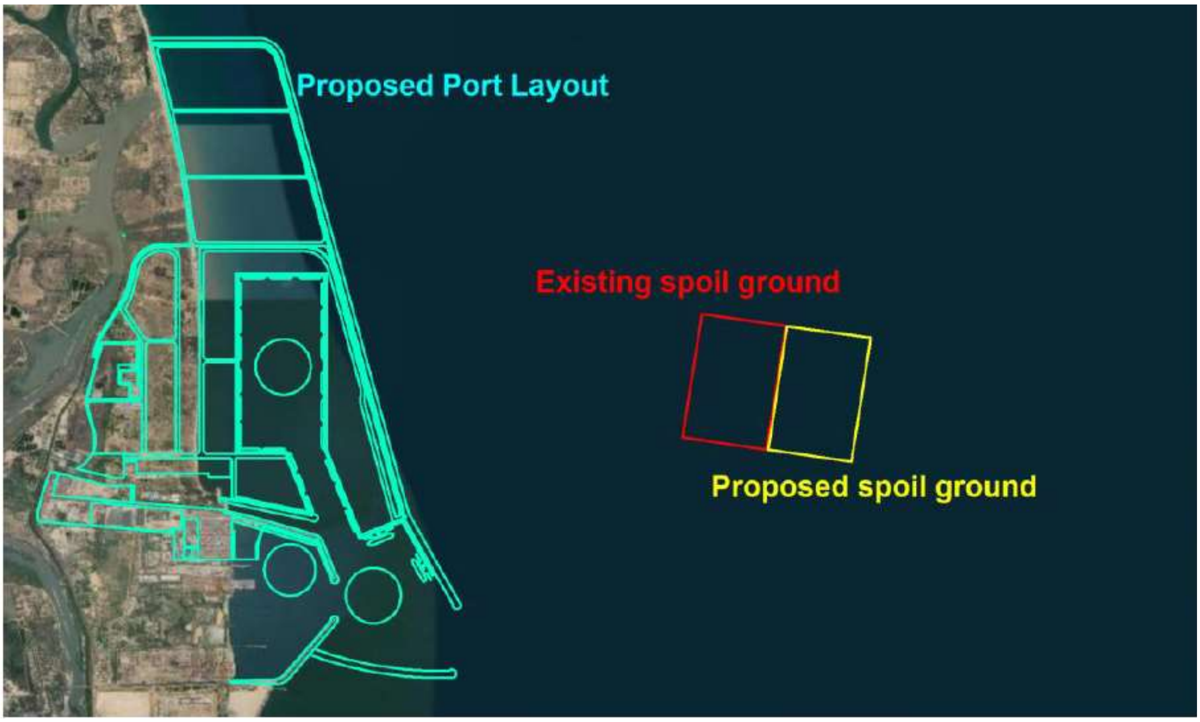


Figure 4-39: Dumping location of dredged materials

Table 4-8: Dredging and Disposal details

Total Quantity	m^3	1260869
Total days for disposal	days	45
Cycles per day	trip	9
Time required per trip	Hours	2.6
Capacity of barge	m^3	3502
Spill rate	m^3/hour	1347

The hydrodynamic model so far configured as a depth integrated 2D model is coupled with MIKE 21 Mud Transport (MT) model. The dispersion of dredge soil at the existing and proposed spoil ground was simulated for 45 days during the pre-monsoon period. A constant sediment disposal/spill rate of 1167m^3/hour was specified (assuming that the 1.2 Million Cu. m of the annual maintenance dredged soil is to be disposed within this time window). The maximum bed level change incurred due to dumping is around 0.53m at both the dumping grounds after 45 days simulation period. The spread of the disposed sediment on the seabed is shown in **Figure 4-40** to **Figure 4-44**.

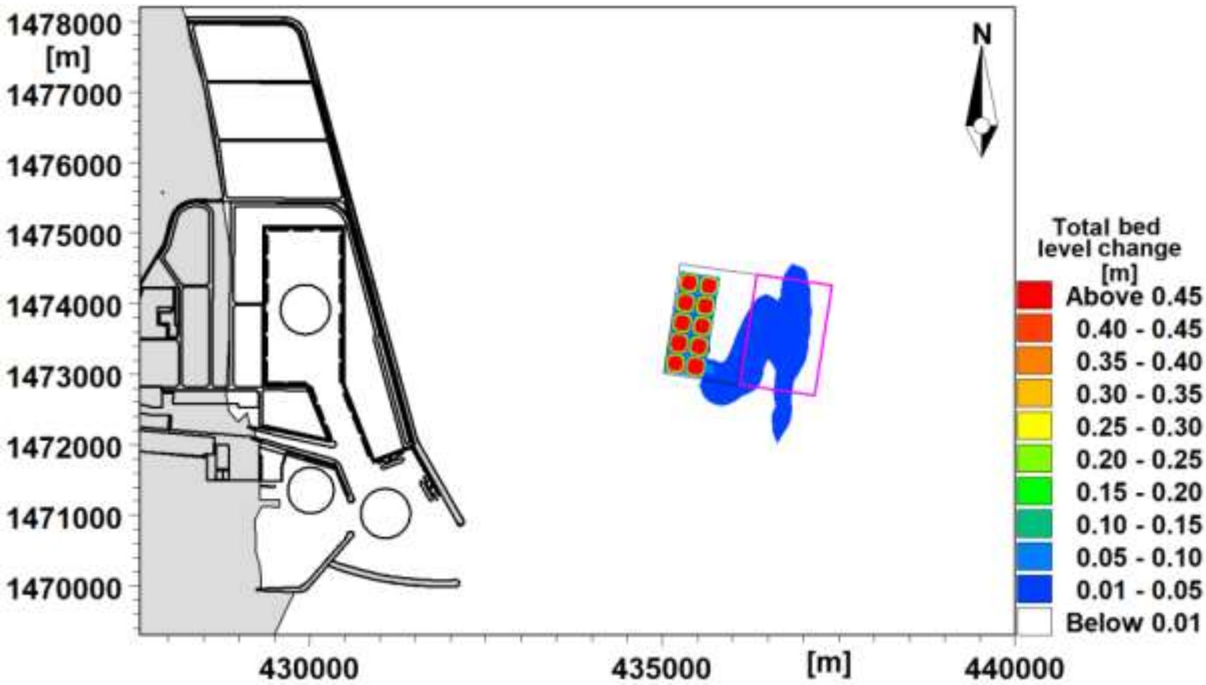


Figure 4-40: Total bed level change at spoil ground after 10 days of dumping

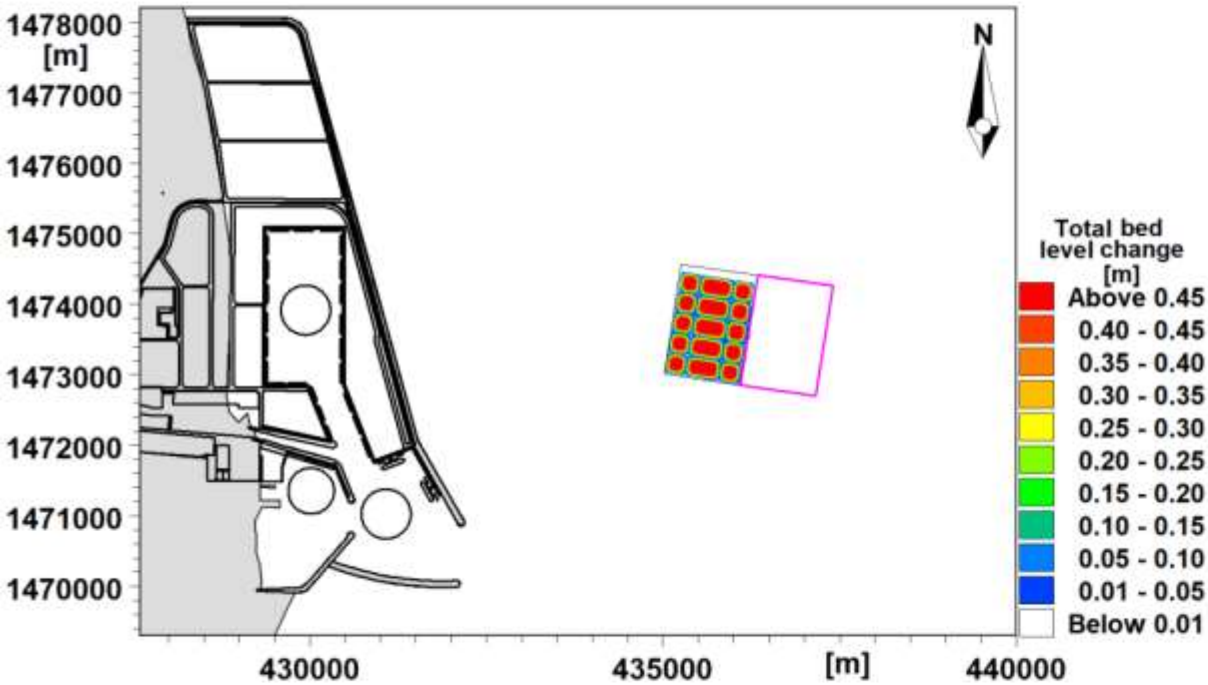


Figure 4-41: Total bed level change at spoil ground after 20 days of dumping

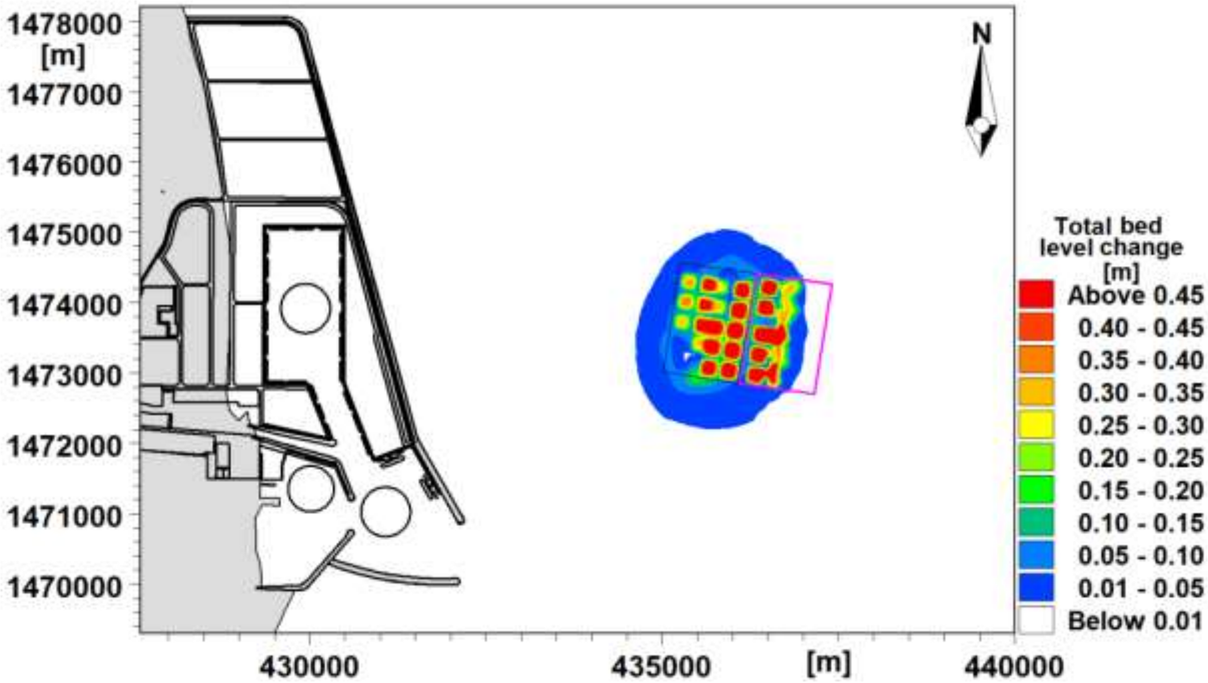


Figure 4-42: Total bed level change at spoil ground after 30 days of dumping

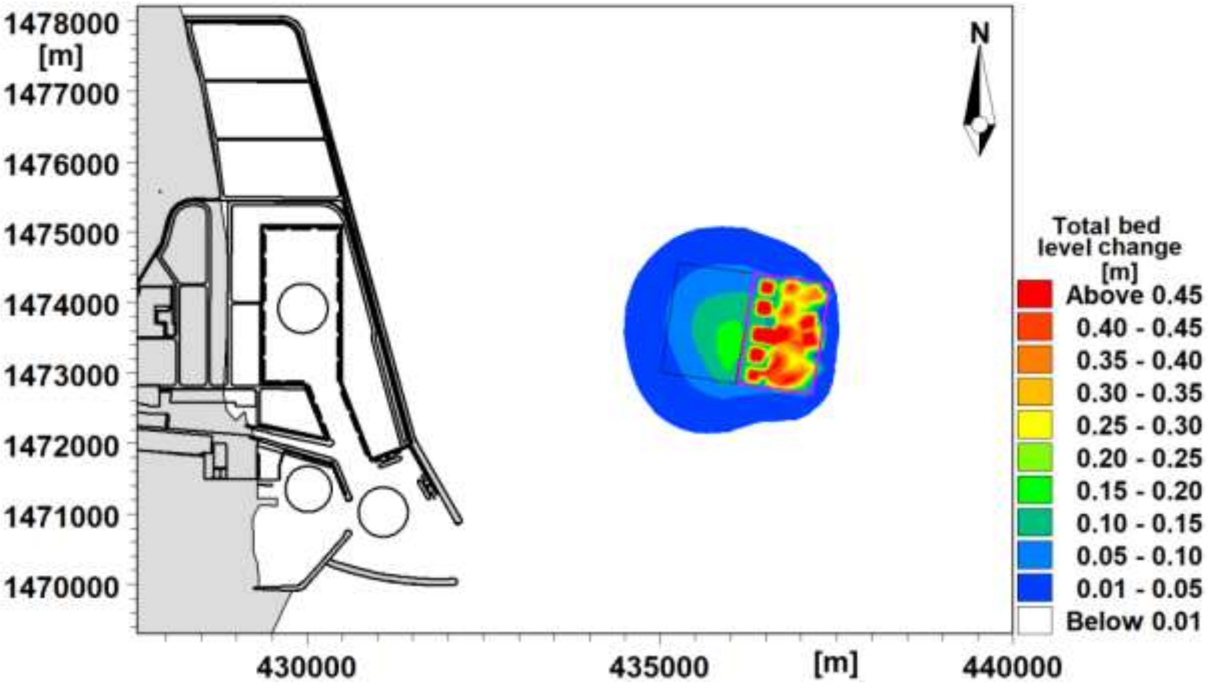


Figure 4-43: Total bed level change at spoil ground after 40 days of dumping

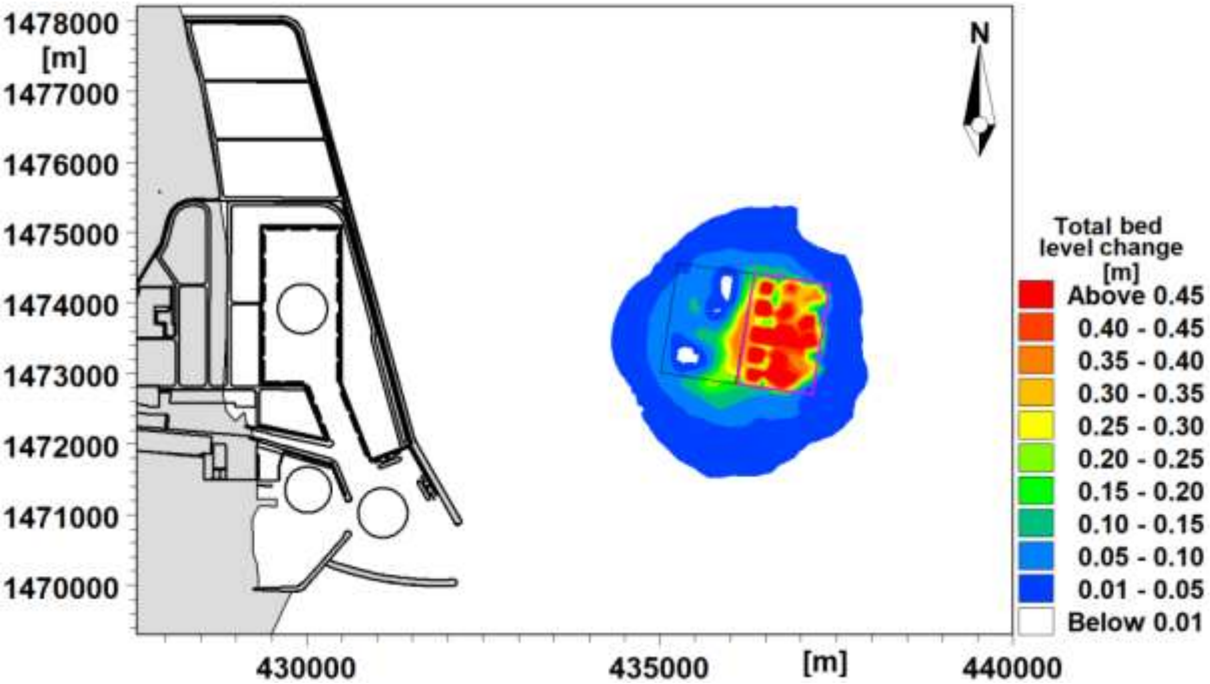


Figure 4-44: Total bed level change at spoil ground after 45 days of dumping

4.4.2.2 Impact due to Construction of Seawater Intake/Marine Outfall System

As part of the proposed Master Plan development, a 30 MLD seawater desalination plant is proposed by MIDPL. The quantity of the raw water drawn will be 75 MLD and quantity of product water produced will be 30 MLD. The final product water will be utilized for the drinking and operational water purpose for MIDPL.

The proposed intake and outfall locations for the proposed 30 MLD desalination plant are shown in **Figure 4-45**.

Figure 4-45: Intake and Outfall locations for 30 MLD desalination plant

Intake and outfall location details for proposed 30 MLD plant is presented in **Table 4-9**. The geographical positions of the intakes and outfall are chosen according to the information received from MIDPL. The intake and outfall locations were simulated using MIKE 21 FM Advection-Dispersion (AD).

Table 4-9: Intake and outfall locations for 30 MLD capacity desalination plant

Parameter	Intake	Outfall
MIDPL Proposed 30 MLD Plant (Option-1)		
Easting [m], UTM 44	431590	429843
Northing [m] UTM 44	1475433	1472733
Depth [m w.r.t CD]	13	9
Discharge rate [m3/sec]	0.86	0.52
Excess temperature [°C]	-	-
Excess Salinity [PSU]	-	35
MIDPL Proposed 30 MLD Plant (Option-2)		
Easting [m], UTM 44	431007	429843
Northing [m] UTM 44	1477212	1472733
Depth [m w.r.t CD]	13.4	9
Discharge rate [m3/sec]	0.86	0.52
Excess temperature [°C]	-	-
Excess Salinity [PSU]	-	35
MIDPL Proposed 30 MLD Plant (Option-3)		
Easting [m], UTM 44	429466	429843
Northing [m] UTM 44	1478450	1472733
Depth [m w.r.t CD]	10.7	9
Discharge rate [m3/sec]	0.86	0.52
Excess temperature [°C]	-	-
Excess Salinity [PSU]	-	35

The potential marine environmental impacts during construction phase may arise due to laying of pipeline of marine intake/ outfall and transportation of construction equipment and storage of construction materials.

In marine side construction, there are two principal zones of construction activity each requiring a different technique, namely, in-shore/surf zone and the offshore zone. The construction of submarine pipelines through the surf zone will cause temporary disturbance to the seabed along the alignment. The exposed portions of the pipelines can become a new habitat for marine organisms.

The realignment of exiting intake & outfall of CMWSSB 100 MLD plant, if needed will be taken up in consultation with CMWSSB

4.4.2.3 Mitigation Measures

Construction within the surf zone requires that the pipe be placed in a trench excavated to a depth sufficient to provide protection of the completed pipeline during periods of heavy seas. In sandy surf conditions the pipe must be buried to a depth below the minimum profile level, which can be expected, and/or provided with other means to maintain stability. Where the sea bottom is rock, the pipe may be placed in an excavated trench, backfilled and provided with a concrete protective cover.

Construction of intake/outfall structures will be carried out in such a manner, which will have minimum impact on marine ecology. It shall be ensured that there will be minimum ecological disturbance. Adoption of good construction management practices such as construction activity will be confined within the project site, selection of trenching equipment etc., will minimize the impacts on surrounding ecology to the bare minimal level.

4.4.2.4 Impact on Marine Water Quality

Marine water quality will be impacted due to dredging, trenching and disposal, construction of cargo berths and offshore structures/facilities. Direct impact of these activities on marine water quality would be increased turbidity due to suspended sediment and will be predominant during dredging.

Turbidity due to dredging operation varies with depth and lateral distance from dredger location. During dredging, transport of sediment depends on velocity and fine material concentration. Very fine cohesive material will remain in suspension for a long time and is independent of hydrodynamic conditions. Due to above factors, there will be an increase in turbidity due to suspended sediment in water column. Thus, it can be inferred that dredging would cause a short-term and localised impact on marine water quality.

Apart from turbidity, the marine water quality may be affected due to aqueous discharge (oily wastes, sanitary wastes, etc.) from the dredgers, barges and workboats involved in the activities. No discharge from the dredgers or work boats shall be allowed into marine waters.

The dredging activity will be confined within the project site and the impact due to dredging will cease upon completion. The impact due to dredging can be minimised with the implementation of a dredge management programme.

4.4.2.5 Impact on Marine Ecology

Capital dredging, reclamation, expansion of approach channel and construction of cargo berths etc., will result in disturbance to marine ecology.

Turbulence – Changes in Dissolved Oxygen (DO) Levels: During dredging, oxygen-demanding compounds, nutrients and sediments from the sea bed enter into water column. Since concentrations of oxygen-demanding compounds are normally much higher in pore water than in water column, it will cause a drop in oxygen concentration. Nutrients may stimulate primary production when light and temperatures are sufficient and may cause eutrophication problems when released in favourable conditions. DO levels in bottom sediments, which are usually low, would increase during dredging period. Changes in DO levels and noise are likely to result in localised and short-term impacts on marine ecology.

Removal of Benthic Communities associated with Bottom Sediments: Dredging would result in removal of benthic communities associated with bottom sediments in the dredging area. During dredging, sessile forms are removed along with sediments and mobile species tend to move away and are likely to increase species diversity in areas adjoining dredging site. Further, it is observed that due to movement of mobile species and transfer of nutrients during dredging, there will be an increase in species diversity and density in areas adjoining the dredging operation.

To mitigate impacts on marine ecology, measures such as selection of equipment and dredgers, environmental monitoring and regulating activities based on monitoring results will be adopted.

Smothering Effect Due to Settling of Sediment: Settlement of the suspended sediments can result in the smothering or blanketing of sub-tidal communities and / or adjacent inter-tidal communities. Presently, the marine biota in the Eastern Coast of India is already subjected to considerable changes in turbidity due to large-scale littoral movement, which is a recurring regular natural phenomenon. Therefore, it would be able to withstand localised turbidity induced during the dredging.

4.4.2.6 Changes in Seabed Profile

Generally construction of marine structures may alter the seabed profile. In the present expansion, marine structures include laying of piles which in turn involves lowering of piles into the seabed. The changes in the seabed could be in terms of disturbance to the strata and localised sediment dispersion. The dispersed sediment tends to increase the turbidity of the seawater resulting in an impact on the food chain of the marine biota.

Numerical modelling studies on hydrodynamics, littoral drift and sediment transport resulting from dredging and disposal have been carried to assess the impact due to change in seabed and the results are discussed in above sections which shows that changes are not significant.

4.4.2.7 Mitigation measures

Prior to commencement of dredging, a Dredging Management Programme will be prepared and implemented, which include the following details.

- A schedule for dredging shall be prepared and list of DO(s) and DO NOT(s) shall be circulated among the people involved in construction activities
- It is proposed to check turbidity levels with baseline turbidity levels as a reference during dredging and at disposal site.
- Currently, there are no standards in India to regulate turbidity levels during dredging. It is proposed to check turbidity levels during construction phase with baseline turbidity levels as a reference during dredging.
- It will be ensured that suitable dredging equipment is deployed to minimise the suspension of fine sediments at the dredge site. The turbidity at the dredged site will also be minimised through adoption of less intrusive dredging techniques along with timing of the dredging activity (avoiding sensitive periods).
- Dredging activity will be regulated during rough sea conditions.
- Environmental Monitoring Programme comprising of monitoring of marine water quality, marine sediment quality and marine ecology will be initiated one week prior to commencement of dredging and will be carried out throughout dredging period.
- It will be ensured that barges/workboats have slop tanks for collection of liquid/solid waste generated on board. Discharge of wastes into sea will be prohibited.
- Spill control measures will be adopted while fuelling dredgers, barges, workboats, etc.
- Pre and post dredge material disposal bathymetry survey at disposal location shall be carried out
- Based on the TSS/Turbidity monitoring results during dredging, nearby receptors if any impacted would be provided with suitable mitigations measures such as silt screen to contain the turbidity.

Marine, Estuarine, Creek waters, Backwater and Mangrove habitat baseline biodiversity were assessed and impacts were identified due to proposed development. Impacts on Marine Ecology/Biodiversity and mitigations are presented under biodiversity management plan in **Section 9.5** of **Chapter 9.**

4.4.2.8 Due to Pile Driving for Various Offshore Structures

The construction of offshore structures such as berths will require piling activity. During Piling, Bentonite slurry will be used as a drilling fluid. Bentonite mud circulation is used in advancing the bore holes to stabilise the sides and bottom of the bore holes along with casing pipes. Bore hole is always kept filled with drilling mud to prevent any hydrostatic pressure within bore hole. They also help the drilling process by lubricating the bits and coating the drill cutting and thus facilitating their raise to the surface.

Bentonite is an inert and non-toxic material which is widely used in an aqueous suspension during piling (water based mud). The overflow slurry with bored mud/soil etc., that comes out along with bentonite slurry will need to be recovered as much as possible by adopting best available construction methods in order to minimise the impact on marine environment.

Settled sediments may be removed from over flow slurry and bentonite can be reused repeatedly provided its properties are carefully monitored and kept under control. Release of bentonite in to the marine environment either accidental spill or during normal piling activity, will increase the turbidity and create smothering effect on the benthic communities. It is observed that the benthic communities are likely to recover with in short time following completion of construction.

4.4.2.9 Mitigation Measures

- Regular Leak Check of bentonite slurry pumps, pipelines etc.,
- Periodic Marine water and sediment quality monitoring in and around piling areas.
- Spills expected during normal operations are very less and short term in nature. It will cease upon the completion of construction activities.
- Accidental Spills if any has to be recovered by adopting available appropriate technologies.

4.4.3 Potential Impact during Operation

4.4.3.1 Navigation Simulation Study

MIDPL has appointed BMT Consultants (India) Private Limited (BMT) to conduct Navigability assessment of the Kattupalli port expansion master plan. BMT prepared input files required for the simulation based on the information provided by MIDPL. The wind and wave data was utilised in the creation of the run matrix. The data of the currents measured in the region was analysed and a model was created and studied. Same was applied on the chart.

The runs were conducted using BMT's in house REMBRANDT V6.0 simulation software. The software was developed by BMT UK. The software was developed for running full mission bridge simulation and then exported to be used on Windows based computers/Laptops. The algorithms governing the simulation are same in the desktop version as in the FMBS version, with the added benefit of mobility. The REMBRANDT V6.0 is type approved by DNV and widely used in the maritime industry worldwide.

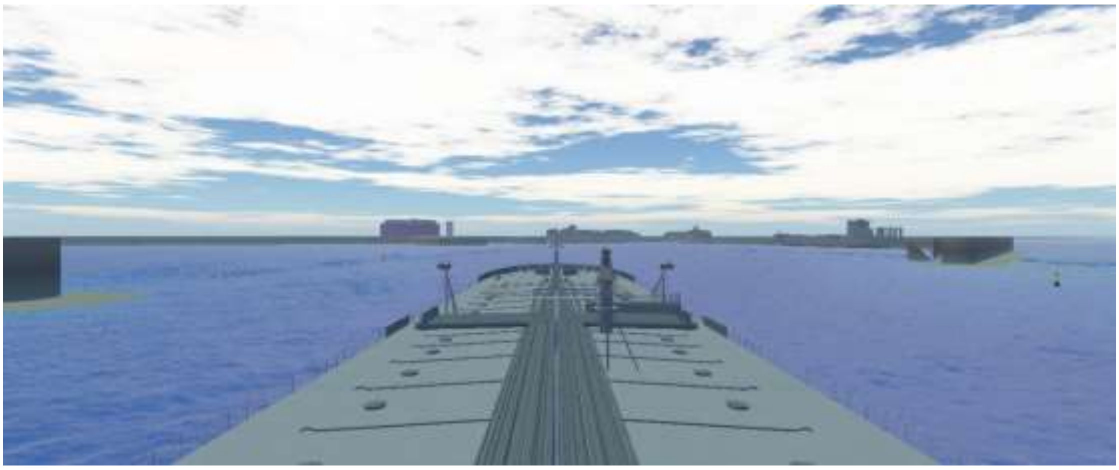


Figure 4-46: Visual 3D bridge view of vessel entering Kattupalli Port (Existing Terminal)

For the present study, however a 3D view was not developed and only a 2D analysis was carried out. The particulars of the vessel are shown below for ready reference:

Table 4-10: Vessel Particulars

Ship Name	Vessel Type	L.O.A (m)	Beam (m)	Design Draft (m)
Vessel 1	Bulk Carrier (Loaded)	300	50	18.3
Vessel 2	Bulk Carrier (Ballast)	300	50	9.0

Based on the simulation of all the runs, the following conclusions are drawn and recommended.

Conclusions:

- The outer channel width was found to be adequate for the design vessels.
- The overall layout of the master plan was found to feasible for the navigation of the vessel model used (300m Bulk carrier)
- Based on the simulations, the layout can be considered suitable and adequate for the manoeuvring of other type of vessels, like container vessels, of the same dimensions as the model used.
- The channel width in the narrow channel was found to be sufficient for the design vessel. However, care needs to be taken, regarding the vessels to be moored on either side of the channel and the effects of a passing vessel on them.
- The deepest draught vessel simulated in the channel was 18.30m.
- It is recommended that minimum UKC should not be less than 10% of the draft of the vessel in the channel and 20% at entrance to the channel in unsheltered areas.
- The vessel model simulated was found to be satisfying the above criteria. It is to be noted that the simulation was carried out with a universal water depth.
- The recommended diameter of turning circle required for the largest design vessel (LOA-300m) is 540m as per Indian standards 4651 Part V.
- Turning of the vessel was not simulated inside the turning circle, but the proposed turning circle with a diameter of 750m was found to be in compliance with the Indian standards and more than enough for the design model used in the simulation.
- The critical part of arrival or departure maneuver was observed to be in the narrow channel region leading to the inner basin. Care must be provided to maintain the vessel on course at this point using tugs and vessels systems.
- During the simulation runs, the vessel speed in the narrow channel region was maintained at 4-5 knots. The feasibility of the same needs to be studied.

- The bollard pull of the available tugs were found to be sufficient for the design vessels.
- Four tugs of 50 T bollard pull were used during the simulations and were found to be sufficient.
- However, based on review by Pilot, it was noted that the 4 tugs might increase the banking effect while the vessel in steaming along the berths and might cause the passing vessel to get too close to the moored vessel.
- Hence a critical run was chosen, and the simulation was carried out with three tugs of 50T BP each.
- Also one of the emergency runs (Emergency Run no 1), was also re run with 3 tugs.
- Three tugs were found to be adequate for the manoeuvre. Hence it is concluded that other runs can also be carried out with three tugs.
- The current inside the breakwater although in the region of 0.1-0.3 kts, they did have an effect on the vessels' manoeuvrability, especially at slow speeds..

Recommendations:

- It is recommended that a full Navigation simulation study along with met-ocean study be conducted before commencement of operations/construction, to establish operating limits of the port.
- It is recommended to use 3 tugs of 50T bollard pull for berthing, unberthing operations of large vessels.
- As per the master plan the 2 liquid berths are being planned to be established at the outer basin. A QRA study is recommended to ascertain the suitability of the location for such operations.
- A QRA and dynamic mooring analysis study is recommended to ascertain the effects of passing vessel on the moored vessels in the narrow channel and the inner basin.
- In case of any resource failure (tug fail, engine fail or steering fail), it is recommended to control the momentum of the vessel with the available tugs and drop anchor as soon as possible.
- If any emergency is experienced in the channel, then the arrival manoeuvre should be aborted, and the vessel should be taken back out to sea for repairs.
- If emergency occurs inside the breakwater, then effort should be made to secure the vessel to a berth or vessel to be moved to the centre of the turning circle and anchors dropped, to facilitate repairs.
- It is recommended that the Pilots, Tugboat Masters and crew are provided with adequate training and familiarisation. It is recommended that the key personnel are familiarised with the emergency procedures to deal with emergencies like engine and steering failure.
- It is recommended that the tugs be on standby near the breakwater as soon as the pilot is on board the calling vessel, in order to minimize the response time in case of any emergencies.
- Nothing in the above recommendations shall overrule the Master of the vessel in exercising his/her discretionary powers over matters of safety and security of his/her vessel.

4.4.3.2 Impact on Marine Water Quality and Ecology in Harbour Basin

Due to Aqueous Discharges: During the operation phase there will be continuous movement of cargo vessels and port crafts round the clock. There is a possibility of aqueous discharges from the cargo vessels such as dumping of ship wastes (sullage) / sewage, bilge water, solid wastes, etc. if not regulated.

In Kattupalli port, provision of reception facilities will be explored to receive the residues and oily mixtures generated from ship operations according to provisions of the International Convention for the Prevention of Pollution from Ships, 1973/78 (MARPOL). In addition, reception facilities for garbage, waste oil and bilge water from the ships shall also be provided. The bilge water will be collected by authorised waste recyclers and taken for further treatment.

In addition, land-based sources of pollution such as runoff from the cargo berths, waste water, and sewage from the port operations would also affect the marine water and sediment qualities in the harbour basin, if disposed without proper treatment.

Due to Maintenance Dredging: During the operational phase, maintenance dredging of the approach channel and the harbour basin will be carried out in order to maintain the required draft in the channel for the free movement of the vessels. The maintenance dredge quantity for the expansion plan is estimated at 1.25-2.0 Mm^3/Annum. The maintenance dredge spoil will be dumped at identified offshore disposal location approximately 4.5 km from proposed port.

As pollution control measures are proposed to be adopted, no significant impact are anticipated from maintenance dredging on water quality except locally due to suspension of bottom sediment resulting in increased turbidity levels. Further, during the disposal of the dredge spoil at the identified disposal ground, the dredger hopper will be shifted to minimize the increase in turbidity/suspended solids concentration and built up of the bed material.

Due to Cargo Spills during Handling: Spills do not occur during normal operations, as the cargo will be handled by mechanised ship-loaders/unloaders. In the event of accidental spills of cargo during transfer from / to the ships, the marine water quality, sediment quality and ecology in the harbour basin will be impacted.

Due to Oil Spills during Fuelling: Oil spills do not occur during normal fuelling operations. In the event of accidental oil spills during fuelling of the ships / port crafts, the marine water quality in the harbour basin will be impacted. To minimise the impacts on marine water quality, the spills will be recovered as per oil spill contingency plan.

4.4.3.3 Mitigation Measures

- Ships visiting the port will comply with MARPOL convention and avoid such discharges
- A standard format of the advance notification form for waste delivery to port reception facilities and standard format for the waste delivery receipt following a ship's use of port reception facilities as recommended by Marine Environment Protection Committee, IMO will be maintained
- During emergency, provision of waste reception facilities and tie up with authorized vendors will be explored to receive the residues and oily mixtures generated from ship operations.
- Settling ponds will be provided for collection of runoff from cargo storage areas. The settled material will be retrieved and sent back to respective stockyards. The supernatant water will be used for dust suppression for the cargo stockyards.
- It will be ensured that the dumping of the maintenance dredge spoil would be uniform and only within the identified dredge disposal locations
- Environmental Monitoring Programme comprising of monitoring of marine water quality, marine sediment quality and marine ecology will be initiated one week prior to commencement of maintenance dredging and will be carried out during the dredging period

- In case of any cargo spillage during transfer from/to ships, it will be attempted to recover the spills.
- Oil spill control equipment such as booms / barriers will be provided for containment and skimmers will be provided for recovery.
- Except SPM all the port cargo handling activities will be carried out within the harboured waters. As the accidental spills will be in harboured waters, it would not spread spatially and the response time for shutting down the fuelling, containment and recovery will be quicker.

Ballast Water Management

Ballast water is water held on a ship to maintain balance and stability while sailing. Water is typically taken up in one location and emptied in another, resulting in the release of marine organisms into a new environment. This causes non-native species and pathogens to be introduced, which can be harmful to the environment and human health.

Ballast water management guidelines are applicable for ships and there are no guidelines for ports and harbours. The guidelines to ships issued by DG Shipping vide Merchant Shipping Notification No. 13/2001 requires the ships to follow guidelines promulgated through International Maritime Organisation (IMO). The highlights of the guidelines are as follows:

- Ships shall conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 m in depth prior to calling at a port.
- Where ballast water exchange at 200 nautical miles to nearest land is not possible, the exchange should take place at least 50 nautical miles from nearest land and in water at least 200 m in depth.
- Ships shall carry out ballast water exchange with an efficiency of at least 95% volumetric exchange.
- The master and crew of the vessel shall be familiar with the essential shipboard procedures relating to ballast water.
- Each ship shall have on board a ballast water record book which may be an electronic recording system. Port officers may inspect the ballast water record book and ask for relevant copies of record book.

4.4.3.4 Impact due to Seawater Intake/outfall

4.4.3.4.1 Salinity and Excess Temperature

Recirculation study performed for proposed 30 MLD plants. Intake and outfall details for proposed 30 MLD plant is provided in **Table 4-9**. The geographical positions of the intakes and outfalls are chosen according to the information received from MIDPL. The intake and outfall locations were simulated using MIKE 21 FM Advection-Dispersion (AD).

The scenarios cover variations of the following variables that influence the current pattern in the vicinity of the Kattupalli port:

- Ambient current (tide conditions)
- Meteorological conditions (water temperature and wind)
- Seasonal conditions (winter, summer)

A hydrodynamic model using DHI’s 2D model system, MIKE 21 Flexible Mesh (FM) was set up and calibrated based on field data collected during pre-monsoon season. Water level and currents along the open boundaries of the model were taken from hydrodynamic model prepared as part of this study. High resolution model has been implemented in the outfall location.

Each model simulation covers tidal variation of 15 days covering spring and neap conditions. The originally functioning CMWSSB intake is relocated to alternate location as this will be falling within the Master Plan area and cause water quality issues with the port operations.

- Scenario - MIDPL outfall location with three proposed intake options located outside the breakwater

The intake and outfall of both the desalination plants are modelled as a so-called set of “connected sink and source”. This means that the intake (sink) temperature and salinity is the actual absolute (and time varying) temperature/salinity at the location of the intake point. The temperature/salinity at the source point is the (time varying) intake temperature or salinity plus the specified excess temperature/salinity of the plant. From this it follows that any possible recirculation will increase not only the intake temperature/salinity but also the outfall temperature/salinity.

The results are presented as excess salinities i.e. the salinity increase above the ambient salinity caused by the MIDPL desalination plant outfall. The model cannot reproduce in detail the flow around the intake and outfall. This would require an extremely detailed computational mesh and the simulation time would be excessive. Instead the location of intake sinks, and outfall sources must be placed so they give a realistic representation of the effect of actual flow conditions near the structures on mixing and turbulence.

Model simulations are covering the spring and neap tide conditions. The maximum excess salinity calculated for every model point as a maximum value out of 15 days simulation.

Figure 4-47 to **Figure 4-50** shows the mixing of the excess salinity and temperature released from proposed MIDPL 30 MLD outfall during the 15 days simulation with time varying tidal currents.

In all the simulations the excess salinity does not exceed 1.5 PSU at the outfalls, and this has further not reached to the intake locations considered outside the proposed Master Plan breakwater. Due to the excess salinity at the outfall, the dense plume is directed downwards to the bottom and maximum spreading can be found at the bottom.

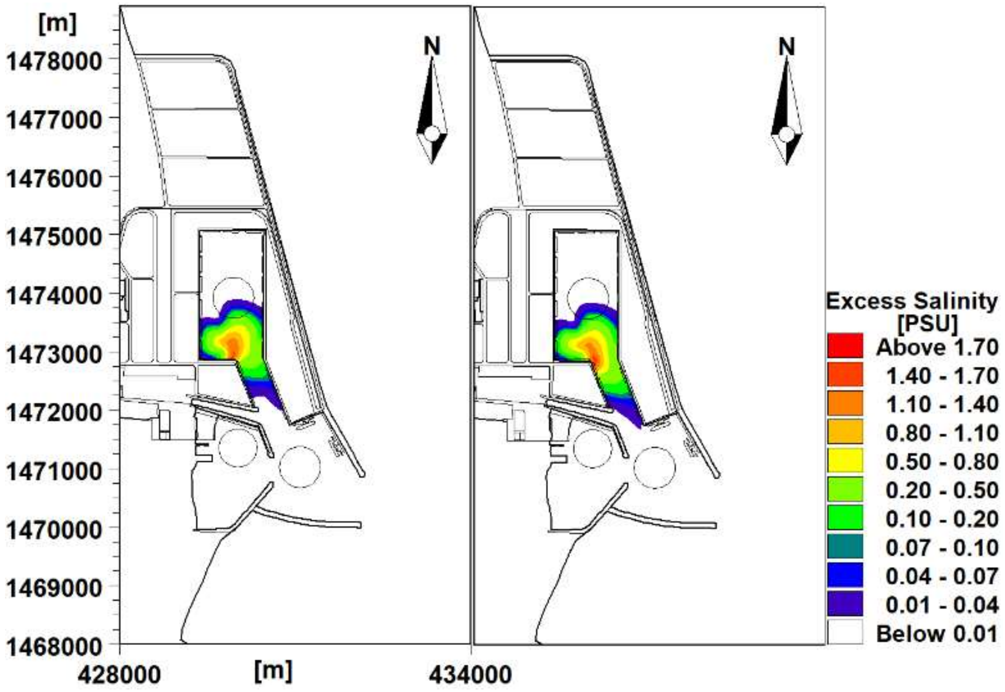


Figure 4-47: Maximum excess salinity at MIDPL 30 MLD outfall location (Left: Spring flood; Right: Spring ebb)

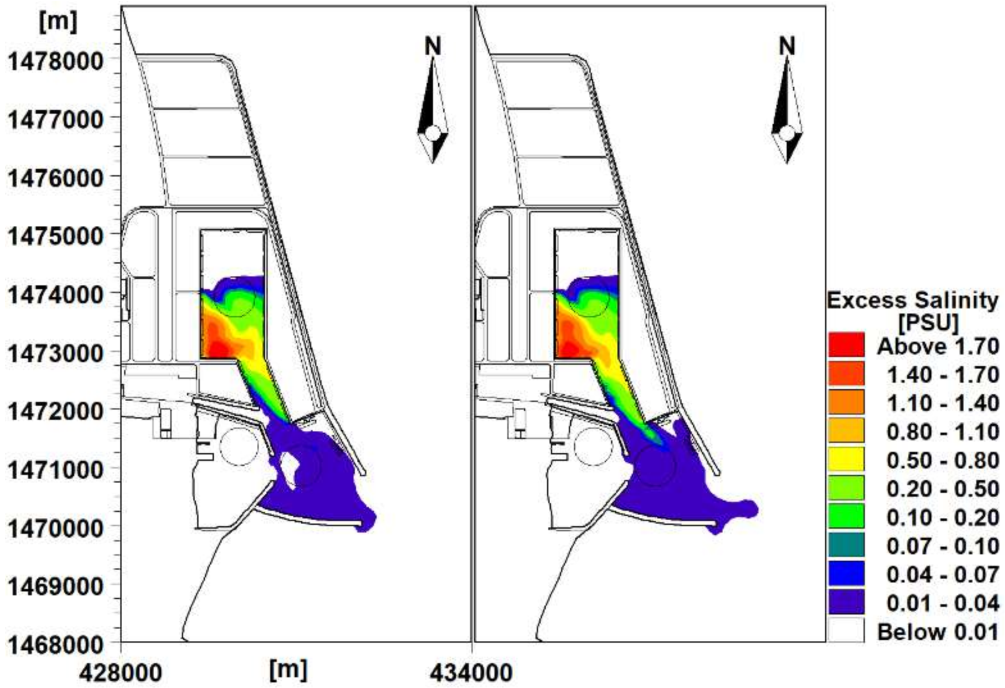


Figure 4-48: Maximum excess salinity at MIDPL 30 MLD outfall location (Left: Neap flood; Right: Neap ebb)

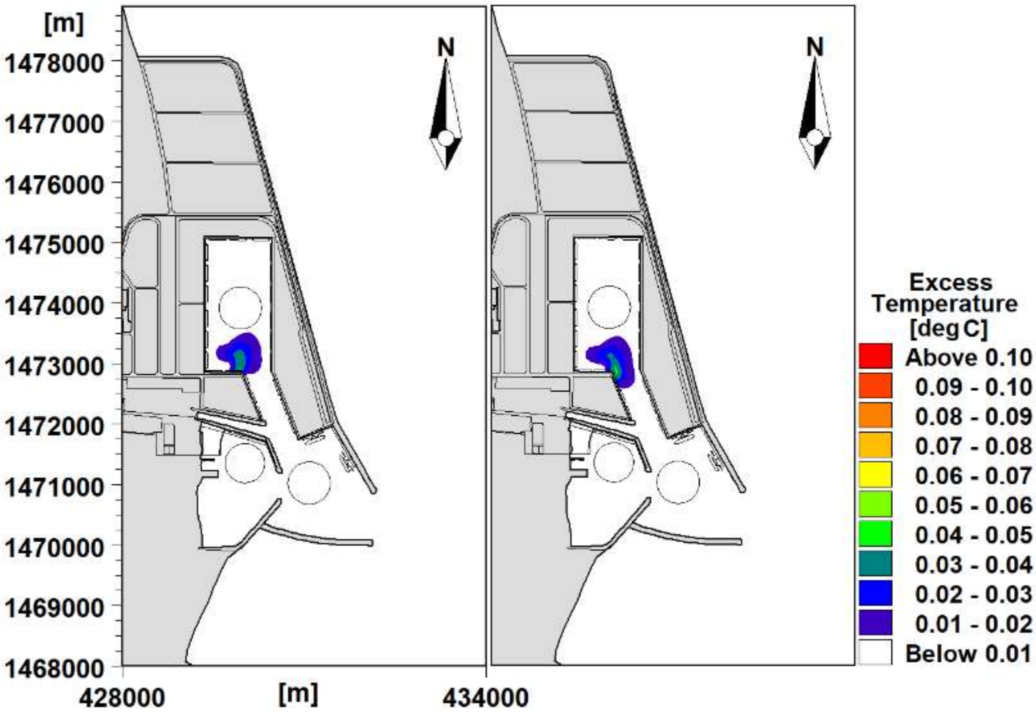


Figure 4-49: Maximum excess Temperature at MIDPL 30 MLD outfall location (Left: Spring flood; Right: Spring ebb)

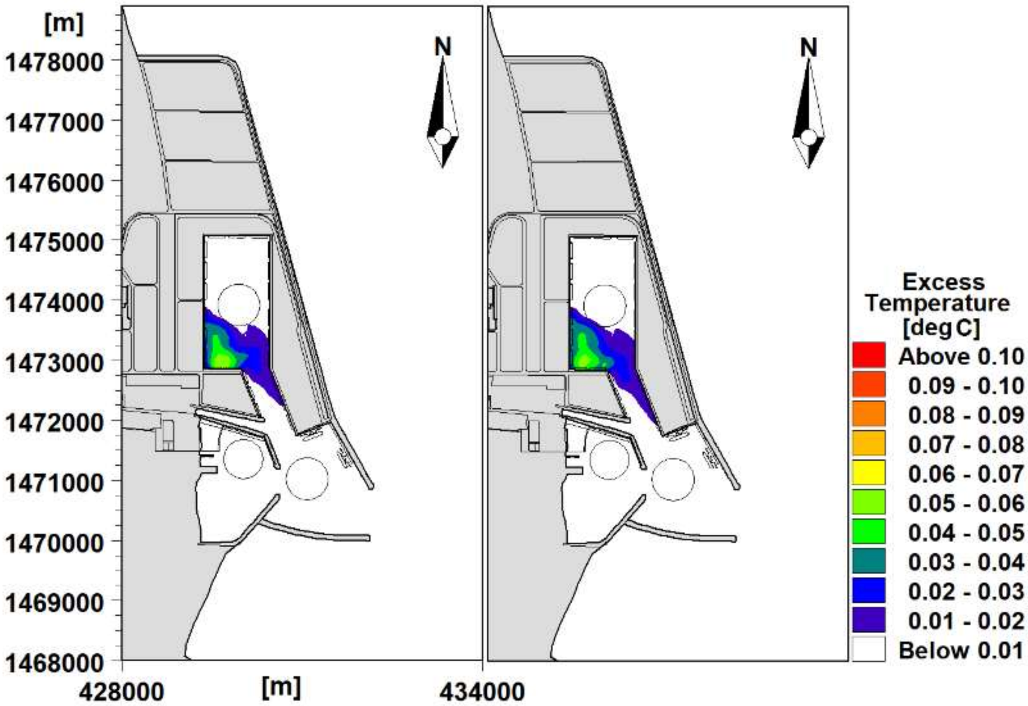


Figure 4-50: Maximum excess Temperature at MIDPL 30 MLD outfall location (Left: Neap flood; Right: Neap ebb)

Conclusions

In all the simulations the excess salinity does not influence at the intake locations. At outfall location the excess salinity does not exceed 5 PSU. The brine should result in a salinity increase of no more than 0.1 PSU at the edge of the zone where spreading extends.

On the basis of the above presented figures, it is concluded that the 30 MLD outlet result in excess salinity below 1.5 PSU at the point of discharge and 0.1 PSU at the farthest point from the outlet. For 30MLD outlet the excess temperature is comparatively less, and the values are 0.18°C and 0.07°C respectively

4.4.3.4.1.1 20 MMTPA LNG/LPG Processing Facility – Intake & Outfall

The intake and outfall discharge quantities from and into the Kattupalli port region pertaining to proposed 20 MMTPA LNG/LPG processing facility is approximately 1,20,000m^3/hr. The proposed facility will discharge processed water back into the open sea at the finalized disposal point (out of two optional locations) through a discharge outfall pipeline with decrease in temperature. The quantity of the discharge from the processing facility is around 1,20,000m^3/hr.

Scenario Details

Each model simulation covers tidal variation of 15 days covering spring and neap conditions. The two intake options are considered outside the port area for functioning 20 MMTPA LNG/LPG processing facility (**Figure 4-51**).

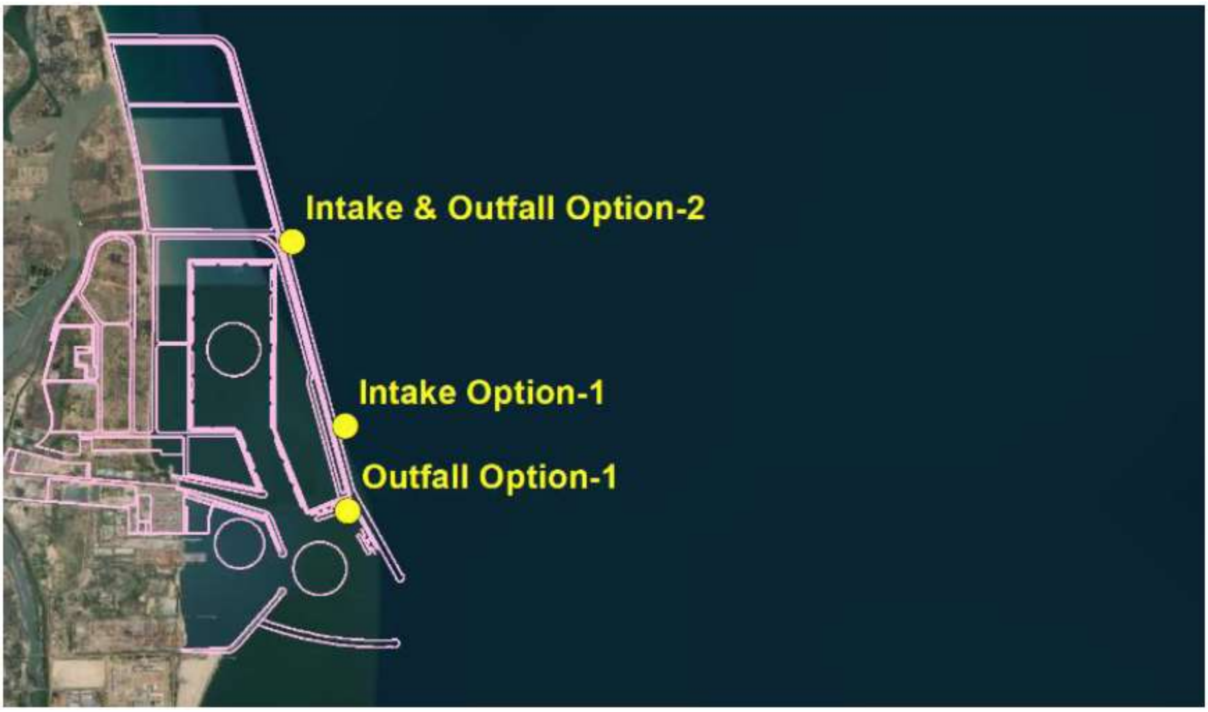


Figure 4-51: Intake and outfall location for 20 MMTPA LNG/LPG processing facility

- Option-1: Outfall location inside the port and intake extended outside the proposed breakwater
- Option-2: Intake and outfall location are provided outside the proposed breakwater

A hydrodynamic model using DHI's 2D model system, MIKE 21 Flexible Mesh (FM) was set up and calibrated based on field data collected during pre-monsoon season. Water level and currents along the open boundaries of the model were taken from hydrodynamic model prepared as part of this study. High resolution model has been implemented in the outfall location.

Results

The results pertaining to variation of temperature in the vicinity of discharge point for 15 days (one spring and neap period).

Coldwater from the LNG/LPG plant discharged at outfall option 1. **Figure 4-52** and **Figure 4-53** shows the variation of temperature during flood and ebb tide during spring and neap phase of tide. The dispersion is taking place inside the port and around the proposed breakwater tip with less temperature difference in comparison to ambient temperature.

The Coldwater from the LNG/LPG plant discharged at outfall option-2 location, which is located outside the breakwater. **Figure 4-54** and **Figure 4-55** shows the variation in temperature during flood and ebb tide during spring and neap phase of tide. It can be observed from the figure that the dispersion is taking place at outside breakwater. The difference in temperature is less in comparison to ambient temperature because of the prevailing environmental conditions outside the breakwater.

The dispersion is more and occupying a larger patch area at disposal location. Temperature values lower during the spring and neap period at option 2.

Finally, it can be concluded that there will not be any recirculation and there will be no impact on water qualities at the intake as well as at the shore due to the disposal taking place at the proposed outfall discharge location option-1.

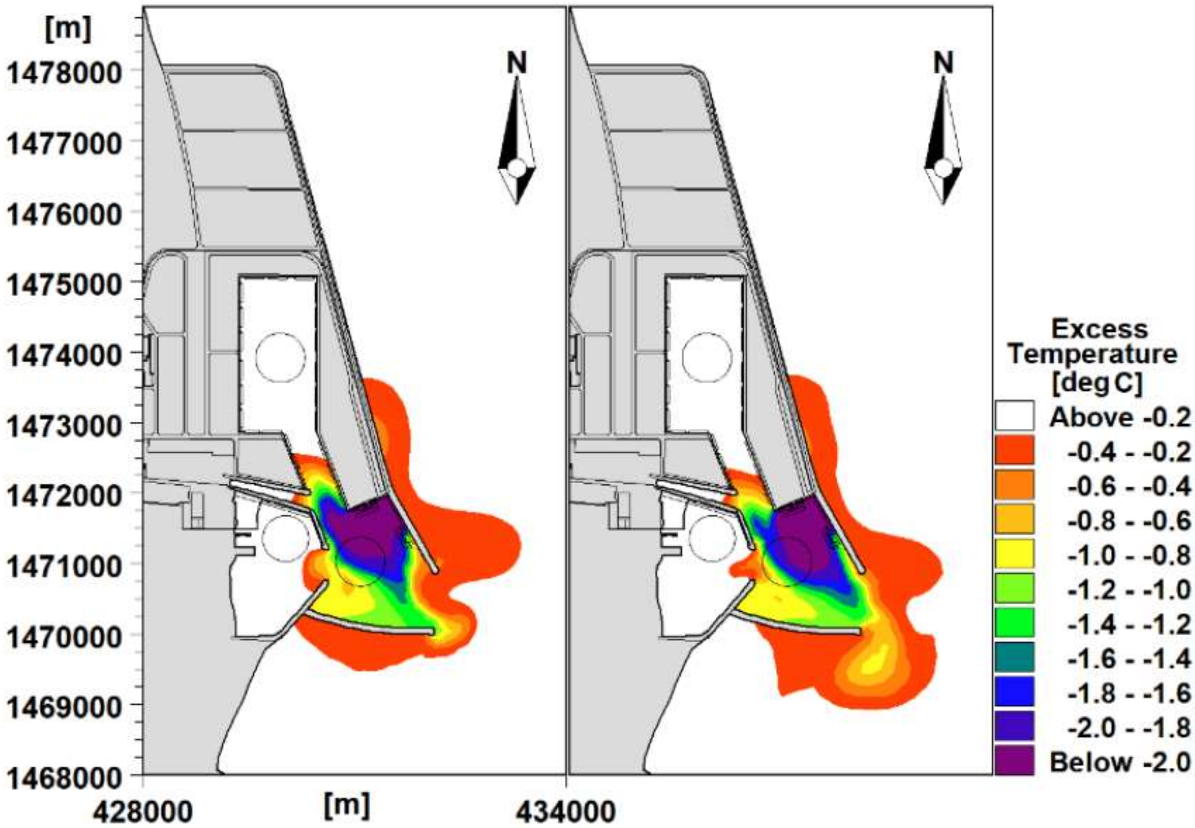


Figure 4-52: Temperature dispersion of cold water from LPG/LNG Plant during spring tide at outfall location option-1 (Left: Spring flood; Right: Spring ebb)

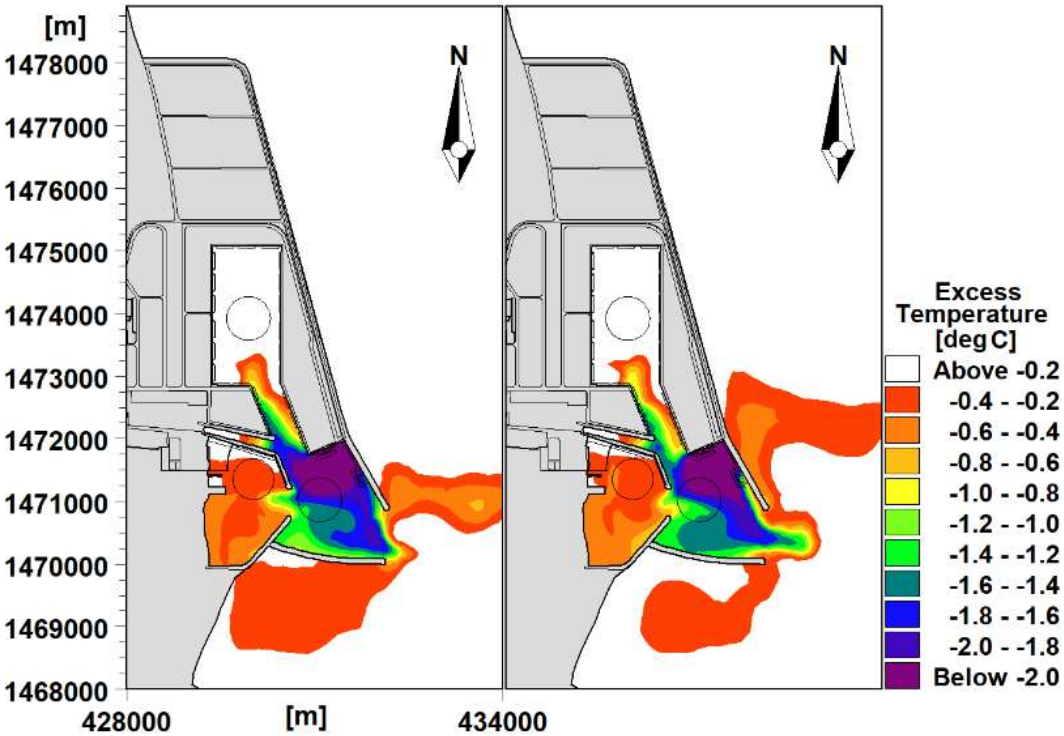


Figure 4-53: Temperature dispersion of cold water from LPG/LNG Plant during Neap tide at outfall location option-1 (Left: Spring flood; Right: Spring ebb)

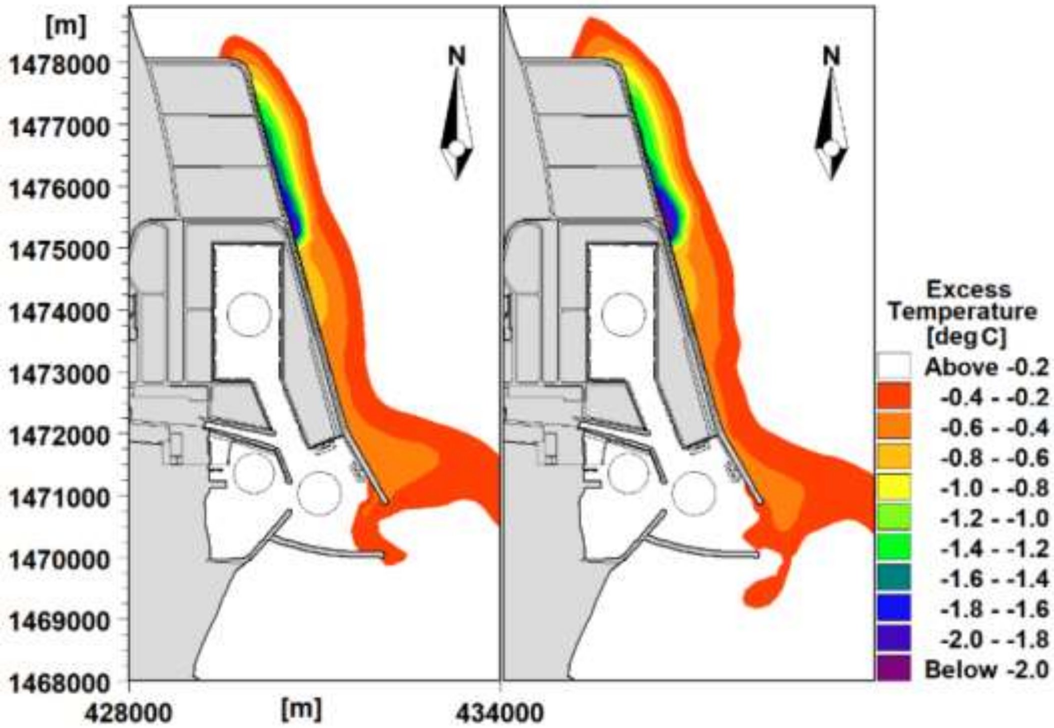


Figure 4-54: Temperature dispersion of cold water from LPG/LNG Plant during spring tide at outfall location option-2 (Left: Spring flood; Right: Spring ebb)

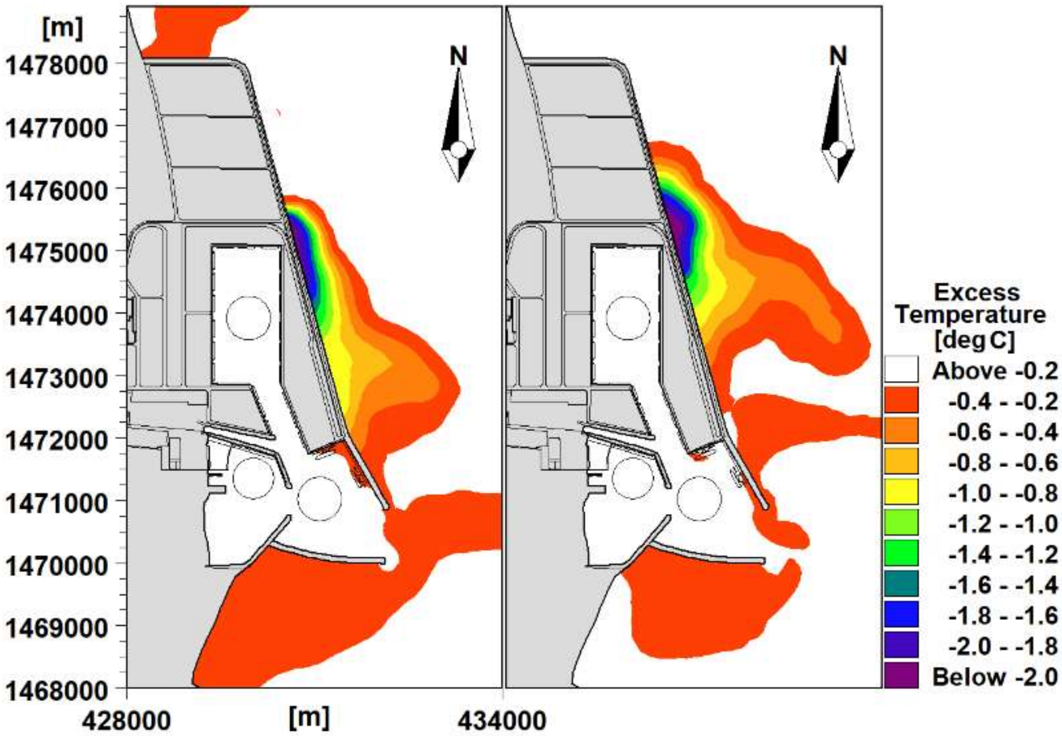


Figure 4-55: Temperature dispersion of cold water from LPG/LNG Plant during spring tide at outfall location option-2 (Left: Spring flood; Right: Spring ebb)

4.4.3.5 Mitigation Measures-Use of Low-Impact Intake Technologies – Coarse/Fine/ Wedge wire Screen Intakes

Coarse/Fine Screens: Open ocean intakes are typically equipped with coarse bar screens (**Figure 4-56**), which typically have openings between the bars of 20 mm to 150 mm followed by smaller-size ("fine") screens with openings of 1 mm to 10 mm (**Figure 4-57**), which preclude the majority of the adult and juvenile marine organisms (fish, crabs, etc.) from entering the sea water systems. While coarse screens are always stationary, fine screens could be two types – stationary (passive) and periodically moving (i.e., rotating) screens.

Figure 4-56: Intake Bar Screen

Figure 4-57: Fine Intake Screen

Wedge Wire Screens: Wedge wire screens are cylindrical metal screens with trapezoidal-shaped "wedge wire" slots with openings of 0.5 to 10 mm. They combine very low flow-through velocities, small slot size, and naturally occurring high screen surface sweeping velocities to minimize impingement and entrainment. This is the only open intake technology approved by US EPA as Best Technology Available. The screen design intake velocity is 0.5 feet/sec (0.1524 m/s) or less and the slot size is appropriate for the size of eggs, larvae, and juveniles of any fish and shellfish to be protected at the plant intake site.

Wedge wire screens are designed to be placed in a water body where significant prevailing ambient cross flow current velocities (≥ 1 fps) exist. This high cross-flow velocity allows organisms that would otherwise be impinged on the wedge wire screen intake to be carried away with the flow. An integral part of a typical wedge wire screen system is an air burst back-flush system, which directs a charge of compressed air to each screen unit to blow-off debris back into the water body, where they are carried away from the screen unit by the ambient cross-flow currents.

Even though there are several designs available, the model that employs the cylindrical Edge-Wire screen has shown the maximum efficiency (> 99% for impingement and 80 to 90% for entrainment problems). Some recent models have also incorporated efficient self-cleaning systems so that the inflow is not affected due to impingement (blocking of the screens by marine biota).

If chlorination is done, then the freely available chlorine at any point of time should be kept within 0.5 mg/l. Residual chlorine present in the return water can have synergistic effects on the flora and fauna of the receiving water.

4.5 Biological Environment (Coastal and Marine Ecology)

4.5.1 Potential Impact due to Port Location

Biological resources in the marine zone are very minimal as there were no critical ecosystems such as coral reefs and seagrasses.

4.5.1.1 Impact on Mangrove Areas

The changes in wave and current pattern to be caused by the construction of breakwaters and births are likely to affect the flushing of water into Ennore Creek and Pulicat Lake. The possible alteration in the flushing is likely to affect the dependant mangroves and associated biodiversity. In the north side of Kattupalli, the distance between the sea and Buckingham Canal is very short (about 1 km), and hence it is likely that shoreline changes caused by the proposed construction of breakwaters and births would destabilize this area causing damages to the nearby mangroves.

Patches of Mangroves are observed in Ennore creek, Kosisttalaiyar river (connecting Ennore creek and Pulicat lake), mouth of the Buckingham canal and Pulicat lake region of the study area. These mangroves are scattered and MIDPL has excluded these mangroves from the port activity and will implement the conservation measures.

Three species of mangroves *Avicennia marina*, *Avicennia* sp., and *Rhizophora mucronata* are observed in the study area. Well grown mangroves are observed in the larger patches and few places along the banks of the river. Stunted grown *Avicennia marina* were observed in the places were flushing of water is poor or absent.

During construction phase of Revised Master plan there may be accidental illegal cutting of mangroves by contract labours. During operation fugitive dust emissions are envisaged due to cargo handling if proper mitigation measures are not implemented. Minimum 50 m buffer will be provided near the mangrove area and all the construction will be limited as per master plan.

In addition, there are threat to the existing mangroves due to natural calamities such as cyclone and illegal cutting by locals.

4.5.1.2 Mitigation/Mangrove Conservation Measures

Mangrove habitats occurring along the Ennore Creek, Kosasthalaiyar River, Buckingham Canal and Pulicat Lake are critical for the associated biodiversity and fishery resources. Three mangrove species namely *Avicennia marina*, *Avicennia* sp. and *Rhizophora mucronata* are available in the area along with five halophytic plants. Establishment of facilities for the port is a continuous process and the expansion of infrastructure over the coming years will bring about notable changes in the landscape and seascape in and around the port. Long term human activity of this magnitude will have repercussions on the mangroves, and their conservation and management deserve top priority. Any impact on the mangrove habitats may affect the livelihood of the dependant fishermen. The following measures can be taken to monitor the health of mangroves and associated biodiversity in the proposed project area.

Though there is no direct impact on the existing mangroves, it is the responsibility of the project proponents to take care of the existing nearby mangrove area without any damage. A dedicated action plan should be in place for continuous mangrove monitoring and maintenance.

- It should be ensured that wastes generated during the construction and operation phases do not in any case enter the mangrove waters.
- Special attention should be given to chemical and hydrocarbon spillages in the port waters. Immediate measures should be taken to contain spillage and to reduce impact.
- Oil emergency contingency plan is to be put in place. Waste oil, garbage and building material rubble should be managed in such a way that they do not reach mangroves.
- Exhaustive baseline information on mangrove characteristics such as canopy height, sapling, seed, leaf length, etc. has been collected during the baseline study. Based on this baseline information, vegetation structure of mangroves should be studied once in a year. This assessment and the data generated earlier could be used to check short-term and long-term mangrove health.
- Mangrove formations in the vicinity of the port should be mapped using GIS and RS once in a year to monitor changes in their physical extent. The base maps will track changes, if any, in the physical extent in subsequent years. These mapping exercises will help monitor changes in the mangrove formations.
- As an integral part of mangrove ecosystem, mangrove macrofauna is a reliable indicator of the health status of this ecosystem. Regular monitoring (once in six months) of mangrove macrofaunal abundance, diversity and composition will throw light on the diversity and dynamics of this ecosystem. Comparison of data over the years will reveal the status of mangrove faunal component, which could be linked with overall ecosystem changes.
- During the initial induction period, environmental training and awareness imparting should be given to all port related personnel and contractors on the ecological and environmental importance of coastal habitat and the measures necessary to protect and preserve this habitat.

- Greenbelt will be developed along the port boundary which will act as an additional buffer and shelter belt for mangroves.
- Dust suppression measures, closed conveying system, wagon and truck loading silos etc., will also act as a buffer to prevent the likely fugitive emissions from dry bulk cargo storage areas and handling.
- Revised Master Plan ensures the water flushing near the mangrove areas (both northern and southern side).
- Proposed marine outfall for LNG/LPG/Desalination plant is sufficiently away from the mangrove area and separated by reclaimed land/backup area.
- Awareness will be given to workers in the port and locals about the importance of mangroves and their conservation.
- Discharge of wastes/waste water during construction and operation would not be allowed
- Illegal cutting of mangroves for firewood by workers during the construction and operation phases of port would be strictly prevented and awareness will be given to locals for illegal cutting and importance of mangroves
- Shoreline changes are suggested to monitor.
- Construction near mangrove areas shall be taken with due care.
- Mangrove Conservation Plan is presented in **Section 9.5.4** of **Chapter 9**

4.5.1.3 Impact on avifauna and other animals

The landforms observed in the study area include river, mudflats, waterlogged area, canal, creek, lake, cultivable land, non-cultivable land, sand dunes and coastal track, and hence the density and diversity of birds are considerably high. At least 32 species of migratory and resident birds were sighted during the study period. The most common birds recorded are *Ardea intermedia*, *Mycteria leucocephala*, *Pelecanus philippensis*, *Tringa glareola* and *Himantopus himantopus*. The increase in the volume of traffics is likely to have an adverse effect on the environment and lead to air pollution, noise pollution and water pollution. The extension and construction of new lanes will affect the land use pattern of the proposed area. Common mammals such as buffaloes, squirrel, field mouse, bat, house rat and hare were commonly sighted.

Marine, Estuarine, Creek waters, Backwater and Mangrove habitat baseline biodiversity were assessed and impacts were identified due to proposed development. Impact and mitigations were presented under biodiversity management plan in **Section 9.5** of **Chapter 9**.

4.5.2 Potential Impact due to Construction

4.5.2.1 Laying of Sub-sea pipelines

The laying of sub-sea pipelines would require minor dredging and hence would affect the benthic organisms that live in the area. A localized sedimentation is very likely and it would affect both benthic and pelagic organisms. When plankton and benthic organisms are affected, it would affect the dependant fishery resources.

- Require minor dredging and hence would affect the benthic organisms that live in the area
- A localized sedimentation is very likely and it would affect both benthic and pelagic organisms
- Benthic and pelagic organisms living in the vicinity are likely to be affected

Mitigations Measures

- Planning of environmentally hostile activities during lean fishing season
- Turbidity curtains can be used to minimize sediment transport
- The minor and major oil/chemical spillages should be effectively controlled with appropriate tools and equipment
- Monthly sample collection and monitoring should be done to understand the changes in benthic biota
- Pre installation side scan sonar surveys will determine if there are significant seabed features that should be avoided.
- Development of Waste Management Plans to minimize the chance of pollution causing incidents .
- Compliance with MARPOL prohibitions on dumping trash and debris in the ocean

4.5.2.2 Effect of Excess Salinity on Marine Life

The salinity of standard seawater varies between 32-35 ppt. The increase of salinity can have the following effects on marine life. (*Neuparath et al*, 2002):

- Development of species and the propagation activity and faster individual growth.
- Survival of larval stages of animals and life expectancy (shorter or longer generation time).
- Population density of organisms (higher or lower population growth rate).
- Breeding of species and reproductive traits.

Survival of larval stages of marine life is very low at 40 ppt. In an experiment conducted by Estudillo *et al* of the Aquaculture Department, Southeast Asian Fisheries Development Centre (SEAFDEC), Philippines, larvae of mangrove snapper (*Lutjanus argentimaculatus*). Were reared in salinity media of 16, 24, 32 & 40 ppt. Survival was significantly lowest at 40 ppt (4.3%).

According to some studies about the effects of changes in the salinity of sea water on marine organisms, the primary and apparent changes might occur firstly in mobile species such as plankton and fish, the reaction will be highest in those organisms with a plankton stage in their life history (Hiscock *et al,* 2004). There are very limited numbers of documented studies or experiments have been done about the impacts of salinity and temperature fluctuation on the flora species neither sedentary organism.

4.5.2.3 Impact on Aquatic Ecology

Since the cover placed over the vertical terminal of an offshore intake pipe is a “velocity cap”, the cover converts vertical flow into horizontal flow at the intake entrance to reduce fish entrainment. Fish will avoid rapid changes in horizontal flow and velocity cap intakes have been shown to provide reduction in fish impingement.

4.5.2.4 Mitigation Measures

- Discharge of wastes/waste water without treatment into the sea during the construction and operation should not be allowed
- Awareness shall be given to workers about the importance and conservation of terrestrial and marine ecology

Marine, Estuarine, Creek waters, Backwater and Mangrove habitat baseline biodiversity were assessed and impacts were identified due to proposed development. Impact and mitigations were presented under biodiversity management plan in **Section 9.5** of **Chapter 9**.

4.5.2.5 Impact on Terrestrial Flora

The Project site is located in coastal area and do not have any significant vegetation/large well grown natural flora or any endangered species of flora except mangroves and natural scrub and shrubs. Baseline status of vegetation clearly suggests that the port site does not have any plant species of higher conservation significance. The proposed construction activities will involve removal of grass and scrub areas. Impact due to dry bulk cargo dust such as coal dust emissions from stockyard and transport is envisaged during operation of the port.

4.5.2.6 Mitigation measures during construction

Impacts arising out of domestic wastewater, sewage, construction related and other anthropogenic waste that are likely to reach the water bodies namely Bay of Bengal, Kosasthalaiyar River, Buckingham Canal, Ennore Creek and Pulicat Lake should be reduced through provision of adequate sanitary facilities and disposal of wastes during construction. Waste oil, garbage and building material rubble should be managed in such a way that they do not reach the water bodies. Provision of adequate drainage should be in place to solve stagnation and subsequent contamination of coastal waters. Site cleanliness and removal of any oil, grease and other spillages to designated pits are mandatory. It is important that construction related activities near intertidal zone are confined within the smallest area possible, which will very much reduce the construction related impacts on the coastal waters. Appropriate stringent monitoring plan (Monitoring Protocol in **Section 9.5.3** of **Chapter 9**) should be in place for water bodies such as Bay of Bengal, Kosasthalaiyar River, Buckingham Canal, Ennore Creek and Pulicat Lake, to take all necessary precautionary and remedial measures

4.5.2.7 Biodiversity Conservation and Management Plan

The main aim of Conservation of Biodiversity is to ensure “No Net Loss”. The biodiversity-related Conventions are based on the premise that further loss of biodiversity is unacceptable. Biodiversity must be conserved to ensure it survives, continuing to provide services, values and benefits for current and future generations. The following approach has been chosen by the International Association of Impact Assessment (IAIA) to help achieve ‘no net loss’ of biodiversity:

1) Avoidance of irreversible loss of biodiversity.
2) Seeking alternative solutions to minimize biodiversity losses.
3) Use of mitigation to restore biodiversity resources.
4) Compensation for unavoidable loss by providing substitutes of at least similar biodiversity value.
5) Looking for opportunities for enhancement.
6) The MIDPL undertakes to enforce and strictly adhere to the provisions of the following acts and legislations for conservation of biodiversity as applicable:

- The Environment (Protection) Act (1986):
- The Biological Diversity Act (2002)
- Wild Life (Protection) Act (1972) Forest Conservation Act (1980)
- Recognition of Forest Rights Act, (2006)

Marine, Estuarine, Creek waters, Backwater and Mangrove habitat baseline biodiversity were assessed and impacts were identified due to proposed development. Impact and mitigations were presented under biodiversity management plan in **Section 9.5** of **Chapter 9**.

4.5.2.8 Impact due to Capital Dredging and Disposal

Capital Dredging will be carried out at proposed berthing facilities and extension of navigation channel which may cause disturbance to biological environment. Dredging removes bottom biota and dumping of dredged material covers bottom habitat. Piles, rubble mounds and concrete surfaces will form new habitat. The likely impacts on marine ecology are discussed in **Section 9.5.2** of **Chapter 9**

4.5.2.9 Mitigation Measures during Dredging and Disposal

In addition to the mitigation measures followed in **Section 9.5.2** of **Chapter 9,** the following will be adopted:

- Appropriate selection of equipment for dredging
- Uniform disposal of dredged material at identified disposal location

4.5.2.10 Impact on Ecology due to Reclamation

The port area proposed to be reclaimed is majorly in the inter tidal area. These areas are going to be reclaimed with 85 MCM of dredged material. There will be loss of marine biodiversity due to reclamation.

4.5.2.11 Mitigation Measures during Reclamation

While reclaiming the existing area, bunds will be provided with a suitable overflow facilities so that only clear water will be returned to the harbour basin. Mangroves in the vicinity of the Port will be not be disturbed during reclamation.

Care shall be taken during reclamation and reclamation bund shall be constructed to ensure that no impact on surrounding biota.

4.5.2.12 Impact on Ecology during Construction Activities

The impacts caused due to construction activities include the following:

- Exhaust emissions from diesel run engines, construction machinery and vehicles
- Dust suspension during site preparation, construction, trenching and material transport
- Noise caused by vehicles transporting construction material
- Noise caused by handling of construction materials
- Noise & exhaust emissions from diesel run engines of construction machinery
- Interference to fishermen and fishing activities during seaside construction activities.

During construction the transport of construction material will cause dust emission, emission of exhaust gases from vehicles such as CO_2, CO and NO_x. The fugitive dust may coat the leaves of plants and trees. Fauna that occur in the study area may get disturbed with the sound of vehicles, construction and construction equipment.

4.5.2.13 Mitigation Measures

Spraying of water during handling of construction materials like sand and gravel will minimise dust emission. Properly maintained vehicles will produce reduced noxious emission. Temporary labour camps shall have proper sanitation facilities. The impacts caused by construction to fauna are temporary and not long term and most (if not all) of the observed and documented flora and fauna of the project area will adapt to these impacts.

4.5.3 Potential Impact due to Operation

4.5.3.1 Impact due to Aqueous Discharges and Mitigation Measures

On the intake side of the desalination plants, small organisms such as fish larvae and fingerlings can get sucked into the desalination plant. But the release of brine back into the sea causes more impact than the intake. Brine will be substantially higher in salinity and warmer than normal oceanic water and this condition would make it more difficult for marine life to survive in the immediate vicinity of the discharge. The brine will also have chemicals, and chronic exposure to these chemicals would make the marine organisms accumulate them in the food chain.

If CPCB norms are not followed, the end products of the ETP may contain biodegradable organic substances and micro-organisms, non-biodegradable and toxic substances that can contaminate coastal waters. Sewage sludge is the solid, semisolid, or slurry residual material that is produced as a by-product of wastewater treatment processes. If the sludge is not treated properly it would cause serious environmental problems.

During the operation phase there will be continuous movement of cargo vessels and port crafts round the clock. There is a possibility of aqueous discharges from the cargo vessels such as dumping of ship wastes (sullage) / sewage, bilge water, solid wastes, etc. if not regulated. The likely impacts and corresponding mitigation measures to be followed are discussed in **section 4.4.3.2** and **4.4.3.3** respectively.

4.5.3.2 Potential Impact due to Cargo Operations

During cargo handling operations in the water front and offshore berth, discharges and emissions are likely. Dry bulk cargoes generally produce a lot of dust which can impact both benthic and pelagic organisms and would consequently affect the fishery resources. Liquid bulks that are handled via pipelines may carry the hazard of static sparks, spillage and emissions, which would also affect the organisms that live in the vicinity.

Due to Cargo Spillage during Handling: Spills do not occur during normal operations, as the cargo will be handled by specialised ship-loaders/unloaders. In the event of accidental spills of cargo during transfer from / to the ships, the marine water quality, sediment quality and ecology in the harbour basin will be impacted.

4.5.3.3 Mitigation Measures

- Spill contingency plan as a part of Disaster Management Plan will be adopted in accordance to the cargo will be handled
- Spill recovery/immediate response measures will be displayed at cargo handling areas
- Material Safety data Sheet (MSDS) of cargo being handled will be displayed
- Mock drills will be conducted at periodic intervals

4.5.3.4 Maintenance Dredging and disposal

Maintenance dredging and disposal to ensure depths will be a major operational activity on a continual basis. Potential turbidity and suspended solids would affect the dredged and disposal areas. The suspension of sediment in the water column is likely during maintenance dredging and disposal and will have their likely impact on benthic and pelagic organisms. Associated fishery resources are also likely to be affected during maintenance dredging and disposal during the operational phase.

4.5.3.5 Mitigation and Management Measures on Maintenance dredging

Maintenance dredging to ensure depths as required for navigation of vessels will be a major operational activity on a continual basis. The following mitigation and management measures are recommended during port operation. Suitable dredging equipment for fine sediments should be used to minimize the level of turbidity during maintenance dredging operations. If the sediment is contaminated, measures are to be taken in order to limit the lateral movement of turbid water during dredging activity. Appropriate silt curtains should be used to reduce sediment transportation. Dredging activity should not be undertaken during periods of rapid water current and strong trade winds. Establishment of a dredging monitoring (see Monitoring Protocol section) and emergency response plan will be useful to monitor the direction of the plume and to monitor for equipment malfunction and accidental dredge spills.

Impacts to the dredge material relocation ground and adjacent areas should be minimised through relocation of the dredge material in such a manner as to uniformly spread it over the relocation ground. Detailed assessment on water quality and biological resources should be carried out to identify the problems at the earliest.

4.5.3.6 Ship Traffic

During the operational phase, ship traffic will be very high in the vicinity of the proposed project area and so is likely to cause pollution. The pollution related to ship traffic includes fuel leakage from ships, leaching of antifouling paints, transfer of harmful aquatic organisms, dumping of wastes and oil spills. Apart from these disturbances, air pollution, noise pollution and wave generation would also affect the environment. Further, increased shipping traffic would affect the paths of fishing boats near the proposed project area and would make the area prone to collisions with larger marine animals such as dolphins.

In case of an oil spill inside the port, all the organisms inside the port, starting from plankton to fishes, will be significantly affected. Oil spills outside but adjacent to the port will mostly affect the organisms in the northern side of the port. The impacts of oil spills last long and will have detrimental effects on the benthic and pelagic organisms.

4.5.3.7 Impact due to Operational Activities

During Operation phase of the project as well as movement of vehicles may cause the fauna to flee because of the noise. Operational activities as well as the exhaust from DG sets will also result in the emission of exhaust gases such as CO, SO_2, NO_x and PM. In addition to the above; dust from the dry bulk cargo transported from the berths to stockyard through conveyors and transportation via road and rail may be respired by the fauna, if not handled properly. Dry bulk dust may be ingested by herbivorous species since the Particulate matter may coat the surface of vegetation. Dry Bulk cargo dust coating the leaf surfaces of vegetation results in blockage stomata (leaf pores responsible for gaseous exchange and water vapour exchange) and reduced photosynthetic performance.

4.5.3.8 Mitigation Measures

The solid waste generated from the port during operational phase should be properly segregated, stored and disposed. All the constructions should be planned in such a way that it does not restrict the prevailing tidal entrance in the mangrove habitats through Pulicat mouth and Ennore mouth. The minor and major oil/chemical spillages should be effectively controlled with appropriate tools and equipment. Critical parameters such as suspended solids, DO, BOD and nutrients should be regularly monitored and compared with baseline study. Use of biocides should be kept at the minimum and their concentration at the outlet should be regularly tested. Comprehensive and easy to implement Standard Operating Procedure (SOP) should be made for each category of cargo in order to avoid oil or chemical spillages. The operating staff at the berth should be trained in such operations and also in handling emergencies. Transfer of bulks to the coal stack yards should only be through closed conveyors. Water sprinkling should be done at stack yards prone to generate wind-blown dust.

- Dry bulk cargo shall be transported through covered conveyors from berth to the stockyard and greenbelt and dust suppression measures will be provided at stockyard and while loading trucks and wagons
- Dry bulk cargo transporting wagons and trucks will be covered with tarpaulin covers.
- All vehicles for proposed cargo handling will confirm to Pollution Under Control (PUC) norms

4.5.3.9 Impact due to Lighting and Mitigation Measures

The glare of the port complex lighting system is likely to cause adverse impacts on the Nocturnal fauna and marine creatures.

4.5.3.10 Mitigation Measures for Light Pollution

- All outdoor lighting, roadway lighting, wharf lighting, and lighting mounted on masts or other elevated structures will include no other luminaries except full cut-off luminaries. Full cut-off luminaries shall meet the (Illuminating Engineering Society of North America) IESNA classification for “full cut-off,”
- All outdoor lighting, roadway lighting, wharf lighting, and lighting mounted on masts or other elevated structures will be of the minimum lamp wattage to achieve required safety within the lighted area.
- No area lighting or any lighting mounted on masts or other elevated structures will include fluorescent lamps, mercury vapour (MV) lamps, metal halide (MH) lamps, or other broad-spectrum high-intensity discharge lamp types.
- No lighting of grounds, building walls, signs, cranes, or other elevated structures will employ flood lighting, up-lighting, or other forms of directional lighting aimed above the horizon.
- Where ever possible, use full cut-off fixtures that specify shielding that keeps light at least 15^0 below the horizontal plane of fixture.
- Where ever possible, use low-pressure sodium vapour lamps or other light sources that exclude wavelengths less than 520 nm.

4.6 Air Environment

4.6.1 Potential Impact during construction

4.6.1.1 Impact due to Transportation of Construction Material

Construction material may result into emissions during its transportation; therefore it shall be brought into covered condition.

The existing roads will be utilised for the transportation of raw materials for the construction during the Revised Master plan development and same is under widening by the state government. Transporting the construction material through sea/inland waterways route will also be explored during construction phase.

4.6.1.2 Emission during Construction at site

During the construction activities, the sources of potential impacts on the air quality at the construction site can be categorised as:

- Exhaust emissions from diesel run engines, construction machinery and vehicles
- Dust suspension during site preparation, construction and material transport

Grading, soil compaction and reclamation will be involved as a part of site preparation before undertaking construction work. Area development will involve developing the internal road, utilities and services etc. Fugitive dust is expected particularly during dry weather conditions due to the site preparation and movement of transport vehicles for materials and personnel. Emissions from diesel power generators, construction equipment and transport vehicles will affect the air quality within the work areas, if not adequately managed. Movement of materials such as cement, steel, sand, etc. will cause disturbance to the adjoining communities/communities enroute.

The baseline concentrations of Particulate Matter (PM_{10} and $PM_{2.5}$), SO_2, NO_2 and CO are within the limits of NAAQS stipulated by CPCB. With the present background concentrations of air quality parameters, it is expected that there will only be a mild build-up of air pollutants.

Further, because of the prevailing strong winds along the coastal region and the resulting dispersion the impact on air quality from pollutants would be reduced. The impacts during construction are short-term in nature and will cease on completion of the construction.

Further, adoption of suitable mitigation measures will ensure that these impacts are rendered insignificant.

4.6.1.3 Mitigation Measures

Construction Yard

- During planning, it will be attempted to prevent / minimise disturbance to adjacent properties / habitations. If unavoidable, same will be restored with consent from affected persons.
- Adequately sized construction yard will be provided at the site for storage of construction materials, equipment tools, earthmoving equipment etc. In addition, temporary field offices and worker amenities will be provided. Appropriate spill control measures and labelling / handling procedures will be maintained.
- Construction sites will be provided with enclosures on all sides to prevent dispersion of dust and transmission of noise.
- Drainage system will be provided at construction yard. Measures will be taken to prevent silting of natural drainage due to runoff from construction areas.
- Proper area will be demarcated for storage of construction material. This will enable proper management of the materials including control of seepage and spillage thereby preventing contamination of the project area.

Movement of Machinery and Equipment

- Movement of material will be mostly during non-peak hours and regulated during peak hours. Mobile equipment such as intermittently used machines and transport vehicles will be either switched off or throttled down to a minimum.
- On-site vehicle speeds will be controlled to reduce excessive dust suspension in air and dispersion by traffic.
- Only PUC certified vehicles will be used for the transportation of material and equipment etc.
- Construction equipment and transport vehicles will be periodically washed to remove accumulated dirt.
- Vehicles transporting construction material susceptible for fugitive suspension will be covered with tarpaulin and will be prohibited from stopping near settlements.

Dust suppression

- Water sprinkling will be carried out to suppress fugitive dust during earthworks and along unpaved sections of access roads.

Environmental Awareness

- Environmental awareness program/training will be organised to the personnel involved in developmental works.

4.6.2 Potential Impact due to Operation considering Revised Master Plan

The impact on air environment due to the operation of Kattupalli port during the Revised Master Plan has been predicted based on air quality modelling studies. The AAQ model studies covered the following:

- Point sources ie., Emissions from Ships/Vessels during Berthing, Submerged Combustion Vaporizer (SCV) for LNG Regasification Units and Boiler for Steam Generation for LPG terminal
- Area Source i.e., Dry Bulk Cargo Storage (Coal/Iron Ore/Lime stones/Mines & Minerals and other Dry Bulk) Stockyards for Particulate Matter (PM)
- Line source i.e., increased vehicular activity due to normal and generated traffic on the road proposed in the dedicated corridor
- Volume Sources such as (Un)loading points at the berths, at trucks loading and train loading areas

FSRU is planned as a part of Revised Master Plan for handling of LNG, therefore, the emissions pertaining to FSRU such as emission due to captive power generation will likely to impact the air environment. However, onshore LNG terminal planned as a part of the Revised Master Plan development of Kattupalli port considered emission from Submerged Combustion Vaporiser (SCV) as continuous emissions for AQM Study. Considering the Seawater based Regasification for the proposed FSRU, no emissions are envisaged from SCV.

It is observed that the impact on air environment due to the emissions from FSRU on board power generation will be lesser (2 Generators 7530KW capacity emits NO_2 – 2.51 g/s each against SCV emission of 2.94 g/s NO_2) than the emissions considered due to SCV emission. The PM_{10} emissions from the proposed LNG FSRU on-board Power generation units are not significant as Natural Gas will be used as a fuel and hence the impact on Air Environment due to this FSRU is insignificant.

Similarly FSO is planned as a part of the revised master plan for handling of LPG, therefore, the emissions pertaining to FSO such as heating of LPG (Propane and Butane) in the FSO by using on-board heat exchanger will likely to impact the air environment. However, onshore LPG terminal planned as a part of the Revised Master Plan development of Kattupalli port considered the emission from HSD based Boiler as a continuous emission for AQM study. Hence, the same will take care of the emission from the on-board heat exchanger and no additional emissions are envisaged.

4.6.2.1 Sources of Emission considered for Air Quality Modelling

Following sources of emission are identified as a part of proposed development of Revised Master Plan of Kattupalli port and considered in the air quality modelling study.

A. Point Sources

1. Emissions from Ships/Vessels visiting the Kattupalli Port

During the operational phase, there will be an increase in the vessel traffic and hence, emissions from the vessels will also increase. The exhaust from tugs, launches, diesel operated small boats, dredgers etc. will add to pollution load during operational phase. With the increase in the number of ships and boats, their operation and movement of cargo to and fro will also increase. These activities will increase the pollution load in the atmosphere.

Number of ships/vessels visiting the Kattupalli Port facility for Revised Master Plan has been arrived based on the cargo handling rate and berth occupancy. Number of vessels expected to be berthed continuously are around Fourteen (14) ships per day.

Apart from a very few exceptions where power cables from land/offshore sources are connected and used on board vessels in port (Cold ironing), ships are self-sufficient regarding energy supply. Potential sources of emissions of vessels are from the Main Engine (ME) and Auxiliary Engines (AE) and others such as boilers, emergency diesel engines and waste incinerators and emissions from are relatively very small and can be considered negligible.

Main Engine (ME) will be used primarily for ship propulsion. Normally MEs are shut down in port, while Auxiliary Engine (AE) will be used for Electric power generation on board for lighting, ventilation, cranes, pumps etc. When a shaft generator on the MEs is used, the pollutants emitted as a result have been identified as a threat to the air quality.

During the berthing time, the main engine of the ships will be turned off and the Auxiliary engines will be turned on to meet the auxiliary power requirement. It is assumed that the auxiliary engines will be running continuously during berthing. The vessel auxiliary engine power is assumed based on the type of cargo handled at the berth and details of the same along with emissions factors considered are given in **Table 4-11**.

Table 4-11: Details of Vessel Auxiliary Engine and Emission Factors

S. No.	Cargo	Auxiliary Engine Capacity (KW)	Emission Factor (g/kwh)		
			PM	SO_2	NO_X
1.	LNG/LPG/Cryogenic	960	2.0	12.1	7.4
2.	POL	960	2.2	11.5	12.0
3.	Container	1200	1.2	5.2	13.2
4.	Liquid	1200	2.2	10.7	13.2
5.	Multipurpose	1200	1.2	5.2	12.8
6.	Bulk Cargo	1500	1.2	5.2	13.4

2. Emission from LNG Terminal Regasification Unit

LNG will be vaporized in shell and tube type vaporizer (STV) with LNG on the tube side and an ethylene glycol water mixture on the shell side. Then the eco-friendly technologies such as either Sea water or Ambient Air will be used to reheat the ethylene glycol or may be used directly to heat the LNG also. Hence there is no emission expected from the regasification process. However, for back up purpose, submerged combustion vaporiser (SCV) is proposed during winter (2 Nos can handle upto 10MMTPA). Roughly 90 days of working has been considered for calculating emissions from SCV. As SCV will be using Natural gas as a fuel, exhaust emission mainly consist of Nitrogen oxides (NO_X) and Carbon Monoxide along with insignificant quantities of Particulate Matter. Emissions from SCV are considered as continuous emission and other utilities are electric driven.

3. Emission from Boiler for Steam Generation for LPG Terminal

In the LPG terminal, propane and butane are heated in separate heating trains to 15°C in two steps. First preheating of refrigerated propane liquid at -44.4°C is performed in Propane Heater and preheating of refrigerated Butane at -4.4°C is done in Butane Heater by condensing hot propane vapours at 37°C to avoid freezing problems by direct heating with steam. Second the propane used for heating Propane and Butane is vaporized in a kettle type Propane Vaporizer by condensing steam. The steam condensate is used to heat the Propane and Butane/Propylene to 15°C in Propane Heater and Butane Heater respectively.

Steam is generated in the facility using 20 MT/hr HSD fired boiler (1 No. can handle upto 5.75 MMTPA). The generated LP steam is used to heat propane and butane before sending them to blending section. The steam condensate is collected and taken to condensate storage tank for further processing. The emissions from the boiler were estimated based on the typical fuel consumption for 20 MT/hr HSD based boiler and HSD characteristics.

The emission details for the point sources in the study region are given in **Table 4-12**.

Table 4-12: Point Sources Emission Details

Stack Details					Emissions (g/s)			
Stack Code	Stack Height (m)	Stack Velocity (m/s)	Stack Dia (m)	Exit Temp (K)	PM_{10}	$PM_{2.5}$	SO_2	NO_2
1	**Stacks of Auxillary Engine of Vessels during Berthing**							
P1	18	25	0.8	593	0.40	0.16	1.73	4.40
P2	18	25	0.8	593	0.40	0.16	1.73	4.40
P3	18	25	0.8	593	0.50	0.20	2.17	5.58
P4	18	25	0.8	593	0.50	0.20	2.17	5.58
P5	18	25	0.8	593	0.73	0.29	3.57	4.40
P6	18	25	0.8	593	0.59	0.23	3.07	3.20
P7	18	25	0.8	593	0.53	0.21	3.23	1.97
P8	18	25	0.8	593	0.40	0.16	1.73	4.27
P9	18	25	0.8	593	0.40	0.16	1.73	4.27
P10	18	25	0.8	593	0.40	0.16	1.73	4.27
P11	18	25	0.8	593	0.40	0.16	1.73	4.27
P12	18	25	0.8	593	0.40	0.16	1.73	4.27
P13	18	25	0.8	593	0.40	0.16	1.73	4.27
P14	18	25	0.8	593	0.40	0.16	1.73	4.27
2	**Submerged Combustion Vaporiser Stacks**							
LNG1	30	7.73	1.4	360	-	-	-	2.94
LNG2	30	7.73	1.4	360	-	-	-	2.94
3	**Boiler Stack for Steam Generation for LPG Terminal**							
LPG1	38	22	0.4	588	0.34	0.13	7.64	5.20

B. Area Sources (Dry Bulk Cargo such as Coal/ and Iron Ore/Lime stones/Mines & Minerals, etc and other Dry Bulk Stockyards)

The Dry Bulk cargo such as Iron Ore/Lime stones/Mines & Minerals, other Dry Bulk and coal etc. to be imported or exported will be stored at their respective stockyards. The proposed storage is likely to generate fugitive dust emissions due to wind.

Due to the fugitive dust emission from the stockpile, the dust particles will be carried by the wind and causes pollution. This would pollute other clean areas of the port. The Dry Bulk Cargo dust particles carried by the wind likely to cause dust emission in the neighbouring villages also.

The dry bulk cargo (represented in terms of coal and iron ore) handling system in the form of covered conveyer system and transfer points for the transportation from the berths to the stockyard proposed to be provided.

Coal is susceptible to spontaneous combustion, most commonly due to oxidation of pyrite or other sulphidic contaminants in coal. Coal reacts with atmospheric oxygen even at ambient temperatures and this reaction is exothermic. If the heat liberated during the process is allowed to accumulate, the rate of the above reaction increases exponentially and there is a further rise in temperature. When this temperature reaches the ignition temperature of coal, the coal starts to burn and the phenomena is described as spontaneous combustion.

The spontaneous combustion of the coal as shown **Exhibit 4-1** would take place due to the voids in the pile and free flow of air. Initiation of spontaneous combustion is through development of hot spots in the coal stockpiles. This results in degradation of the coal. Wind and moisture in the coal play a major role in the spontaneous combustion of the coal. Wind supplies more oxygen for combustion. When the coal absorbs moisture, heat is generated. This heat increases the temperature of the coal. During the spontaneous combustion of coal, some gases would be produced. This gas is also carried by the wind and causes pollution in the surrounding environment.

Exhibit 4-1: Spontaneous Combustion of Coal

The significant factors to be considered for prevention of this development are as follows:

- Ventilation

- Coal Quality: low carbon content and large amounts of volatile components support combustion
- Particle Size: the smaller the particles, the larger the surface, the higher the risk
- Stockpile Design
- Humidity
- Frequent spraying of water at coal stockyard

Coal dust is prone to ignition depending on its concentration in air and presence of ignition sources. Coal dust therefore represents a significant explosion hazard in coal storage and handling facilities where coal dust clouds may be generated in enclosed spaces. The significant factors which contribute to the dust explosion are:

- Concentration of dust in suspension
- Sufficient oxygen to enable combustion
- Source of energy for ignition
- A certain degree of confinement of the suspended dust mixed with oxygen

Coal dust poses a possibility of reduced lung function. Workers exposed to coal dust may develop lung damage and pulmonary fibrosis. The occupational exposure standard (OES) for coal dust is 2 mg/m^3 of respirable dust (Exposure limit eight-hour TWA). OES is the level of dust at which there is no evidence of injury to people exposed day after day.

Wet suppression has proved to be the most effective means for controlling fugitive dust emissions and spontaneous combustion from stockpiles. Moisture is added to capture the dust particles that are already airborne. It is basically designed to prevent lift off of dust from stockpile and road area. The nature and particle size of dust generated in the material handling system changes with change in size and characteristic of the material. In practice, the size of the dust particles has a very wide spectrum. A careful control of Air and Water Flow & Pressure is therefore necessary to obtain optimum dust suppression results. For this purpose, pressure regulators are provided in the system. Water is sprayed in at regular intervals depending on the site condition. The dust control is achieved by the agglomeration of dust particles with finely atomized water droplets equal to / close to / larger than the dust particles as the case may be, the collision between the water droplets and dust particles plays an important role in the process of agglomeration and heavier mass thus formed settles down to the source. Plain water dust suppression has been considered for top of Mobile hopper & Truck receipt area discharge chute. The system has been designed to control dust nuisance of the working environment during un-loading of coal from Grab & at the peripheral location of discharge chute of belt feeder towards truck receipt.

The fugitive emission from the Dry bulk cargo storage areas represented in terms of coal and iron ore stockyards and handling area are worked out considering the proposed air pollution control measures such as dust suppression measures and greenbelt etc. Since the fugitive emissions from the existing stockyards are considered in the baseline monitoring, the same is not considered as a part of air quality modelling for the proposed expansion.

The details of Dry bulk cargo storage areas represented in terms of coal and iron ore handling and likely emission from storage area are given in **Table 4-13**.

Table 4-13: Area Sources Emission Details

S. No	Details of Emission	Stockyard represented in terms of	
		Coal	Iron Ore
1	Total Dry Bulk Cargo (MMTPA)	85	
2	Silt Content (%)	3	5
3	Storage Duration (Days)	365	365

S. No	Details of Emission	Stockyard represented in terms of	
		Coal	Iron Ore
4	Stockpile Area (m^2)	1320000	1160000
6	Emission due to Wind Erosion from Stockyard (g/s) without control	11.93	17.48
8	Total Emissions with control (g/s-m^2) (80% of total emissions)	7.23E^{-06}	1.21E^{-05}
9	PM_{10} Emissions after Incorporating the Control Measures (g/s-m^2)	4.34E^{-06}	7.23E^{-06}
10	$PM_{2.5}$ (g/s-m^2)	1.74E^{-06}	2.89E^{-06}

C. Line Sources

The cargo volume to be handled for Revised Kattupalli Port as per the traffic projections will be around 320 MMTPA. Revised Master plan is assumed to be fully operational by 2040.

Therefore the increased vehicular traffic estimated for the year 2040 has been considered for Air Quality Modelling. It is proposed that part of the cargo will be transported through road proposed in the dedicated road/rail/utility corridor and part will be transported by rail. As the rail lines will be electrified, no emission is envisaged from the rail line proposed. Hence, only emission from road traffic is considered as a line source of emission.

The number of vehicle per day i.e. Heavy Vehicles and Light Commercial vehicles on the proposed road comprises of two components i.e. Normal Traffic Projection due to the developments in the region which will be diverted on the proposed road and Generated Traffic due to Kattupalli port Revised Master Plan development. The emission factors for heavy and light vehicles are taken from the report published by CPCB. EURO VI emission factors are assumed to be implemented and are considered for calculating the vehicular exhaust emissions.

As per traffic Projections, the number of vehicles (both Light and Heavy) on proposed road has been considered for air quality modelling. The details of the emissions[24] from the heavy, light and 2/3 wheeler vehicles are given in **Table 4-14** to **Table 4-20**.

Table 4-14: Emission Details of vehicles on Port Access road

Parameter	Port Access Road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	3175	2515	4788
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0009	0.0004	0.0002
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0038	8E-05	0.0018
Emission rate of $PM_{2.5}$ (g/s)	0.0015	3E-05	0.0007
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	0.1443	0.0075	0.0423

Table 4-15: Emission Details of vehicles on CICT road

Parameter	CICT Road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	2049	801	278
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0005	0.0001	0.00001
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0020	2E-05	0.0001
Emission rate of $PM_{2.5}$ (g/s)	0.0008	9E-06	0.00004
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300

[24] *All the emission factors(g/km) were taken from the National Summary Report-"Air quality monitoring, emission inventory and source apportionment study for Indian cities" developed by Central Pollution Control Board based on detailed study reports prepared by NEERI, TERI, ARA, IITK, IITM.*

Parameter	CICT Road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Emission rate of NO_x (g/s)	0.0784	0.0020	0.0021

Table 4-16: Emission Details of vehicles on SH-56

Parameter	SH-56		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	7915	7524	7570
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0073	0.0043	0.0010
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0305	8E-04	0.0093
Emission rate of $PM_{2.5}$ (g/s)	0.0122	3E-04	0.0037
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	1.1672	0.0731	0.2172

Table 4-17: Emission Details of vehicles on SH-107

Parameter	SH-107		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	3025	615	5963
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0026	0.0003	0.0007
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0109	6E-05	0.0069
Emission rate of $PM_{2.5}$ (g/s)	0.0044	2E-05	0.0028
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	0.4171	0.0056	0.1600

Table 4-18: Emission Details of vehicles on SH-104

Parameter	SH-104		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	1653	302	5592
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0013	0.0001	0.0006
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0053	3E-05	0.0057
Emission rate of $PM_{2.5}$ (g/s)	0.0021	1E-05	0.0023
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	0.2016	0.0024	0.1327

Table 4-19: Emission Details of vehicles on peripheral road

Parameter	Peripheral road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	23803	6923	4960
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0032	0.0006	0.0001
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0133	1E-04	0.0009
Emission rate of $PM_{2.5}$ (g/s)	0.0053	4E-05	0.0004
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	0.5104	0.0098	0.0207

Table 4-20: Emission Details of vehicles on Attipattu road

Parameter	Attipattu road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Vehicle Trips per Day	2549	2909	1468

Parameter	Attipattu road		
	Heavy Vehicle	Light Vehicle	Two/Three Wheeler
Emission factor of SO_2 (g/km)	0.0040	0.0030	0.0006
Emission rate of SO_2 (g/s)	0.0006	0.0005	0.00005
Emission factor of PM (g/km)	0.0300	0.0008	0.0010
Emission rate of PM_{10} (g/s)	0.0026	8E-05	0.0005
Emission rate of $PM_{2.5}$ (g/s)	0.0011	3E-05	0.0002
Emission factor of NO_x (g/km)	0.6900	0.0500	0.1300
Emission rate of NO_x (g/s)	0.1008	0.0076	0.0113

These emissions are assumed as continuous in nature and this line source is considered as a string of volume sources for Air Quality modelling for prediction of impacts.

D. Volume Sources

1. Bulk Cargo Unloading Points at Berths

Unloading points at the bulk cargo berths which are likely to generate fugitive dust emissions are considered for Air Quality modelling. Covered and mechanized unloading points with dust suppression system to be provided which will reduce the fugitive emissions to the minimum. Fixed cone nozzles will be placed at receiving hoppers. Since the fugitive emissions from the loading points of existing berths are considered in the baseline monitoring, the same is not considered as a part of air quality modelling for the proposed expansion. The details of the emissions from the proposed transfer points are given in

Table 4-21: Emission Details due to unloading points at berths

S. No	Details of Emission	Unloading at Bulk Berths
1	Total Dry Bulk Cargo (MMTPA)	85
2	Number of Unloading Points	5
3	Unloading Emission Factor (kg/t)	0.0017
4	Total Emission due to unloading points (kg/year)	144500
5	PM_{10} Emission due to single unloading point (g/s) Without Control	4.582
6	PM_{10} (70% Control with closed unloading including water sprinkling) With Control	1.375
7	$PM_{2.5}$ With Control	0.550

2. Bulk Cargo Loading Points to Train/Truck

Wagon loader for train loading and silos arrangement for truck loading proposed to be provided. Loading points are likely to generate fugitive dust emissions. The covered and mechanized unloading points with dust suppression system are provided which will reduce the fugitive emissions to the minimum. Fixed cone nozzles will be installed, at regular intervals, at discharge point of shuttle conveyor on Rapid loading System. Since the fugitive emissions from the existing loading points are considered in the baseline monitoring, the same is not considered as a part of air quality modelling for the proposed expansion. The details of the emissions from the proposed transfer points are given in **Table 4-22**. The wagon loading and silo truck loading systems are shown in **Exhibit 4-2** and **Exhibit 4-3**.

Table 4-22: Emission Details due to Train/Truck Loading Points

S. No	Details of Emission	Details of Loading Points
1	Total Dry Bulk Cargo (MMTPA)	85
2	Number of Train (Un)loading Points	14
	Number of Truck (Un)loading Points	2
3	Loading Emission Factor (kg/t)	0.00017
4	Emission due to Single (Un)loading for Train (kg/year)	826
	Emission due to Single loading for Truck (kg/year)	1445
5	PM_{10} Emission due to single train (Un)loading points (g/s) Without Control	0.026

S. No	Details of Emission	Details of Loading Points
	PM_{10} Emission due to single truck loading points (g/s) Without Control	0.046
6	PM $_{10}$ (70% Control with closed loading including water sprinkling) With Control for single train (Un)loading points	0.0079
7	$PM_{2.5}$ With Control for single train (Un)loading points	0.0031
	PM $_{10}$ (70% Control with closed loading including water sprinkling) With Control for single truck loading points	0.014
	$PM_{2.5}$ With Control for truck loading points	0.011

As these emissions are continuous in nature, these are considered for Air Quality modelling for prediction of impacts.

Exhibit 4-2: Wagon Loading System

Exhibit 4-3: Truck Loading System

Dust Control System at the receipt and discharge points works on the principle of agglomeration. Dust particles released from a material handling plant which become air borne, are made to pass through a blanket of extremely fine dry fog. Plain water is mixed with compressed air in a ratio through highly efficient acoustic nozzles which produces millions of minuscule water droplets which when kept entrapped within an enclosure in a dust generating transfer point, can efficiently contain and control even fine dust particle.

Each application point shall be provided with requisite number of Dual-fluid Dry Fog Acoustic oscillating type Nozzles. Flow Control Box is provided for a group of nozzles to regulate the pressure of compressed air and water as per requirement. Maximum moisture addition is within 0.1%.

E. Other Emissions

Other emissions include fugitive emissions from liquid cargo handling and transfer operations, emissions from emergency DG set and LNG and LPG flares etc. Fugitive emission can be controlled by selecting suitable equipment, appropriate handling methods etc., and hence no emissions from these sources were considered.

As all the above emissions are expected only during emergency situation, they were not considered in the air quality modelling study.

4.6.2.2 AERMOD Model

AERMOD is a 'near-field, steady-state' Gaussian model. It uses boundary-layer similarity theory to define turbulence and dispersion coefficients as a continuum, rather than as a discrete set of stability classes. Variation of turbulence with height allows a better treatment of dispersion from different release heights. AERMOD requires Surface as well as Upper Air data as meteorological input.

4.6.2.2.1 Model Assumptions

The following are the assumptions for the air quality modelling;

- Uses rural dispersion
- Stack-tip downwash
- Model assumes receptor on flat terrain
- Used calms processing routine
- Used missing data processing routine
- No exponential decay
- No Dry and Wet Depletion

4.6.2.2.2 Input Data

The following technical details of Kattupalli Port are considered for Air Quality Modelling studies:

- Point Sources: The Point source inputs are given in **Table 4-12**
- Area Sources: The area source inputs (Emissions from Dry Bulk Cargo Stockyard) are given in **Table 4-13**
- Line Sources: The Line source inputs (Vehicular Emissions) are given in **Table 4-14** to **Table 4-20**
- Volume Sources: The volume source inputs (unloading of Dry Bulk Cargo at berths and loading of Dry Bulk Cargo to train and trucks) are given in **Table 4-21** to **Table 4-22**

4.6.2.2.3 Meteorological Data Considered

For the purpose of carrying out the air quality modelling study, site specific meteorological data (pre-processed from MM5) for the year of March 01, 2019 to February 29, 2020 obtained from Lakes Environment, Canada was used. The raw met data have been processed in AERMET view to create surface and upper air data which can be used as inputs to AERMOD.

<u>Wind Speed and Wind Direction</u>

The wind roses were drawn for the met files obtained on a sixteen-point compass (N, NNE, NE, ENE; E, ESE, SE, SSE; S, SSW, SW, WSW; W, WNW, NW, and NNW). Wind pattern representing 24 hours for the year of March 2019 to February 2020 is discussed. The frequency occurrence of wind at various speeds was calculated on the basis of total number of observations recorded in the respective wind speed category. The overall wind pattern recorded for 24 hours during the year March 2019- February 2020 is given in **Figure 4-58**. The predominant wind directions observed were from South South East followed by South East, South; calm conditions prevailed for 0.66% of the total time. The average wind speed was observed to be 4.29 m/s.

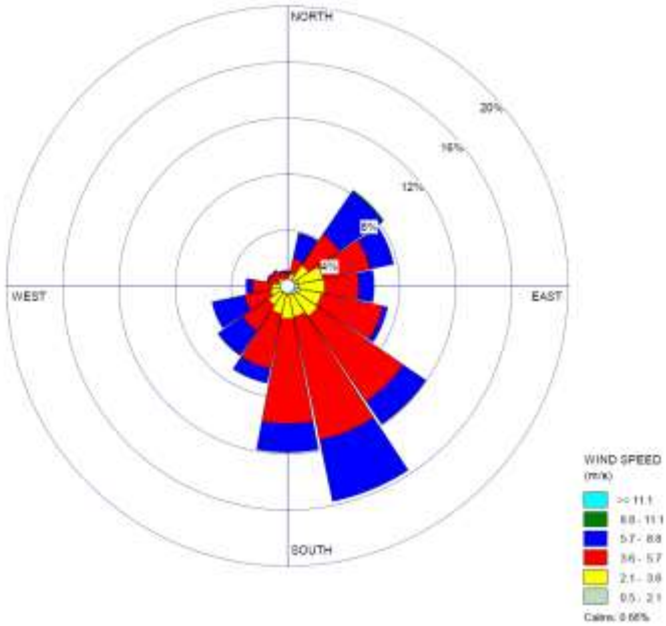


Figure 4-58: Annual Wind Rose

4.6.2.3 Receptors

The details of the receptors which are monitored for the baseline data as a part of CEIA Study within 10 km radius of the boundary of the Revised Master Plan are given in **Table 4-23**.

Table 4-23: Receptors for Air Quality Modelling

Location No.	Receptors	Distance (km)	Azimuth Directions
I	**Ambient Air Quality Monitoring Locations**		
A1	Attipattu	2.3	SW
A2	Kattupalli	Within the site	
A3	Kalanji	Within the site	
A4	Karungalikuppam	0.6	N
A5	Neidavayal	3.2	W
A6	Uranambedu	Within the site	
A7	Kattur	1.5	NW

4.6.2.4 Model Results

The 1st highest 24 hour, resultant concentration and annual average incremental concentrations for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 are given in **Table 4-24** to **Table 4-28**.

Table 4-24: 1st 24-hour Average Incremental and Resultant Concentration of PM_{10}

Location No.	Receptors	1st 24 Hour Average Incremental Concentration (µg/m³)	Baseline Concentration (µg/m³)	1st 24Hour-Resultant Concentration (µg/m³)	NAAQ Standards (µg/m³)- 1st 24 Hour
AQ1	Attipattu	7.96	80	87.96	**100**
AQ2	Kattupalli	10.06	61	71.06	
AQ3	Kalanji	8.23	68	76.23	
AQ4	Karungalikuppam	7.15	62	69.15	
AQ5	Neidavayal	11.40	78	89.40	
AQ6	Uranambedu	10.11	77	87.11	

Location No.	Receptors	1st 24 Hour Average Incremental Concentration (µg/m³)	Baseline Concentration (µg/m³)	1st 24Hour-Resultant Concentration (µg/m³)	NAAQ Standards (µg/m³)- 1st 24 Hour
AQ7	Kattur	9.75	86	95.75	

Table 4-25: 1st 24-hour Average Incremental and Resultant Concentration of $PM_{2.5}$

Location No.	Receptors	1st 24 Hour Average Incremental Concentration (µg/m³)	Baseline Concentration (µg/m³)	1st 24Hour-Resultant Concentration (µg/m³)	NAAQ Standards (µg/m³)- 1st 24 Hour
AQ1	Attipattu	3.02	38	41.02	60
AQ2	Kattupalli	3.58	27	30.58	
AQ3	Kalanji	2.92	30	32.92	
AQ4	Karungalikuppam	2.67	27	29.67	
AQ5	Neidavayal	4.33	33	37.33	
AQ6	Uranambedu	4.04	33	37.04	
AQ7	Kattur	3.60	40	43.60	

Table 4-26: 1st 24-hour Average Incremental and Resultant Concentration of SO_2

Location No.	Receptors	1st 24 Hour Average Incremental Concentration (µg/m³)	Baseline Concentration (µg/m³)	1st 24Hour-Resultant Concentration (µg/m³)	NAAQ Standards (µg/m³)- 1st 24 Hour
AQ1	Attipattu	6.38	9	15.38	80
AQ2	Kattupalli	2.44	6.8	9.24	
AQ3	Kalanji	3.68	6	9.68	
AQ4	Karungalikuppam	4.29	6.8	11.09	
AQ5	Neidavayal	1.29	7.3	8.59	
AQ6	Uranambedu	3.60	7.3	10.90	
AQ7	Kattur	3.94	6.1	10.04	

Table 4-27: 1st 24-hour Average Incremental and Resultant Concentration of NO_2

Location No.	Receptors	1st 24 Hour Average Incremental Concentration (µg/m³)	Baseline Concentration (µg/m³)	1st 24Hour-Resultant Concentration (µg/m³)	NAAQ Standards (µg/m³)- 1st 24 Hour
AQ1	Attipattu	21.89	17.9	39.79	80
AQ2	Kattupalli	5.56	14.6	20.16	
AQ3	Kalanji	7.82	15	22.82	
AQ4	Karungalikuppam	10.04	15.2	25.24	
AQ5	Neidavayal	6.93	15.1	22.03	
AQ6	Uranambedu	9.69	16.4	26.09	
AQ7	Kattur	8.25	17.2	25.45	

Table 4-28: Annual Average Incremental concentrations of PM_{10}, $PM_{2.5}$, SO_2, and NO_2

Location No.	Receptors	Annual Average incremental concentrations				NAAQ Standards (µg/m³)- Annual concentrations			
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	PM_{10}	$PM_{2.5}$	SO_2	NO_2
AQ1	Attipattu	0.57	0.22	0.30	3.14	60	40	50	40
AQ2	Kattupalli	2.05	0.78	0.68	1.63				
AQ3	Kalanji	1.92	0.72	0.40	0.99				
AQ4	Karungalikuppam	0.95	0.36	0.48	1.40				
AQ5	Neidavayal	1.34	0.52	0.14	1.50				

Location No.	Receptors	Annual Average incremental concentrations				NAAQ Standards (µg/m³)- Annual concentrations			
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	PM_{10}	$PM_{2.5}$	SO_2	NO_2
AQ6	Uranambedu	0.98	0.38	0.19	1.43				
AQ7	Kattur	1.54	0.60	0.27	1.59				

4.6.2.5 Isopleths

The Isopleths for 1st incremental 24-hour Average Concentration of all the parameters are shown in **Figure 4-59** to **Figure 4-62**.

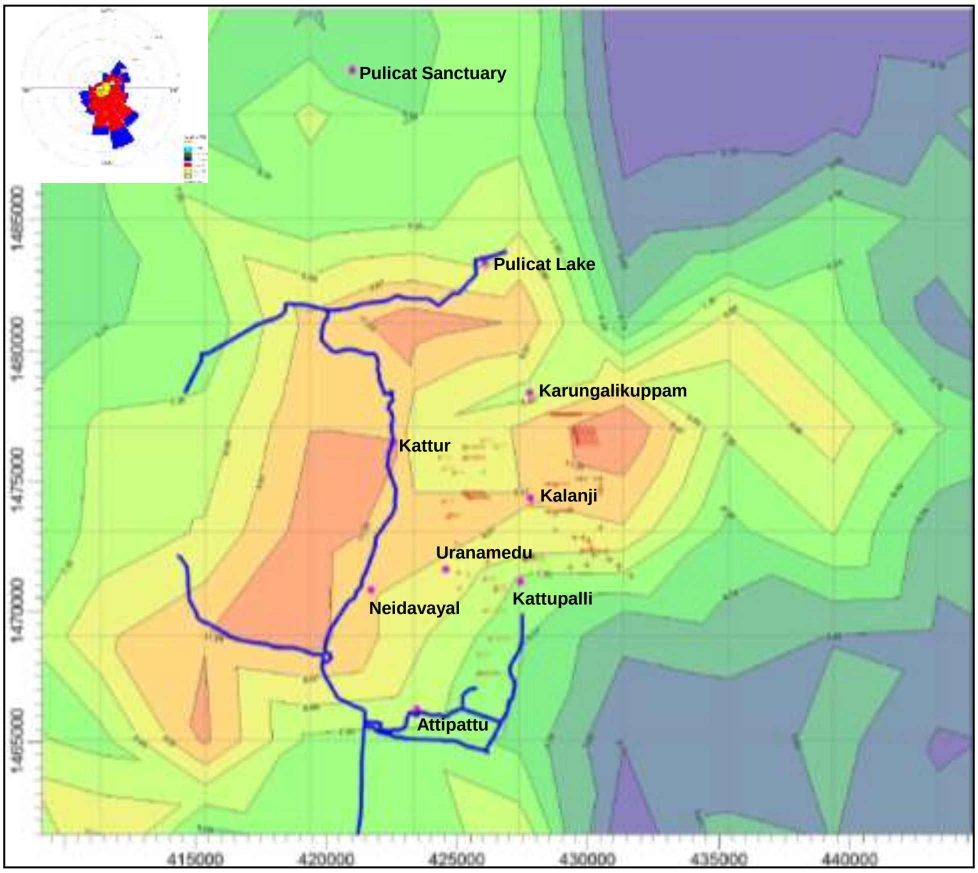


Figure 4-59: Isopleth for 1st 24-Hr Average Incremental Concentration of PM_{10}

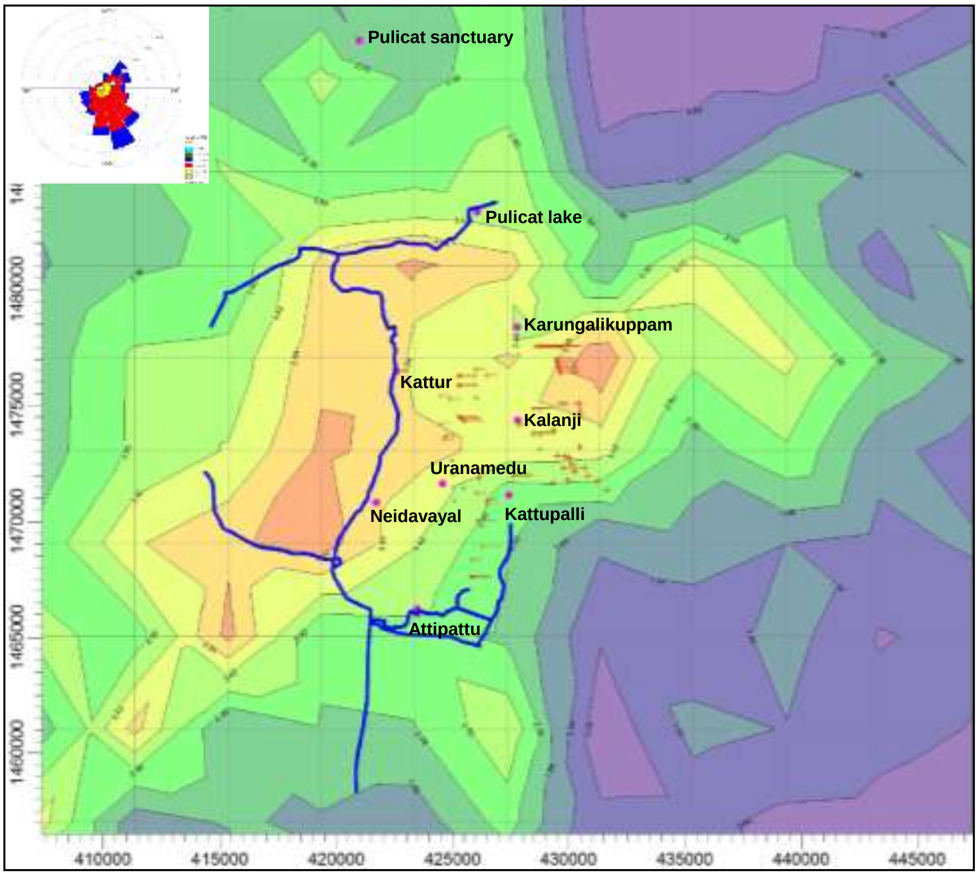


Figure 4-60: Isopleth for 1st 24-Hr Average Incremental Concentration of $PM_{2.5}$

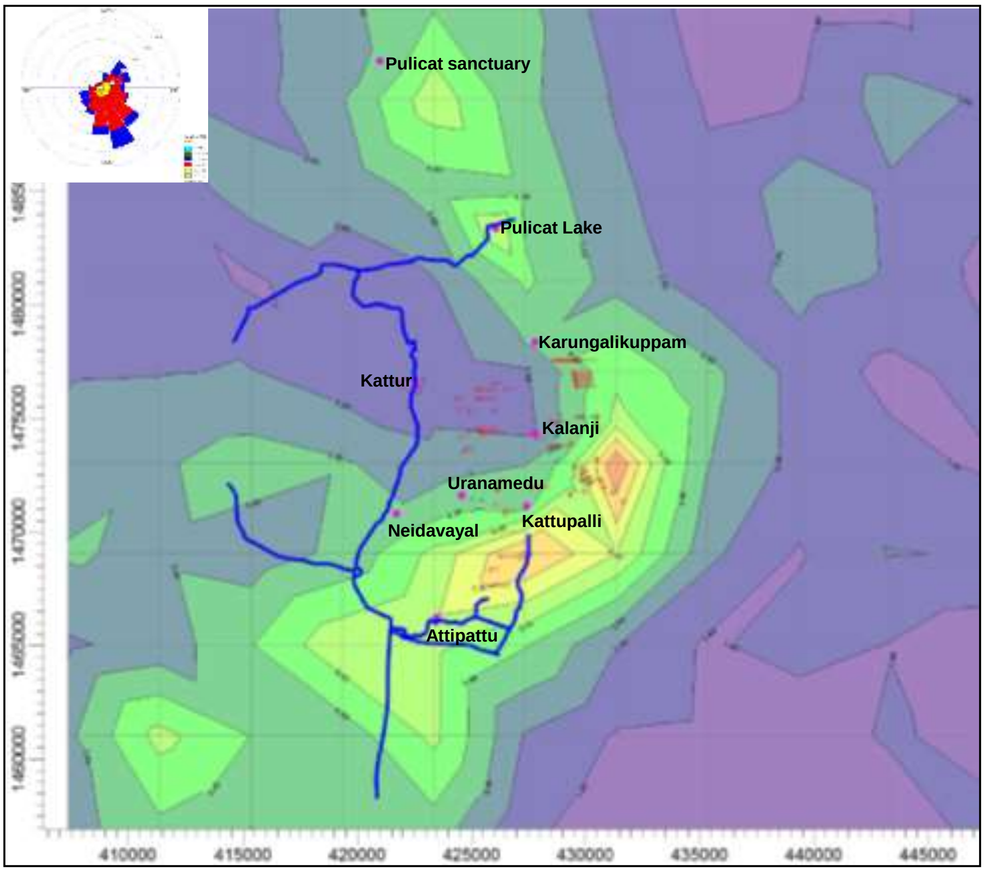


Figure 4-61: Isopleth for 1st 24-Hr Average Incremental Concentration of SO_2

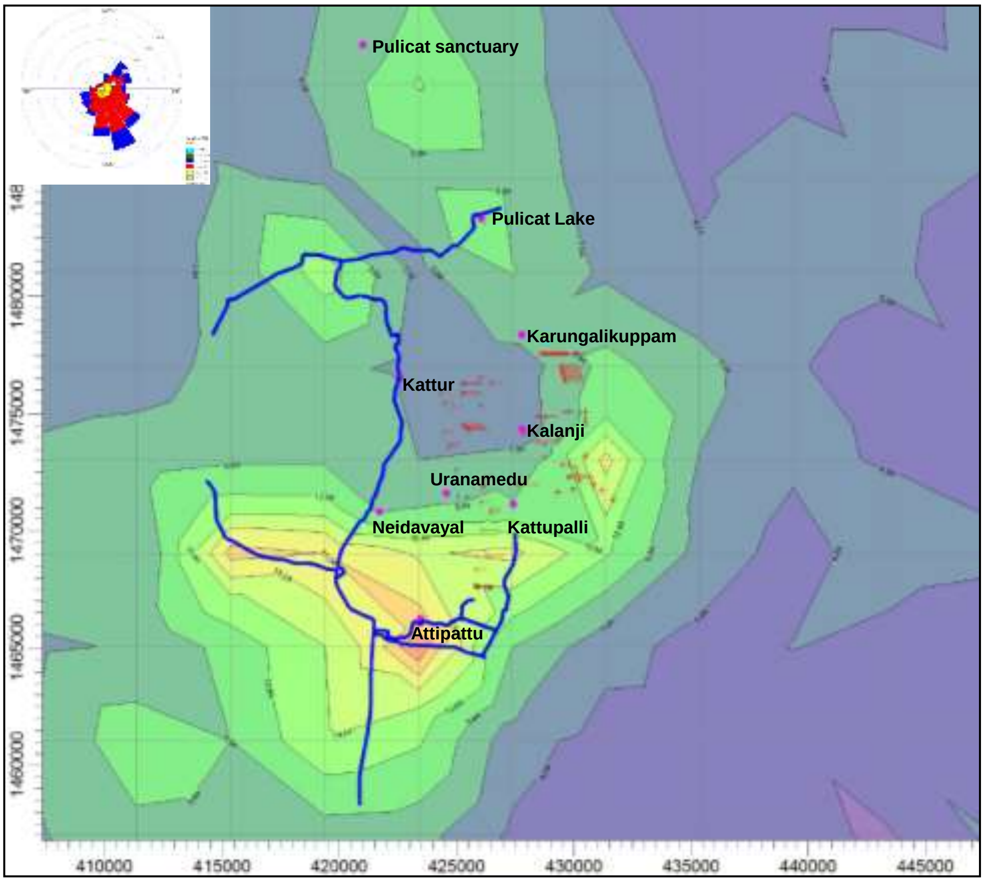


Figure 4-62: Isopleth for 1st 24-Hr Average Incremental Concentration of NO_2

4.6.2.6 Observations at Receptors

The 1st highest 24 Hour average and annual average resultant concentrations of PM_{10}, $PM_{2.5}$ SO_2 and NO_2 for AAQ monitoring receptors locations are found to be within the National Ambient Air Quality Standards (NAAQS), 2009.

Based on the results, additional measures such as, wind screen/wind shield shall be provided along the periphery of stockyard. However, Wind screens will be provided along stack yard. Particulate Emissions from the dry bulk stockyard will also be minimised by providing greenbelt around the stockyard and boundary wall apart from dust suppression by water sprinklers.

4.6.2.7 Mitigation Measures

- Ambient air quality monitoring will be carried out regularly at selected locations in the predicted maximum impact zone in order to check and compare the predicted concentrations with the measured concentrations.
- Water sprinkling will be carried out on road surfaces in the project area.
- Greenbelt of adequate width will be developed around the cargo storage areas in particular and along the boundary of project area to minimize the likely impacts due to air pollution.
- The open stockpile of the other Project/ Break cargo if any shall be covered with Tarpaulin sheets
- The Annex VI of MARPOL Convention deals with the “Regulations for the Prevention of Air Pollution from Ships”. It sets limits on NO_2 and SO_x emissions from ship exhausts,

and prohibits deliberate emissions of ozone depleting substances. It also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs). The vessels are required to comply with the regulations and should have the "International Air Pollution Prevention Certificate". The project proponent will take all appropriate measures to comply exhaust emission from vessels in accordance with MARPOL regulations and Euro Emission standard norms so as to reduce pollution load in the air environment.

- Mechanized loading/ unloading system from the loading/unloading area to the stocking yards and in to the vehicles is proposed
- All trucks before leaving the storage yard will be showered with water with adequate system as shown in **Exhibit 4-4**, will be covered with tarpaulin or any other effective measure/device completely and also that trucks are not over loaded as well as there is no spillage during transportation
- Wagons will be covered with tarpaulin before leaving the coal terminal yard as shown in **Exhibit 4-5**.
- Vehicle carrying the bulk cargo should not be overloaded by raising the height of carriage
- Plantation/Greenbelt shall be considered all along the periphery of the dusty cargo handling premises.
- Atomized water sprinkling shall be carried out on the top of the heap at regular intervals to prevent dusting, fire & smoke
- Regular sweeping of bulk cargo dust from internal and main road and also ensure that there is adequate space for free movement of vehicles
- All the engineering control measures and state of art technology including covered conveyer belts & transfer points, mechanized loading and unloading, provision of silo etc. will be provided for curbing the pollution
- Adequate firefighting measure to avoid any fire or related hazards including adequate water storage facility, and the premises shall be exclusively used for storage of the coal.
- Dust suppression measures (such as at Ship unloader discharging in to hoppers, Stockyards, Discharge and feeding points of conveyors, Rapid loading system etc.) shall be implemented.

Exhibit 4-4: Automatic Tyre Wash System

Exhibit 4-5: Covered Coal Wagons

4.7 Noise & Vibration

4.7.1 Potential Impact during Construction

4.7.1.1 Due to Port Construction Activities

Construction activities increase ambient noise levels. There would be impact on noise levels due to the following:

- Vehicles transporting construction material
- Diesel run engines of construction machinery and dredgers
- Pile driving activities during construction of cargo berths.

Noise is an inherent part of construction activity and response of species / communities would be either attracted or diverted away from the region. Noise generated from diesel engines of dredgers, workboats, etc. could result in movement of mobile faunal species away from area of operation.

There would be a degree of avoidance behaviour (flight) exhibited by marine species initially and they would eventually be expected to return once they become accustomed to increased noise levels or once the noise source has moved or ceased. Noise generating sources are mobile and the impact will be short-term in nature.

Noise generated from construction activities will be predominantly confined within port site and will impact construction workers at site. Impacts due to these activities would be short-term in nature and localised.

4.7.1.2 Mitigation Measures

The following mitigation measures will be followed to minimise the noise generation and the associated impacts.

- During construction, noise levels will be maintained below threshold levels stipulated by Central Pollution Control Board (CPCB) by selecting appropriate equipment, machinery and using enclosures. Procurement of machinery/construction equipment will be done in accordance with specifications conforming to source noise levels less than 75 dB (A).

- Only well-maintained construction equipment, which meets the regulatory standards for source noise levels, will be used. Any equipment emitting high noise, wherever possible, will be oriented so that the noise is directed away from sensitive receptors.
- Noise attenuation will be practised for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers. The attenuation devices will be properly maintained throughout the construction period.
- High noise generating activities such as piling and drilling will be scheduled to minimise noise impacts.
- Personnel exposed to noise levels beyond threshold limits will be provided with protective gear like earplugs, muffs, etc. especially construction personnel involved in pile driving operations. Rotation of personnel will also be adopted.
- Periodic maintenance of the equipment to be used in the developmental works will be carried out. Worn out parts will be replaced and rotating parts will be lubricated to minimise noise emissions.
- Ambient noise levels will be monitored at regular intervals during construction phase of the project.
- All haul roads (for truck transport and other vehicles) within the boundary and outside will be maintained properly to avoid excessive noise levels from Engine acceleration and deceleration.

4.7.1.3 Impact due to vibration

During the construction activities, vibrations may be envisaged. The vibrations could be result of activities like excavation, piling, blasting (if required), movement of heavy equipment, etc. mitigation measures will be followed as appropriate during the construction phase.

4.7.2 Potential Impact due to Port Operation

During the operational phase, noise will be generated due to the operation of the generators, pumps, engines of boats and ships, cranes for handling of goods, cargo and shipment vehicles. Noise will also be generated considerably from the warehouse, repair and maintenance block, service area, goods loading and unloading point. Activities like container handling, container storage, periodic dredging, vehicle movement on internal road etc. will also contribute in increase in ambient noise levels.

The container terminal is characterized by the presence of many noise sources operating continuously. The more common noise sources are cranes, gantry cranes, gate cranes, reach-stackers, and terminal tractors.

A noise source common to all ports is the induced terrestrial traffic constituted by transportation vehicles like trains and heavy and light-weight vehicles entering or exiting the port area. Because of the intrinsic characteristics of these sources, their impact can be perceived even far away from the port area and is difficult to identify without a specific study.

4.7.2.1 Noise modelling Study

For Noise modelling study, it is considered that the port is active during day hours more when compared with the night time. The maximum equivalent noise levels are considered as 70 dBA for day and 65 dBA for night time. These noise levels are evolved from different case studies already conducted by different port authorities. The traffic noise emission is modelled using RLS90 traffic noise model. The traffic volume count is used for the calculation purpose.

Fundamental data sets such as geographical, topographical and meteorological data, building information and population, traffic network, traffic volume and vehicle speed, and composition of types of vehicle were assumed and considered for the development of noise prediction model.

Day and Night scenarios were simulated to produce traffic-induced noise levels using the validated model considering traffic flow measures such as types of vehicles, vehicle speeds, types of road surface, redirecting portion of heavy vehicles to alternative routes and noise barrier usage.

The traffic noise emission during day time and night time is calculated at 10 traffic survey locations.

The L_d is calculated for the time period: 7.00 - 22.00 Hrs and L_n is calculated for 22.00 to 7.00 Hrs.

where,

L_d = daytime equivalent sound level (dBA)

L_n = nighttime equivalent sound level (dBA).

Figure 4-63 and **Figure 4-64** shows the isopleths representing the noise propagation during day time (7-22 hrs) and night-time (22 to 7 hrs) respectively due to road traffic.

Figure 4-65 and **Figure 4-66** shows the isopleths representing the noise propagation during day and night time respectively due to port activities.

Figure 4-67 and **Figure 4-68** shows the combined noise levels from road traffic and port area activities for day and night time respectively.

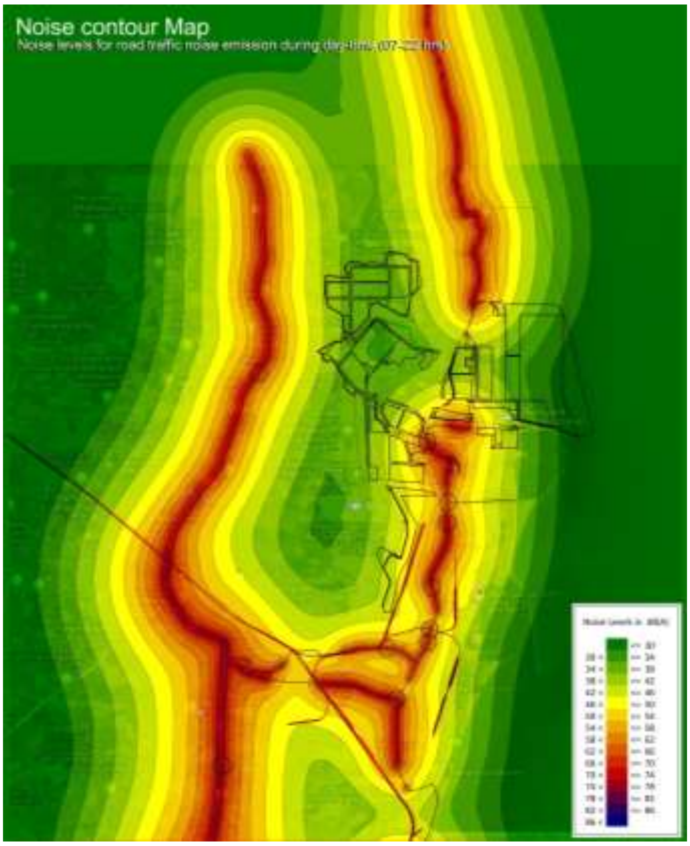


Figure 4-63: Isopleth showing noise levels (dBA) induced from road traffic during Day time

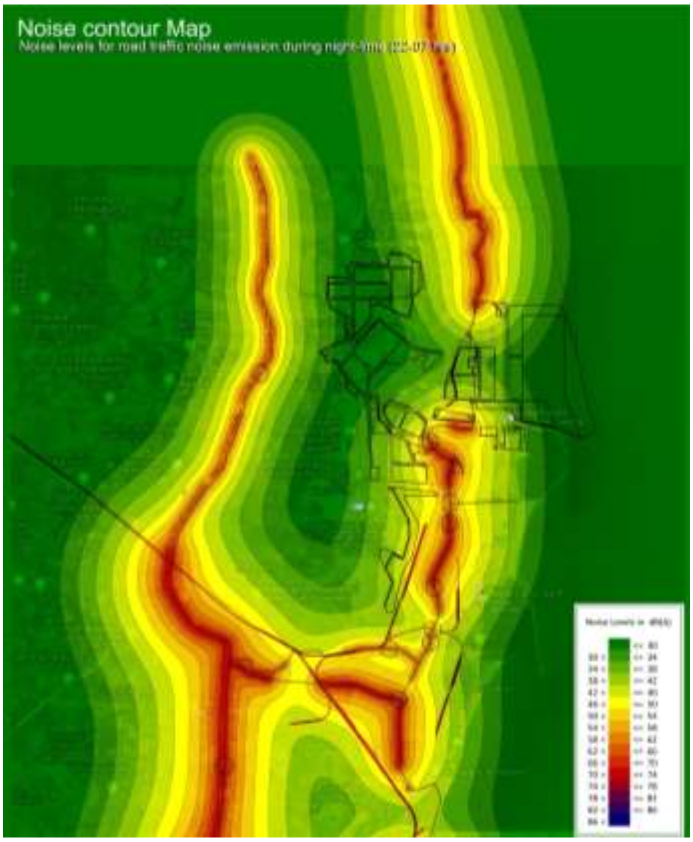


Figure 4-64: Isopleth showing noise levels (dBA) induced from road traffic during night time

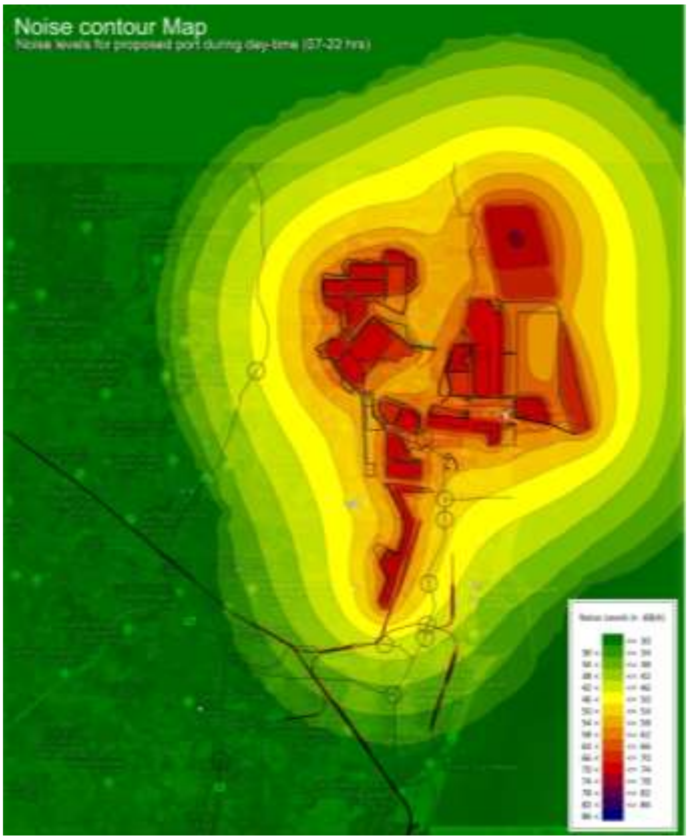


Figure 4-65: Isopleth showing noise levels (dBA) induced from port activities during Day time

Figure 4-66: Isopleth showing noise levels (dBA) induced from port activities during night time

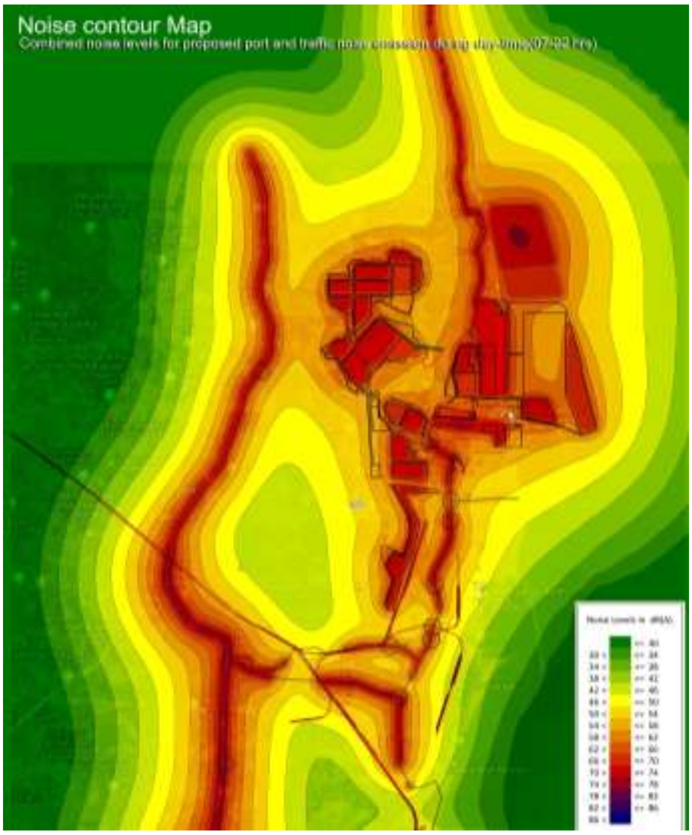


Figure 4-67: Isopleth showing noise levels (dBA) induced by combined sources during Day time

Figure 4-68: Isopleth showing noise levels (dBA) induced by combined sources during night time

4.7.2.2 Mitigation Measures

- The occupational noise exposure to the workers in the form of 8 hourly time weighted average will be maintained within the prescribed OSHA standard limits.
- Noise attenuation will be practised for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers. The attenuation devices will be properly maintained.
- Workers exposed to excessive noise will use appropriate Personal Protecting Equipment (PPE) including ear plugs, muffs, or both when engineering or administrative controls are not feasible to reduce exposure.
- Rotation of personnel will be adopted to minimize the exposure to high noise levels.
- Periodic maintenance of the equipment to be used will be carried out. Worn out parts will be replaced and rotating parts will be lubricated to minimise noise emissions.
- Ambient noise levels will be monitored at regular intervals during operation phase of the project.
- Greenbelt will attenuate the increase in noise levels at landside facility.
- To ensure that all the transportation vehicles construction machinery will be periodically checked for minimal noise generation to comply OHSAS and ambient noise standards in the surrounding area.
- Labelling equipment at a prominent location to indicate the approximate level of noise it generates in operation will also be done. Where the reading is less than 85 dB, then the equipment should be labelled using the green coloured label with no specific noise exposure precautions required for usage of less than 8 hours. Where the reading is equal to or greater than 85 dB, then the equipment should be labelled using the red coloured

label and the operator should wear hearing protectors. In addition, those persons working within 5 m of the equipment should also wear hearing protectors or take other appropriate control measures to protect against noise. Suggested formats for these labels are shown in the **Figure 4-69**.

Figure 4-69: Format of Noise labels

4.7.2.3 Impact due to Vibration

Vibrations are expected to be generated by various activities associated with the proposed project operations. Heavy machinery and equipment such as cranes, pumps, conveyor belt, unloaders/loaders etc., are likely to generate vibrations during operational phase and may cause exposures to the workers/operators in those areas. The impact of vibrations beyond the site would be negligible during normal operation phase. However, the impacts on workers engaged in the operational areas would be considerable due to occupational exposure. The impacts shall be minimized with appropriate mitigation measures.

4.7.2.4 Mitigation Measures

- Machines, equipment and vehicles must have criteria to control noise and vibration
- The machine and equipment likely to generate vibration shall be fixed based on the detail designing of foundation.
- The machinery equipped with latest vibration-reduction technology shall be used which will help minimise the vibrations.
- The vibration dampers shall be provided around the source of generation.

4.8 Solid Waste Management

4.8.1 Potential Impact due to Port Construction

Solid waste is likely to be generated during the construction phase of the development. Improper solid waste disposal may also lead to skin diseases. Moreover solid waste will attract vermins, rats and deteriorate the general aspect of the site and its surroundings. Organic wastes generated during construction will be minimal and will comprise mainly of domestic refuse like food, fallen leaves, and branches etc. and waste by workers on site. The inorganic waste likely to be generated during construction include

- Concrete rubbles and blocks
- Cement sheets

- Wooden and metallic beams
- Paper, plastic, cartons
- Blocks, rocks, boulders
- Broken tiles, glass debris
- Metal debris, cans and tins
- Wood, straw and timber remains

Poor construction procedures generate excessive wastes increasing the construction costs and results in disposal of otherwise valuable resources. The solid waste generated during construction phase may impact soil quality, water quality and public health if not regulated properly. Improper solid waste disposal may also lead to skin diseases. Moreover solid waste will attract vermins, rats and deteriorate the general aspect of the site and its surroundings. Appropriate measures need to be taken for adequate disposal of solid wastes generated during construction phase of the project.

4.8.1.1 Mitigation Measures /Solid Waste Management

The various types of solid wastes generated during the construction phase will be segregated into two main categories, viz., non-hazardous and hazardous. All non-hazardous waste will be covered under solid waste management.

- Dredged material will be used for reclamation and any excess/unused dredge material will be disposed at an offshore dumping site
- Construction waste will be used within port site for filling of low lying areas. Other wastes which can be re-cycled will be sold.
- General refuse generated on-site will be collected in waste skips and separated from construction waste.
- A local authorised waste recycler will be employed to remove general refuse from the site, separately from construction waste and hazardous wastes, on regular basis to minimise odour, pest and litter impacts.
- The burning of refuse at construction sites will be prohibited.

4.8.1.2 Hazardous Materials Management

- Hazardous materials such as lubricants, paints, compressed/liquefied gases (LNG/LPG), and varnishes etc., will be stored as per the prescribed/approved safety norms.
- The construction site will be secured by fencing with controlled/limited entry points.
- Hazardous wastes will be disposed at nearest Treatment, Storage and Disposal Facility (TSDF) through approved TNPCB vendors. Hazardous materials will be stored as per prescribed safety norms in locations with restricted entry and with fire-fighting facilities.
- Medical facilities including first aid will be available for attending to injured workers Occupational Health Construction Equipment and waste.

The solid waste generated during the construction phase of the revised master development will be managed as per the latest regulations such as Solid Waste Management (SWM) Rules, 2016; Construction and Demolition (C&D) Waste Management Rules, 2016, Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016 (as amended) etc.

4.8.2 Potential Impact during Operation

Waste generated from cargo operations such as remains of bulk cargo storage, rubbish from unpacking, treatment plant wastes and canteen wastes from daily activities. The quantity of municipal solid waste generated from canteen and administrative areas is estimated at about 0.750 TPD for Revised Master Plan development, of which 60% will be bio-degradable and 40% non-biodegradable. These wastes will generate odour and health impacts if not managed properly.

4.8.2.1 Mitigation Measures

- 5 R (Reduce /Reuse/Recover/Recycle and Re Process) principles shall be explored.
- Proper collection and disposal of solid waste from office establishment and town ship based on the Central Public Health and Environmental Engineering Organization (CPHEEO) manual on “Municipal Solid Waste Management, 2014.
- The solid waste from the utilities like canteen shall be segregated as biodegradable and non-biodegradable waste and collected separately by providing bins at respective places.
- The collected biodegradable waste shall be subjected to composting and the compost will be used as manure for the development of green belt within the port.
- The non-biodegradable waste like plastic shall be handed over to approved vendors of TNPCB or can be handed over to authorized cement industry for co processing.
- Used oil/Spent oil & Used Battery, Containers/Barrels/liners Contaminated with HW/Chemicals and Sludge from oil water separator will be collected and disposed to TNPCB/CPCB approved vendors or nearest TSDF/CHWIF.
- Hazardous wastes will be handled as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016. Hazardous wastes will be disposed through approved TNPCB vendors.

4.9 Socio-Cultural Impact

4.9.1 Potential Impact due to Port Location

4.9.1.1 Relocation of Local People

The revised master plan of Kattupalli Port will be developed in an area of about 2472.85 ha which is majorly reclaimed land and balance is vacant government land. Careful site selection for the proposed project ensured that the land is uninhabited. Hence, there will be no direct Project Affected People (PAPs)/Project Affected Families (PAFs) due to the proposed project development and no Resettlement and Rehabilitation (R&R) is envisaged.

Hence, no rehabilitation and resettlement (R&R) is envisaged and this impact is completely avoided.

4.9.1.2 Fishing Activities

The construction of cargo berths, approach trestle and activity of capital dredging, etc. are likely to impact the fishing activity near port. Fishermen in the study area operate motorised and non- motorised fishing boats. Fishermen with motorised boats generally go up to 10 km in the sea for fishing.

The approach channel of the port is oriented from south to south east whereas fishing boats travels from south to east and north. Fishing is being carried out at deep sea. At present, fishermen are well aware about the vessel movement’s route at Kattupalli Port.

Safe navigation routes will be earmarked for movement of fishing vessels and the route will be finalised in consultation with fish landing authorities and fishing communities. However, necessary sign boards and marker buoys shall be installed and interactions shall be initiated with the fishing community about the marker buoys indicating the areas of operation so that they may avoid those areas during construction period. Storm water drainage network is planned to facilitate the proper drainage pattern of the area and the requirements of local villagers for tide water and boat movement has been duly considered in the drainage plan. All Appropriate measures will be taken to minimize the hindrance to fishing activity during construction & operation phase. .

4.9.1.3 Enhancement of Local Economy

It is anticipated that the proposed development will generate and support diverse economic development during its construction and operation. Economic benefits, direct and secondary, will include job creation and increased business spending throughout the construction and operation phases. Secondary economic impacts will be created through the provision of goods and services to the port and the subsequent increase in employment and business activity necessary to produce these goods and services.

Port activities may result in the hiring of local labour and procurement of various commodities from a local market. The local economy will be boosted by port-related activities and be greatly involved in urbanization and industrialization

4.9.2 Potential Impact during Port Operation

4.9.2.1 Impacts due to Inland Cargo Movement

Proposed project will handle different types of cargo which will be transhipped majorly through rail and remaining by road to the respective destinations. Traffic predictions show that additional traffic loads due to operations as well as on road users due to revised master plan. Hence the existing and proposed road connectivity will be able to handle the cargo movement and not envisaged to create adverse impacts and congestion to existing public infrastructure.

4.9.2.2 Impact due to Vessel Movement

The vessels visiting the Port may discharge the wastewater, oily wastes and bilge water which can impact the nearby beaches, if not properly controlled. Ship traffic may disturb fishing activities like fishing nets getting entangled with the moving vessels in outer harbour areas which may cause financial losses to fishing communities. The possibility of accidents in the ship traffic may affect local people.

4.9.2.3 Mitigation Measures

- The waste reception facilities shall be developed as per the Guidelines issued by Government of India (GoI).
- The bilge water will be collected by authorized waste recycler and taken for further treatment.
- Hold washing will not be permitted in the port limit and port will ensure the ships to follow MARPOL convention to prevent the discharges into harbour areas.
- In case of accidental spill, contingency plan will be followed.
- Safe navigation routes will be earmarked for movement of fishing vessels and the route will be finalised in consultation of fishing harbour authorities and fishing communities.

4.9.2.4 Navigation Aspects and Impact due to Approach Channel

The bathymetry data reveals more variation in the cross-shore direction than the alongshore direction in coastal environment. Also, the seabed at Kattupalli Port is complex with varied slope between Ennore Creek and Pulicat Creek. The slope at the south of Ennore port is relatively steep (1 in 300) at Ennore Creek, while the slope on the north of Kattupalli port is flat (1 in 500) with submerged shoals extending in north-easterly direction. The bathymetry data reveals submerged shoals, which is a morphological feature formed along 10m water depth contour at the waterfront of proposed project site.

Navigability of the Approach Channel has been analysed and found that the channel is operable safely to accommodate the designed traffic. Other than fishing vessels in the project region, no other major vessels movement are envisaged near proposed approach channel. Regular interactions will be carried out with the fishing community on importance of channel marker buoys and other navigational aids.

4.9.2.5 Employment Potential

During operational phase, the port is likely to generate employment of 1500 people on direct basis and around 4500 people will get employment indirect basis.

4.9.2.6 Public Health and Safety

The proposed revised master plan development of Kattupalli Port is to be developed considering the latest and relevant safety guidelines, codes and manuals. Hence the risk associated with public health and safety due to the operation of the proposed project is negligible. An effective Disaster Management Plan (DMP) which includes Onsite and Offsite emergency plan for existing operation and will be suitably updated and will be followed to minimize the probability of occurrence of emergency situations and mitigate the impacts.

Chapter 5
Analysis of Alternatives

Chapter 5 Analysis of Alternatives

5.1 Site Alternatives

LTSB had approached MoEF&CC to bifurcate the existing Environmental and CRZ Clearance in the name of L&T Shipbuilding for Shipyard and MFF related activities and in the name of MIDPL for Port and common infrastructure related activities. Environmental and CRZ Clearance bifurcation completed on mutually acceptable division of responsibilities between LTSB & MIDPL and bifurcated EC was granted to MIDPL vide letter no. F. No.10-130/2007-IA.III dated February 9, 2018. The ownership of Kattupalli port has been transferred from LTSB to MIDPL with effect from 28th June, 2018. MIDPL obtained CRZ Clearance for development of rail corridor at Kattupalli Port through vide letter no. F. No.11-22/2019-IA.III dated December 02, 2019.

Current proposal is for expansion/development of Kattupalli port master plan. Since the Kattupalli port is operational, no other site selection criterion has been considered for Revised Master Plan development and study of site alternatives has least significance as the proposal is for expansion of the existing port.

LTSB Shipyard and Kamarajar Port are located on south side and therefore there is no much scope for expansion in southern part of the existing port. Port expansion is being proposed mostly towards North, east and west ward directions.

5.2 Layout Analysis

Different layout options were considered through modelling studies with a view to optimise the port design with minimum coastal/environment/social impact and considering other suitable operational conditions

The proposed expansion area is also selected on the basis of pre dominant wind direction. Present proposal is away from existing habitation areas and ~2.1 km from the declared Pulicat Bird Sanctuary. As per the Minutes of 34th ESZ Expert Committee Meeting for the declaration of Eco Sensitive Zone (ESZ) around Wildlife Sanctuaries/National Park held on 06th March 2019, in the MoEF&CC Tamilnadu government has decided not to propose any eco sensitive zone for Pulicat Birds Sanctuary.

Majority of areas under proposed expansion will be developed through reclamation of sea in order to avert Resettlement and Rehabilitation (R&R). Further, government and private land, as proposed are free from human settlements.

Revised Master Plan was finalised and considered to be the best, inline to positive impact on the coastal environment, with minimal sediment infiltration in the port, thus reducing the impacts associated with maintenance dredging and its disposal and also providing best suitable conditions for port operation, improving tranquil conditions in the port area.

Chapter 6
Environmental Monitoring Programme

Chapter 6 Environmental Monitoring Programme

In this chapter, Environmental Monitoring Programme for the proposed Revised Master Plan of Kattupalli port is discussed. Environmental Monitoring Programme is an important component during environmental management of the project. The institutional mechanism to implement the planned mitigation and monitoring measures during all stages of the project is discussed in **Table 9-1**. The project management especially the Environmental Management Cell (EMC) (described in **Section 9.2**) should always go for a rational approach with regards to environmental monitoring. This includes judicious decision making in consultation with institutional stakeholders such as Tamil Nadu Pollution Control Board (TNPCB) or reputed environmental consultants for appropriate changes in the monitoring strategy, i.e., changes in the sampling frequency, sampling location, monitoring parameters and any new/additional requirements.

Following are the main objectives of the environmental monitoring program:

- Provides information for documentation of monitoring of mitigation measures and impacts
- To act as a tool for the statutory authorities for unanticipated adverse impacts or sudden changes in the environmental condition due to the proposed project
- Provides information that could be used for evaluating the effectiveness of implemented mitigation measures
- Provides information that could be used to verify predicted impacts and thus validate impact prediction techniques
- Effectiveness of the mitigation measures being followed during construction and operational phases can be assessed and the measures can be revised, made more stringent and reinforced based on the monitoring results
- Provides guidance to comply with relevant environmental rules/regulations
- Environmental Monitoring can also serve a basic component of a periodic environmental regulatory auditing program for the proposed project
- Serves as a tool to monitor and modify the mitigation measures and implementation arrangements, if any.

The Environmental Monitoring Programme for construction as well as operation phases shall be implemented by project proponent. Besides the monitoring, compliances to all Environmental Clearance and CRZ conditions and permits from TNPCB/MoEF&CC/TNSCZMA shall be monitored and reported periodically. The likely significant impacts and mitigation measures addressed in **Chapter 4** will also be monitored through structured EMP in **Table 6-1**.

Since it is existing port, the environmental monitoring is being carried out as a part of compliance and the latest compliance report are submitted to regional office of MoEF&CC is given as **Appendix E** (half yearly compliance report - April to September 2020). Hence construction phase and operation phase monitoring plan is prepared considering RMP development integrating existing/approved monitoring activities currently being carried out. The environmental parameters to be monitored during construction and operational phases of RMP of the project, sampling locations and frequency of monitoring, applicable standards, etc. are presented in **Table 6-1**.

6.1 Environmental Monitoring Programme

Table 6-1: Environmental Monitoring Programme for Construction and Operation Phase

S. No.	Environmental Attributes	Parameters to be Monitored	No. of Sampling Locations	Frequency of Monitoring	Standards Methods for Sampling & Analysis	Compliance
Construction Phase						
1	Air Quality	As per NAAQS, CPCB 2009.	Six (06) • Kattupalli • Kalanji • Urnambedu • Kattur • At Gate Complex of Kattupalli Port • At marine terminal of Kattupalli Port	Weekly twice as per Standard	As per standard methods of measurement as suggested in NAAQS (2009).	National Ambient Air Quality Standards, November, 2009 given as **Appendix G.**
2	Noise Levels	Day and night noise levels	Six (06) • Kattupalli • Kalanji • Urnambedu • Kattur • At Gate Complex of Kattupalli Port • At marine terminal of Kattupalli Port	Once in a month	Portable hand-held noise level meter.	National Ambient Noise Standards given as **Appendix H.** Noise Limit for Generator Sets is given as **Appendix I.**
3	Water Quality	Physical, Chemical and Biological	Groundwater (Three - 03) • Kattupalli • Kalanji • Urnambedu Surface water (Twenty three - 23) • Pulicat Lake - 4 Locations • Kosasthalaiyar River – 7 Locations • Buckingham Canal - 4 Locations	Once in a month	sampling and analysis by using standard methods.	IS10500:2012 drinking water standards which is given as **Appendix J.** ISI-IS2296-1982 standards for use based classification of surface water given as **Appendix K.**

S. No.	Environmental Attributes	Parameters to be Monitored	No. of Sampling Locations	Frequency of Monitoring	Standards Methods for Sampling & Analysis	Compliance
			• Ennor creek – 3 locations • Mangrove area near the Proposed site – 5 locations			
4	Soil	Soil texture, type, electrical conductivity, pH, infiltration, porosity, etc.,	Four (04) • Kattupalli • Kalanji • Urnambedu • Inside port area	Once in a year	Collection and analysis of samples as per IS 2720.	Baseline Soil Quality data as provided in **Chapter 4**.
5	Meteorology	Wind speed, wind direction, rainfall, temperature, humidity.	Existing Meteorological station at Kattupalli port	Hourly measurement during construction	IMD/CPCB guidance manual.	-
6	Marine Water Quality/ Plankton and Benthic Communities/ Sediment Quality	Physical, Chemical and Biological/ Phytoplankton, Zooplankton and Benthic Communities	Marine Water, Sediment Quality and Biological assessment 23 locations	Once in Month	Water sampler (using NISKIN Sampler) and analysis by using standard methods. Plankton net of diameter of 0.35 m, No.25 mesh size 63 μ and analysis by using standard methods. Grab Sampling and analysis by using standard methods.	Primary water quality standards for coastal water (SW–IV) for harbour water given as **Appendix L.** Baseline marine Plankton and Benthic Community data as given in this EIA Report.
7	Fish Population Monitoring	Diversity and Abundance	Six (06) locations around the project area (proposed berth and reclaimed area)	Quarterly Once	sample survey, data collection from nearby fish landing centres	-
8	Rapid underwater biodiversity Assessment	Diversity and Abundance	Marine Zone (in line with baseline data)	Once in two years	Transect line methods by SCUBA diving, standards survey methods and include underwater photography	-
9	Stack Monitoring	PM, SO_2, NO_2 , NMHC (as C) and CO and CO	DG sets	Once in a month	Standard Stack emission monitoring and analysis methods.	Emission limits for new diesel engine more than 800 kW for generator set **Appendix M.**
10	Drinking Water Supply	Physical, Chemical and Biological	Four (04) locations Drinking Water supply Source within Project Site And at Construction Camp.	Once in a month	Grab Sampling and Analysis.	IS10500:2012 drinking water standards which is given as **Appendix J.**

S. No.	Environmental Attributes	Parameters to be Monitored	No. of Sampling Locations	Frequency of Monitoring	Standards Methods for Sampling & Analysis	Compliance
11	Groundwater level	GW level monitoring	Three (03) • Kattupalli • Kalanji • Urnamedu	Once a quarter	Water level monitoring	
12	Mangrove Area Monitoring	Species composition and vegetation structure; Density, height, growth and canopy; Associated fauna and flora. Numbers, species composition, size and structure of fish populations; Avifauna (Diversity and abundance) etc	Mangrove area near the Proposed site – 5 locations	Half Yearly	Standard Method	
Operation Phase						
1	Air Quality	All Twelve (12) parameters as per NAAQS, CPCB 2009. PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, O_3, Pb, NH_3,C_6H_6, BaP, As and Ni, VOCs	Six (06) • Kattupalli • Kalanji • Urnambedu • Kattur • At Gate Complex of Kattupalli Port • At marine terminal of Kattupalli Port	Weekly twice as per Standard	Fine Particulate Samplers, Respirable Dust Sampler fitted with Gaseous sampling arrangements, CO analyser / portable CO meter, etc., and methods of measurements as suggested in NAAQS (2009). As per the CPCB Manual (Volume-I): Guidelines for the Measurement of Ambient Air Pollutants.	National Ambient Air Quality Standards, November, 2009 given as **Appendix G.**
2	Noise Levels	Day and night noise levels	Six (06) • Kattupalli • Kalanji • Urnambedu • Kattur • At Gate Complex of Kattupalli Port • At marine terminal of Kattupalli Port	Once in a month	Portable hand-held noise level meter.	National Ambient Noise Standards given as **Appendix H.** Noise Limit for Generator Sets is given as **Appendix I.**
3	Water Quality	Physical, Chemical and Biological	Groundwater (Three - 03) • Kattupalli • Kalanji • Urnambedu	Once in a month	Grab sampling and analysis by using standard methods.	IS10500:2012 drinking water standards which is given as **Appendix J.** ISI-IS2296-1982 standards for

S. No.	Environmental Attributes	Parameters to be Monitored	No. of Sampling Locations	Frequency of Monitoring	Standards Methods for Sampling & Analysis	Compliance
			Surface water (Twenty three - 23) • Pulicat Lake - 4 Locations • Kosasthalaiyar River – 7 Locations • Buckingham Canal - 4 Locations • Ennor creek – 3 locations • Mangrove area near the Proposed site – 5 locations			use based classification of surface water given as **Appendix K.**
4	Soil	Soil texture, type, electrical conductivity, pH, infiltration, porosity, etc.,	Three (03) • Kattupalli • Kalanji • Urnambedu	Once in a year	Collection and analysis of samples as per IS 2720.	Baseline Soil Quality data as provided in **Chapter 4.**
5	Meteorology	Wind speed, wind direction, rainfall, temperature, humidity.	Existing Meteorological station at Kattupalli port	Hourly measurement	IMD/CPCB manual.	-
6	Marine Water Quality/ Plankton and Benthic Communities/ Sediment Quality	Physical, Chemical and Biological/ Phytoplankton, Zooplankton and Benthic Communities	Marine Water, Sediment Quality and Biological assessment 23 locations	Once in a month	Bottom sampler (Niskin Sampler) and analysis by using standard methods. Plankton net of diameter of 0.35 m, No.25 mesh size 63 μ and analysis by using standard methods. Grab Sampling and analysis by using standard methods.	Primary water quality standards for coastal water (SW–IV) for harbour water, given as **Appendix L.** Baseline marine Plankton and Benthic Community data as given in this EIA Report.
7	Fish Population Monitoring	Diversity and Abundance	Six (06) locations around the project area (proposed berth and reclaimed area)	Quarterly Once	Sample survey, data collection from nearby fish landing centres	-
8	Rapid underwater biodiversity Assessment	Diversity and Abundance	Marine Zone (in line with baseline data)	Once in two years	Transect line methods by SCUBA diving, standards survey methods and include underwater photography	-
9	Stack Monitoring	PM, SO_2, NO_2 , NMHC (as C) and CO and CO	DG sets	Periodic /Continuous	Standard Stack emission monitoring and analysis methods.	Emission limits for new diesel engine more than 800 kW for generator set **Appendix M.**

S. No.	Environmental Attributes	Parameters to be Monitored	No. of Sampling Locations	Frequency of Monitoring	Standards Methods for Sampling & Analysis	Compliance
10	Groundwater level	GW level monitoring	Three (03) • Kattupalli • Kalanji • Urnamedu	Quarterly once	Water level monitoring	
11	ETP/STP	Physical, Chemical and Biological Parameters	• ETP outlets • STP outlets	Once in a month	Analysis by using standard methods.	Design ETP inlet and STP standards given as **Appendix N.**
12	Mangrove Area Monitoring	Species composition and vegetation structure; Density, height, growth and canopy; Associated fauna and flora. Numbers, species composition, size and structure of fish populations; Avifauna (Diversity and abundance) etc	• Mangrove area near the Proposed site – 5 locations	Once in a Year	Standard Method	
13	Concrete structures outside the newly constructed berths	Biodiversity: Epifauna, Fish Population	• In and around concrete structures outside the newly constructed berths	Once in a Quarter	Standard Method	

6.2 Compliance Reports

As a part of environmental monitoring programme, following compliance reports shall be submitted to TNPCB and Regional Office of MoEF&CC:

- Half yearly compliance report on 1st June and 1st December of each calendar year
- Environmental statement for the financial year ending 31st March to TNPCB on or before 30th September every year
- Annual returns in Form 4 as per Hazardous and other Waste (Management and Transboundary movement) Rules, 2016 on or before 30th June
- Format for maintaining records of hazardous and other waste in Form 3 as per Hazardous and Other Waste (Management and Transboundary movement) Rules, 2016
- Safety data sheet for hazardous chemicals shall be maintained as per schedule 9 of MSIHC rules, 1989 (amended 2000)
- Format for maintaining notification of major accident in schedule 6 as per MSIHC rules, 1989 (amended 2000)
- Return in Form VIII as per Batteries (Management and Handling) Rules, 2001 and amendment thereof as per norms
- Format for maintaining records of E waste in Form 2 as per E-Waste (Management) Rules, 2016.

A MoEF&CC and NABL accredited Laboratory will be appointed by project proponent for conducting regular monitoring of air quality, noise levels, water quality, sediment quality, biological parameters, primary conductivity, chlorophyll estimation and bacterial estimation. Monitoring during construction and operation phases will be carried out by engaging authorized agencies.

6.3 Plantation Monitoring Programme

Kattupalli Port has so far made plantation of around 16.73 Ha. inside Port Complex and also developed Nursery for sapling preparation. For the revised Master Plan Greenbelt development will be in 241 Acres (~97.5 Ha) Existing Greenhouse Nursery will be suitably strengthened and upgraded for supplying the sapling to meet the greenbelt development requirement for proposed RMP of Kattupalli port.

In general Plantation Monitoring Programme will include following;

- Development of nursery
- Treatment and sowing of seeds
- Survival rate of plant
- Planting of seedlings
- Fencing of plantation area
- Weeding and soil working
- Replacement/Inter planting
- Watch and ward of plantation

During operation phase periodic monitoring of plantation growth, manuring, watering, pruning, and replacement will be performed in order to properly maintain vegetation, greenbelt and green cover.

6.4 On-site Mock Drills Requirements

On-site mock drills are very important as it helps employees to be aware of the safety procedures and how to react at the time of crisis. Conducting mock drills at regular intervals enhances preparedness and checks the viability of environmental/Disaster Management Plan (DMP). Mock drills are essential for the following reasons:

- Helps in revising/improving the environmental/disaster management plan

- Helps evaluate whether responsible officials are trained efficiently for unforeseen events
- Helps in evaluating whether adequate/appropriate emergency equipment are being maintained

To ensure efficient environmental/disaster management, project proponent shall conduct periodic on-site mock drills in case of occurrence of activities, such as:

- Fire
- Power breakdown
- Bomb threats
- War alerts/terrorist attacks
- Natural calamities (cyclones, floods, earthquakes)

Mock drills should also involve fire department, police, municipal authorities, hospitals and other department/agencies that are mandated to provide emergency support. Documenting the outcome of mock drills is an important aspect as this helps in revising the existing plan more efficiently.

Chapter 7
Additional Studies

Chapter 7 Additional Studies

7.1 Risk Analysis

Risk Assessment study was carried out to assess risks associated with the construction and operation of the Revised Master Plan of Kattupalli Port. A systematic Risk Analysis/Assessment (RA) will help in identification of the hazards and associated risk. The RA thus carried out also provides inputs for formulating the onsite Disaster Management Plan (DMP). The RA can be broadly divided into three basic steps:

- Hazard Identification
- Risk Analysis
- Discussion and Recommendations/Risk Mitigation Measures

7.1.1 Hazard Identification

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents. Potential Hazards identified in the proposed project have been broadly classified as below:

- Hazards during Construction Phase
    - Mechanical Hazards
    - Transportation Hazards
    - Physical Hazards
    - Storage and Handling of Hazardous Materials
- Hazards during Operation Phase
    - Material Hazards
    - Handling Hazards
- Hazards due to Natural Calamities
    - Earthquake
    - Tsunami
    - Cyclone
    - Flood

7.1.1.1 Hazards during Construction Phase

Potential hazards during the construction phase of the project could be due to the mechanical hazards, navigation/ transportation hazards, physical hazards and storage and handling of hazardous materials.

Mechanical Hazards: Mechanical hazards during the construction phase arise due to the moving parts in the machinery, especially the belts and bolts of the construction equipment, which are heavy and pose a threat to the work personnel. Other hazards include falling (during working at heights), falling objects like hand held tools, etc., failure of slips and traps created for scaffolding; and due to faulting of electrical equipment.

Navigation/ transportation Hazards: The planning of access/egress to the construction site also plays a significant role in minimizing the associated hazards such as vehicles/ barges collision.

Physical Hazards: The noise and vibrations generated during the construction phase may affect the worker's health, hinder effective communication and may jeopardise sensitive organs. In addition to noise and vibration, hot works also pose a considerable hazard to the workers.

Storage and handling of hazardous materials: During the construction period, storage of hazardous materials like fuel for the engines, lubricants, paints and other flammable materials is likely to pose a fire and explosion risk. Due care shall be taken in locating these materials away from the work place, free of any influence of temperature or sparks or fire. Proper wiring of the electrical appliances like lights, exhausts, etc., would be made to ensure that there are no live wires causing short circuits to ignite these materials.

7.1.1.2 Hazards during Operational phase

The following are the cargo proposed to be handled at Kattupalli port and its storage type during revised master Plan development (**Table 7-1**).

Table 7-1: Cargo to be Handled and Storage Details

S. No.	Cargo Type	Cargo Mix	Storage Type	Other Process
1.	Multipurpose (Including Liquid Cargo)	Coal / Iron ore / limestone / Mines & Minerals & other dry bulk	Open	-
		Fertilizers and raw materials for manufacture of fertilizer / food grains / sugar / clinker / cement / Project cargo / timber & wood / machines/ Iron steel products / Break Bulk etc.	Open/Covered	-
		Container	Open	-
		All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals and other Liquid cargos. PoL Such as LPG, Motor Spirit, Naphtha, High Speed Diesel, Crude Oil, Aviation Fuel, Kerosene, Low Sulphur Heavy Stock/ Furnace oil, Carbon Black Feedstock (CBFS), Paraffin, Bitumen, Lube oil, Asphalt, etc.,	Tank Farms / Bullets/ etc., and Handling & Transportation by Pipeline	-
2	Gas / Cryogenics/Liquid,	LNG, Propane, Butane, LPG, CNG, NG and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals and other Liquid cargos, List includes but not limited to the following: LNG, Ethylene, Propylene (Propene), Propane, Butadiene, Butane, LPG, Pentane, Ethyl Mercaptan, Motor Spirit, Propylene Oxide, Hexane, Naphtha Acetone, Methyl Chloride / Chloro Methane, Cyclohexane, Benzene, Ethyl Acetate, Acrylonitrile Acetonitrile, Methyl Methacrylate, Methyl acrylonitrile, Methanol (Methyl Alcohol), Isopropyl Alcohol, Ethyl Alcohol (Ethanol), Ethylene di chloride, Methyl Isobutyl Ketone, Ethyl Benzene, N-Butyl Acetate, Isobutyl Alcohol (Iso Butanol), N-Butyl Alcohol (N-Butanol), Epichlorohydrin, Styrene, O-Xylene, High Speed Diesel, Cumene, Crude Oil, Aviation Fuel, Kerosene, Acetic Acid, Acetic Anhydride, Non-edible/Mentha Oil, Low Sulphur Heavy Stock/ Furnace oil, Carbon Black Feedstock (CBFS), Aniline, Methyl Ethyl Ketone Peroxide, Ethyl Hexanol-2, Vinyl Chloride, Phenol, Naphthalene, Ethylene Glycol, Mono Ethylene Glycol, Toluene 2.4 -di isocyanate, Diphenyl	Tank Farms/Bullets/Full Containment tanks and Handling & Transportation by Pipeline	LNG/LPG Regasification

S. No.	Cargo Type	Cargo Mix	Storage Type	Other Process
		Methane Di-Isocynate, Edible oil/Palm Oil, Paraffin, Bitumen, Sulphur, Lube oil, Asphalt, Coal, CNG, NG, Ammonia (NH3), Diammonium Phosphate, Muriate of Potash (MOP), Soda Ash (Sodium Carbonate), Urea, Limestone, Caustic Soda, Sulphuric acid, Phosphoric acid, Piperine/ Piperdine, Chloroform, Hydrochloric Acid (HCL)		

Material Hazards: The above-mentioned cargo/materials will be handled at the Kattupalli Port facility as part of revised Master Plan development. The Cargoes such as Dry bulk cargo, Multipurpose & General Cargo and Container are mostly Non-Hazardous in nature except impact due to Particulate matter which was studied already as a part of Air Quality modelling.

Liquid cargo and Cryogenic Gases can be classified as hazardous Cargo based on its Characteristics such as flammability, explosiveness, toxicity or corrosiveness etc. Hence these cargoes are considered for Quantitative Risk Assessment.

The ratings for a large number of chemicals based on flammability, reactivity and toxicity are given in NFPA (National Fire Protection Association) Codes and Material Safety Data Sheets (MSDS). The properties, NFPA classification and hazards due to exposure of cargo handled are presented in **Appendix O**.

Handling Hazards: Kattupalli Port Revised Master Plan Development involves handling of various materials in the form of Solid and Liquids. The hazards related to material transport and (un)loading may be due to accidents of vehicles, breaking of (un)loading arms, failure in mechanical transmission components, etc. The handling hazards include:

- Insufficient knowledge on hazardous nature of chemical in use leading to inappropriate handling of the chemical
- Failure to use appropriate control measures and Personal Protective Equipment (PPE)
- Use of expired/worn Personal Protective Equipment (PPE)
- Failure of liquid/solid delivery tools
- Possible hazards during ship movements at the port are collision, grounding, etc.
- Likely hazards during loading and unloading of cargo
- During ship unloading operations, the possible hazard may arise due to collision by another vessel and others

Cargo handling: A fully mechanized ship loading/unloading system is planned at the berths. The major components of the mechanised ship loading/unloading system are: Ship unloaders, loaders and connected conveyor system/ pipelines etc.

Ship movements/Navigation Hazards: The navigation hazards during operation phase are grounding and collision of vessels at Kattupalli Port area. However, these would be controlled by suitable vessel traffic management by Kattupalli Port.

Ship (un)loading: During ship unloading operations, the possible hazard may arise due to collision by another vessel and others.

Transfer operation: The transfer operation involves transfer of cargo from (un)loaders to the belt conveyor through chutes/ marine (un)loading arms in to Pipelines. During this operation there is a possibility of mal-operation / non-synchronisation / misalignment leading to cargo spillage.

Conveyor system: The main hazards related to belt conveyors are mechanical. Other hazards are produced by non-compliance with ergonomic principles when workers operate near the conveyor (operation station, control of the process, loading and unloading); failure or malfunction or safety-related control systems; electrical hazards; and thermal phenomena (such as heat, fire or explosion). The mechanical hazards are mostly related to:

- Mechanical power transmission components (e.g., drive shaft, reducing gears) that can cause damage by entrainment (by a belt or on nip points), crushing or entanglement (human body entangled around a rotating part) on contact with rotating components;
- Other moving components (e.g., idlers, pulleys, belt) that can cause damage by entrainment in nip points, abrasion and burns;
- Pinching zones (e.g., feeder, skirt-board, skirt-board seal) that can cause damage by shearing and crushing;
- Moving loads that can cause damage by shearing and crushing between the load and a fixed component, or an impact;
- Moving sub-assemblies (e.g., ejectors, switches, transfer mechanism) that can cause damage by shearing and crushing;

Slip and Trip Hazards: Workers performing cleaning operations are exposed to slippery working surfaces and tripping hazards. This places workers at risk of:

- Slipping off, oily and greasy ladders
- Slipping and falling on oily decks
- Tripping over equipment, hoses, and vessel structures

7.1.1.3 Hazardous Material Inventories

Identification of hazards is the most important step to improve the safety of any process /operation. The hazard study is designed to identify the hazards in terms of chemicals, inventories, and vulnerable processes/operations.

Except (un)loading, transfer and storage of Liquid cargo such as petroleum products and other chemicals, no manufacturing process or reaction is involved in the operations at Kattupalli port. The operations at Kattupalli port expansion project involves transfer of various petroleum and other products from ships to storage tanks with the help of pumps installed at ships with the help of mechanical (un)loading arms at jetties.

The primary step in hazard analysis of any process is to know the chemical inventories and hazardous properties. Some of the important liquid cargos to be stored[1] in the Kattupalli Port, along with hazardous properties, are given in **Table 7-2.**

Table 7-2: Flammable and Toxic Properties of Chemicals

Cargo Name	Flammability Limits %age		Details of Tank				Operating conditions	
	LEL	UEL	Capacity KL/MT/M³ and Nos.	Dia (m)	Ht (m)	Type	Temp. °C	Pressure atm
Ammonia	15	28	10000 MT/1	26	20	Double Wall Double Integrity	-35	1.0
Butane	1.8	8.5	25000MT/2	61	18.6	Double walled, full containment, Refrigerated	-5	1.0

[1] *Storage of cargo in the CRZ area will be as per the CRZ Notification 2011/2019 (as amended)*

Cargo Name	Flammability Limits %age		Details of Tank				Operating conditions	
	LEL	UEL	Capacity KL/MT/M³ and Nos.	Dia (m)	Ht (m)	Type	Temp. °C	Pressure atm
Crude oil	0.7	7	25000 m³/16	81	15	Floating/ Fixed roof	40	0.6
LNG	5	15	180,000 m³/4 (FSRU Storage b/w 125000 – 216000 m³ (Avg. 170000 m³))	84	45	Fixed tank-Full Containment Type (Moss or Membrane)	-162	1.1
LPG	1.8	8.5	5000 MT/Barge (FSO each compartment storage of max. 25000 MT)	-	-	Double walled, full containment, Refrigerated	Ambient	8
All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products (Representative PoL Naphtha)	1	7.6	10000 KL/24	30	16	Floating/ Fixed roof/ Fixed Cone	Ambient	0.6
Propane	2.1	9.5	25000 MT/2	61	18.6	Double walled, full containment, Refrigerated	-45	1.1
Propylene	2	11	25000 MT/2	61	18.6	Double walled, full containment, Refrigerated	-47	1.1
Diesel	0.5	5	20 m³/2	2.25	5.5	Floating/ Fixed roof	70	0.6

Chemical process industries and petroleum refineries use checklists as a first step in the hazard evaluation procedure. Dow and Mond Fire and Explosion Indices, which make use of past experience to develop relative ranking of hazards are also extensively used. For predictive hazard analysis, Hazard and Operability Studies (HAZOP), Fault Tree Analysis, Event Tree Analysis, Maximum Credible Accident and Consequence Analysis etc. are employed.

In the present study the following procedures are used to identify the hazards.

- Preliminary Hazard Analysis (PHA)
- Maximum Credible Accident and Consequence Analysis (MCACA), which is used for determining the damage distances

7.1.1.4 Preliminary Hazard Analysis (PHA)

A Preliminary Hazard Analysis is carried out initially to identify the major hazards associated with storages and the processes at Kattupalli Port. This is followed by consequence analysis to quantify these hazards. Finally, the vulnerable zones are plotted for which risk reducing measures are deduced and will be implemented.

Table 7-3: Preliminary Hazard analysis for Process and Storages Area

Equipment	Process/Operation	Potential Hazard	Provision
Marine (Un) Loading Arms/ Pipelines	Unloading of material from carrier ship and	Fire & Explosion and Toxic	Regular maintenance and inspection of pipelines as per

Equipment	Process/Operation	Potential Hazard	Provision
	transportation of material from Jetty to Storage tanks in Tank Farm Area (TFA)		OISD-124 and 140
Storage tanks	Storage of material for import and export	Fire & Explosion and Toxic	Tanks design as per IS code & Other prevailing norms and fire protection facilities as per OISD-156

7.1.1.5 Maximum Credible Accident (MCA) Analysis

MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. In this revised master plan development, the proposed cargos (Liquid/Gaseous/Cryogenic) are divided into different class i.e. (i) Class - A Petroleum (ii) Class - B Petroleum (iii) Class - C Petroleum (iv) Excluded Petroleum (v) Other Gaseous Cargos and (vi) Other liquid Cargos. In case of accident, all the above cargo likely to cause Fire & Explosion and Toxic effects except other liquid cargos. Among these cargo, representative items from each class which cause maximum damage distances based on NFPA hazard classification have been selected and risks associated were quantified.

The cargos listed in Class (iv) solids are not considered for QRA, as cargo from other classes (Class A/B/C) which will represent worst scenarios have already been considered. Also, scenarios from other cargos have health hazard as the most probable hazard. The necessary measures will be taken during handling, transfer and storage of such cargos.

The mentioned list in the **Table 7-4** is representative only. However, all the Classified and non-classified hydro carbons, Hazardous and Non-Hazardous Chemicals/cargos other liquid cargo etc., having lesser risk than the representative list considered can be handled at Kattupalli port. Storage of cargo in the CRZ Area shall be as per prevailing CRZ guidelines.

Table 7-4: Representative List of Liquid and Cryogenic Gases Cargos

S. No	Classification	Chemical	Flash Point	H - Health	F - Flammability	R/I – Reactivity / Instability
1.	Chemical Flash Point < 23 deg C	**LNG**	**-187.8**	**2**	**4**	**0**
2.		**Ethylene**	**-136.6**	**2**	**4**	**2**
3.		**Propylene (Propene)**	**-107.8**	**2**	**4**	**1**
4.		**Propane**	**-104**	**1**	**4**	**0**
5.		Butadiene	-76	2	4	2
6.		**Butane**	**-60**	**1**	**4**	**0**
7.		**LPG**	**-60**	**1**	**4**	**0**
8.		Pentane	-49	1	4	0
9.		Ethyl Mercaptan	-48.3	1	4	0
10.		Motor Spirit	-42.7	1	3	0
11.		**Propylene Oxide**	**-37**	**3**	**4**	**2**
12.		Hexane	-22.5	1	3	0
13.		**Naphtha**	**-21.7**	**1**	**3**	**0**
14.		Acetone	-20	1	3	0
15.		Methyl Chloride / Chloro Methane	-20	2	4	1
16.		Cyclohexane	-18	1	3	0
17.		Benzene	-11.1	2	3	0
18.		Ethyl Acetate	-4.4	1	3	0
19.		**Acrylonitrile**	**-1.1**	**4**	**3**	**2**
20.		Acetonitrile	2	2	3	0
21.		Methacrylonitrile	12	3	3	0
22.		Methanol (Methyl Alcohol)	12	1	3	0
23.		Isopropyl Alcohol	12.778	1	3	0

S. No	Classification	Chemical	Flash Point	H - Health	F - Flammability	R/I – Reactivity / Instability
24.		Ethyl Alcohol (Ethanol)	12.78	2	3	0
25.		Methyl Methacrylate	13	2	3	2
26.		Ethylene di chloride	13	3	3	0
27.		Methyl Isobutyl Ketone	14	2	3	1
28.		O-Xylene	17	2	3	0
29.		Ethyl Benzene	21	2	3	0
30.	**Chemical Flash Point >23 deg C <65 Deg C**	N-Butyl Acetate	23.9	1	3	0
31.		Isobutyl Alcohol (Iso Butanol)	28	1	3	0
32.		N-Butyl Alcohol (N-Butanol)	28.9	1	3	0
33.		**Epichlorohydrine**	**31**	**3**	**3**	**2**
34.		Styrene	31.1	2	3	2
35.		**High Speed Diesel**	**35**	**1**	**2**	**0**
36.		Cumene	36	2	3	1
37.		**Crude Oil**	**38**	**2**	**3**	**0**
38.		Aviation Fuel	38	1	2	0
39.		Kerosene	38	1	2	0
40.		Acetic Acid	39	3	2	0
41.		Acetic Anhydride	49	3	2	1
42.	**Chemical Flash Point ≥65 Deg C <93 deg C**	Non-edible/Mentha Oil	65	1	2	0
43.		Low Sulphur Heavy Stock/ Furnace oil	66	2	2	0
44.		Carbon Black Feedstock (CBFS)	66	1	2	0
45.		Aniline	70	3	2	0
46.		Methyl Ethyl Ketone Peroxide	75	3	2	2
47.		Ethyl Hexanol-2	77	2	1	0
48.		**Vinyl Chloride**	**78**	**2**	**4**	**1**
49.		**Phenol**	**79**	**4**	**2**	**0**
50.		Naphthalene	88	2	2	0
51.	**Chemical Flash Point > 93 deg C**	Ethylene Glycol	111	1	1	0
52.		**Toluene 2.4 -di isocyanate**	**127**	**3**	**1**	**2**
53.		Diphenyl Methane Di-Isocynate	135	3	1	1
54.		Edible oil/Palm Oil	162	0	1	0
55.		Paraffin	199	0	1	0
56.		Bitumen	204	2	1	0
57.		Sulphur	207	2	1	0
58.		Lube oil	210	0	1	0
59.		Asphalt	>230	1	1	0
60.		Coal	>127	1	1	0
61.	**Other Gases**	**CNG**	**-**	**-**	**-**	**-**
62.		**NG**	**-**	**1**	**4**	**0**
63.		**Ammonia (NH_3)**	**-**	**3**	**1**	**0**
64.	**Other Cargos**	Diammonium Phosphate	-	2	0	0
65.		Muriate of Potash (MOP)	-	1	0	0
66.		Soda Ash (Sodium Carbonate)	-	2	0	1
67.		Urea	-	2	1	0
68.		Limestone	-	1	0	0
69.		Caustic Soda	-	3	0	1
70.		Sulphuric acid	-	3	0	2
71.		Phosphoric acid	-	3	0	0
72.		Piperine	-	2	1	0
73.		Chloroform	-	2	0	0
74.		Hydrochloric Acid (HCL)	-	3	0	1

A disastrous situation is the outcome of fire or explosion of the released gas in addition to other natural causes, which eventually leads to loss of life, damage to property and/or ecological imbalance.

Crude oil, LPG (Propane/Butane), LNG and Naphtha are mixture of different components/composition. The pressure in the pipeline varies from 8bar (g) (Near jetty) to 1bar (in the tank farm area near the storage tanks). Also other components such as Ammonia and MEG have different composition.

Most of the scenarios are considered for the marine unloading arm, pipelines and storage tanks for the facility. However, only 5mm, 25mm leaks (small and medium) will be responsible for 75% of the incidents occurring at the site. Whereas 100mm leak will be responsible for 15% of the cause for any incident and catastrophic failure/rupture will be responsible for 10% of the incidents. This is based on the data is collected by the International Association of Oil & Gas Producers (IOGP) (From 1970) from its member companies and published in the form of report at an interval of five years.

The accident scenarios expected in this facility are given below:

1. Catastrophic failure of Acrylonitrile M(U)LA @ 8 atm (g) and 25°C
2. Catastrophic failure of Ammonia M(U)LA @ 8 atm (g) and -35°C
3. Catastrophic failure of Butane M(U)LA @ 8atm (g) and -5°C
4. Catastrophic failure of CNG M(U)LA @ 8atm (g) and -44.4°C
5. Catastrophic failure of Crude oil M(U)LA @ 8atm (g) and 70°C
6. Catastrophic failure of Diesel M(U)LA @ 8atm (g) and 50°C
7. Catastrophic failure of Epichlorohydrin M(U)LA @ 8atm (g) and -46.4°C
8. Catastrophic failure of Ethylene M(U)LA @ 8atm (g) and -103.7°C
9. Catastrophic failure of LNG M(U)LA @ 6.2 atm (g) and -160°C
10. Catastrophic failure of LPG M(U)LA @ 8 atm (g) and -42°C
11. Catastrophic failure of Meta Xylene M(U)LA @ 8 atm (g) and 35°C
12. Catastrophic failure of Methylene Dichloride M(U)LA @ 8 atm (g) and 35°C
13. Catastrophic failure of Mono Ethylene Glycol M(U)LA @ 8 atm (g) and 70°C
14. Catastrophic failure of Naphtha M(U)LA @ 8atm (g) and 25°C
15. Catastrophic failure of Phenol M(U)LA @ 8 atm (g) and 80°C
16. Catastrophic failure of Propane M(U)LA @ 8 atm (g) and -44.4°C
17. Catastrophic failure of Propylene M(U)LA @ 8atm (g) and -46.4°C
18. Catastrophic failure of Propylene oxide M(U)LA @ 8 atm (g) and 20°C
19. Catastrophic failure of Vinyl Chloride M(U)LA @ 8 atm (g) and 20°C
20. Catastrophic failure of 2,4-Toluene di Isocyanate M(U)LA @ 8 atm (g) and -4.4°C
21. 18” Acrylonitrile Pipeline from Jetty to Tank Farm Area
22. 18” Ammonia Pipeline from Jetty to Tank Farm Area
23. 18” Butane Pipeline from Jetty to Tank Farm Area

24. 18” Crude oil Pipeline from Jetty to Tank Farm Area
25. 18” Diesel Pipeline from Jetty to Tank Farm Area
26. 18” Ethylene Pipeline from Jetty to Tank Farm Area
27. 36” LNG Pipeline from Jetty to Tank Farm Area
28. 18” Naphtha Pipeline from Jetty to Tank Farm Area
29. 18” Phenol Pipeline from Jetty to Tank Farm Area
30. 18i” Propane Pipeline from Jetty to Tank Farm Area
31. 18” Propylene Pipeline from Jetty to Tank Farm Area
32. 18” Propylene Oxide Pipeline from Jetty to Tank Farm Area
33. 18” Vinyl Chloride Pipeline from Jetty to Tank Farm Area
34. Acrylonitrile vessel at Tank Farm Area (TFA) @ 25°C and 0.6 atm pressure
35. Ammonia vessel at Tank Farm Area (TFA) @ -35°C and 1.0 atm pressure
36. Butane vessel at Tank Farm Area (TFA) @ -5°C and 1.0 atm pressure
37. Propane vessel at TFA @ -45°C and 1.1 atm pressure
38. Crude at TFA @ 70°C and 0.6 atm pressure
39. Naphtha/MS/AF/Kerosene at TFA @ 25°C and 0.6 atm pressure
40. Diesel/FO/LO at TFA @ 40°C and 0.6 atm pressure
41. Toxic damage distances (IDLH) for marine (un) loading arm, storage tank and pipeline failure for Ammonia (300ppm) and Acrylonitrile (85ppm).

The most credible cases like 5mm, 25mm, 100mm and catastrophic failure for pipelines are considered whereas 10 minutes discharge and catastrophic failure for storage tanks are also taken into consideration. Catastrophic failure of marine unloading arm for unloading various materials at jetty are considered for the study. Toxic release scenarios are considered for failure in marine loading arm, storage tank and leak in pipeline from jetty to tank farm area.

The various scenarios considered for carrying out the Risk Assessment for the onshore LNG terminal such as Catastrophic failure of LNG M(U)LA; Pipeline from Jetty to Tank Farm Area; LNG at Tank Farm Area. The various scenarios considered for carrying out the Risk Assessment for the onshore LPG terminal such as Catastrophic failure of Butane, LPG and Propane Marine Loading/unloading Arm (MLA); Pipeline from Jetty to Tank Farm Area; Butane and Propane at Tank Farm Area.

7.1.1.6 Ignition sources

As the pipeline route from jetty to storage tanks will be provided with sufficient buffer on reclaimed land, no sources of ignition are identified. In case of residential area in an around pipeline route, probability of ignition increases. However, jetty where working personnel and hot surfaces will be available (chimney of ship), will pose a threat as ignition source.

7.1.1.7 Natural disasters

Natural disasters are inevitable in nature. In case of natural disasters occurring at the Kattupalli port site such as Tsunami, Cyclone, Hurricane and Earthquake etc., no source of software exists for calculation of damage zones. However, scenarios leading to fire & explosions / toxic gas release for complete rupture of the pipeline, storage tanks and other equipment can be estimated. The damage consequences will be same as domino effects (cascading effects) as one scenario will lead to initiation of another scenario of catastrophic failure of storage vessels and pipelines. The only recommendation to avoid the maximum damage due to natural disasters is to design and construct the facility and equipment as per the international standards by taking maximum allowance for natural disasters into consideration.

7.1.2 Software

PHAST 6.7 (for few scenarios upgraded version PHAST 7.2 is used) is a software product designed to provide a total service for chemical process hazard analysis to DNVGL's customers in industry. PHAST provides the most advanced collection of consequence models for hazard analysis which have been derived from the industry standard risk analysis program PHAST.

7.1.3 Risk Analysis

7.1.3.1 Failure Frequency

The release scenarios considered earlier can be broadly divided into two categories (i) catastrophic failures which are of low frequency and (ii) ruptures and leaks which are of relatively high frequency. Vapour or liquid releases from failure of gasket, seal and rupture in pipe lines and vessels fall in second category whereas catastrophic failure of vessels and full-bore rupture of pipelines etc. fall into first category. Typical failure frequencies are given in **Table 7-5.**

Table 7-5: General failure frequencies

Item	Mode of failure	Failure Frequencies
LNG Refrigerated Atmospheric Vessel	Serious leak catastrophic	$1x10^{-6}$/ yr $5x10^{-8}$/ yr (double containment)
	Full containment type	Same as double walled containment type (Ref.-HSE, UK)
Pressure vessel	Serious leak	1.0×10^{-5}/yr
	Catastrophic	$3x10^{-6}$/yr
	Road Tanker Failure	$1.1x10^{-8}$ per delivery
	Process pipe lines	
=50 mm dia	Full bore rupture	8.8×10^{-7}/m.yr
	Significant leak	$8.8 x10^{-6}$/m.yr
> 50 mm = 150 mm dia	Full bore rupture	2.6×10^{-7}/m.yr
	Significant leak	$6x10^{-5}$ /m.yr
> 150 mm dia	Full bore rupture	$8.8 x10^{-8}$ /m.yr
	Significant leak	$6x10^{-6}$ /m.yr
Hoses	Rupture	$3.5 x10^{-2}$/yr
Check valve	Failure on demand	$1x10^{-4}$/demand
Motor operated valve	Failure on demand	$1x10^{-3}$/demand
Flange	Leak	$3 x10^{-4}$/yr
Pump	Casing failure	$3 x10^{-5}$ per pump/yr
Pump seal single	Leak	$5 x10^{-4}$ per pump/yr
Pump seal double	Leak	$5 x10^{-5}$ per pump/yr
Process Safety Valve	Lifts heavily	$4 x10^{-3}$/yr
	Blocked	$1 x10^{-3}$/yr
	Lifts lightly	$2 x10^{-2}$/yr

L&T Infra Engineering

Item	Mode of failure	Failure Frequencies
	Articulated loading/ unloading arm failure	3 x 10^{-8}/hr of operation
	Full bore vessel connection failure	Failure frequency/10^6 years
<25		30
40		10
50		7.5
80		5
100		4
>150		3

Reference source:

a. *HSE UK- Failure Rate and Event Data for use within Risk Assessments*
b. *OGP-Risk Assessment Data Directory*
c. *OGP-Process Release Frequency*
d. *Loss Prevention in the Process Industries -Frank P.lees.Vol.2 & 3, 2nd edition.*
e. *TNO communication*

These failure rates are for non- corrosive systems like hydrocarbon industry and well suited for the present case. Due attention is to be given for materials of construction and design conditions. Details of Equipment Failures reasons are given below:

S. No	Reason	%
1.	Defective Pipeline	10
2.	Hose Failure	09
3.	Loading Arm Failure	09
4.	Open Valve	05
5.	Leaking Valve	64
6.	Manifold Failure	03

Source: International Tanker Owners Pollution Federation

Assumptions made:

The following assumptions were made during the present study to obtain the best consequence analysis results.

- Average temperature considered: 33°C
- Humidity: 71%
- Surface roughness factor: 25 cm
- Wind speed: 1 m/s, 2 m/s, 3.5 m/s, 5 m/s, 6.5 m/s and 8 m/s
- Stability class: F, E, D and C

7.1.3.2 Consequence Analysis

The accidental release of hazardous chemicals leads to subsequent events which actually cause the damage. The damages are caused by

- Heat radiation
- Toxic effects
- Overpressure effects from explosions.

The nature of damage and extent of damage resulting from an accidental release of a chemical depends on several factors like nature of material, storage conditions, release conditions, atmospheric conditions etc. The sequence of probable events following the release of a hazardous chemical is schematically shown in **Figure 7-1**.

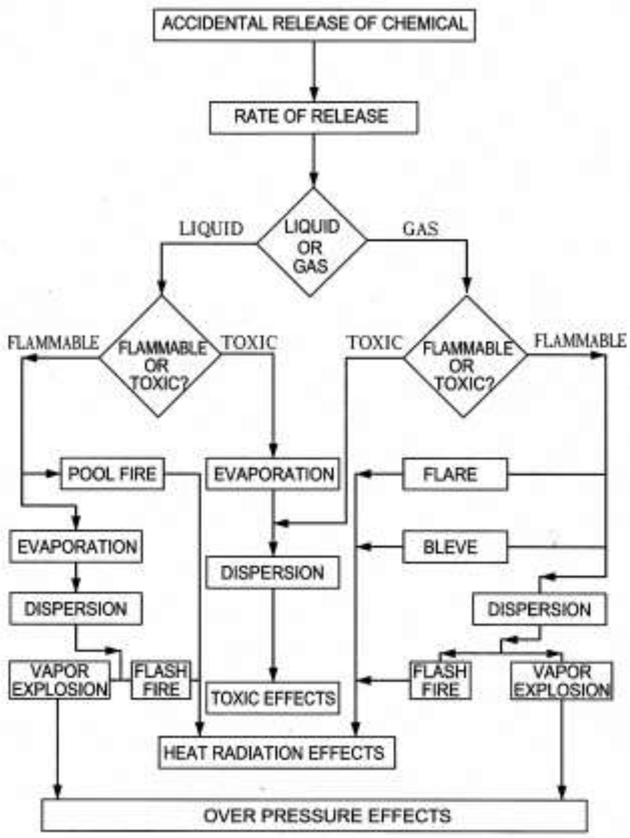


Figure 7-1: Steps in consequence calculations

The best way of understanding and quantifying the physical effects of any accidental release of chemicals from their normal containment is by means of mathematical modelling. This is achieved by describing the physical situations by mathematical equations for idealized conditions and by making corrections for deviation of the practical situations from ideal conditions.

7.1.3.3 Release Models and Source strength

From the flowchart (**Figure 7-1**) it is clear that the first aspect to be considered is modelling the release and source strength of hazardous substances. This depends on the nature of failure of the unit and content of the unit and operating temperature and pressure of the unit. The release may be instantaneous due to total failure of storage unit or continuous due to leakage or rupture of some component of the storage facility. The material discharged may be gas or liquid or the discharge could be manifested through two-phase flow. For cases of outflow where two-phase flow can occur, the calculation possibilities are as follows:

- Liquid outflow
- Vapour outflow
- Gas outflow

The models that are used to calculate the quantity of liquid/vapour released are:

Turbulent free jet: When gas flows out of an opening from a high-pressure container or a pipeline, a free jet, independent of weather conditions can form. If the gas is flammable and a source of ignition is available within the distance for its Lower Flammability Level (LFL) it will result in a flare.

Two-phase outflow: If a liquefied pressurized gas escapes rapidly from a fractured pipeline or vessel, there is a possibility of liquid flashing into vapour because of pressure reduction. This vapour formed influences the amount of two-phase outflow because of two-phase conditions in a pipeline or vessel.

Vapour/liquid outflow: In a vessel when liquid and vapour co- exist, the type of release depends on the position of the leak. Leak in vapour space results in vapour release and leak in liquid position results in liquid release. The rates of discharge for these cases are calculated based on idealised models. Corrections are applied for practical situations.

Evaporation Models: The liquefied materials when released will evaporate and disperse into the atmosphere. The rate of evaporation depends on various factors. The liquefied gas whose atmospheric boiling point is less than the ambient temperature will partly flash into vapour instantaneously taking the required heat of evaporation from the remaining liquid. Cryogenic liquids receive heat from the surface of the land and evaporate. Liquids with boiling points above ambient temperature evaporate only because of the influence of wind. The rate of evaporation depends on the wind speed and size of the pool. The possibility of pumping the spillage back to storage is much higher if the liquid is neither cryogenic nor flashing type, provided it is confined in the bund/dyke of the respective storage tank.

Table 7-6: LNG Release Event Frequencies

LNG Release Event Frequencies					
Equipment	**Release Scenario**	**Release Phase**	**Release Frequency**	**Unit**	**Reference**
Process Vessels	i) 10 & 25 mm hole	Liquid	1.00E-05	Per year	Crossthwaite et al
	ii) 50 & 100mm hole	Liquid	5.00E-06	Per year	Crossthwaite et al
	iii) Full bore rupture	Liquid	1.00E-06	Per year	Crossthwaite et al
Pumps	i) Leak	Liquid	1.00E-04	Per year	COVO Study
	ii) Full bore rupture	Liquid	1.00E-05	Per year	COVO Study
Unloading Arm	i) Leak	Liquid/Gas	4.05E-03	Per year	COVO Study
	ii) Full bore rupture	Liquid/Gas	4.05E-05	Per year	COVO Study
Pipe size 600mm to 750 mm	i) 10 & 25 mm hole	Liquid/Gas	1.00E-07	Per meter per year	Hawksley
	ii) 50 & 100mm hole	Liquid/Gas	7.00E-08	Per meter per year	Hawksley
	iii) Full bore rupture	Liquid/Gas	3.00E-08	Per meter per year	Hawksley
Pipe size 150mm to 500 mm	i) 10 & 25 mm hole	Liquid/Gas	3.00E-07	Per meter per year	Hawksley
	ii) 50 & 100mm hole	Liquid/Gas	1.00E-07	Per meter per year	Hawksley
	iii) Full bore rupture	Liquid/Gas	5.00E-08	Per meter per year	Hawksley
LNG Storage Tank	i) Rupture	Liquid	1.00E-08	Per meter per year	“Purple Book”

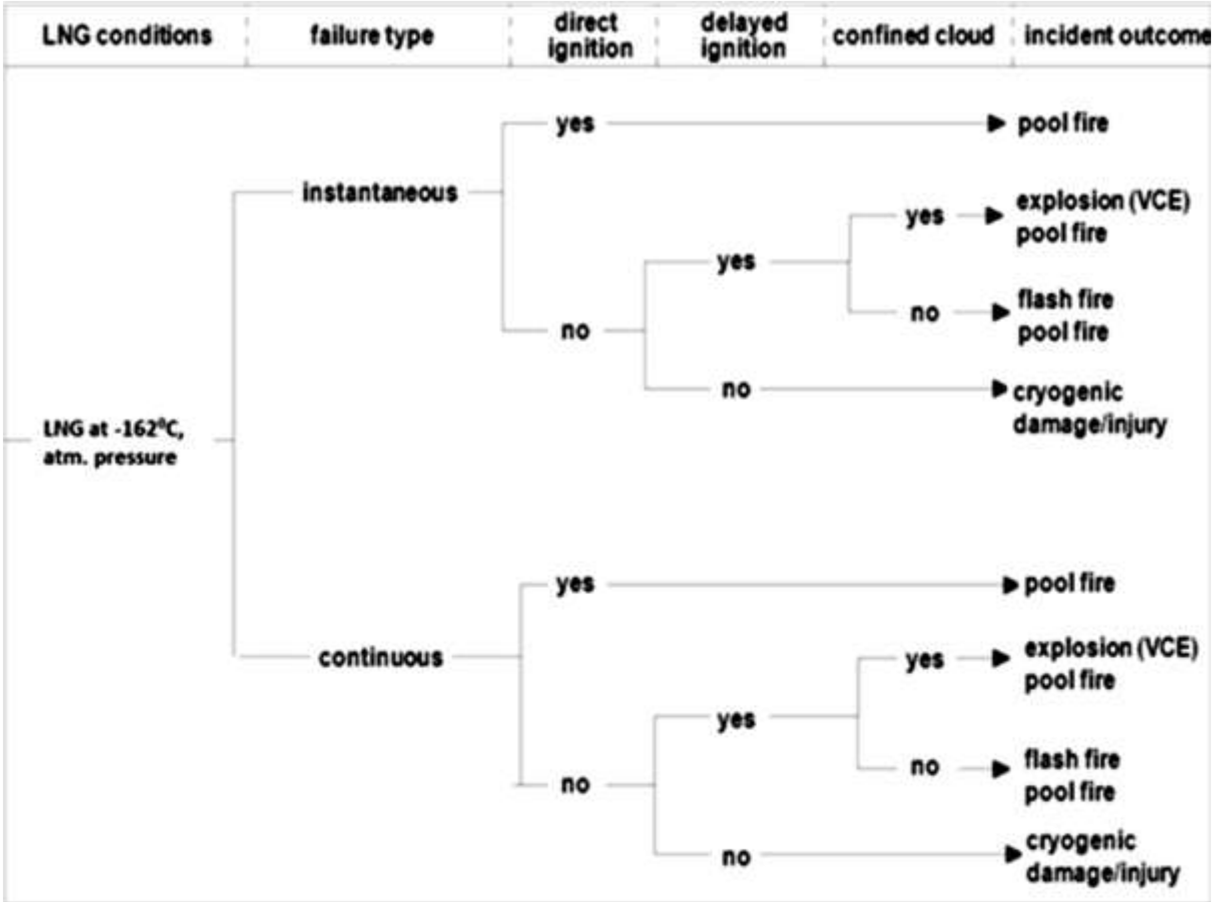


Figure 7-2: Event tree for release of LNG stored at atmospheric pressure

Gas/Vapour Dispersions: Vapour clouds are one of the major sources of worst chemical disasters. These may result from direct release of gas or vapours from flashing liquids or evaporation of spilled liquids. Vapour clouds may give rise to large fires, explosions or toxic effects depending on the nature of the chemical.

Gaussian dispersion models are useful for neutrally buoyant gases with densities equivalent to that of air at the release conditions. For gases/vapours heavier than atmospheric air, Box models are useful. Box models assume that mass transfer occurs by entrainment across the density interface of a cloud with an assumed shape and that internal mixing is fast enough that concentration within the cloud is uniform.

Heat Radiation Models: When flammable liquid is released into atmosphere, and immediate source of ignition is available, it may result in BLEVE, pool fire or flash fire. In the event of delayed ignition, the flammable material release may result in flash fire or vapour cloud explosion. Each of these scenarios is described below in detail.

Pool fires: When a flammable liquid spills, it spreads into a pool. The size of the pool depends on the availability of bund and obstacles. If there are no obstacles or bund, it can spread into a thin film on flat land/floor and upon ignition a pool fire will result. The size of the pool gradually increases with time but it will reach an equilibrium size shortly after ignition when burning rate matches with the release rate. Since most of the liquid cargos handled at Kattupalli port are liquids at room/operating temperatures (Except LNG/Butane/Propane/ etc.,), pool fires are the most probable scenarios in this case.

'BLEVE' and fire balls: A catastrophic failure or total loss of containment (TLOC) of the pressurized liquefied gas vessel can take place for a variety of reasons, including flawed material, fatigue, corrosion, poor manufacture, thermal stresses, pressure stresses and reduction in material strength due to high wall temperatures. Any of these factors could result in a TLOC. However, in most of the accidents, several of these factors combine to cause failure of a vessel leading to a BLEVE. The acronym ‘BLEVE’ stands for Boiling Liquid Expanding Vapour Explosion. Even though BLEVEs were recorded at temperatures far below the atmospheric superheat limit, the superheat in the liquid helps violent or explosive boiling to take place. This incident occurs upon rupture of a vessel containing a liquid with vapour pressure well above atmospheric pressure such as LPG in case of an external fire. Such a rupture can be initiated by several mechanisms.

- Overpressure of a vessel due to overfilling, too small a relief valve and high pipeline pressures.
- Heating of the vapour space of the vessel by an external fire or a flame impingement on a specific spot. Although the relief valve may function according to its set pressure, the tank ruptures because of weakening of steel. This type of BLEVE may occur in a few minutes after the initiation of fire.
- Heating the wetted surface of the vessel through fire underneath. In this case it may take hours to initiate a BLEVE.
- A missile (a portion of a vessel for example) hitting the LPG storage.

According to a study the energy necessary for catastrophic failure must come from the vapour and liquid in the tank. The vapour space energy is available immediately on initial failure of the vessel. However, the liquid energy is available only after a phase change, which requires a finite time period. With rapid depressurization, the boiling process is in non-equilibrium and as a result very large liquid superheats are possible. These are strongly related to PRV setting because this setting ultimately determines the liquid temperature. It was reported that if the PRV setting is near or above the superheat limit, then the boiling process is likely to push the event to BLEVE conditions. The chances of BLEVEs caused by rapid failure of a weakened tank may be reduced by making the tanks stronger. The BLEVEs resulting from high energy can be reduced by limiting the liquid temperature by careful selection of PRV settings.

In BLEVE pressure wave effects are of minor importance particularly in small storages like 30T and 150T bullets. The damage is mainly due to heat radiation. The duration of fireball is about 20-50s whereas the metal of the storage vessel and structural supports can withstand intense heat radiation for much longer duration e.g. flares – 5min, pool fires – 20min, heat radiation level of 37.5 kW/m^2–60 min. Hence heat radiation of BLEVE in one of the bullets is very unlikely to lead to BLEVE of the adjoining bullet. However, the fragments of a bullet on BLEVE may lead to BLEVE in the neighbouring bullet. Considering the duration of BLEVE itself and other factors, BLEVE in other adjoining bullets may be regarded as relatively low probability sequential event/events.

Flares: In case of leak of gas from high pressure container, a turbulent free jet results; if a source of ignition is available within its LFL distance, it will result in a jet or flame close to the point of release whose length extends a little beyond LFL distance. It can continue for much longer duration than BLEVE.

Flash fires: Flammable vapour clouds form as a result of release of flammable gas/vapour, flashing liquids or evaporation from boiling liquid pools. These vapours/gas get dispersed into atmosphere forming explosive/ flammable vapour clouds where the concentration will be within the flammable limits. If there is no source of ignition, the cloud gets further diluted and passes away without causing any damage. However, if the mixture in explosive range comes in contact with a source of ignition, it may result in a flash fire or vapour cloud explosion depending upon the level of turbulence. In flash fire the flame front travels through the flammable mixture and stabilizes at the release point resulting in either a pool fire or jet fire. Any person caught in the cloud envelope is likely to suffer fatal burn injuries. Secondary fires may follow if combustible material is present in the cloud envelopes. Further, instrument and power cables may get burnt, but steel structures are not likely to be damaged.

Explosion models: If a volatile flammable material is released, this will disperse into atmosphere. The concentration of the material in the atmosphere is determined using appropriate dispersion models. The cloud within the upper and lower explosion limits is in flammable range. If this cloud comes into contact with ignition source, it may result in a flash fire or vapour cloud explosion depending on the degree of confinement. The overpressure effects resulting from vapour cloud explosion are calculated using TNT equivalence model. Peak over pressures measured from TNT explosion have been used to estimate those generated by unconfined vapour cloud explosions.

Toxic load models: Whenever there is an accidental release of volatile toxic material into atmosphere, it gets dispersed into the atmospheric air. The concentration of the material in space with respect to time is determined using appropriate dispersion models. The combined effect concentration and exposure time are determined using probit function explained in more detail in the next subsection under impact criterion.

Impact of Thermal Radiation: Damage due to heat radiation to both human beings and process plants are given in **Table 7-7.**

Table 7-7: Damage due to incident radiation

Radiation level (within the fire)	Damage to Equipment	Damage to People
37.5 kW/m²	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
12.5 kW/m²	Minimum energy to ignite with a flame; melts plastic tubing.	1% lethality in 1min
4.0 kW/m²		Injury to people
1.75 kW/m²	-	Pain threshold reached after 60 seconds.
0.7 kW/m²	-	Exposed skin reddens and burns on prolonged exposure time

Thermal radiation and the extent of burn injury depend on the time duration of exposure. Exposure time thermal load and lethality are calculated by Probit equation.

$$Y = -36.8+2.5 \ln(t\ I4/3)$$

Where Y is the probit value
t is time in seconds
I is radiation in W/sq. m

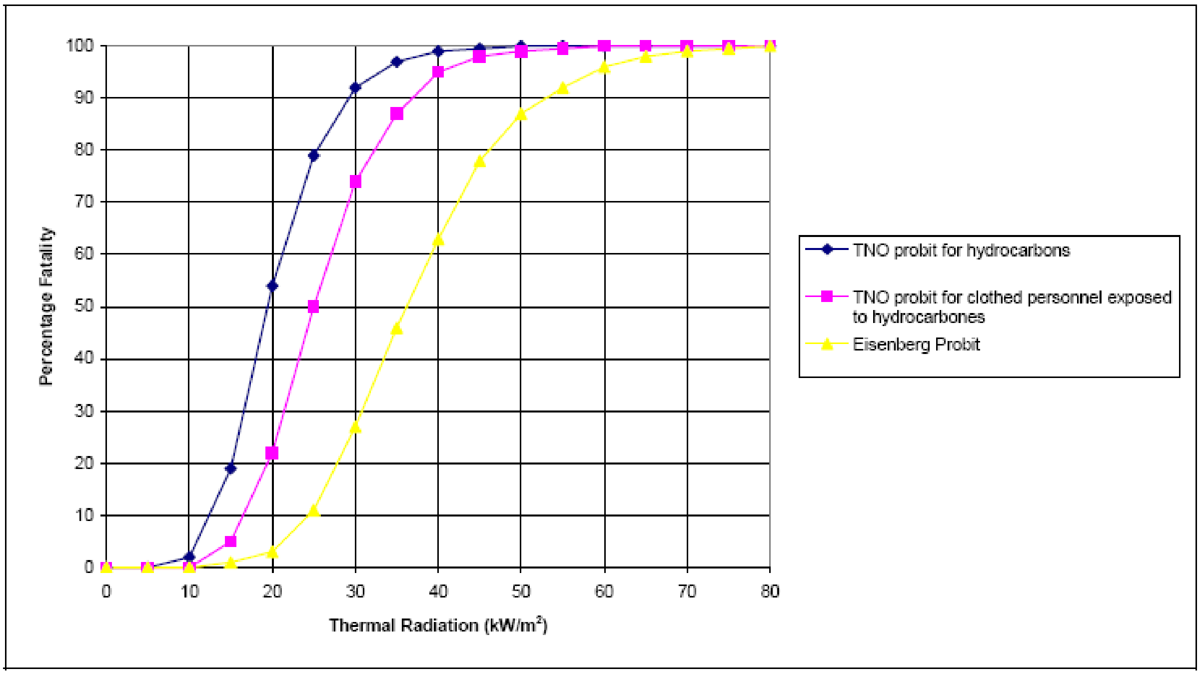


Figure 7-3: Percentage Fatality for 20 Second Exposure based on Thermal Probits

The lethality levels for different thermal loads and different exposure times are given in **Table 7-8**.

Table 7-8: Exposure time, heat radiation and damage levels

Intensity of radiation in kW/m2	Exposure time in sec	% Lethality	% First degree burns
37.5	**28**	**100**	
12.5	**120**	**100**	
4.0	**550**	**100**	
37.5	**4**	**1**	
12.5	**15**	**1**	
4.0	**66**	**1**	
37.5	**7**	**-**	**100**
12.5	**27**	**-**	**100**
4.0	**123**	**-**	**100**
37.5	**1**	**-**	**1**
12.5	**5**	**-**	**1**
4.0	**21**	**-**	**1**

The above times are for unprotected persons. For protected persons the corresponding times will be 50% to 60% higher.

The probit relation for first degree burns are given by the relation

$Y = -39.83 + 3.0186 \ln(t\ I4/3)$

Where Y is the probit value

t is the time in seconds and I is the radiation in (W/sq. m)

Impact of Over pressure: When a flammable vapour cloud ignites, under certain conditions it may result in deflagration thus causing damage due to over pressure effects. The damage depends on the level of over pressure as indicated in **Table 7-9.**

Table 7-9: Effect of over pressure

Overpressure	*Damage*	*Human Injury*
0.3 bar	Heavy structure damage	100% lethality

Overpressure	Damage	Human Injury
0.1 bar	Repairable structure damage	50% lethality
0.03 bar	Major glass damage	Threshold lethality
0.01 bar	10% glass damage	Severe lung damage

Toxic release model: Toxic models are employed to assess the consequences to human health as a result of exposure to toxic gases. When IDLH concentrations (Immediate Danger to Life and Health) are used in conjunction with air dispersion modelling, the resulting analysis can help evaluate the potential consequences of any toxic chemical release from point of view of public health and welfare.

Impact of Toxic Effects: A material may be considered as toxic or poisonous, when a small quantity can cause injurious effect on an average normal adult human being. Almost all materials are injurious to living organisms in case of overdoses. However certain materials are injurious to health and life even at small doses. There are several ways of expressing the severity of the toxic nature of the chemicals. These are:

TLV - Threshold Limit Value: The maximum concentration limit for a normal eight-hour workday and 40 hours per week to which nearly all workers may be repeatedly exposed day after day without any effects on health.

IDLH - Immediately Danger to Life and Health: The maximum concentrations to which a healthy worker can be exposed for 30 minutes and escape without suffering irreversible health effects or escape impairing symptoms.

LDlo - Lethal Dose low: The lowest concentration of a chemical at which some test animals die following inhalation exposure.

LD50 - Median lethal dose: The dose at which 50 percent of test animals die following exposure. Dose is usually expressed as milligrams for kilogram of body weight of the test animal.

The most popular way of expressing lethality of toxic loads is to use Probit functions.

$$P = A + B \ln(Cn\ t)$$

Where P is probit value

A, B and n - constants specific to the chemical

t - Time of exposure in seconds.

c - Concentration in mg/m^3 or ppm

Knowing the concentration level and time of exposure, the percentage lethality may be estimated. However, for most of the chemicals the characteristic constants are not available and, in such cases, IDLH values are used.

7.1.3.4 Meteorological conditions

Evaporation and dispersion of hazardous gases are highly dependent on meteorological conditions like wind speed, direction, stability class etc. Hence proper meteorological information is essential for the estimation of affected zones due to accidental release of chemicals. The latest climatological data of Minabakkam airport and Nungambakkam are the nearest observation centres (IMD Stations) with which we can correlate the wind data for Kattupalli.

Most probable wind directions are from West to East (17.8%), South East to North West (16.45%), south West to North East (16.25%), South to north (16.05%) and East to West (15.8) (based on Minambakkam meteorological station report.

7.1.3.5 Stability Class

The atmospheric conditions of interest are divided into five categories, A, B, C, D, E and F where A is the most in-stable (strong thermal convection) D represents the neutral condition (purely mechanical turbulence) and F the stable stratified case where the mechanical turbulence is strongly damped. Neutral conditions correspond to a vertical temperature gradient of about 1°C per 100m. For the present study, C, D, E, and F (more stable class) classes are considered for damage distance calculations with wind speeds of 1.0, 2.0, 3.5, 5.0, 6.5 and 8.0 m/s.

7.1.3.6 Results of Consequence Analysis

The materials that are proposed to be stored in the tank farm area and handled at Kattupalli port as a part of revised master Plan project are LNG, Propane, Butane, LPG, CNG and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals and other Liquid cargos. These are flammable liquids and any leakage / spillage results in pool fires. The consequence analysis is carried out for all the identified credible scenarios. The results of consequence analysis for all the scenarios are presented in the **Table 7-10** to **Table 7-17**. Since the other chemicals/materials are not flammable in nature and do not pose any threat of explosion, it is recommended to follow Material Safety Data Sheets (MSDS) while handling these materials.

7.1.3.6.1 LFL distances

Lower Flammability Limits (LFL) distances are presented in **Table 7-10**, **Table 7-12**, and **Table 7-14**. The LFL distances are distances up to which, LFL concentration exists. LFL concentration is the minimum concentration of the flammable chemical in air at which, ignition occurs upon contact with any ignition source.

7.1.3.6.2 Heat Radiation Effects

Heat Radiation is the result of fire or explosion occurring upon the ignition of continuous or instantaneous release of flammable materials. Heat radiation effects cause damage to people and property. In the present study as some of the cargos are flammable liquids; heat radiation effects are due to pool fire and jet fires.

In case of pool fire and jet fire, the damage to people and property depends upon the extent of heat radiation per unit area emitted from certain fire. The heat radiation 37.5 kW/m^2 is considered to be lethal and anyone within this heat radiation zone is likely to die. The persons within 12.5 kW/m^2 heat radiation are likely to be injured severely whereas heat radiation 4.0 kW/m^2 will cause minor injuries. For the present study, the heat radiation damage distances are presented in **Table 7-10**, **Table 7-12**, **Table 7-14**.

7.1.3.6.3 Over Pressure Effects

Over pressure effects are due to the vapour cloud explosion. If the leaked flammable chemicals or petroleum products are not ignited immediately, the vapours generated from the pool will form an explosive vapour cloud with air and this could upon ignition results in vapour cloud explosion and over pressure effects. The over pressure damage distances are presented in **Table 7-11**, **Table 7-13, Table 7-15** and **Table 7-17**.

7.1.3.6.4 Toxic Release

The toxic release damage distances are presented in **Table 7-18**.

Table 7-10: Heat Radiation Damage Distances - Marine Loading Arms at Jetty

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
	Catastrophic failure of Marine Loading/unloading Arm (MLA)	4.0 kW/m²	12.5 kW/m²	37.5 kW/m²	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
1	Acrylonitrile @ 8atm (g) and -4.4 ^{0}C	665	540	461	300	308	334	359	391	426
2	Ammonia @ 8 atm (g) and (-35) ^{0}C	752	166/	-	235	243	263	285	302	288
3	Butane @ 8atm (g) and-4.4 ^{0}C	1268	990	821	1593	2537	1802	1490	1318	1174
4	CNG @ 8atm (g) and -44.4 ^{0}C	1170	915	762	250	229	239	257	262	262
5	Crude oil @ 8atm (g) and 70 ^{0}C	817	630	518	662	606	604	632	644	645
6	Diesel @ 8atm (g) and (50) ^{0}C	1357	1055	873	671	609	603	633	638	631
7	Epichlorohydrin (1-Chloro-2,3-Epoxypropane)@ 8atm (g) and -46.4 ^{0}C	**1864**	**1511**	**1287**	524	540	555	566	566	556
8	Ethylene @ 8atm (g) and -103.7^{0}C	1219	982	834	671	609	603	633	638	631
9	LNG @ 6.2atm (g) and (-160)^{0}C	1313	1066	909	654	578	627	680	702	728
10	LPG @ 8atm (g) and -42 ^{0}C	**1808**	**1413**	**1172**	659	579	570	607	618	623
11	Meta Xylene @ 8atm (g) and 35 ^{0}C	588	458	380	282	289	306	323	343	369
12	Methylene Dichloride @ 8atm (g) and 35 0C	1177	991	851	206	207	212	217	228	229
13	Mono Ethylene Glycol @ 8atm (g) and 70^{0}C	206	173	146	99	99	101	103	104	105
14	Naphtha @ 8atm (g) and 25^{0}C	1217	944	778	631	560	546	576	584	580
15	Phenol @ 8atm (g) and 80^{0}C	387	310	263	120	119	120	120	121	121
16	Propane @ 8atm (g) and -44.4 ^{0}C	1246	985	825	1549	2423	1740	1447	1283	1146
17	Propylene @ 8atm (g) and -46.4^{0}C	337	266	224	383	395	422	446	446	409
18	Propylene oxide @ 8atm (g) and 20^{0}C	1261	1000	840	1451	2257	1651	1371	1216	1086
19	Vinyl Chloride @ 8atm (g) and 20 ^{0}C	1227	997	855	1013	1095	1330	1635	1488	1333
20	2,4-Toluene Di-Isocyanate @ 8atm (g) and -4.4^{0}C	150	121	27	93	93	95	96	98	100

Table 7-11: Overpressure Damage Distances - Marine Loading Arms at Jetty

S. No.	Scenario Description	Overpressure Damage Distance (In meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
	Catastrophic failure of Marine Loading/unloading Arm (MLA)	0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar
1	Acrylonitrile @ 8atm (g) and -4.4 ^{0}C	278/280	195/197	185/192	287/294	204/211	195/204	298/303	217/227	213/213
2	Ammonia @ 8atm(g) (saturated liquid)	279/281	192/195	172/174	288/294	199/207	181/189	299/302	213/216	196/200
3	Butane @ 8atm (g) and-4.4 ^{0}C	1736/2628	1641/2564	1614/2546	1825/1366	1809/1246	1804/1222	1251/1156	1232/983	1232/945
4	CNG @ 8atm (g) and -44.4 ^{0}C	399/398	294/281	265/248	396/398	279/284	252/259	394/390	282/276	261/256
5	Crude oil @ 8atm (g) and 70 ^{0}C	787/766	697/655	677/626	751/752	641/650	615/637	744/726	650/640	639/629

S. No.	Scenario Description	Overpressure Damage Distance (In meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
	Catastrophic failure of Marine Loading/unloading Arm (MLA)	0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar
6	Diesel @ 8atm (g) and 50^{0}C	691/630	677/611	673/605	620/640	607/634	603/632	641/634	634/631	632/631
7	Epichlorohydrin @ 8atm (g) and -46.4 ^{0}C	833/840	575/588	514/537	857/881	621/644	570/585	895/892	646/636	584/575
8	Ethylene @ 8atm (g) and -104 ^{0}C	2098/2432	2015/2372	1991/2355	1772/1542	1738/1482	1728/1465	1383/1246	1329/1197	1313/1182
9	LNG @ 6.2atm (g) and -160 ^{0}C	1269/1244	858/797	745/674	1224/1223	783/789	670/689	1213/1189	780/767	693/707
10	LPG @ 8atm (g) and -42 ^{0}C	1166/1138	821/758	729/656	1119/1118	732/735	632/644	1113/1100	728/713	642/633
11	Meta Xylene @ 8atm (g) and 35 ^{0}C	262/263	185/186	174/174	265/268	189/193	180/184	271/272	195/198	186/188
12	Methylene Dichloride @ 8atm (g) and 30 ^{0}C	220/219	166/166	152/152	219/216	166/165	152/156	216/218	166/167	157/158
13	Mono Ethylene Glycol @ 8atm (g) and 70^{0}C	130/131	104/104	96/97	149/150	117/118	108/108	151/153	118/118	108/109
14	Naphtha @ 8atm (g) and 25^{0}C	1080/1083	768/724	687/629	1076/1075	701/699	605/610	1068/1055	690/673	605/592
15	Phenol @ 8 atm (g) and 80 ^{0}C	170/171	131/131	120/120	173/185	132/143	120/130	187/190	143/145	131/131
16	Propane @ 8atm (g) and -44.4 ^{0}C	1663/2598	1583/2451	1560/2434	1776/1456	1752/1446	1746/1443	1310/1156	1291/1146	1285/1143
17	Propylene @ 8atm (g) and -46.4 ^{0}C	1584/2345	1497/2283	1472/2265	1689/1432	1664/1392	1656/1380	1255/1112	1226/1091	1217/1085
18	Propylene Oxide @ 8atm (g) and (200) ^{0}C	688/704	487/500	429/441	725/736	527/544	469/488	724/671	539/495	486/444
19	Vinyl Chloride @ 8atm (g) and -44.4 ^{0}C	1153/1132	1060/1105	1033/1097	985/971	974/827	972/788	1031/1085	913/996	885/982
20	2,4-Toluene Di-Isocyanate @ 8atm (g) and -4.4 ^{0}C	99/100	93/93	92/92	100/100	94/94	92/92	101/101	94/94	92/92

Table 7-12: Heat Radiation Damage Distances – Pipelines from Jetty to Storage Tanks

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
Pipeline from Jetty to Storage Tanks		4.0 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
A	**18inch Acrylonitrile Pipeline**									
1	5mm leak in the pipeline	27	23	20	32	30	18	13	10	9
2	25mm Leak in the Pipeline	126	87	58	226	175	136	123	110	101
3	100mm Leak in Pipeline	413	300	230	291	380	380	345	311	277
4	Line Rupture	433	291	204	320	200	124	86	74	64
B	**18inch Ammonia Pipeline**									
5	5mm leak in the pipeline	28	-	-	10	8	7	6	6	5
6	25mm Leak in the Pipeline	117	98	-	75	93	76	67	59	53
7	100mm Leak in Pipeline	376	324	125	191	221	236	221	202	185
8	Line Rupture	244	182	94	27	29	33	36	39	40
C	**18inch Butane Pipeline**									
9	5mm leak in the pipeline	23	19	16	48	34	23	16	12	10

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
Pipeline from Jetty to Storage Tanks		**4.0 kW/m^2**	**12.5 kW/m^2**	**37.5 kW/m^2**	**F_1**	**F_2**	**$E_{3.5}$**	**D_5**	**$C/D_{6.5}$**	**C_8**
10	25mm Leak in the Pipeline	99	79	67	252	180	143	128	116	110
11	100mm Leak in Pipeline	341	269	226	1086	758	567	492	440	397
12	Line Rupture	514	339	222	1012	630	493	417	357	312
D	**16inch CNG Pipeline**									
13	5mm leak in the pipeline	14	11	9	17	14	9	8	7	6
14	25mm Leak in the Pipeline	60	48	40	175	136	105	91	83	77
15	100mm Leak in Pipeline	210	164	136	382	377	377	393	334	297
16	Line Rupture	449	349	290	457	441	455	482	487	478
E	**18inch Crude Oil Pipeline**									
17	5mm leak in the pipeline	14	10	6	40	33	22	16	12	10
18	25mm Leak in the Pipeline	55	41	33	297	201	156	137	130	121
19	100mm Leak in Pipeline	172	131	107	1236	949	622	536	475	427
20	Line Rupture	450	332	263	1665	1380	1265	1323	878	786
F	**18inch Epichlorohydrin Pipeline**									
21	5mm leak in the pipeline	35	29	25	10	9	7	7	6	6
22	25mm Leak in the Pipeline	144	108	64	23	23	26	28	29	31
23	100mm Leak in Pipeline	382	275	180	55	58	61	65	67	71
24	Line Rupture	356	243	143	97	50	28	18	17	15
G	**18inch Ethylene Pipeline**									
25	5mm leak in the pipeline	23	19	17	56	40	29	22	16	12
26	25mm Leak in the Pipeline	98	80	69	248	196	162	146	137	130
27	100mm Leak in Pipeline	331	270	232	1491	744	611	552	496	457
28	Line Rupture	470	310	214	1469	1757	1027	682	552	460
H	**18inch HSD Pipeline**									
29	5mm leak in the pipeline	21	16	13	40	33	22	15	12	10
30	25mm Leak in the Pipeline	92	70	57	293	196	150	132	124	116
31	100mm Leak in Pipeline	288	221	181	1245	928	606	519	460	415
32	Line Rupture	734	548	436	1684	1391	1267	1320	873	780
I	**36inch LNG Pipeline**									
33	5mm leak in the pipeline	21	18	16	48	34	23	16	12	10
34	25mm Leak in the Pipeline	91	75	65	224	177	144	130	123	116
35	100mm Leak in Pipeline	307	253	218	778	647	559	489	440	410
36	Line Rupture	1506	1216	1028	2063	1771	2037	2128	2082	1802

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
Pipeline from Jetty to Storage Tanks		4.0 kW/m2	12.5 kW/m2	37.5 kW/m2	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
J	**24inch LPG Pipeline**									
37	5mm leak in the pipeline	23	19	16	50	35	24	17	13	10
38	25mm Leak in the Pipeline	100	80	68	249	179	143	129	117	110
39	100mm Leak in Pipeline	341	270	227	1424	746	564	495	442	400
40	Line Rupture	1119	871	717	1932	1598	1462	1575	1594	1120
K	**18inch M-Xylene Pipeline**									
41	5mm leak in the pipeline	39	29	18	19	20	19	14	11	9
42	25mm Leak in the Pipeline	125	69	58	64	74	77	72	69	67
43	100mm Leak in Pipeline	282	151	120	124	136	155	172	163	162
44	Line Rupture	238	101	31	134	78	47	39	36	34
L	**18inch Methylene Chloride Pipeline**									
45	5mm leak in the pipeline	20	17	-	4	4	3	3	3	3
46	25mm Leak in the Pipeline	81	61	-	20	20	18	17	15	14
47	100mm Leak in Pipeline	272	231	194	163	67	68	70	73	76
48	Line Rupture	224	183	133	349	222	131	75	55	41
M	**18inch Mono Ethylene Glycol Pipeline**									
49	5mm leak in the pipeline	38	33	27	11	11	10	9	8	7
50	25mm Leak in the Pipeline	91	63	10	22	22	24	26	27	28
51	100mm Leak in Pipeline	214	150	30	40	40	43	46	47	48
52	Line Rupture	173	107	13	7	7	7	7	7	7
N	**18inch Naphtha Pipeline**									
53	5mm leak in the pipeline	23	18	15	47	35	23	16	12	10
54	25mm Leak in the Pipeline	98	77	65	270	186	144	130	116	109
55	100mm Leak in Pipeline	336	262	218	1364	830	587	505	452	404
56	Line Rupture	791	611	500	1627	1332	1233	1316	889	793
O	**18inch Phenol Pipeline**									
57	5mm leak in the pipeline	53	44	32	11	11	13	12	10	8
58	25mm Leak in the Pipeline	108	61	26	22	22	24	26	27	28
59	100mm Leak in Pipeline	252	147	75	38	39	42	44	46	47
60	Line Rupture	214	107	30	14	14	16	18	19	21
P	**18inch Propane Pipeline**									
61	5mm leak in the pipeline	23	19	16	47	34	23	16	12	9
62	25mm Leak in the Pipeline	98	80	68	242	175	141	125	115	108

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
Pipeline from Jetty to Storage Tanks		4.0 kW/m2	12.5 kW/m2	37.5 kW/m2	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
63	100mm Leak in Pipeline	336	268	228	1352	721	554	482	431	389
64	Line Rupture	796	627	520	1452	1190	1168	1240	836	763
Q	**18inch Propylene Oxide Pipeline**									
65	5mm leak in the pipeline	19	15	13	23	19	12	9	7	6
66	25mm Leak in the Pipeline	81	64	55	207	146	112	97	90	83
67	100mm Leak in Pipeline	277	219	183	1070	666	456	396	349	315
68	Line Rupture	580	456	382	1040	1232	1328	989	875	776
R	**18inch Propylene Pipeline**									
69	5mm leak in the pipeline	23	19	16	48	34	23	16	12	10
70	25mm Leak in the Pipeline	97	79	68	247	181	143	129	118	111
71	100mm Leak in Pipeline	333	267	227	1367	745	569	494	442	398
72	Line Rupture	757	601	504	1528	1348	1299	1337	930	837
S	**18inch Vinyl Chloride Pipeline**									
73	5mm leak in the pipeline	20	16	14	10	9	7	7	6	6
74	25mm Leak in the Pipeline	83	69	60	85	96	89	78	70	64
75	100mm Leak in Pipeline	285	234	202	307	372	388	338	306	273
76	Line Rupture	611	498	428	578	639	802	689	618	548
T	**18inch 2,4-Toluene Di-Isocyanate Pipeline**									
77	5mm leak in the pipeline	41	33	22	10	9	10	11	11	9
78	25mm Leak in the Pipeline	104	59	3	21	21	22	23	23	24
79	100mm Leak in Pipeline	236	139	10	37	37	40	42	42	43
80	Line Rupture	198	101	-	5	5	5	5	5	5

Table 7-13: Overpressure Damage Distances – Pipelines from Jetty to Storage Tanks (Tank Farm Area)

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
		0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar
A	**18inch Acrylonitrile Pipeline**									
1	5mm leak in the pipeline	51/39	37/27	33/23	26/25	16/15	13/12	24/-	15/-	12/-
2	25mm Leak in the Pipeline	352/302	266/216	241/191	252/235	173/160	150/139	216/199	147/135	127/116
3	100mm Leak in Pipeline	516/626	363/459	322/411	629/614	461/436	412/384	581/525	405/359	354/311
4	Line Rupture	856/606	501/316	398/232	424/283	226/151	169/113	205/183	117/103	92/80

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
		0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar
B	**18inch Ammonia Pipeline**									
5	5mm leak in the pipeline	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
6	25mm Leak in the Pipeline	121/143	88/108	78/98	118/104	87/75	78/67	90/87	64/63	56/56
7	100mm Leak in Pipeline	325/359	237/269	212/242	360/346	275/264	251/240	327/303	245/223	221/200
8	Line Rupture	136/131	60/59	39/38	137/133	67/66	47/47	130/138	65/74	46/56
C	**18inch Butane Pipeline**									
9	5mm Leak in the pipeline	68/55	50/39	44/34	40/27	27/16	23/13	26/-	15/-	13/-
10	25mm Leak in the Pipeline	527/436	347/270	295/221	308/256	199/168	167/142	231/211	152/139	130/118
11	100mm Leak in Pipeline	2029/1793	1399/1115	1216/918	1283/1072	813/693	876/584	944/847	610/550	513/464
12	Catastrophic Rupture	2241/1716	1260/960	1117/782	1423/1113	816/649	640/515	956/838	562/495	448/395
D	**18 inch CNG Pipeline**									
13	5mm leak in the Pipeline	24/23	15/15	12/12	-/-	-/-	-/-	-/-	-/-	-/-
14	25mm Leak in the Pipeline	276/235	207/167	187/147	188/167	131/117	114/102	151/136	105/93	91/81
15	100mm Leak in Pipeline	617/653	395/426	355/386	678/701	426/471	381/406	662/592	446/396	384/339
16	Line Rupture	728/736	482/512	445/465	755/768	526/532	472/483	766/756	526/511	478/465
E	**18inch Crude Oil Pipeline**									
17	5mm leak in the Pipeline	49/38	43/33	42/31	27/16	22/12	21/11	16/-	12/-	11/-
18	25mm Leak in the Pipeline	362/277	315/227	302/212	208/178	170/147	159/138	164/161	135/134	127/127
19	100mm Leak in Pipeline	1396/1249	1217/1048	1164/990	870/739	707/603	660/564	655/588	535/479	500/447
20	Line Rupture	2147/1904	1827/1556	1737/1459	1757/1663	1421/1391	1331/1333	1270/1127	1010/902	934/836
F	**18inch Epichlorohydrin Pipeline**									
21	5mm leak in the pipeline	17/-	12/-	11/-	-/-	-/-	-/-	-/-	-/-	-/-
22	25mm Leak in the Pipeline	57/57	33/33	26/26	56/55	32/32	26/26	55/71	32/44	26/37
23	100mm Leak in Pipeline	116/117	73/73	61/61	131/133	85/86	71/72	143/154	89/89	73/84
24	Line Rupture	255/158	148/88	117/67	69/50	37/24	28/16	46/43	23/22	16/15
G	**18inch Ethylene Pipeline**									
25	5mm Leak in the pipeline	86/72	63/51	56/45	44/40	28/27	24/23	28/26	16/16	13/13
26	25mm Leak in the Pipeline	602/475	366/290	298/236	347/290	225/193	190/164	264/244	177/163	152/140
27	100mm Leak in Pipeline	2330/1898	1716/1145	1577/926	1380/1176	879/769	734/651	1038/944	682/623	578/530
28	Catastrophic Rupture	1984/2252	1597/1925	1523/1831	1953/1603	1239/990	1121/812	1393/1198	838/711	677/570
H	**18 inch High Speed Diesel Pipeline**									
29	5mm Leak in the pipeline	42/31	41/31	40/30	21/11	20/10	11/-	10/-	10/-	10/-
30	25mm Leak in the Pipeline	303/205	295/195	292/192	150/139	144/133	142/131	128/117	123/113	121/111
31	100mm Leak in Pipeline	1120/978	1088/940	1078/929	644/546	615/523	607/516	491/438	471/420	465/415

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
		0.03 Bar	**0.1 Bar**	**0.3 Bar**	**0.03 Bar**	**0.1 Bar**	**0.3 Bar**	**0.03 Bar**	**0.1 Bar**	**0.3 Bar**
32	Catastrophic Rupture	1764/1477	1709/1421	1694/1404	1341/1341	1288/1317	1273/1313	933/835	892/799	880/789
I	**36 inch LNG Pipeline**									
33	5mm Leak in the pipeline	66/54	49/38	44/34	38/26	26/15	23/13	24/-	15/-	12/-
34	25mm Leak in the Pipeline	488/404	314/252	263/208	298/258	195/175	165/151	235/217	160/147	139/127
25	100mm Leak in Pipeline	1860/1596	1151/974	946/794	1200/1007	777/664	655/565	890/822	591/554	504/476
36	Catastrophic Rupture	4145/4096	2764/2555	2379/2123	3934/3859	2384/2340	1977/2009	3597/3571	2494/2418	2271/2084
J	**24inch LPG Pipeline**									
37	5mm leak in the pipeline	69/56	50/39	45/34	40/27	27/16	23/13	26/25	16/15	13/12
38	25mm Leak in the Pipeline	553/438	349/264	290/213	313/259	201/169	168/142	233/223	153/149	130/128
39	100mm Leak in Pipeline	2264/1863	1481/1133	1254/921	1299/1080	819/696	679/585	959/850	621/551	524/464
40	Line Rupture	3820/3599	2570/2264	2221/1897	3425/3308	2080/2036	1725/1728	3010/2563	1936/1618	1677/1344
K	**18inch M-Xylene Pipeline**									
41	5mm Leak in the pipeline	30/30	17/17	13/13	26/23	15/15	13/12	22/-	14/-	12/-
42	25mm Leak in the Pipeline	125/136	83/93	70/81	144/146	96/96	82/82	142/148	89/91	73/74
43	100mm Leak in Pipeline	192/205	145/156	132/142	237/262	180/202	164/185	262/268	196/198	176/177
44	Line Rupture	402/263	223/137	173/101	146/112	77/59	57/43	101/94	55/52	41/40
L	**18inch Methylene Chloride Pipeline**									
45	5mm Leak in the pipeline	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
46	25mm Leak in the Pipeline	34/23	25/15	22/12	22/22	14/14	12/12	22/21	14/13	12/12
47	100mm Leak in Pipeline	232/104	161/75	148/67	115/129	79/91	69/80	131/133	92/92	80/80
48	Line Rupture	630/493	389/286	362/245	312/171	194/106	159/86	133/110	79/64	63/51
M	**18inch MEG Pipeline**									
49	5mm Leak in the pipeline	14/14	11/11	11/11	13/-	11/-	11/-	-/-	-/-	-/-
50	25mm Leak in the Pipeline	33/34	25/25	22/22	33/33	25/25	22/22	33/33	25/25	22/22
51	100mm Leak in Pipeline	50/50	37/37	33/33	69/68	50/50	45/45	68/68	50/50	45/45
52	Line Rupture	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
N	**18 inch Naphtha Pipeline**									
53	5mm Leak in the pipeline	68/55	50/39	44/34	40/27	27/16	23/13	26/-	16/-	13/-
54	25mm Leak in the Pipeline	519/435	351/269	302/221	309/257	199/168	167/142	232/212	153/139	130/118
55	100mm Leak in Pipeline	1816/1877	1236/1189	1217/990	1320/1095	839/708	699/596	977/871	634/565	535/476
56	Line Rupture	3197/3001	2149/1885	1861/1578	2845/2539	1734/1645	1440/1413	2085/1846	1301/1159	1074/960
O	**18inch Phenol Pipeline**									
57	5mm Leak in the pipeline	20/19	14/13	12/12	18/17	13/12	11/11	-/-	-/-	-/-

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
		0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar	0.03 Bar	0.1 Bar	0.3 Bar
58	25mm Leak in the Pipeline	48/49	30/30	25/25	48/48	30/30	25/25	48/48	30/30	25/25
59	100mm Leak in Pipeline	56/56	39/39	34/34	80/80	54/54	46/46	80/80	54/54	46/46
60	Line Rupture	46/48	23/23	16/16	46/45	23/22	16/16	44/55	22/32	16/26
P	**18" Propane Pipeline**									
61	5mm Leak in the pipeline	67/54	49/38	44/34	39/26	27/16	23/13	25/-	15/-	12/-
62	25mm Leak in the Pipeline	515/423	336/259	284/211	304/253	197/167	166/141	228/208	151/138	129/117
63	100mm Leak in Pipeline	1911/1782	1410/1091	1317/891	1259/1043	798/677	664/571	928/822	604/535	510/451
64	Line Rupture	3017/2819	1981/1736	1692/1434	2679/2220	1625/1507	1352/1308	1927/1729	1213/1099	1007/916
Q	**18" Propylene Oxide Pipeline**									
65	5mm leak in the pipeline	37/25	26/15	23/12	24/-	15/-	12/-	-/-	-/-	-/-
66	25mm Leak in the Pipeline	333/280	247/189	222/163	218/181	148/122	127/105	164/158	109/107	93/93
67	100mm Leak in Pipeline	1438/1290	1075/880	970/761	959/814	628/538	532/458	722/659	473/432	401/366
68	Line Rupture	1796/1940	1200/1335	1028/1160	2112/1871	1519/1291	1347/1123	1706/1558	1162/1046	1005/897
R	**18" Propylene Pipeline**									
69	5mm Leak in the pipeline	67/54	49/38	44/34	39/27	27/16	23/13	25/-	15/-	12/-
70	25mm Leak in the Pipeline	504/429	332/267	283/220	305/254	198/167	166/141	229/219	152/148	129/128
71	100mm Leak in Pipeline	1891/1778	1376/1103	1294/907	1264/1058	806/689	673/582	943/837	616/546	521/462
72	Line Rupture	2755/2778	1918/1803	1699/1544	2664/2431	1693/1565	1449/1388	2105/1858	1341/1189	1119/995
S	**18" Vinyl Chloride Pipeline**									
73	5mm Leak in the pipeline	20/-	14/-	11/-	-/-	-/-	-/-	-/-	-/-	-/-
74	25mm Leak in the Pipeline	141/151	101/111	90/100	135/121	99/88	89/78	109/107	77/76	68/68
75	100mm Leak in Pipeline	583/659	399/471	346/417	642/574	472/415	422/369	541/507	384/353	339/308
76	Line Rupture	1077/1181	732/822	644/719	1318/1201	968/862	867/764	1130/1048	792/718	694/622
T	**18 inch 2,4-Toluene Di-Isocyanate Pipeline**									
77	5mm Leak in the pipeline	-/-	-/-	-/-	-/12	-/11	-/10	11/-	10/-	10/-
78	25mm Leak in the Pipeline	27/27	22/22	21/21	27/27	22/22	21/21	27/27	22/22	21/21
79	100mm Leak in Pipeline	35/35	32/32	31/31	35/49	32/43	31/41	49/49	43/43	41/41
80	Line Rupture	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

Table 7-14: Heat Radiation Damage Distances (HRDD) – Tank Farm Area (TFA)

S. No.	Scenario Description	Heat Flux Damage Distance (in meter)			LFL Distance(in meter)					
		4.0 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
A	**Acrylonitrile vessel at Tank Farm Area (TFA) @ 25 ⁰C and atmospheric pressure**									
1	Catastrophic rupture of Acrylonitrile vessel	1769	1247	934	1808	1428	1241	1137	1113	1095
2	10 minute release from Acrylonitrile vessel	2369	1908	1612	4496	5190	4910	4773	4457	2679
B	**Ammonia vessel at Tank Farm Area (TFA) @ -35 ⁰C and 1atm pressure**									
3	Catastrophic rupture of Ammonia vessel	891	716	563	1546	1401	846	819	829	844
4	10 minute release from Ammonia vessel	835	703	467	97	102	110	114	118	120
C	**Butane vessel at Tank Farm Area (TFA) @ -5 ⁰C and 1 atm pressure**									
5	Catastrophic rupture of Butane vessel	2643	1818	1203	7738	5603	4591	3527	2830	2679
6	10 minute release from Butane vessel	1458	1134	936	3544	2366	1541	1272	1111	983
D	**Crude Vessel at Tank Farm Area (TFA) @ 70 ⁰C and 0.6atm pressure**									
7	Catastrophic rupture of Crude vessel	-	-	-	8877	6733	5488	5002	4696	4469
8	10minute release from Crude vessel	842	1035	1354	6082	7082	6579	6200	5987	3901
E	**High Speed Diesel at Tank Farm Area (TFA) @ 40 ⁰C and 0.6atm pressure**									
9	Catastrophic rupture of Diesel vessel	-	-	-	504	379	312	326	340	348
10	10 minute release from Diesel vessel	123	93	75	520	195	151	140	133	127
F	**LNG at Tank Farm Area (TFA) @ -162 ⁰C and 1.1 atm pressure**									
11	Catastrophic rupture of 180,000M^3 LNG vessel	4117	2231	561	23460	36760	19980	12470	10850	9407
12	10 minute release from LNG vessel	5645	4574	3883	10230	13250	11580	10760	12010	9039
G	**MEG at Tank Farm Area (TFA) @ 70 ⁰C and 0.6atm pressure**									
13	Catastrophic rupture of MEG vessel	637	473	-	143	174	184	181	190	198
14	10minute release from MEG vessel	548	384	-	-	-	-	-	-	-
H	**Naphtha at Tank Farm Area (TFA) @ 25⁰C and 0.6atm pressure**									
15	Catastrophic rupture of Naphtha vessel	-	-	-	5526	4181	3468	3291	3193	3136
16	10minute release from Naphtha vessel	1943	1496	1222	5121	4933	4475	4393	2720	2386
I	**Propane vessel at TFA @ -45 ⁰C and 0.6atm pressure**									
17	Catastrophic rupture of propane vessel	3219	1721	368	2297	1898	1691	1695	1722	1734
18	10minute release from Propane vessel	1374	1083	902	2898	2074	1444	1197	1050	935

Table 7-15: Overpressure Damage Distances (OPDD) – Tank Farm Area (TFA)

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
		0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar	0.03 bar	0.1 bar	0.3 bar
A	**Acrylonitrile vessel at Tank Farm Area (TFA) @ 25 ⁰C and atmospheric pressure**									
1	Catastrophic rupture of Acrylonitrile vessel	2914/2618	2133/1767	1933/1558	2450/2367	1540/1410	1332/1195	2317/2274	1335/1277	1125/1077
2	10 minute release from Acrylonitrile vessel	6954/7570	4618/5723	4145/5337	8518/8134	5944/5661	5312/5071	7036/6010	4482/3838	3742/3208
B	**Ammonia vessel at Tank Farm Area (TFA) @ -35 ⁰C and 1 atm pressure**									
3	Catastrophic rupture of Ammonia vessel	2003/1930	1238/1196	1018/993	1849/1808	1086/1017	890/821	1768/1731	986/960	795/771
4	10 minute release from Ammonia vessel	444/437	214/218	147/154	424/423	213/219	152/160	413/414	216/223	159/167
C	**Butane vessel at Tank Farm Area (TFA) @ -5 ⁰C and 1 atm pressure**									
5	Catastrophic rupture of Butane vessel	14520/11280	10050/7430	8789/6399	7751/6373	5302/3823	4723/3401	6005/5717	3540/3335	3067/2832
6	10 minute release from Butane vessel	4480/3672	3941/2891	3740/2620	3270/2635	2278/1852	1908/1561	2268/1991	1604/1411	1357/1195
D	**Crude Vessel at Tank Farm Area (TFA) @ 70 ⁰C and atmospheric pressure**									
7	Catastrophic rupture of Crude vessel	11000/8852	9615/7464	9213/7068	7510/6925	6166/5618	5793/5270	6537/6174	5255/4918	4927/4622
8	10minute release from Crude vessel	6349/7814	5545/7167	5432/7048	8027/7713	6983/6613	6735/6353	7200/5611	6238/4498	6039/4176
E	**High Speed Diesel at Tank Farm Area (TFA) @ 70 ⁰C and atmospheric pressure**									
9	Catastrophic rupture of Diesel vessel	531/401	511/381	505/375	332/322	311/301	305/295	321/311	301/291	295/285
10	10 minute release from Diesel vessel	531/-	511/-	505/-	-/-	-/-	-/-	-/-	-/-	-/
F	**LNG at Tank Farm Area (TFA) @ -162 ⁰C and 1.1 atm pressure**									
11	Catastrophic rupture of 180,000M³ LNG vessel	13340/12590	9337/11520	7847/11380	12030/11970	9308/7941	9050/7327	12190/12530	7672/7542	7039/6677
12	10 minute release from LNG vessel	15450/16349	11320/13290	10220/12810	17980/17380	13760/12600	12380/11090	16080/15580	11560/11820	10380/10420
G	**MEG at Tank Farm Area (TFA) @ 70 ⁰C and atmospheric pressure**									
13	Catastrophic rupture of MEG vessel	487/505	261/287	196/224	493/460	290/278	230/225	447/441	273/278	223/231
14	10minute release from MEG vessel	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
H	**Naphtha at Tank Farm Area (TFA) @ 25 ⁰C and atmospheric pressure**									
15	Catastrophic rupture of Naphtha vessel	10660/9247	7288/5914	6332/4965	8395/5526	5064/4747	4161/3884	7792/7568	4520/4296	3677/3496
16	10minute release from Naphtha vessel	7461/8551	5714/6045	5335/5403	8537/7553	5691/5251	4969/4675	6305/5433	3967/3447	3289/2872
I	**Propane vessel at TFA @ -45 ⁰C and 1.1 atm pressure**									
17	Catastrophic rupture of propane vessel	4526/4116	3224/2810	2753/2342	3786/3620	2507/2355	2059/1945	3494/3412	2270/2196	1893/1842
18	10minute release from Propane vessel	3800/3457	3278/2652	3084/2356	3036/2452	2121/1728	1780/1459	2126/1866	1509/1329	1279/1129

Table 7-16: Heat Radiation Damage Distances-Bullets and Associated Pipelines

S. No.	Scenario Description	Heat Radiation Damage Distance (in meter)			LFL Distance (in meter)					
	Bullet area	4.0 kW/m²	12.5 kW/m²	37.5 kW/m²	F_1	F_2	$E_{3.5}$	D_5	$C/D_{6.5}$	C_8
A	**8” Pipeline from Butane Bullet**									
1	5mm leak in pipeline	15	12	11	15	12	8	7	6	6
2	25 mm leak in pipeline	67	54	46	130	130	101	87	81	74
3	100 mm leak in pipeline	231	183	155	198	185	199	213	216	220
4	Catastrophic rupture of pipeline	511	403	339	234	218	236	258	265	267
B	**8” Pipeline from Propane bullet**									
1	5mm leak in pipeline	18	14	12	14	12	10	9	8	7
2	25 mm leak in pipeline	77	63	54	110	117	122	112	105	99
3	100 mm leak in pipeline	267	216	184	225	234	250	261	262	259
4	Catastrophic rupture of pipeline	453	364	310	261	266	284	300	303	301
C	**8” pipeline from Propylene bullet**									
1	5mm leak in pipeline	18	15	13	15	14	11	9	8	7
2	25 mm leak in pipeline	79	65	56	118	127	133	121	114	107
3	100 mm leak in pipeline	276	223	192	235	245	262	271	272	269
4	Catastrophic rupture of pipeline	438	353	302	268	273	291	307	310	308

Table 7-17: Overpressure Damage Distances –Bullets and Associated Pipelines

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
A	**8” Pipeline from Butane bullet**	**0.03bar**	**0.1bar**	**0.3bar**	**0.03bar**	**0.1bar**	**0.3bar**	**0.03bar**	**0.1bar**	**0.3bar**
1	5mm leak in pipeline	21/20	15/14	12/12	-/-	-/-	-/-	-/-	-/-	-/-
2	25mm leak in pipeline	174/184	132/141	116/126	163/137	127/104	113/92	133/119	103/91	91/80
3	100mm leak in pipeline	270/277	211/215	198/196	283/281	220/220	200/205	278/281	217/213	203/199
4	Catastrophic rupture of pipeline	322/329	262/258	245/234	335/342	265/274	243/256	343/337	274/269	256/253
B	**8” pipeline from Propane bullet**									
1	5mm leak in pipeline	20/20	14/14	12/12	-/-	-/-	-/-	-/-	-/-	-/-
2	25mm leak in pipeline	162/172	127/136	113/123	178/165	145/133	132/122	153/140	123/112	111/101

S. No.	Scenario Description	Overpressure Distance (in meters)								
		F_1/F_2			$E_{3.5}/D_5$			$(C/D)_{6.5}/C_8$		
3	100mm leak in pipeline	257/260	209/215	199/206	266/274	228/237	224/233	274/271	235/228	228/223
4	Catastrophic rupture of pipeline	302/306	251/258	239/248	316/328	274/285	264/283	332/330	287/284	284/277
C	**8" Pipeline from Propylene bullet**									
1	5mm leak in pipeline	21/20	15/14	12/12	20/-	14/-	12/-	-/-	-/-	-/-
2	25mm leak in pipeline	177/186	139/148	124/134	192/178	156/145	143/132	166/154	134/123	122/112
3	100 mm leak in pipeline	267/271	219/225	211/215	277/286	239/249	234/244	286/280	247/239	244/229
4	Catastrophic rupture of pipeline	307/312	256/263	247/253	322/334	281/292	275/286	338/335	294/289	287/283

Table 7-18: Toxic damage distances in various cases of release of chemicals containing toxic content

S. No.	Scenario Description	Toxic damage distances (IDLH)					
		$F_{1.0}$	$F_{2.0}$	$E_{3.5}$	$D_{5.0}$	$C/D_{6.5}$	$C_{8.0}$
1	Failure of 24"**Acrylonitrile** marine loading arm - 85ppm	6428	5789	7648	4900	3958	3263
2	5mm leak of 18" Acrylonitrile pipeline from jetty to tank farm	553	584	311	199	161	127
3	25mm leak of 18" Acrylonitrile pipeline from jetty to tank farm	1574	2724	1450	990	804	669
4	100mm leak of 18" Acrylonitrile pipeline from jetty to tank farm	3702	8109	4594	2919	2312	1851
5	Catastrophic rupture of 18" Acrylonitrile pipeline from jetty to tank farm	4360	8913	3476	1943	1397	1025
6	Catastrophic rupture of 10000MT Acrylonitrile storage tank	18630	46090	18830	7547	6363	5645
7	10minute release of 10000MT Acrylonitrile storage tank	15180	20520	23550	18470	18820	5645
8	Failure of 12" **Ammonia** marine loading arm - 300ppm	3788	14350	9871	5608	4186	3239
9	5mm leak of 18" Ammonia pipeline from jetty to tank farm	417	480	256	169	143	118
10	25mm leak of 18" Ammonia pipeline from jetty to tank farm	1911	3140	1378	869	700	582
11	100mm leak of 18" Ammonia pipeline from jetty to tank farm	11190	11230	5867	3302	2462	1902
12	Catastrophic rupture of 18" Ammonia pipeline from jetty to tank farm	21200	31960	6240	3089	2035	1403
13	Catastrophic rupture of 10000MT Ammonia storage tank	53290	52460	31640	15580	10710	8434
14	10minute release of 10000MT Ammonia storage tank	50000	50000	32400	15900	9960	6493
15	Failure of 24"**2,4-TDI** marine loading arm –2.5ppm	681	813	865	917	981	1053
16	5mm leak of 18" TDI pipeline from jetty to tank farm	66	88	102	63	40	26
17	25mm leak of 18" TDI pipeline from jetty to tank farm	189	248	329	416	279	213
18	100mm leak of 18" TDI pipeline from jetty to tank farm	323	416	501	602	704	801
19	Catastrophic rupture of 18" TDI pipeline from jetty to tank farm	234	377	509	158	138	111

7.1.3.7 Observations

7.1.3.7.1 Damage Contour Mapping

Damage contouring is the representation of damage distances of hazardous scenarios at identified locations on plot plan. Damage contours are drawn for the most credible scenarios as well as for such scenarios which can pose maximum damage to the site and its surrounding area in any study.

However, handling and storage of particular liquid cargo/chemicals/Gas/ Cryogenics etc., will depend on the business requirement as well as readiness of the infrastructure therefore Quantitative Risk Assessment will again be carried out once the exact location for handling and storage is finalized for a particular cargo. This will enable MIDPL to obtain required approvals from competent Authority to facilitate the specific operation.

In the present study, the damage contours are drawn for the following scenarios.

Heat Radiation:

(i) Catastrophic failure of Epichlorohydrin Marine Unloading Arm at Jetty

(ii) Catastrophic failure of LPG Marine Unloading Arm at Jetty

(iii) 25mm leak of 18" Acrylonitrile pipeline from Jetty to Tank Farm Area

(iv) 25mm leak of 18" Epichlorohydrin pipeline from Jetty to Tank Farm Area

(v) Catastrophic rupture of LNG Vessel at Tank Farm Area

(vi) Catastrophic rupture of Propane Vessel at Tank Farm Area

(vii) Catastrophic rupture of 8" Outlet Pipeline from Butane Vessel at Tank Farm Area

Vapour Cloud Explosion (Over pressure damage distances):

(viii) Catastrophic failure of Butane Marine Unloading Arm at Jetty

(ix) Catastrophic failure of Propane Marine Unloading Arm at Jetty

(x) 25mm leak in 18" Epichlorohydrin pipeline from Jetty to Tank Farm Area

(xi) 25mm leak in 24" LPG pipeline from Jetty to Tank Farm Area

(xii) 25mm leak in 18" Naphtha pipeline from Jetty to Tank Farm Area

(xiii) 25mm leak of 12" Acrylonitrile outlet pipeline of storage tank at Tank Farm Area

Toxic Release Damage Distance:

(xiv) 25mm leak of 18" Acrylonitrile pipeline from jetty to tank farm

(xv) 25mm leak of 18" Ammonia pipeline from jetty to tank farm

7.1.3.8 Pool Fires/Jet Fires

The scenario of catastrophic failures of marine unloading arms, pipelines leakage and leaks and catastrophic failure from storage vessels were considered to identify the impact of heat radiation and explosion over pressure on the other units, facility and surrounding area including people living in the vicinity. Damage contours for some of the scenarios not considered as credible were drawn to find out the maximum distances.

In case of catastrophic failure of marine unloading arm for Epichlorohydrin operated at 8atm pressure and -46.4 degree centigrade, the area getting affected due to 37.5kW/m^2 will be around 1287m in radius. This scenario will affect the ship and other facilities in the radius of 1287m. The damage contours are shown in **Figure FD0701.**

Catastrophic failure of LPG marine unloading arm operated at 8atm and -42 degree centigrade, the area getting affected due to 37.5kW/m^2 will be around 1172m in radius. This scenario will affect the ship and other facilities in the radius of 1172m. The damage contours for the scenario is represented through **Figure FD0702.**

In case of leakage of 25mm from 18” Acrylonitrile and Epichlorohydrin pipeline, the chemicals Acrylonitrile and Epichlorohydrin will spread over the land covering an area in 58m and 64m radius due to 37.5kW/m^2 heat radiation. The damage contours are shown in **Figure FD0703** and **Figure FD0704.**

The heat radiation damage distance in case of catastrophic rupture of LNG and Propane vessel which is a critical issue will extend up to 561m and 368m due to 37.5kW/m^2 heat radiation. The damage contours are shown in **Figure FD0705** and **Figure FD0706.**

Catastrophic failure of 8” butane pipeline attached to butane bullet will spread in area of 339m radius due to 37.5kW/m^2 heat radiation. The scenario is shown in **Figure FD0707.**

7.1.3.9 Vapour Cloud Explosion (Overpressure)

The overpressure generates due to explosions in a facility. Some of the scenarios which are considered for heat radiation scenarios were considered for overpressure also and the contours are drawn.

In case of catastrophic failure of marine unloading arm for Butane operated at 8atm (g) pressure and -4.4 degree centigrade, the over pressure distances are reaching up to 2546m radius for a value of 0.3bar. The damage contours are shown in **Figure FD0708**. This scenario will lead to domino effect.

Catastrophic failure of Propane marine unloading arm operated at 8atm (g) and -44.4 degree centigrade, the over pressure distances are reaching up to 2434m radius for a value of 0.3bar. Since the leakage is at jetty, the ships and the working personnel at the jetty will be heavily affected. The damage contours for the scenario is represented through **Figure FD0709**. The occurrence of this scenario is having high potential of domino effects.

In case of leakage of 25mm from 18” Ethylene, 24”LPG and 18” Naphtha pipeline, the overpressure damage distance will spread over the land covering an area in 298m, 290m and 302m radius for a value of 0.3bar. The damage contours are shown in **Figure FD0710, Figure FD0711** and **Figure FD0712.**

For 25mm leak of 18 inch Acrylonitrile pipeline out of Storage tank at tank farm area, the damage distances due to 0.3bar will extend up to 191m in radius. The damage contours are represented in the **Figure FD0713.**

Even though, the over pressure distances are presented, it is to be observed that the chances of vapour cloud explosion in case of flammable liquids are minimum, whereas pool fire occurrence is more likely. The proper action like fire water spray along with aqueous film forming foam (AFFF) during any emergency by the personnel employed at the facility helps in reducing / mitigating / escalation of the event.

7.1.3.10 Toxic Gas Dispersion Effects

The toxic release damage distance (IDLH) for the toxic material handled is given **Table 7-2**. The damage contour for 25mm leak of 18” Acrylonitrile pipeline from jetty to tank farm and 25mm leak of 18” Ammonia pipeline from jetty to tank farm concentration will extend up to 2724 m and 3140 m respectively. These toxic release scenarios are shown in **Figure FD0714** and **Figure FD0715**.

7.1.3.11 Domino Effects

It is observed from the damage contours presented in above sections shows that many scenarios are affecting the other units in the facility. Thermal radiation and overpressure produced during an incident such as heavy leakage and rupture of a pipeline containing flammable material can cause severe damage to nearby storage tanks in the tank farm area leading to another tank on fire and explosion one by one i.e. may initiate a secondary incident in a chain reaction. This phenomenon is called the ‘domino effect’, ‘cascading effect’, or ‘chain of accidents’. The extent of damage depends on radiation or overpressure intensity, the duration of exposure, the type of material, the response of protection (e.g. water deluge) systems - automatic and manual etc. Practical ‘rules of thumb’ found in literature, provide values of thermal radiation or overpressure corresponding to a given degree of damage. American Institute of Chemical Engineers (AIChE) considers heat flux of 37.5kW/m^2 as the limit for severe damage to process equipment, while The Netherlands Organization for Applied Scientific Research (TNO) identifies critical radiation intensities of 100kW/m^2 and 25kW/m^2, for rupture and deformation of structural elements, respectively. In both cases, the duration of exposure is considered to be 15-20minutes. Concerning explosion consequences, TNO suggests the overpressures of 0.5bar - 1bar can cause cylindrical tank displacement or failure of connecting pipes, and overpressures above 1bar can cause failure of spherical tank supports.

Cascade analysis is carried out for all the probable scenarios to know the larger consequences due to these effects. Examining the scenarios with the above criteria, it is observed that all the incidents can cause cascade effects if their affected damage distance are more than 50meters. The damage distance of less than 50m in tank farm area will also create domino effect.

This analysis indicates that the distance between the tanks, trained personnel and the fire-fighting facilities available at the site will play a major role in averting any domino effect. The tanks shall be installed with fire water sprinkler system to provide cooling during fire. Fire hydrants / monitors with remote operation mode at appropriate locations will help in restricting the spread of fire to cover the entire area and prevent the occurrence of the domino effects. By providing fire water sprinkler system in other solid storage (coal) and handling is done will help will avert major fire.

7.1.4 Discussion and Recommendations

7.1.4.1 Discussion

MIDPL is proposing to import, store and export cargos as per **Section 7.1.1.5**, at Kattupalli port as a part of revised master plan development. Proposed Liquid cargo/PoL storage tanks will be provided with sufficient dyke capacity.

All the credible scenarios such as 5mm, 25mm 100mm and full-bore rupture of transfer lines have been considered. In case of any major pipeline leak / rupture the control valves at ship or near the storage tank close the supply.

- The maximum heat radiation damage distances due to pool fire / jet fire due to catastrophic failure of marine unloading arm of Epichlorohydrin for 37.5kW/m^2 intensity is about 1287 m and for 12.5kW/m^2 extends up to 1511 m confined to the facility boundary. The other material damage distances are much lower than the Epichlorohydrin. The impact of the heat radiation will be on port personnel and property.
- The maximum overpressure damage distance for catastrophic failure of unloading arm of unloading arm of Butane for 0.3 bar overpressure extends up to 2546 m and that for 0.1bar up to 2564 m.

Most credible scenarios have been considered for storage tanks in the tank farm area are 10 minutes discharge from storage tanks and catastrophic failure.

- For 10 minute discharge from LNG tank in the tank farm area, the heat radiation damage distances are maximum as compared to other materials stored in the tank farm area. The distances due to pool fire / jet fire / fire ball for 37.5kW/m^2 intensity is about 3883m and for 12.5kW/m^2 extends up to 4574m.
- The maximum overpressure damage distance for 10 minutes discharge from LNG from storage tank extends up to 12380m for 0.3bar and that for 0.1bar up to 13760m.

The catastrophic failure of marine unloading arm for all the materials at jetty has been considered as the ultimate scenario effecting the personnel, ship and the facility.

- In the event of catastrophic failure of marine unloading arm for transferring Epichlorohydrin, the damage distance due to pool fire / jet fire for 37.5kW/m^2 intensity is about 1287m and for 12.5kW/m^2 extends up to 1511. Similarly for LPG MULA failure, the damage distance due to pool fire / jet fire for 37.5kW/m^2 intensity are about 1172m and for 12.5kW/m^2 extend up to 1413m. For other compounds, the distances obtained for heat radiation are lower than these two compounds.
- 0.3bar overpressure for Butane extends up to 2546 m and that for 0.1bar up to 2564 m.

The damage distances for the scenarios like catastrophic failure of storage tank, 100mm leak and 10 minutes discharge are higher than those in case of 5mm and 25mm leakage of transfer lines. The scenario i.e. storage tank failure and pipeline rupture are not much credible as per the historical records obtained from Oil & Gas Processing reports. The failure frequency of these scenarios is 5 x 10^{-6} per year. Whereas scenarios like 5mm, 25mm and 100mm leakage scenarios and leakage from flanges/ gasket and pinhole on storage tanks are much more credible. Regular maintenance, NDT testing, inspection and intelligent pigging of pipelines will help in avoiding any leakage from the pipelines.

The damage distances for all the credible scenarios may lead to domino effect only when the heat sustains for a longer duration of time and hence there should be necessary arrangement of fire-fighting facility as per various national and international codes for the facility to avoid any major incident.

7.1.4.2 Recommendations

The following are the recommendations to minimize the consequence effects due to any accident which takes place and for the safe storage and handling of the hazardous products at the site.

1) It is recommended to follow all the applicable Indian laws such as MSIHC Rules; CA (EPPR) Rules; PLI Act & Rules; Explosives Act & Rules; SMPV Rules; Gas Cylinder

Rules; Factories Act & Rules; ODS (R&C) Rules; Petroleum Act & Rules; Port Act & Rules; Dock Act & Rules etc..

2) Fire-fighting equipment shall be provided as per OISD 117 & 156 and API RP 2021/API RP 2030.

3) Storage tanks, pipelines and other components should meet IS/API/OISD/prevailing International standards for structural design integrity and operational performance to avoid catastrophic failures during normal operation and during exposure to natural hazards and to prevent fires and explosions. Applicable standards typically include provision for overfilling protection, metering and flow control, fire protection (including flame arresting devices), and grounding (to prevent electrostatic charge). Overfill protection equipment include level gauges, alarms, and automatic cut-off systems.

4) It is recommended to install ESDs on all the pipelines at safe distance from jetty so that the facility downstream is isolated in case of an emergency. The consequence of an event is greatly reduced by installing ESDs and thereby reducing the risk to bring it to ALARP

5) It is recommended to develop a detailed Disaster Management Plan prepared for the site with firefighting facilities available and to be provided in future to handle any untoward incident. Organogram with actions and duties assigned/actions to be taken by the responsible authorities. It should be revised for any modifications carried out at the installation.

6) For any changes/modifications in future for the pipelines/storage tanks etc., it is strongly recommended to conduct the Risk Assessment study for the final size of the pipeline, storage tanks etc. This will help in preparing a more realistic Disaster Management Plan to avoid occurrence of any major incident. The existing DMP shall be amended on time to time based on the actual implementation plan by incorporating the findings as per the revised risk assessment.

7) Loading / unloading activities should be conducted by properly trained personnel according to pre-established formal procedure to prevent accidental releases and fire / explosion hazards. Procedures should include all aspects of the delivery or loading operation from arrival to departure, connection of grounding system, verification of proper connection and disconnection of marine loading arm, adherence to no-smoking and no-naked light policies for visiting personnel.

8) Quick isolation of mechanical loading arm in case of spillage from the ship/tanker or pipelines near the jetty to avoid personnel and property loss.

9) Floating roof tanks emit VOCs through both storage and working losses. To minimize evaporative losses, both external and internal floating roof systems use decks, fittings, and rim seals to allow the roof to adjust in relation to the liquid level in the tank. Evaporative losses occur through the rim seals and deck fittings and residual liquid on the tank walls that is exposed during liquid withdrawal activities.

   - Installing decks, fittings, and rim seals according to design specifications of prevailing standards to minimize evaporative losses.
   - Protecting rim seals from wind and weather damage and conducting regular maintenance.

10) To identify the hazards present in the system, a detailed hazard identification study such as Hazard and Operability study (HAZOP) should be undertaken. All hazards identified

should be examined and appropriate mitigating measures developed and implemented. HAZOP close out report should be prepared for all the actions recommended in the report.

11) For all the tanks where there is a single in/outlet line, an ROV (or an equivalent design to allow isolation of the tank from the line in an emergency) should be provided.

12) The remote operable tank isolation valves should be operable locally, from the unloading ship and from the control room. The ROVs should be provided with limit switches. Valve status indication (based on limit switch output) and an emergency shutdown button should be provided in the following locations

    - At the respective ship/tanker loading / unloading points, to close the relevant tank valves, also stopping all pumps associated with that loading operation.
    - In the control room.

13) MIDPL has to ensure that first aid equipment and manpower resources are at place to deal with emergencies, in consultation with emergency services to rescue any personnel, trapped or immobilized by an accident scenario.

14) Install high resolution closed circuit TV camera and hydrocarbon detectors in the tank farm area for any leakage from the flanges / valves.

15) Implement and maintain appropriate safety management systems to control the managerial and organizational factors that can impact on the overall risk associated with the hazardous materials.

16) Regular checks / maintenance and testing of instruments, valves and flange joints as per strict schedule will enhance the safety in the premises. Pipelines, flanges and valves require special attention to minimize the failure rate.

17) All components (e.g. roofs and seals) should undergo periodic inspection for corrosion and structural integrity and be subject to regular maintenance and replacement of equipment (e.g. pipes, seals, connectors, and valves). Cathodic protection system should be installed to prevent/minimize corrosion, as necessary. Epoxy coating for the pipelines may be provided for protection against external corrosion.

18) Guidelines and procedures for entering and cleaning the storage tanks are to be followed as per API RP 2016 / OISD 129 / IS 9964 Part I and II.

19) Prevention of potential ignition sources such as:

    - Proper grounding to avoid static electricity build up and lightening hazards (including formal procedures for the use and maintenance of grounding connections)
    - Use of intrinsically safe electrical installations and non-sparking tools.
    - Implementing permit systems and formal procedures for conducting any hot work during maintenance activities, including proper tank cleaning and venting.

20) It is recommended to provide passive fire protection system for all the structures, pipelines, major equipment on the jetty as they are exposed to jet fire hazard.

21) Consider linking foam and fire water system. Considerations should be given to directly inject AFFF foam compound into the respective fire mains (at 6 percent strength), which can act as a vehicle to transport foam solution to user points on either site for mobile response foam branches / cannons.

22) Facilities should be properly equipped with fire suppression equipment that meets internationally recognized technical specifications for the type and amount of flammable material stored at the facility.

23) Preparation of a fire response plan supported by the necessary resources and training, including training in the use of fire suppression equipment and evacuation. Procedures may include coordination activities with local authorities or neighbouring facilities.

24) Provide drainage around POL tanks to assure spills collect away from tank. Provide bund to assure that spill areas are minimum in size.

25) The Cascade effects may be caused mainly due to various scenarios mentioned earlier Sections. The probabilities of occurrence of such an incident's are $8.8x10^{-8}$ per meter per year and 3.3×10^{-7} per meter per year respectively and hence are remote. Even in the event of such an incident occurring, the presence of an ignition source can lead to fire and explosion hazards. The probability of the presence of an ignition source is also very remote and the probability of ignition with no ignition sources is about 0.1 and the probability of explosion given an ignition is also about 0.1 (Lees, 1996). Hence the risk for cascade effects is negligible.

26) Onsite emergency plan should be prepared and updated from time to time and fine-tuned if required taking into consideration the hazard potential due to proposed pipelines and storages as indicated by the present report. This will help in handling the actual emergencies efficiently and in keeping the damage to minimum extent possible.

27) Provision of fire safety training and response as part of workforce health and safety induction/training, including training the use of fire suppression equipment and evacuation, with advanced fire safety training provided to a designated fire- fighting team.

28) Safety measure as given from **Section 2.5.11** to **Section 2.5.16** of this EIA report shall be ensured

29) Do's and Don'ts shall be displayed prominently in the site near the pipelines and at all workplaces. Regular maintenance shall be carried out under the supervision of an authorized person.

30) Important telephone numbers of emergency shall be displayed prominently in bold letters in the plant site and administration building.

31) Caution boards shall be displayed near the pipelines for all working person.

- No smoking signs
- No flames or pilot lights or electrical gadgets.
- Emergency contact numbers.
- Keep distance from pipelines. Pipeline is guarded during any maintenance work to avoid hitting any object to it.

7.2 Disaster Management Plan (DMP)

The important aspect in emergency management is to prevent by Technical & Organizational measures, the unintentional escape of hazardous materials out of the facility and minimize accidents and losses.

Disaster - Disaster means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade cause, or by accident or negligence which result in substantial loss of life or human suffering or damage to, or degradation of, environment, and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Disaster Management - Disaster Management implies continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary as expedient for

- Prevention of danger or threat to any disaster
- Mitigation or reduction of risk of any disaster or its severity or consequences
- Capacity building
- Preparedness to deal with any disaster
- Prompt response to any threatening disaster situation or disaster
- Assessing the severity of magnitude of effect of every disaster
- Evacuation rescue & relief
- Rehabilitation and reconstruction

National Disaster Management Plan (November, 2019) Vision states that "Make India disaster resilient across all sectors, achieve substantial and inclusive disaster risk reduction by building local capacities starting with the poor and decreasing significantly the loss of lives, livelihoods, and assets in different forms including economic, physical, social, cultural, and environmental while enhancing the ability to cope with disasters at all levels".

The port area represents a complex interphase between human activities and natural environment. Inherent to its location, a port is exposed to natural calamities like cyclones, floods, earthquake, Tsunami and similarly human activities may lead to hazardous situation arising out of handling and storage of dangerous goods and shipping incident caused by collisions, grounding, sinking and oil spillage. The mitigation of these major incidents requires coordinated effort involving inter department and external organization. Environment Protection Act, 1986 stipulates that there should be an On-Site & Off-site Contingency and Disaster Plan for each industry/facility.

7.2.1 Kattupalli Port Existing DMP

Emergency response and Disaster Management Plan has been prepared for existing Kattuaplli Port and being implemented by Kattupalli Port including development of an effective On-site & Off-site Contingency and Disaster Management Plan for Co-ordination between District Administration, Tamil Nadu Maritime Board, Fire Service, Police Department, Medical Services, Transport Department, etc. was ratified by District Administration.

The On-site & Off-site Contingency and Disaster Management Plan has been developed as per guidelines of National Disaster Management Act, 2005 to establish a framework for a coordinated inter agency and port community response to a significant Disaster incident occurring within MIDPL and to mitigate the effect of an unfortunate events which has the potential to affect persons and environment outside the boundary of MIDPL as well as other installations, enlisting detailed responsibilities of different agencies.

The Disaster Management Plan being implemented in Kattupalli port approaches the six elements i.e., Prevention, Mitigation and Preparedness In pre-disaster phase, and Response. Rehabilitation and Reconstruction in post-disaster phase.

The very purpose of this plan is to activate the emergency response organization smoothly and effectively, once the emergency is declared. The plan details the arrangements for responding to emergency scenarios, covering in details the following aspects:

- To assess and define emergency including level of risk
- To contain the incident and bring it under control
- To coordinate with mutual aid members and Government authorities
- To minimize damage to lives, property and the environment
- To rescue and evacuate workers to safe areas
- To provide necessary assistance to casualties

This response plan will identify what needs to be done during various situations and how it needs to be done. However, the action plan to achieve the recommended objectives can only be met if all the assigned responsibilities either for a particular person or dept. are performed.

7.2.1.1 Assumptions

For this plan to be effective, it is necessary that:

- Coordinators, key personnel and other emergency response personnel are familiarized with this action plan.
- On-site resources are mobilized in minimum time.
- Assistance from outside agencies is readily available.
- The drills for identified emergencies are regularly exercised.
- The emergency responses are reviewed and updated based on latest developments, other information and requirements in order to improve effectiveness of the MIDPL-ER & DMP

7.2.1.2 Classification of Emergencies

Different types of emergencies that may arise at MIDPL can be broadly classified as:

a) Nature – I (On – Site Emergency):

Any Incident that possess the potential to cause injuries to personnel & damage to property and Environment in the vicinity of incident & which can be controlled within company by plant personnel without outside help.

It can be further subdivided into two levels:

Level – I The emergency is perceived to be a kind of situation arising due to an incident which is confined to a small area and does not pose an immediate threat to life and property and which can be handled with the resources available within the premises.

Level – II The emergency is perceived to be a kind of situation arising due to an incident which poses threat to human lives and/ or property, having potential to affect large area within the factory premises. This kind of situation is beyond the control of internal resources and requires mobilization of additional resources from other sections/ departments and help from outside agencies. The situation requires declaration of On – Site emergency.

b) Nature – II (Off – Site Emergency – Level III)

Outside emergency deals with measures to prevent and control emergencies affecting public and Environment outside the factory/premises.

The emergency is perceived to be a kind of situation arising out of an incident having potential threat to human lives and property not only within MIDPL but also in surrounding areas and environment. It may not be possible to control such situations with the resources available within MIDPL. The situation may demand prompt response of multiple emergency response groups as have been recognized under the District Emergency plan for Kattupalli Port. A similar situation in neighbouring industry that may affect MIDPL and also falls under this category. Only Site Main Controller will be having the authority to declare Level – III Emergency.

7.2.1.3 Identification of potential Emergency situation

MIDPL has established procedures to conduct HSE meetings, HSE audits, HSE walk and risk / aspect assessment to identify potential accident and emergency situations in the plant. The emergency situations, besides natural / man-made calamities, which have potential to cause serious injuries or loss of lives, damage to property and serious disruption inside and outside the organization or to environment, have been identified as fire, explosion and toxic/corrosive liquid release due to following locations / reasons – apart from physical common hazards Eg. fall from height, electrocution, fall of material, drowning etc.

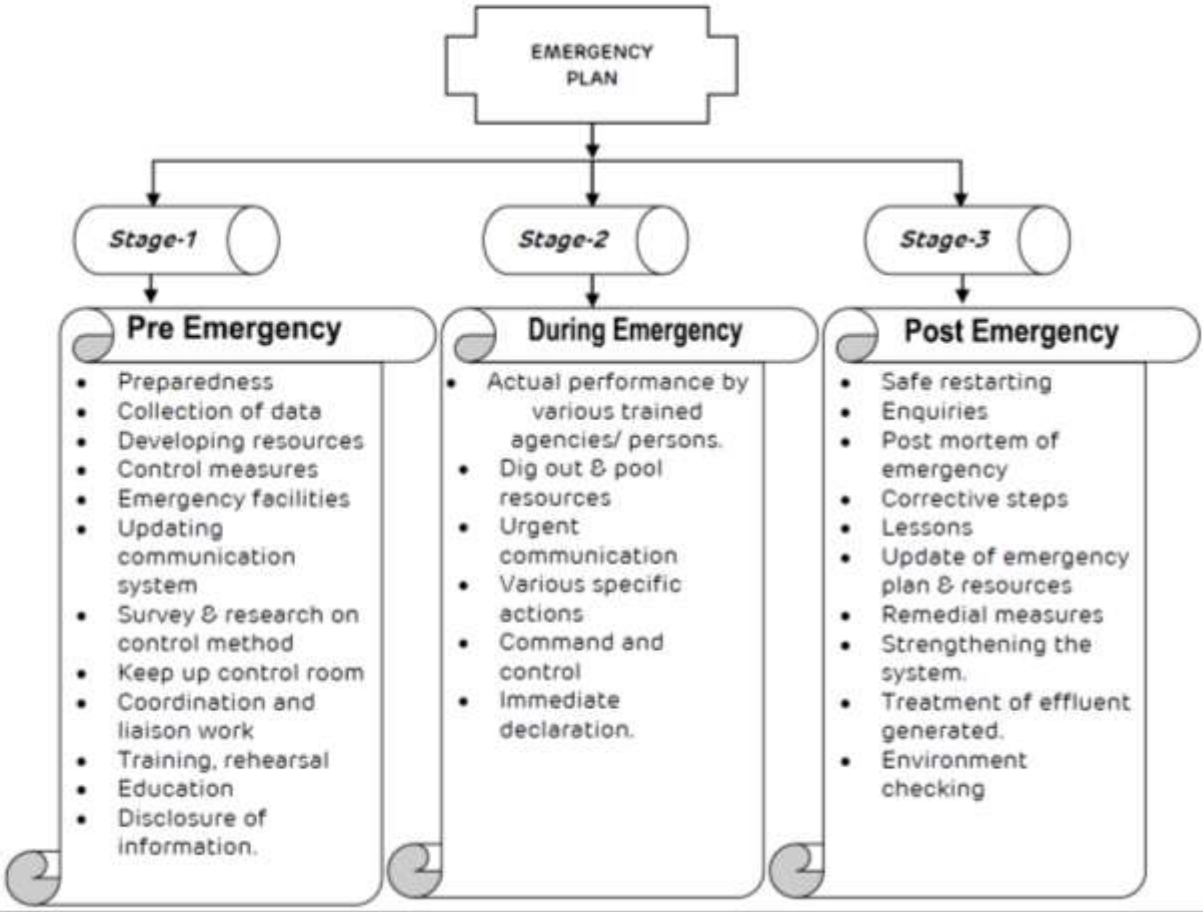
Site location and probable failure / hazard	Type of incident
Gas cylinders	Fire, explosion
Harbour and yard (collapse/fall of EOT, gantry, RTG crane, hydra, fall of person, drowning, vehicular hazards)	Personal injury to more than 1 person
Oil, chemical spillage, leakage, spill of radiation	Land contamination, water contamination, fire , personal injury
Neighbouring industries	Flammable gas release

7.2.1.4 Potential Emergencies

S. No.	Emergencies
1.	Cyclonic Storm/Hurricane
2.	Earthquake
3.	Tsunami
4.	Flood
5.	Industrial unrest
6.	Bomb Threat /drone attack
7.	War
8.	Food/ Water Poisoning
9.	Fire / Explosion
10.	Transportation / Storage Accidents involving Hazardous Material- leakage of flammable, corrosive, toxic substance or radiation
11.	Medical Emergencies & Response
12.	Marine Emergency
13.	X-Ray Radiation

7.2.1.5 Stages of Emergency Plan

The plan consists of the actual performance of duties & responsibilities by designated personnel and other agencies. Therefore, the plan is divided into three stages.



7.2.1.6 Roles and Responsibilities

For control of an emergency, MIDPL has established an Emergency Response Organization headed by **Managing Director (alternate – next Sr. Officer In-charge)**, who shall be the Site Main Controller. This emergency response organization will provide the command and control structure to coordinate and direct the response to an emergency, and depending on the circumstances of the emergency will consists of:

Management Team

- Business Head (Site Main Controller)
- HSE & Fire – HOD or senior most functionary of the department
- Site Incident Controller – HOD or senior most functionaries available at site
- Deputy Site Incident Controller – Section Head

Primary Support Team

Coordinators (HOD or senior most functionaries)

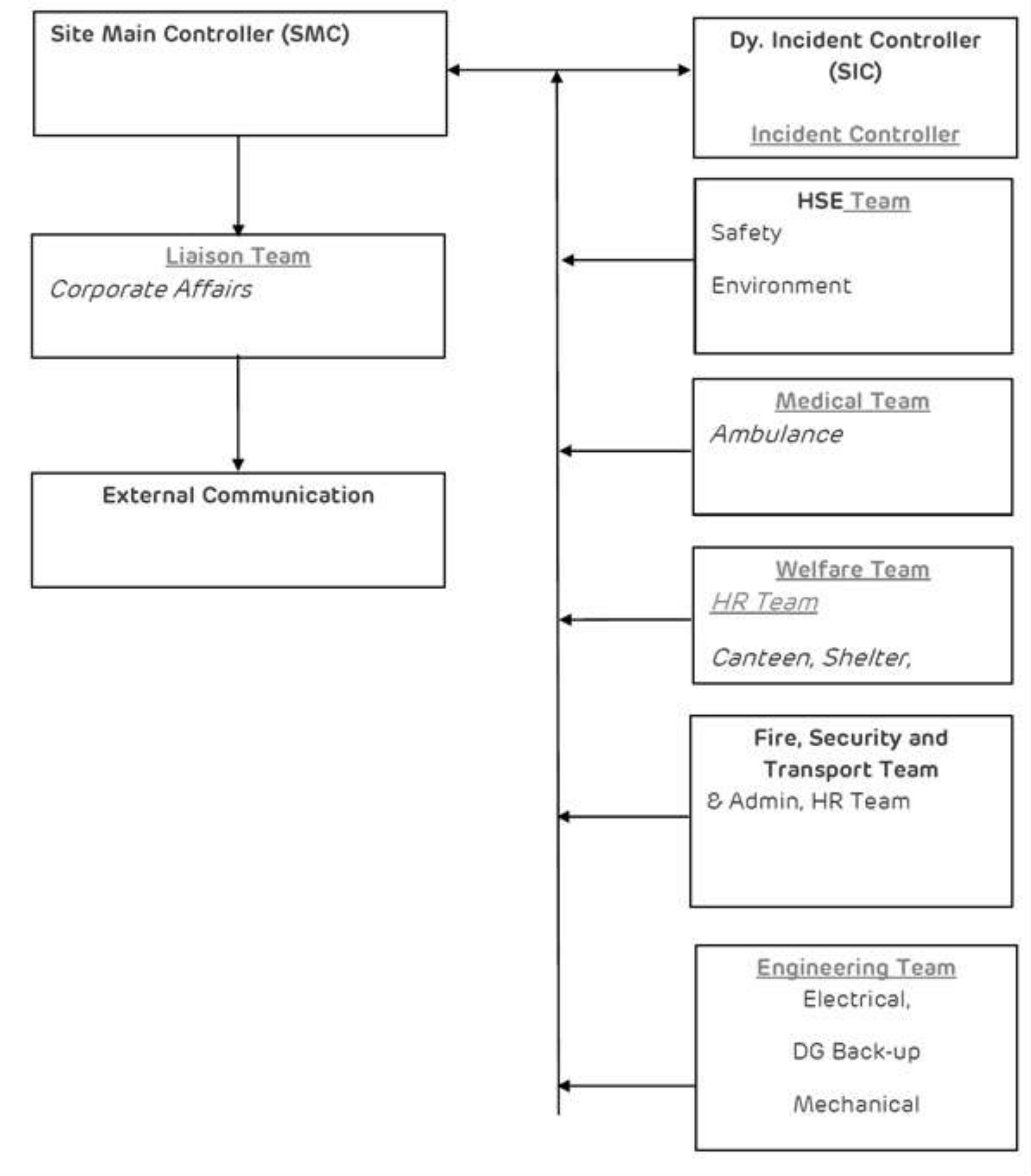
- HSE & Fire Services
- Marine
- Security Services
- Occupational Health Centre
- Engineering Services
- Human Resource
- Administration

Secondary Support Team

Coordinators (HOD or senior most functionaries)

- Finance & Accounts
- Commercial
- Administration (Transport Cell)
- Administration (Welfare & Canteen)
- Corporate Communication

7.2.1.7 Organization Chart for Onsite Emergency Plan

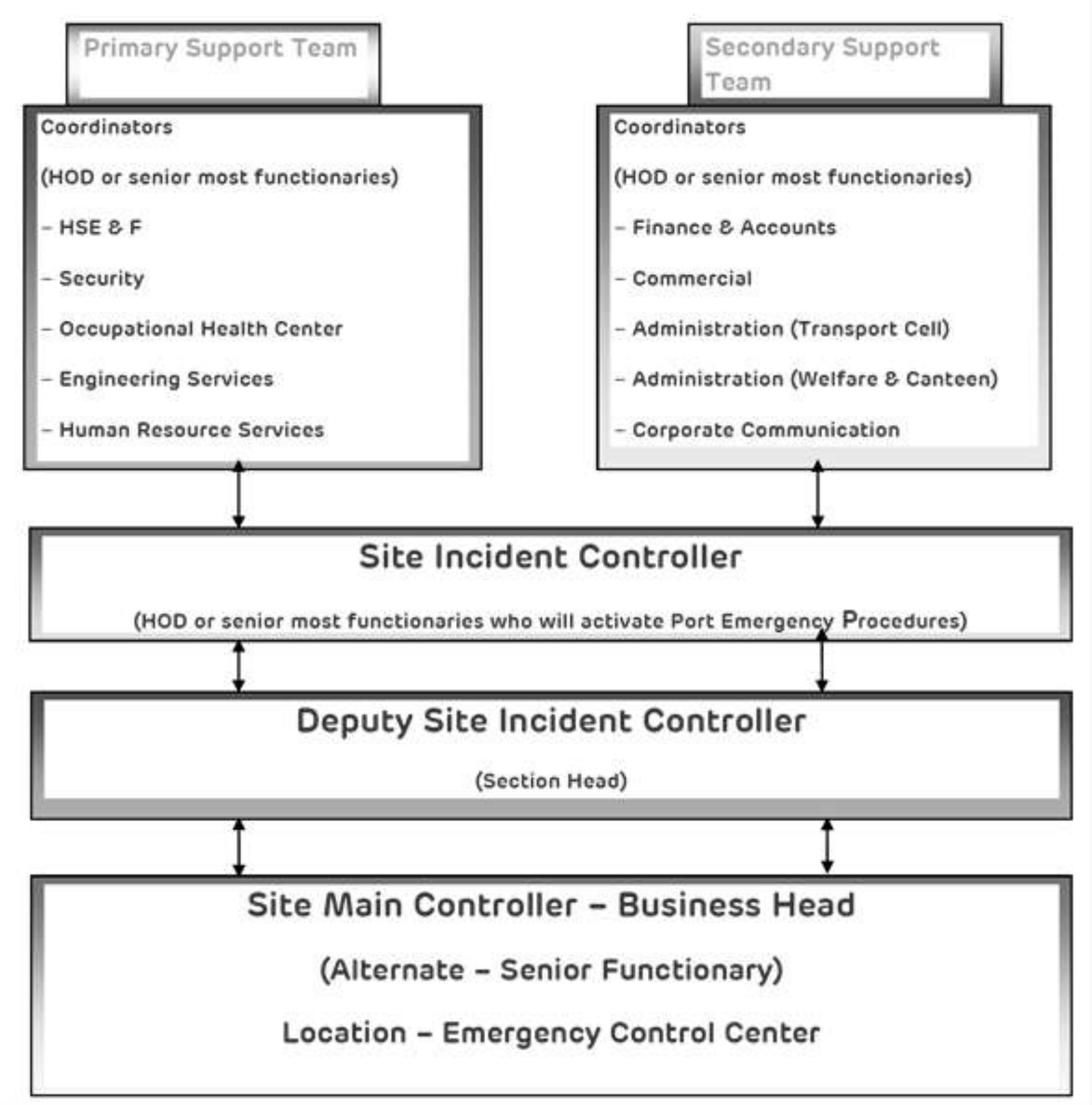


Only Site Main controller can activate the emergency response organization. An Emergency Control Center has been established in the Marine Control Room (Alternate – Security Control Room – Port Operation Building).

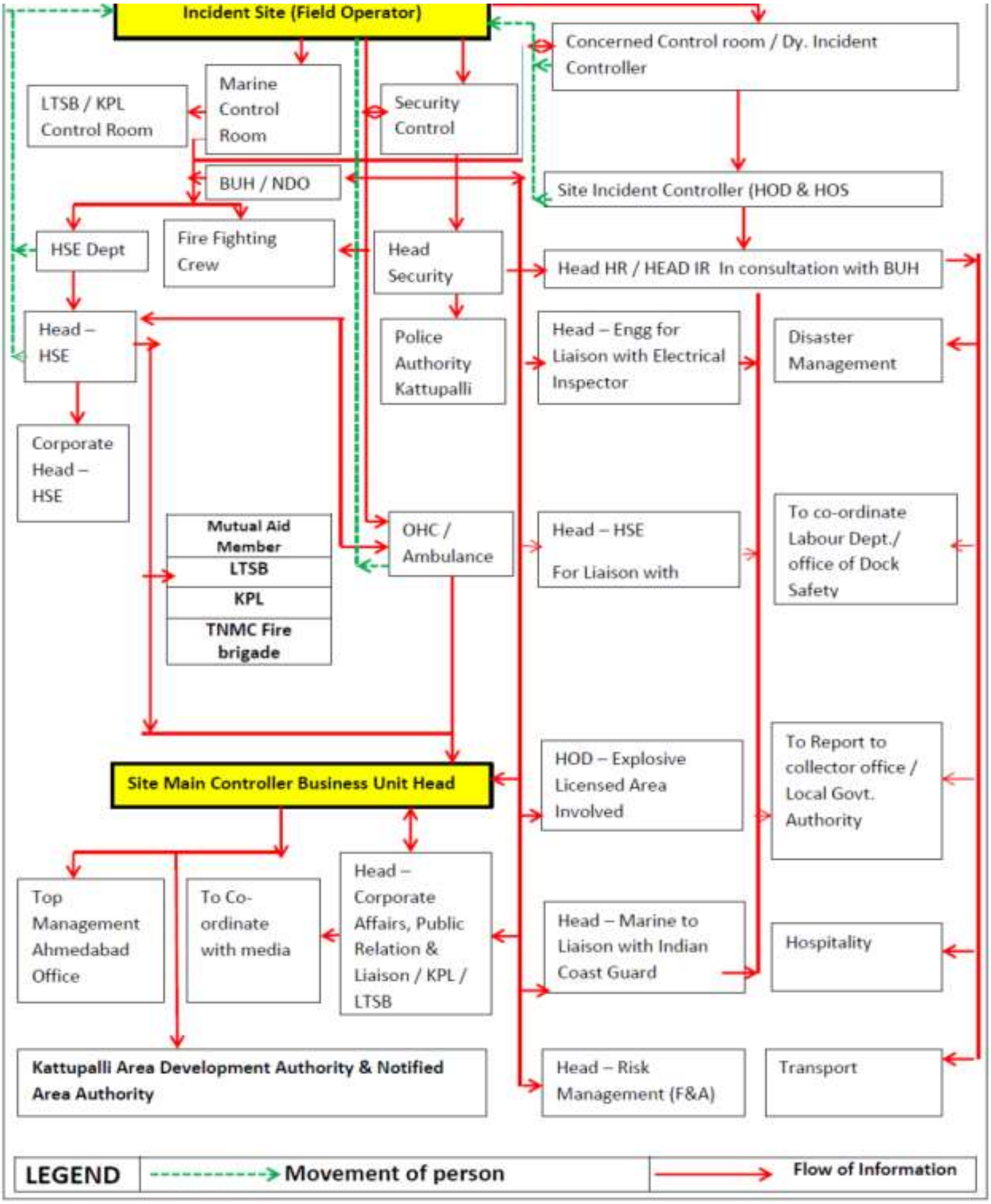
The primary role of the emergency response organization in an emergency shall be:

- Determine the degree to which the emergency response organization shall be activated.
- Determine extent of actual action required, organize and render assistance to Site Incident Controller.
- Coordinate with all other concerned.

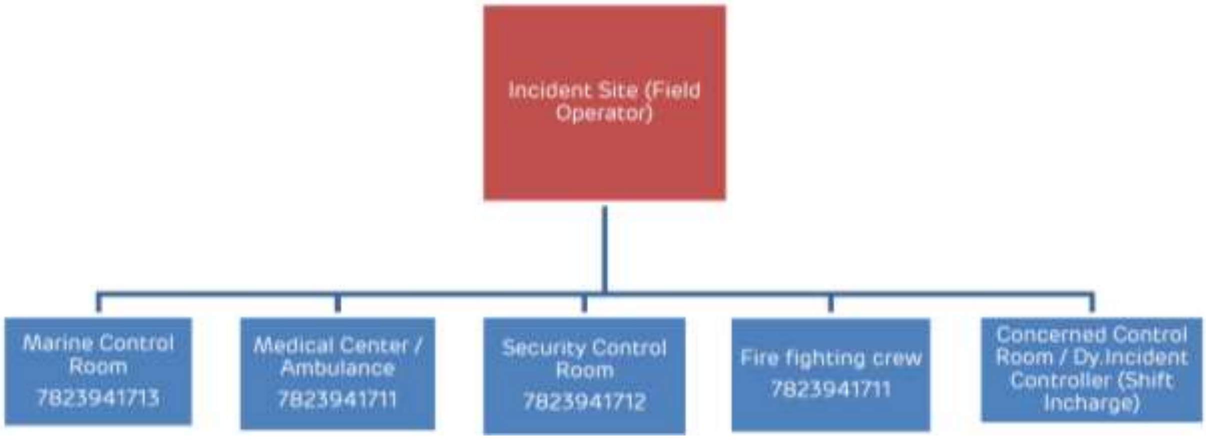
7.2.1.8 Emergency Team Reporting Plan



7.2.1.9 Emergency Response Flow Chart



7.2.1.10 Flow of Information



7.2.1.11 Duties and Responsibilities

7.2.1.11.1 Site Main Controller

- Has overall responsibility for the conduct of all emergency operations within the port complex. During off-duty hours, he will coordinate with NDO/ Deputy Incident Controller and if required rush to the site and take control of the situation from the NDO/ Deputy Incident Controller.
- The Operational Head (OH)/ BUH will be stationed at the Marine Control room.
- Shall immediately assess the situation and its consequences, formally declare the level of emergency and order appropriate action with minimum extent of casualties.
- If required, he will discuss with Incident Controller, Head-HR and Head – HSE and instruct concerned person to call for help from outside or to Govt. authority for escalation of response action including Offsite emergency declaration.
- Responsible for the overall effective & swift emergency response

7.2.1.11.2 Night Duty Officer

The NDO is bound to act as the 'Site main controller' during emergencies that happen at night in the absence of OH /BUH. He will station himself at the Marine Control Room. He will be in touch with Deputy Incident Controller at incident site and appraise concerned HODs. He will inform the status and hand over the charge of SMC to OH/BUH once he reaches site.

- Has overall responsibility for the conduct of all emergency operations within the port complex.
- Shall immediately assess the situation and its consequences, will stay in contact with the OH/ BUH and in coordination with him declare the level of emergency and order appropriate action with minimum extent of casualties.
- If required, he will discuss with Incident Controller, Head-HR and Head – HSE and instruct concerned person to call for help from outside.
- In case of instructions from OH/BUH, NDO will inform Govt. authority for escalation of response action including Offsite declaration.
- Responsible for the overall effective & swift emergency response.

7.2.1.11.3 Site Incident Controller

The Shift in-charge is bound to act as the 'Site incident controller' during emergencies that happen at night in the absence of the respective HOD. He will be in touch with Site Main

Controller at incident site and appraise concerned HODs. He will inform the status and hand over the charge of SIC to HOD/ HOS once he reaches site as required by the OH/BUH.

- He shall take charge of incident and remedial actions.
- Shall ensure that all emergency teams are available at site and necessary resources are available.
- He will remain in constant communication with respective control room and Emergency control Centre to update site situation and also render any assistance required.
- He shall keep coordination with all primary support teams at incident site.
- He shall ensure that Rescue, Medical assistance is provided with minimum response time.

7.2.1.11.4 Emergency Support Officers- Area Officers/Key personnel

Shall immediately assess the scale of emergency and report to Site Main Controller for instructions/directions.

- Shall be responsible for operations in affected area with priorities as under:-
    - Safety of personnel, property and equipment
    - Pollution and environmental impact control
    - Damage and loss control
    - Minimum curtailment of port activities
- Shall liaise with other heads of department for their support and assistance.
- Shall ensure continual reporting of situation to Site Main Controller and shall recommend calling for external resources as appropriate.

7.2.1.11.5 HOS-Administration (Transport Cell, Welfare & Canteen)

- Shall report to Site Incident Controller immediately and assist him as directed.
- Shall coordinate the activities of administration units.
- Shall arrange for transportation of whatever nature for use in the situation.
- Arrange for hot drinks / snacks / foods as requires at incident location.
- Arrange for transport of higher authorities to the terminal
- Transport vehicles would be provided near emergency control center.

7.2.1.11.6 HOD-Human Resources

- Shall report immediately to Site Incident Controller and assist him as directed.
- Shall ensure Assembly Points are manned and all persons reporting there properly identified.
- Shall ensure that persons reporting are assembled in a manner so that counting is easy.
- Shall arrange to record full details of all persons affected by the incident and to inform next of kin as appropriate.
- Shall inform and liaise with local bodies and authorities in respect of the incident/ emergency.

7.2.1.11.7 HOD-Corporate Affairs

- Shall assume the role of Public Relation Officer (PRO) for communication, dissemination of information, status and facts (preparation of communiqués, statements etc.)
- Shall co-ordinate with business related statutory and Government organization.

7.2.1.11.8 HOD-Engineering Services

- Shall ensure immediate electrical isolation of the incident location thereafter; arrange availability of power after ascertaining safety of doing so.
- Shall liaise with the Engineering Services of organizations in close neighbourhood for sourcing of supplemental equipment resources and assistance.
- Arrange for emergency lighting / power should the need arise through the shift electrician.
- Organize for evacuation of material inventory should there arise the possibility of fire.
- Ensure that machines such as lifting tools, tackles, pump, torch lights, ropes etc. are available for emergency purposes in good conditions at all times.

7.2.1.11.9 HOD-Security

- Stop the visitors' entry and he shall ensure for access control and restriction of unauthorized entry at port premises.
- Instruct the security to occupy pre-determined post for controlling security of installation.
- Call up additional help from Barracks.
- Ensure that unauthorized persons / vehicles do not enter the gate.
- Provide security men for firefighting & rescue.

7.2.1.11.10 HOD-Finance & Accounts

- Shall report immediately to Site Incident Controller and assist him as directed.
- Shall ensure availability of funds and cash for all emergent requirements.
- Shall depute all available department personnel to assist HR in their activities.
- Shall ensure that under writers, shareholders, lenders, bankers and other Financial Institutions and statutory bodies are kept advised of the situation as appropriate.

7.2.1.11.11 HOD-Stores/ Commercial

- Ensure availability of materials required by the Site Incident Controller.
- Issue materials from central stores round-the-clock (if required).
- Arrange emergency procurements from local dealers/ vendors or from neighbouring industries.
- Arrange transportation of materials from central stores to the site of incident in coordination with the Coordinator (Transport Cell).

7.2.1.11.12 HOD-Fire Services

- He will report to Site Incident Controller and has the single motive – concern for safety of personnel during emergency response operations.
- He will lead and guide the fire crew.
- He will ensure that the firefighting, rescue and search operations are carried out in safe manner.
- He will ensure that additional firefighting media, manpower or resources are available and used.
- He will ensure safety of fire crew members and fire fighting vehicles.

7.2.1.11.13 HOD-Safety

- He will normally function as an advisor to the Site Incident Controller.
- Coordinate with Commercial/other resources to mobilize additional resources, viz. spill containment equipment/ firefighting equipment/ personal protective equipment, spare breathing air cylinders etc., as may be required at the site of incident.

- He shall ensure that critical spares and equipment related to safety are identified and minimum stock is available at store.
- He shall ensure that immediate treatment has been given to causality.
- He shall ensure availability of ambulance round the clock

7.2.1.11.14 HOS-Occupational Health Center

- Contact Site Main Controller. Report at Emergency Control Center or at Occupational Health Center as instructed by the Site Main Controller. He shall ensure that ambulance with paramedics/self-report to incident site in time.
- Organize first aid arrangements for the affected persons at the site of incident (in cold zone) as may be necessary.
- Ensure that adequate paramedical staff, equipment and medicines are available at the Occupational Health Center. Mobilize additional resources (if necessary).
- Liaise with the local medical authorities and city hospitals, if the casualties are high and situation demands external medical help.
- Coordinate with the Coordinator - Transport for transporting victims to various

7.2.1.11.15 HOS-Information Technology

- Shall ensure that internal and external communication systems are available.
- He shall ensure that all IT related infrastructure / resources are available for emergency team in working condition.

7.2.1.12 External and Mutual Aid

In case of an emergency, which poses threat to human lives or/ and property, within MIDPL as well as in the surrounding neighbourhood areas, it may not be possible to control such situations with the resources available at MIDPL. In such situations, additional resources are mobilized from other department, agencies, which include:

- Neighbouring Industries (Mutual Aid Members)
- Government Authorities

If it may not be possible to confine the emergency situations within the MIDPL area, in such situations, information will be passed on to Govt. Authorities to activate Off Site Emergency Plan.

7.2.1.12.1 Mutual Aid Members

MIDPL is having good relationship with nearby industries. MIDPL is also exploring tie-up with various industrial associations working in the region having members from other major industries of the area. The mutual aid members shall:

- Respond promptly to the emergency call as and when communicated.
- Send their fire tenders/ crewmembers along with necessary supplies/ materials at the site of incident (as requested) and report at the MIDPL Security Gate and get instructions from security personnel on duty. These resources and personnel shall be deployed as directed by Site Incident Controller.
- The crew in–charges of the mutual aid members shall be responsible for safety of their crew engaged in emergency operations.

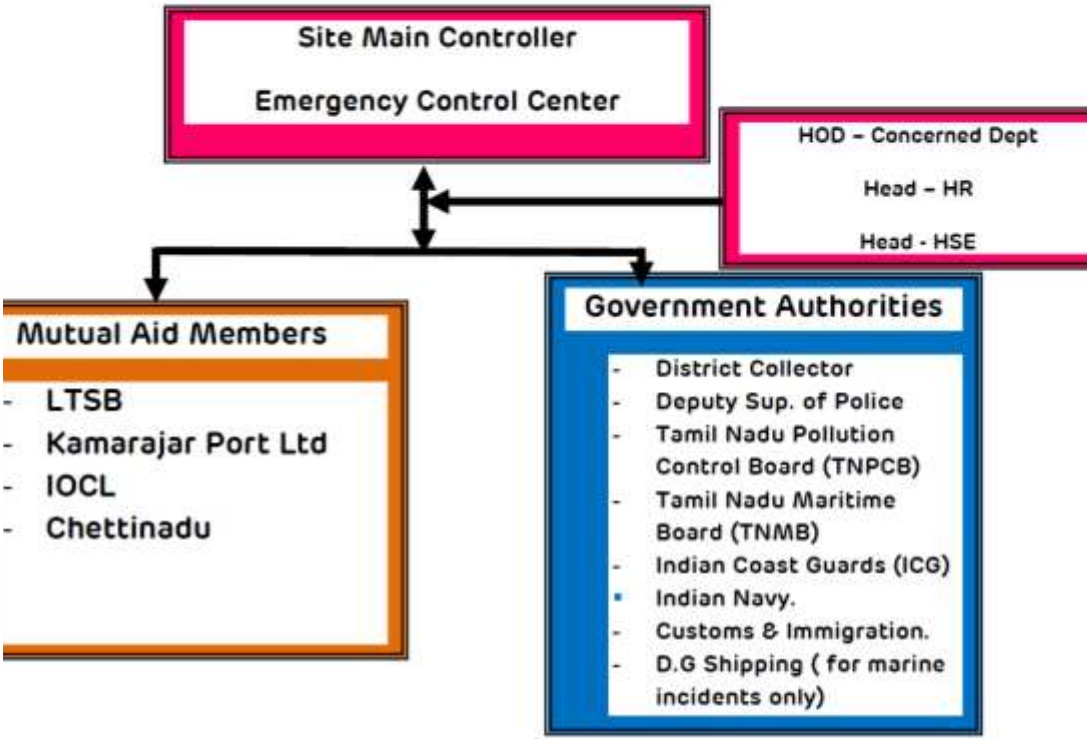
7.2.1.12.2 Government Authorities

If the situation demands response from multiple groups / teams, MIDPL shall report and may seek assistance from various Government Authorities as have been recognized under the District Disaster Management Plan.

These may include:

- District Collector
- Fire Department (Home Department, Government of Tamil Nadu)
- Police Commissioner
- Tamil Nadu Pollution Control Board (TNPCB)
- Tamil Nadu Maritime Board (TNMB)
- Indian Coast Guards (ICG)
- Indian Navy
- Immigration & Customs
- MMD / Director General Of Shipping
- Radiation protection office

7.2.1.12.3 External Aid Providers



7.2.1.13 Emergency telephone numbers

S. No.	Designation	Mobile No.	Office
1	BU Head	9099005552	69201
2	Operational Manager	8980048850	69160
3	CEO office	9418007872	69212
4	Head – HSE	9840463354	69170
5	Head - Marine	8980048817	69199
6	Head - LT	8980048821	69178
7	CT – Operation	7574894379	69181
8	HSE	7823990358	69171
9	HSE	7299990151	69171

S. No.	Designation	Mobile No.	Office
10	Fire	9790805142	69171
11	Engg. Service	7299972522	69144
12	Engg. Service	7299991959	69148
13	Head - Security	8980016218	69036
14	Head – HR	6357160093	69043
15	IR / Admin	9941015554	69130
16	Head - Commercial	7069083024	69110
17	Store	7299990767	69198
18	Marine	9841044132	69197
19	Security Control Room	7823941712	69044
20	Fire & Safety Control Room	7823941711	69171
21	Occupational health Centre	27969156	69156
22	Ambulance	27969156	69156
23	Corporate Head – OH&S	9099900383	58363
24	Head - Corporate Affairs	98843 05901	69207
25	Marine Control Room- Radio officer	27969050	69050
26	LTSB - Control room	7823940059	-
27	KPL - Signal station	04427950013	-

(Source: Emergency Response and Disaster Management plan of MIDPL, Kattupalli port)

7.2.1.14 Emergency Kit, Fire Fighting Facilities, Safety Arrangement

The following items of hazard / emergency kits are under procurement/have been procured.

Protective Clothing

- Proximity suit – 2 nos.
- High voltage lineman's gloves – 2 nos.
- Overalls – 10 nos.
- Goggles (polycarbonate lens) – 5 nos.
- Hard hats – 10 nos.
- Boots (steel toe) – 2 nos.
- Safety harness – 4 nos.

Breathing Apparatus

- Positive pressure self-contained breathing apparatus – 1 no.
- Spare cylinders – 1 no.

First Aid Equipment

- Extinguishers capable for handling Class A, B, C and D fires. – 268 nos.
- First aid kit – 07 nos.
- Resuscitator– 1 nos.
- Well-equipped ambulance – 1 no.
- First Aid Trained personnel

Spill Care Kit

- Heavy Duty Sorbent pads (15”X19”) – 12 nos.
- Sorbent Booms (5” X 10”) – 03 nos.
- Polypropylene sorbent Pillows (18” X 18”) – 03 nos.
- Sorbent roll (30” X 150’) - 02 nos.
- Nitrile Gloves – 02 pairs
- Safety Goggles – 01 nos.
- Disposable bags – 01 nos.

- Disposal Coveralls – 4 nos.
- Barricading Tap – 01 nos
- Instruction Book – 01 Nos
- Chemical Gum boots – 01 Nos
- ABEK Mask – 01 Nos

Monitoring Devices

- pH paper strips
- Indication wind system – Wind Sock - 2 nos
- Hand held Multi Gas Detector – 1 no.

Adequate Number of Fire Tender

Fire Tender - 1no (having capacities of 5000 liters of water + 500 foam) with adequate numbers of other firefighting equipment.

Personal Protective Equipment

Sufficient nos. of PPEs viz. Safety Helmets, Safety Shoes, Safety Goggles, Hand Gloves, Ear Plugs / Muffs, Dust Masks, Life Jackets, Hi visibility jackets, Full Body Harness etc. considering the work strength as well as buffer stock will be kept ready for routine consumption and to deal with any emergency.

7.2.1.15 Fire Fighting Facilities / Systems Are Available At MIDPL

General

- Adequate firefighting systems are provided for protection of berths, buildings and facilities of the port.
- The firefighting facilities are based upon OISD guidelines.
- The pumps and fire water pipe network system are provided to serve hydrants suitably located around the entire premises with Extinguishers, Hydrants, Hose boxes and Monitors. The Fire & Safety staff of the MIDPL Port covers the entire premise and provides suitable fire protection coverage with mobile equipment, personnel, etc.

Fire Station

The Fire station is the Control Centre of the Fire & Safety concerned matters. The Fire Station Control Room is active continuously 24 hours a day, 365 days a year. The control room is equipped with modern communication gadgets like, Wireless set, internal telephone & Mobile phones. Apart from the communication systems, the Fire fighting vehicle - Water Tender is stationed there. All sorts of firefighting equipment and appliances are stowed in the Fire Station.

The below given is the list of some of the equipment stowed at Fire Station.

- Spare fire extinguishers and foam compound drums (25% of distribution quantity) – 56nos.
- Delivery Hose pipe – 15 nos.
- Branch Pipes & Foam making equipment. – 25 nos.
- Fire suits – 2 nos. (Foam tender)
- First aid kit – 01 nos. (Foam tender and Water tender)
- Safety Harness – 2 nos.
- Ropes – 5 nos.
- SCBA – 01 no. (Foam tender & Water tender)

- PPEs - goggles, Apron, shoes, gloves, nose mask, gumboots – Sufficient in spare qty.

7.2.1.16 Drills & Training

Emergency response drills are conducted on quarterly basis to ensure effective response by not only the staff within MIDPL complex but also by external aid members (as required). The participation & actions will depend on the level of emergency drill planned, as per **Table 7-19**.

Table 7-19: Levels of emergency drills

Drill	Duration	Port Level	Complex Level (MIDPL + LTSB / KPL)	Multi Stakeholder Level	Notes
Siren Testing Drill(Proposed)	2 Minutes	Every Week (Tuesday)	--	--	Test of siren condition.
Emergency Response Drill	1 – 2 hours	Monthly	Yearly	Yearly	Consists of interactive discussions of a simulated scenario among members of Emergency response team and also involve mobilization of personnel & equipment.
ISPS Drill	1 – 2 hours	Quarterly	Yearly	Yearly	Consists of interactive discussions of a simulated scenario among members of emergency response team but does not involve mobilization of personnel & equipment.
Oil Spill Response Drill	1 – 2 hours	Quarterly	Yearly	Yearly	Consists of interactive discussions of a simulated scenario among members of emergency response team but does not involve mobilization of personnel & equipment.

7.2.1.17 Training

The importance of training to personnel involved in responding to any emergency scenario is recognized and acknowledged. The training to employees at MIDPL is as per following table:

Course	Duration	New recruit	Existing staff	Frequency	Notes
Induction Training	One Day	X	--	On joining the organization	All employees on joining shall undergo the training
Fire Fighting Training	Half Day	All new and existing staff	Once in a year	For Basic Fire Fighting and Practical Fire Extinguisher demo	Fire Fighting Training
First Aid training	2 Day		Selected staff	Once in Two year	External agency to train staff on First Aid

7.2.1.18 Reporting & Investigation

Reporting

Any incident / accident (whether minor or major) shall be reported. The main objective of incident reporting is to:

- Provide first-hand information to all the concerned
- Initiate investigation
- Prepare failure analysis report

- Report to the Government authorities (if required)

References

- Procedure for Incident Reporting
- Incident Report Format
- Work Injury Report

7.2.1.19 Communication & Public Affairs

Communication

Communication, an integral part for handling any emergency, helps in taking quick decisions, efficient & effective control of the emergency. Communication between the Emergency Control Center & the Field Command Post is established by means of:

- Telephone
- Mobile
- Port Announcement System
- Wireless Radio
- E – Mail
- Emergency Vehicle

Communication, including Offsite declaration between the Emergency Control Center and external authorities will be by:

- Telephone
- E – Mail
- Fax
- Emergency Vehicle

Communication to persons working in the field, other stack holders and general public outside the premises is established by means of:

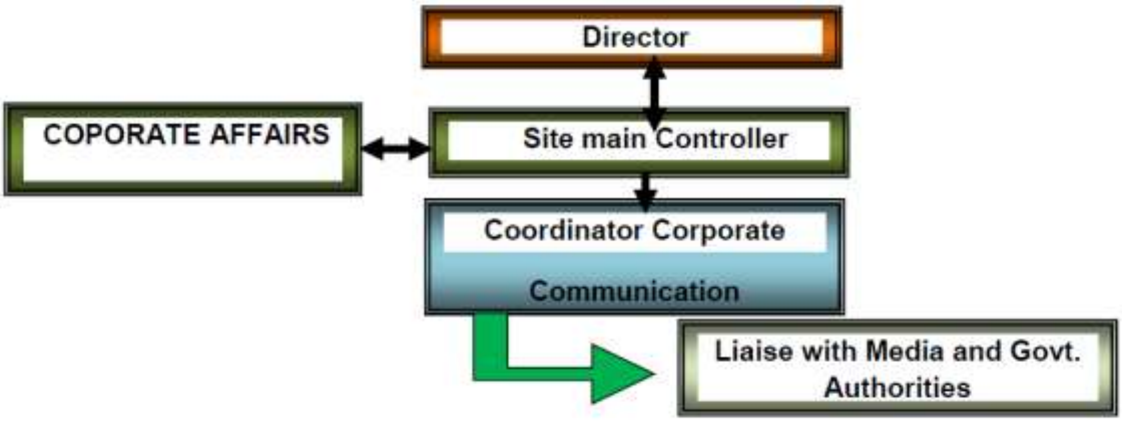
- Port Announcement System
- Siren installed on GHC-1 and MRSS-1
- Vehicle mounted Public Announcing System – 1 nos.
- Mobile hand held Public Announcing System
- Messengers

Communication to Mutual Aid members / Neighbouring industries shall be initiated by Site Main Controller.

Concerned Head of the Department where the incident happened will inform Site Main Controller for communication to Govt. Authorities and after discussion – SMC will advise concerned agency / corporate affairs to communicate with Govt. Authorities.

7.2.1.20 Public Affairs

All press statements should be discussed with the MIDPL corporate affair and agreed before release. The press statement will be made by MIDPL corporate affair.



The existing DMP do recognise the continuous improvement of different strengths and capacities that different groups use to prepare for, cope with and respond to a disaster. The existing DMP shall be revised considerably by improving, strengthening and upgrading the approach (including facilities) and adding new dimensions to be more useful and effective in addressing the difficult challenges of disaster risk reduction requirements of Proposed RMP.

7.2.2 Fire and Explosion Response Plan

7.2.2.1 Fire Fighting Details in MIDPL

Department Profile

Occupational Health Safety and Fire Department (OHS&F) is ably led by Head safety with 4 safety officers. MIDPL also comprises with a Fire Team led by Fire Supervisor with 12 fire crew covering 3 shifts (24*7).

7.2.2.2 Fire Equipment's in MIDPL

Fire Water Pump House

MIDPL is equipped with state of art Fire water pump house with an underground storage tank of 12 lakhs Lts. capacity and 5 pumps (2 Electrical, 2 Diesel, and 1 Jockey Pump).

Pump characteristics are given below

Pump Number	Type	Capacity	RPM	Pump Make	Mode	Photo
1	Diesel	137m3/hr	1500	Kirloskar Brothers Ltd	Auto/Manual	
2	Diesel	171m3/hr	1500	Kirloskar Brothers Ltd	Auto/Manual	
3	Electrical	137m3/hr	1480	Kirloskar Brothers Ltd	Auto/Manual	
4	Electrical	171m3/hr	1485	Kirloskar Brothers Ltd	Auto/Manual	
5	Jockey	10.8M3/hr	2880	Kirloskar Brothers Ltd	Auto/Manual	

Fire Tender

MIDPL is facilitated with a Fire Tender with the following features

Make	TATA Turbo 1616
Water tank material	SS 304
Water Tank Capacity	5500lts
Pressure	2250LPM @ 7kg/cm2
Foam tank material	SS 304
Foam Tank Capacity	500lts
Discharge	1800LPM
DCP Extinguishers	75 kg – 2nos
Co2 Extinguishers	22.5 kg – 4nos
BA Set	1no (Oxygen cylinder 2nos)

Figure 7-4: Fire Tender In MIDPL

Fire Extinguishers

MIPDL is spread across an area of about 350 acres and based on the hazards present across the specific areas different fire extinguishers are placed at various strategic locations. 390 Fire Extinguishers are available at MIDPL.

Table 7-20: Fire Extinguishers at MIDPL

Sl. No	Location	Number of Extinguishers	Type of Extinguishers
1	Main gate	2	ABC
2	MRSS	7	ABC,Co_2
3	DG room	5	Foam, Co_2
4	Gate complex	8	ABC,Co_2
5	Weigh bridge	2	ABC,Co_2
6	Raw water pump house	2	ABC,Co_2
7	Immigration Building	1	ABC
8	Customs Building	8	ABC,Co_2
9	POB	24	ABC,Co_2,Foam
10	Fuel station	5	ABC,Co_2,Foam
11	Workshop	6	ABC,Co_2
12	Commercial - Stores	4	ABC,Co_2,Foam
13	Workshop Substation	2	Co_2
14	Effluent Treatment Plant	1	Co_2
15	Quay office	2	ABC,Co_2
16	TNMB ROOM	1	ABC
17	Fire Pump House	5	ABC,Co_2,Foam
18	Marine Signal Station	6	ABC,Co_2
19	Quay substation	5	ABC,Co_2
20	ACP Warehouse	2	Co_2
21	Container Scanner building	7	ABC,Co_2
22	Fire Tender	7	ABC,Co_2
23	Reach stacker	3	ABC,Co_2
24	Empty Container handling	1	ABC
25	Diesel Bowser	1	ABC

Sl. No	Location	Number of Extinguishers	Type of Extinguishers
26	Jetty Area	53	ABC,Co_2
27	CT Yard	75	ABC,Co_2
28	Liquid Terminal Building	64	ABC,Co_2

Inspection and Maintenance

All the Extinguishers are inspected by fire crew on monthly basis as per the Adani Green Book-Fire Extinguisher Inspection Checklist. And the same will be reviewed by Duty Safety Officer.

Fire Hydrant Points

As per the legal legislations fire hydrant points are placed at various strategic locations with 51 Single Hydrant Points and 12 Double Hydrant Points.

Table 7-21: Fire Hydrant Point Details

Sl. No	Location	Number of Hydrant	Type of Hydrant
1	North Side CB-2	7	Single Hydrant
2	East Side CB-1	5	Single Hydrant
3	South Side Road	12	Single Hydrant
4	West Side	5	Single Hydrant
5	North Side -F&S	3	Single Hydrant
6	Fuel station	2	Single Hydrant
7	Work Shop RD	2	Single Hydrant
8	MRSS	1	Single Hydrant
9	North Side F/P	5	Single Hydrant
10	QSS	5	Single Hydrant
11	ACP Ware House	2	Single Hydrant
12	Scan Building	2	Single Hydrant
13	Liquid Terminal	12	Double Hydrant

Inspection and Maintenance:

All the hoses and hydrants are inspected by fire crew on monthly basis as per the Adani Green Book-Inspection Checklist. And the same will be reviewed by Duty Safety Officer.

Fire Sand Buckets

As per the legal legislations Fire sand buckets (33) are placed at various strategic locations.

Table 7-22: Sand Bucket details

Sl. No	Location	Number of Fire Sand Bucket
1	POB	3
2	Work Shop Substation	2
3	QSS	3
4	MRSS	2
5	MRSS DG	3
6	PAB TRANSFORMAR 1	4
7	PAB TRANSFORMAR 2	4
8	LT pump house entrance	4
9	LTF right side	4
10	LT substation entrance left side	4

Inspection and Maintenance:

All the Fire Sand Buckets are inspected by fire crew on monthly basis as per the Adani Green Book-Sand Buckets Inspection Checklist. And the same will be reviewed by Duty Safety Officer.

Water Monitors

As per the legal legislations water monitors (12) are placed at various strategic locations.

Water Monitors details

Sl. No	Location	Number of Water Monitors
1	POB Building	1
2	MRSS	1
3	Signal Tower	1
4	Liquid Terminal	9

Fire Sprinkler System

Fire sprinkler systems are installed at 2 locations, in MRSS transformers and in signal station.

Fire Detection System

Fire Alarm Systems is designed to detect the presence of fire by monitoring the environmental changes with combustion.

1. Fire alarm panel
2. Smoke detector
3. Heat Detector
4. Hooter
5. Manual Call Point (MCP)

Depicts Fire Detection System Status In MIDPL

S.No	Fire alarm panel location	Activation status
1	POB	ON
2	MRSS	ON
3	PAB	ON
4	Customs building	ON
5	Marine tower	ON
6	QSS	ON
7	Engineering workshop	ON
8	Container Scanner Area	ON

Inspection and Maintenance:

All the Fire Detection Systems come under the AMC contract to E2B solutions. All the Fire Detection Systems are inspected on monthly basis and currently all are working fine.

- All the Extinguishers are inspected by fire crew on monthly basis as per the Adani Green Book-Fire Extinguisher Inspection Checklist. And the same will be reviewed by Duty Safety Officer.
- All the hoses and hydrants are inspected by fire crew on monthly basis as per the Adani Green Book-Inspection Checklist. And the same will be reviewed by Duty Safety Officer.

Exhibit 7-1: Fire Extinguisher Inspection

Exhibit 7-2: Hydrant Inspection by the Fire Crew

Exhibit 7-3: Depicts sprinklers in MIDPL

Exhibit 7-4: Depicts Various Fire Detection Systems in MIDPL

7.2.2.3 Training and Mock Drills

Trainings form an important crux of Firefighting. For the FY year 2019-20 around 100 employees including contractor staff were given basic firefighting training.

Exhibit 7-5: Firefighting Training

Exhibit 7-6: Mock drill

7.2.2.3.1 MIDPL has the following Certifications

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- ISO 45001 Occupational Health and Safety Management System
- Fire and Rescue Services Licence

A complete fire protection system that includes fire extinguishers, fire hydrant system and communication facilities, has been installed. MIDPL is having a system for maintaining all fire protection systems and training employees for emergency preparedness. The fire extinguishers are being checked / inspected periodically by a trained staff. Telephones provided at all control rooms to communicate in case of any fire situation.

7.2.2.4 Planning & Preparedness for Fire & Leakages

Plan to deal with fire can be divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least: o Port Engineer (01), Fire Team Member (01), Port Operators (02), Electrician (01). ▪ Maintain inventory of emergency items (Hardware) & supplies as necessary ▪ Liaise with HOS – Fire Services to: o Maintain adequate fleet of fire tenders & firefighting equipment. o Maintain patrolling to eliminate potential sources of fire hazard. o Impart regular refresher training to auxiliary fire squad members.
Action During Effective period	
Emergency Response Team	▪ Activate / Raise an alarm. Try to contain fire. ▪ Liaise with Site Main Controller, HOS – Fire and HOS – Occupational Health Services to: o Evacuate non-essential personnel o Ensure all action, material, equipment is in place to tackle the emergency in a shortest possible time. o Ensure that the fire spread should be within minimum area and all possibilities of escalation to be checked and corrective action should be in place. o Ensure search & rescue

Action By	Activity
	○ Ensure causalities receive attention. ▪ Liaise with HOD – Security to restrict movement in affected area.
Action After Effective Period	
Emergency Response Team	▪ Assess damage. ▪ Implement fire preventive measures. ▪ Undertake restorative measures & repairs. ▪ Liaise with HOS – Occupational Health Services to follow up on causalities

Table 7-23: Methods of Dealing with Different Types of Fire & Leakages

Fires from minor oil spillage on deck or jetty	Use dry chemical or extinguishers or water fog or water spray
Fire from large spillage of oil or burst hose on deck or jetty	Use large dry chemical appliance and follow up with foam or water fog/spray. Cool surrounding area/risks with water spray
Fires from spillage of oil on surrounding waters	Emulsification of oil with water jets or apply foam coverage as appropriate
Ammonia gas	Use dry chemical, carbon dioxide, water spray or alcohol resistant foam from upwind position
Phosphoric/Sulphuric Acid	Dry powder, carbon dioxide (CO_2), water fog or spray
Electrical fires Fire in buildings-canteen	Switch off power-use CO_2 or dry chemical extinguishers
Fire in office involving combustible material	Use dry powder fire extinguishers-water spray, use breathing apparatus.
LPG and LNG fires	Should not be extinguished until source of leakage is under control. Dry chemical is the most effective. Cover affected area with water spray to reduce radiant heat.
Fire in cargo tanks	Use foam or steam smothering.

Table 7-24: Departmental Action during Fire at Jetty

DEPT	ACTION
Harbour Master & Vessel	1. Signal station informs conservator, Harbour Master and PSO on VHF 6/14/12/Land line/Mobile. 2. Master of the vessel ceases all cargo or bunker operations close the manifold valves 3. Disconnected hoses and consults with conservator and Harbour Master for un berthing & also ensures the immediate action of the vessels fire fighting squad. 4. If necessary Master may request for additional resources and/ or- evacuation of injured. 5. SIGNAL STATION informs conservator, Deputy Conservator, Harbour Master, PSO & Fire station of incident. 6. Conservator assesses works together with Harbour Master, PSO and Master of vessel to ascertain in the status and crisis level. 7. HM informs crisis management group the status and crisis level. 8. Pilots on standby for shifting out vessel – directs fire fighting tugs – keeps mooring crew and launch standby to un berth vessel. 9. DC maintains close liaison with HM and monitors progress and strategy of containment and extinguishing. 10. Reconfirms stoppage of cargo operations.
PSO	1. Ensures that fire tenders are ready at the jetty and takes over action group. 2. Ensures area cordons off. 3. Executes search & rescue with fire fighting team. 4. Inform conservator and need for additional resources.
E&M Dept.	1. Ensures isolation of the electric power on berth.
Medical	1. CMO/Medical Incharge keeps ambulance standby at berth and provides first aid and burn treatment to the injured.

Table 7-25: Action Plan during Fire at Administration Building

DEPARTMENT	ACTION
Administration	1. First sight-Raises alarm (break glass – uses fire extinguishers to extinguish fire). 2. Head admin supervises the action. 3. Overall in charge of action group. 4. Switch of electric supply.

	5. Never throw water on electric box. 6. Inform fire station / PSO / Signal station / Conservator. 7. Evacuate people in orderly manner 8. Sr. most section head shall be last to leave premise. 9. Muster all people and confirm head count for any missing people 10. On incident termination arrange alternative office space.
PSO	1. Deploy fire tender. 2. Assist transfer of sensitive documents. 3. Assist in evacuation / search & rescue of personnel. 4. Cordoning off area. 5. Apprise conservator of the area.
Civil Engg. Dept.	1. Assess cost to rectify damage portion of building.
E&M Dept.	1. Ensures isolation of electric power to admin building.
Medical	1. Keeps ambulance standby. 2. Provide first aid victim.

Table 7-26: Action Plan during Fire at Bulk Material Handling Area

DEPARTMENT	ACTION
HARBOUR MASTER	1. BUH in charge raises alarm by informing port signal station & fire station simultaneously uses fire extinguishers to extinguish fire. 2. Switch off power supply and all cargo operation ceases. 3. Informs on-site action group, conservator and PSO 4. Shed I/c mobilises all manpower in the area surrounding the site to bring the firefighting appliances in the area, to extinguish the fire. 5. The senior most traffic official on site will mobilise all the work force, labour and cargo handling appliances available in the area. 6. TM ensures the removal of all the unaffected cargo from the shed to a safe place. 7. TM ensures that the details of types of cargo and quantity of cargo in the shed should be kept ready and given to of port fire service that comes first to the scene of the fire. 8. TM shall ensure that the labour working inside the shed is assembled for a head count. 9. Keeps all tugs and craft on standby. 10. Recall pilots for movement of vessels. 11. Inform all vessels to be standby.
PSO	1. Arrives with fire tenders and resources and takes over fire fighting. 2. Conducts search and rescue and evacuation of affected person. 3. Cordon off the affected area. 4. Apprise conservator and resources required.
Civil Dept.	1. Survey and assess the cost to rectify the damage portion of the cargo storage shed.
E&M Dept.	2. Ensures isolation of the electric power to cargo storage shed.
Medical	3. Keeps ambulance standby by off administration building. 4. Provides first aid to the injured.

Table 7-27: Action Plan during Fire/ Explosion off Berth

SHIPBOARD EMERGENCY PLAN		FIRE / EXPLOSION OFF BERTH
Action to be considered	**Port**	**Responsibility**
IMMEDIATE ACTION • Consider sounding emergency alarm • Initiate vessel emergency response procedure • Inform port signal station about nature of explosion.	Port signal station	Informs PSO, HM & conservator and vessels on jetty about incident
INITIAL RESPONSE • Cease all cargo and / or bunkering operation • Close manifold valves • Fire squads to position deemed best for fighting the fire • Inform terminal/loading master/bunkering personnel	PSO	• Place fire tender next to ship • Cordon off jetty • Inform conservator and assess resources required • Oil spill team standby

SECONDARY RESPONSE • Stop air intake into accommodation • Consider to stop non-essential air intake to engine room • Determine the extent of the damage, and decide what damage control measures can be taken • Determine whether there are casualties • Contain the fire and prevent it from spreading to other parts of the vessel • Asses health hazards from smoke • If possible, position the vessel to minimise the wind effect • Start recovering of any casualties • Notify authorities and outside organisation, as appropriate • Evaluate evacuation of non-essential crew	HM	• Keep pilot & tug ready • Stop all cargo operation • If required vacate ship from jetty
FURTHER RESPONSE • Assess the possibility of pollution from leakage • Fit scupper plugs if spillage on deck • Check all tanks and compartments • Alter trim if necessary • Transfer bunker internally, if required • Require assistance as deemed necessary • Comply with reporting procedures • If required, obtain permission from local authorities and/or the terminal to continue normal operation	CMO/Medical Incharge	• Ambulance and first aid team standby on jetty

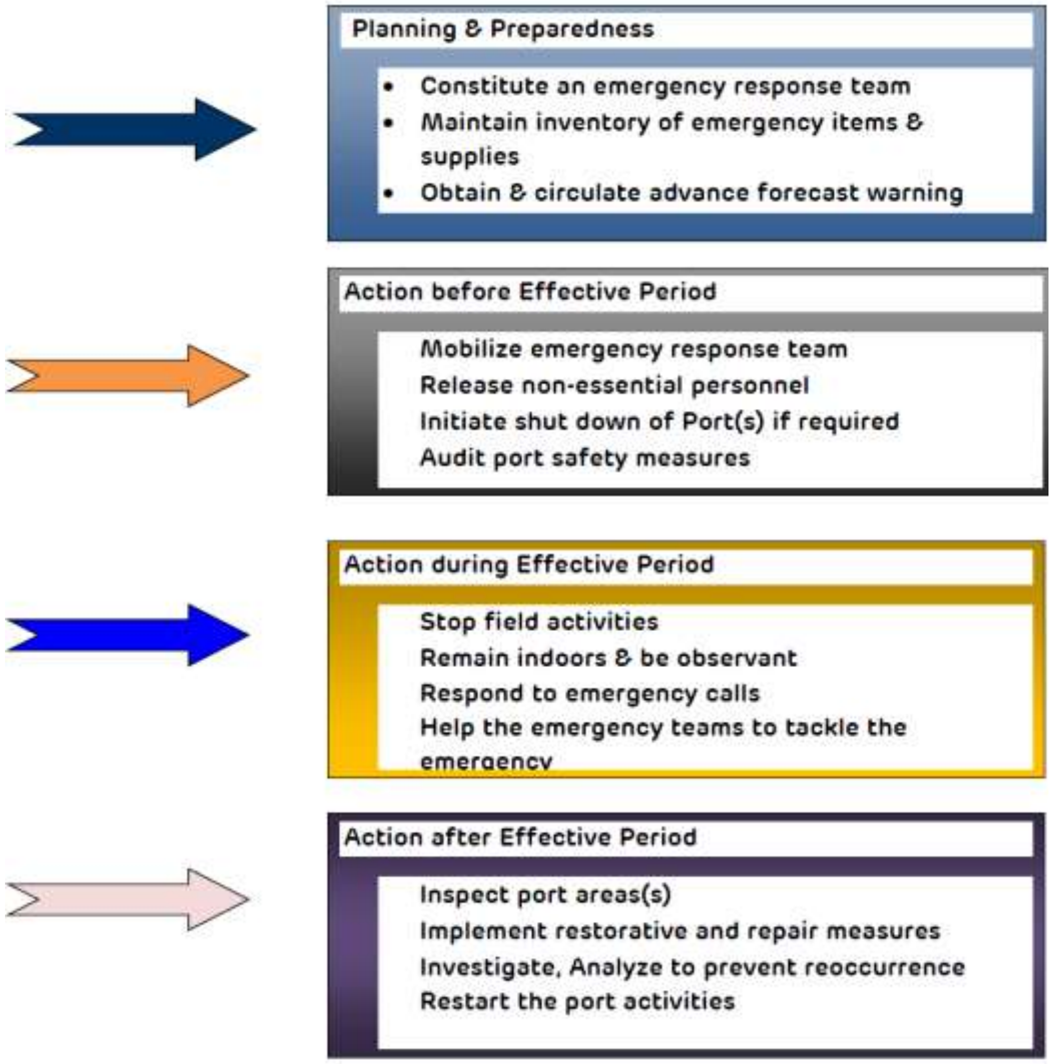
The existing Fire & Safety equipment and provisions shall be updated considerably by improving, strengthening and upgrading the approach (including facilities) and adding new dimensions to be more useful and effective in addressing the difficult challenges of disaster risk reduction requirements of Proposed RMP.

7.2.3 Categorization of Emergencies

Kattupalli Port existing DMP has the general action plan to deal with various categories is explained below

Emergencies (Occurrence – with due warning)	Emergencies (Occurrence – without warning)
• Cyclonic Storm/ Hurricane • Earthquake • Flood • Tsunami • Industrial Unrest • Bomb Threat • War	• Food/ Water Poisoning • Fire • Major Release of Flammable/ Toxic Chemicals& Radiation • Transportation accidents involving Hazardous Materials • Marine Emergency • Medical Emergency • Drone Attack

7.2.3.1 EMERGENCIES (WITH DUE WARNING)



7.2.3.2 EMERGENCIES (WITHOUT DUE WARNING)

At the initial stages, the emergency organization chart shall be put into action. If the incident goes beyond control, the site main controller will actuate the DMP at the appropriate stage as considered necessary.

The plan is to be drawn by appointing key personnel and defining their specific duties that will be handy in emergency. To control the emergency in the most effective manner it is important that roles and responsibilities are well defined and the command structure is absolutely clear.

The key roles exercised during the emergency are those of “site main controller” (whose main function is to take charge of the incident) and of the “incident controller” (whose main function would be to take overall charge of rescue, facilitation, coordination, communication etc.). In addition, other individuals would be assigned specific responsibilities. These people would report to “site main controller" or “incident controller” during the time of emergency and would work under his/her instructions.

7.2.4 Action Plan for Cyclonic Storms/Hurricane

Cyclonic storms/ hurricanes are intense depressions, which develop in tropical latitudes and are often the cause of very high winds and seas. The wind blows around the center of a tropical storm in a spiral flow inward, anti-clockwise in Northern Hemisphere and clockwise in Southern Hemispheres. Plan for tackling cyclonic storm/ hurricane can be broadly divided in following stages:

<table>
<tr><th>Action By</th><th>Activity</th></tr>
<tr><td colspan="2">Planning & Preparedness</td></tr>
<tr><td>Port Key Person</td><td>Constitute Emergency Response Team(s) comprising of at least:
▪ Port Engineer (01), Safety HOD, Security HOD, Fire Team Member (01), Marine HOD, Electrician (01).
▪ Maintain inventory of emergency items (Hardware) & supplies as necessary
▪ Liaise with HOD – ES for Civil & Mechanical Support (including supply of spares).
▪ Liaise with HOD – HR for food stock, water, blankets & bedding and medicine.
▪ Liaise with Port Operation Control.
▪ Liaise with Site Main Controller
▪ Mobilize Emergency Response Team(s).</td></tr>
<tr><td colspan="2">Action Before Effective Period</td></tr>
<tr><td>Port Key Person</td><td>▪ Initiate Port shut down based in
o Consultation with site main controller
▪ Audit port area(s) for safety measures to ensure that;
o Loose items are secured
o Electric machinery is covered and protected against water ingress.
o Storm water drains are cleared of any obstructions
▪ Implement preventive & precautionary measures (including but not limited) to ensure:
o Inventory of emergency supplies is maintained.
o Material and equipment that can possibly be damaged by water ingress is elevated.
o Windows & doors are weather tight.
o Roof mounted equipment are braced.
o Material & equipment that cannot be moved are covered.
o Sandbags are placed in doorways where flooding from storm water can occur.</td></tr>
<tr><td colspan="2">Action During Effective period</td></tr>
<tr><td>Port Key Person</td><td>Stop
➢ All field activities
➢ All permits to work</td></tr>
<tr><td>Emergency Response Team</td><td>Ensure all personnel remain indoor, observant and be alert to:
➢ Detect any damage to equipment or buildings.
➢ Development of unsafe conditions
In consultation with Site Main Controller:
➢ Make all possible efforts to reach the site of incident/ damage.</td></tr>
<tr><td>Port Key Person</td><td>Act appropriately to control prevalent incident/ damage</td></tr>
<tr><td colspan="2">Action After Effective Period</td></tr>
<tr><td>Port Key Person & Emergency Response Team</td><td>▪ Audit Port area(s) for damage assessment & prepare report.
▪ Undertake restorative measures & repairs based on audit report on:
o Damaged equipment & buildings.
o Unsafe conditions.</td></tr>
<tr><td>Port Process Group</td><td>Initiate restart up of the Port</td></tr>
</table>

7.2.4.1 Department Wise Emergency Action Plan for Cyclone

Department	Emergency Action Plan for Cyclone
Dry Cargo Department	▪ Stop all stevedoring activities, bring all Mobile Harbour cranes to shore, safely park the cranes and down its booms. ▪ Inform all contractors to remove all their equipment from jetty area and safely park

	at shore, in case of crane down its boom. ▪ Arrest all barge / ship loaders, and Mobile truck loading hoppers at its wheel to prevent horizontal movement due to wind and secure from its top by arranging guy ropes. ▪ Stop loading / unloading of ship and measure the ship cargo quantities along with clients surveyor and communicate Marine Dept. / shipping agencies to take the ship to anchorage area
Container Terminal Department	▪ All Mobile cranes to park safely with brakes on and anchor fixed. ▪ Inform all contractors' workmen to move from jetty area at safe location. ▪ Close the doors of all containers which are stored in yard. ▪ All containers in single stack to be removed. ▪ Stop loading / unloading of ship.
Marine Department	▪ Receive forecast from time to time and inform the following: - 1. Marine HOD 2. Pilots 3. Flotilla 4. all concerned dept. ▪ Monitor weather parameters ▪ In coordination with Cargo Operations Department, instruct all ship captains to take the ships anchorage basis wind/swell parameters exceed. ▪ Stop all activities at jetty area. ▪ Ensure the jetty areas are free from loose and unsecured materials / equipment's. ▪ Update all departments about the latest weather conditions. ▪ Ensure TUG's are secured in protected part of basin.
Security Department	▪ Close the gate and stop allowing visitors and transport trucks either inward or out ward. ▪ Ensure vehicles are parked at designated parking areas, with wheels are blocked. ▪ Instruct all drivers to take shelter at canteens (concrete buildings).
Fire Department	▪ Equip the fire tender with rescue equipment, safely park the fire tender and secure its wheel by providing blocks. ▪ Drainage and storm water channels checked for clearance
Project Management Cell	▪ Stop all activities, park the cranes and equipment at safe location, lower the booms of cranes and secure them. ▪ Ensure all erected structures are secured with guy ropes and ties are provided. ▪ Remove all loose materials from top of buildings and structures or secure them. ▪ Ensure all workmen are sheltered at safe locations like canteens (concrete buildings). ▪ Secure the Jetty area piling rigs and cranes by tying with guy ropes. ▪ Stop all project vehicle movements and ensure the vehicles are parked at safe location with wheels are blocked. ▪ Ensure all vehicles and cranes are removed from break water embankments.

7.2.5 Flood

Floods are usually caused by excessive runoff from precipitation or snowmelt, or by coastal storm surges or other tidal phenomena. Floods are sometimes described according to their statistical occurrence. A fifty-year flood is a flood having a magnitude that is reached in a particular location on average once every fifty years. In any given year there is a two percent statistical chance of the occurrence of a fifty-year flood and a one percent chance of a hundred-year flood.

Action By	Activity
Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least: ○ Port Engineer (01), Fire Team Member (01), Port Operators (02), Electrician (01) ▪ Maintain inventory of emergency items (Hardware) & supplies as necessary ▪ Liaise with HOD – HR to identify control centres equipped with; ○ Communication facilities ○ Emergency vehicles/ equipment. ○ List of emergency contacts & suppliers. ○ Medical facilities
Action During Effective period	

Action By	Activity
Individuals	▪ Do not panic ▪ Avoid standing near to sea side ▪ Stand near columns or duck under sturdy furniture ▪ Assemble at emergency assembly point
Action After Effective Period	
Site Incident Controller	▪ Liaise with Site Main Controller for shut down of Port(s) if required ▪ Liaise with HOS – Security and HOS – Fire Services to search & rescue ▪ Liaise with HOS – Occupational Health Centre to provide first aid to the victims and remove causalities (if any) ▪ Report at site
Port Key Person	▪ Assess damage ▪ Undertake restorative measures & repairs ▪ Liaise with HOD – Human Resources & Administration

7.2.5.1 Department Wise Emergency Action Plan for flood

Department	Emergency Action Plan for Cyclone
Dry Cargo Department	▪ Stop all stevedoring activities outside near jetty side, bring all Mobile Harbour cranes to shore, safely park the cranes and down its booms – switch off the power supply. ▪ Inform all contractors to remove all their equipment from jetty area and safely park at shore, in case of crane down its boom. ▪ Arrest all barge / ship loaders, and Mobile truck loading hoppers at its wheel to prevent horizontal movement due to water flow and secure from its top by arranging guy ropes. ▪ Stop loading / unloading of ship and measure the ship cargo quantities along with clients surveyor and communicate Marine Dept. / shipping agencies to take the ship to anchorage area
Container Terminal Department	▪ All Mobile cranes to park safely with brakes on and anchor fixed. ▪ Inform all contractors' workmen to move away from jetty area at safe higher elevation location. ▪ Close the doors of all containers which are stored in yard. ▪ All containers in single stack to be removed. ▪ Stop loading / unloading of ship.
Marine Department	▪ Receive forecast from time to time and inform the following: - 1. Marine HOD 2. Pilots 3. Flotilla 4. all concerned dept. ▪ Monitor weather parameters ▪ In coordination with dry cargo instruct all ship captains to take the ships to anchorage. ▪ Stop all activities at jetty area. ▪ Ensure the jetty areas are free from loose and unsecured materials / equipment. ▪ Update all departments about the latest weather conditions. ▪ Ensure TUG's are secured in protected part of basin.

7.2.6 Tsunami

A tsunami is usually caused by an underwater earthquake or volcanic eruption and often causes extreme destruction when it strikes land. It is a series of waves which travel outward on the ocean surface in all directions in a kind of ripple effect. Since the waves can start out hundreds of miles long and only a few feet high, they would not necessarily be noticeable to a passing ship or a plane flying overhead. The plan to deal with Tsunami can be divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least: ○ Port Engineer (01), Fire Team Member (01), Port Operators (02), Electrician (01), Marine Control Officer (01), POC Officer (01).

Action By	Activity

	▪ Maintain inventory of emergency items (Hardware) & supplies as necessary
	▪ Liaise with HOD – Marine to identify control centers equipped with:
	  ○ Communication facilities
	  ○ Emergency vehicles/ equipment (tugs, speed/mooring boat)
	  ○ List of emergency contacts (POC, Marine Control, Deputy PFSO, Port Security)
	  ○ Occupational Health Facilities

Marine Department	ACTION BEFORE EFFECTIVE PERIOD AFTER GETTING WEATHER WARNING ▪ Receive forecast from time to time and inform the following: - 1. Marine HOD 2. Pilots 3. Flotilla 4. all concerned dept. ▪ Monitor weather parameters ▪ In coordination with dry cargo instruct all ship captains to take the ships to anchorage. ▪ Stop all activities at jetty area. ▪ Ensure the jetty areas are free from loose and unsecured materials / equipment ▪ Update all departments about the latest weather conditions. ▪ Ensure TUG's are secured in protected part of basin.
Action During Effective period	
Individuals	▪ Do not panic ▪ Avoid standing near to sea side ▪ Stand near columns or duck under sturdy furniture ▪ Assemble at emergency assembly point
Action After Effective Period	
Site Incident Controller	▪ Liaise with Site Main Controller for shut down of Port(s) if required ▪ Liaise with HOS – Security and HOS – Fire Services to search & rescue ▪ Liaise with HOS – Occupational Health Center to provide first aid to the victims and remove causalities (if any)
Port Key Person	▪ Report at site ▪ Assess damage ▪ Undertake restorative measures & repairs ▪ Liaise with HOD – Human Resources & Administration

7.2.7 Earthquake

Earthquake is most likely to occur without pre-warning and so its severity and destructive potential are highly unpredictable. Earthquake can result in collapse of buildings, structures & elevated equipment, heavy casualties apart from fracture of underground pipelines and uprooting of energized wires etc. The plan to deal with earthquake can be divided in following stages:

Action By	Activity
Planning & Preparedness	

Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least:
	  ○ Port Engineer (01), Fire Team Member (01), Port Operators (02), Electrician (01).
	▪ Maintain inventory of emergency items (Hardware) & supplies as necessary
	▪ Liaise with HOD – HR to identify control centres equipped with:
	  ○ Communication facilities
	  ○ Emergency vehicles/ equipment
	  ○ List of emergency contacts & suppliers
	  ○ Medical facilities.

Action During Effective period	
Individuals	▪ Do not panic ▪ Avoid standing near windows, external walls ▪ Stand near columns or duck under sturdy furniture ▪ Assemble at emergency assembly point
Action After Effective Period	
Site Incident Controller	▪ Take head count. Activate Port emergency plan

Action By	Activity
	▪ Liaise with Site Main Controller for shut down of Port(s) if required ▪ Liaise with HOS – Fire Services to initiate search & rescue ▪ Liaise with – Occupational Health Centre Services to provide first aid to the victims and remove causalities (if any).
Port Key Person	▪ Report at site ▪ Assess damage ▪ Undertake restorative measures & repairs ▪ Liaise with HOS –Occupational Health Centre to follow up on causalities.

7.2.8 Industrial Unrest

Industrial relation between personnel and management may deteriorate because of any reason. Problems, which may arise due to industrial unrest, include:

- Dharna / Strike/ Hunger strike
- Unofficial gatherings/ Gate meetings/ Forceful entry
- Work to rule/ Go slow/ Disobedience
- Gherao / Rasta roko
- Intimidation & Use of force
- Support from local & criminal elements
- Sabotage

In such a scenario, to ensure smooth operation of Port, protection of lives and property, well-coordinated effort is needed from all concerned. Plan to deal with industrial unrest can be broadly divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	Constitute Emergency Response Team(s) comprising of at least: ○ Security Officer (01), Port Engineer (01), Fire Team Member (01), Port Operators (02) ▪ Maintain inventory of emergency items (Hardware) & supplies as necessary ▪ Liaise with HOD – HR for food stock, water, blankets & bedding and medicine.
Action Before Effective Period	
Port Key Person	▪ Liaise with Site Main Controller ▪ Liaise with HOD – Security for security & vigilance requirements. ▪ Liaise with HOD – HR for planning of accommodation of additional personnel and transport for additional requirements of vehicle (if any).
Action During Effective period	
Port Key Person	Liaise with HOD – Security for ▪ Strengthening security at sensitive points. ▪ Ensuring protection of lives & property. ▪ Vigilance & patrolling. ▪ Maintaining law & order. Liaise with Site Main Controller for ▪ Updates on the situation.
Action After Effective Period	
Port Key Person	▪ Assess damage (if any). ▪ Liaise with Site Main Controller for restoring normalcy.

7.2.9 Bomb Threat

Bombs can have devastating effect not only on the Marine Infrastructure Developer Private ltd but also on neighbouring areas. Hence any threat received regarding plantation of the bomb shall be viewed seriously.

Plan to deal with bomb threat can be divided in following stages:

Bomb scare / Terrorist Attack

The primary objective during any bomb threat or security threat is to minimize loss of life, minimize injury, minimize damage to assets and prevent any pollution. Hence the area under threat to be evacuated and cordoned.

Key Person	Action
Receiver of threat call	Inform MIDPL control Room Try to remember/write the information received verbatim
MIDPL control	Inform PFSO & Dy. PFSO (MIDPL) Inform Security Control Room and pass the information received Inform Fire and Safety Dept Inform Medical Team
Security	Isolate the area/port Evacuate the suspected area Care would be exercised to distribute the staff in small groups preferably away from known assembly points. This is required as terrorists may send bomb scare at site and then explode devices by remote at assembly points to inflict greater damage. Bomb snuffing and diffusing squad would be requested from the police. All transport vehicles incoming and outgoing would be checked for unidentified objects. No personnel would be allowed to remain at site until site is declared safe In case of any terrorist attack on terminal/jetty area, efforts would be made to protect life of the people. No firearms are allowed in the terminal. No action should be taken in haste by anyone as it could be misread by the terrorists. Police and other agencies would be informed and all support would be extended to them.
Medical team	Stand by for any casualty
Fire team	Stand by for any blast and fire out break
Dy. PFSO (MIDPL)	Act in consultation with the PFSO Report to Coast Guard Report to Marine Police Report to DG Shipping

7.2.10 War

During an outbreak of war, bombarding by enemy planes at Kattupalli site can have devastating effects.

Plan to deal with bomb threat can be divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least: ○ Port Engineer (01), Fire Team Member (01), Port Operators (02), Electrician (01). ▪ Maintain inventory of emergency items (Hardware) & supplies as necessary, including but not limited to items specified in Chapter-20 ▪ Make arrangements for camouflage the flares. ▪ Liaise with HOD – Security to increase awareness in the Port personnel regarding war.
Action Before Effective Period	
Port Key Person	▪ Liaise with Port Operation Centre. ▪ Liaise with HOD – Security for ○ Intensifying vigilance & patrolling.
Action During Effective period	
Port Key Person	▪ Liaise with Site Main Controller for minimizing light (during night) & obtaining updated information. ▪ Liaise with HOD – Security for evacuation of non-essential personnel.
Action After Effective Period	
Port Key Person	▪ Assess damage (if any). ▪ Liaise with Site Main Controller for restoring normalcy.

7.2.11 Food/Water Poisoning

Plan to deal with food / water poisoning can be divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	▪ Liaise with HOS – Occupational Health Services: ○ To impart training regarding food/ water poisoning. ○ For supply of medicines, saline water etc.
Action During Effective period	
Port Key Person	▪ Liaise with Site Main Controller & HOS – Occupational Health Services to: ○ Conduct epidemiological investigation to identify the cause. ○ Take preventive measures to avoid recurrence. ○ Follow up on causalities.

7.2.12 Danger associated with the exposure to ionizing radiation

The machine makes use of X-ray emissions and is intended to inspect only vehicles and the objects they contain.

Plan to deal with radiation can be divided in following stages:

Action By	Activity
Planning & Preparedness	
Port Key Person	▪ Constitute Emergency Response Team(s) comprising of at least: ○ Operator / accelerator (01), Fire Team Member (01), Electrician (01).& Qualified Technician (01) ▪ Maintain inventory of emergency items (Hardware) & supplies as necessary ▪ Liaise with HOS – Fire Services to: ○ Maintain adequate fleet of fire tenders & firefighting equipment. ○ Maintain patrolling to eliminate potential sources of fire hazard. ○ Impart regular refresher training to system operator.
Action Before Effective Period	
Port Key Person	▪ Activate / Raise an alarm. Try to protection of radiation. ▪ Liaise with Site Main Controller, HOS – Fire and HOS – Occupational Health Services to: ○ The radiological safety system provides protection for personnel by monitoring the following: ○ authorization for the accelerator to be switched on, ○ shutdown of emission in the scanning zone and/or complete shutdown of the accelerator, ○ Access to the scanning zone. ○ Evacuate non-essential personnel ○ Ensure all action, material, equipment is in place to tackle the emergency in a shortest possible time. ○ Cover the spill with absorbent pads, but do not attempt to clean up. Confine the movement of all potentially contaminated personal to prevent the further spread of contamination .prevent personnel from entering the contaminated area ○ If the spill is on the skin, flush thoroughly and wash with mild soap and lukewarm water. ○ Ensure causalities receive attention. ▪ Liaise with HOD – Security to restrict movement in affected area.
Action After Effective Period	
Emergency Response Team	▪ Determine contamination extent with most frequent sensitive detector ▪ Remove contaminated clothing ▪ Flush the affected area with copious quantities of lukewarm water for 15 to 20 minutes ▪ Wash with mild soap and water work lather into contaminated area by rubbing gently for 3 minutes. Rinse thoroughly

Action By	Activity
	▪ Implement fire preventive measures. ▪ Undertake restorative measures & repairs. ▪ Liaise with HOS – Occupational Health Services to follow up on causalities

7.2.13 Transportation/ Storage Accidents involving Hazardous Material/Transport Accident

Various material including hazardous materials are transported to and from Marine Infrastructure Developer Private Ltd by tank Lorries, containers. These hazardous materials are stored in Tanks or containers of suitable material and design in Liquid Terminal, container terminal or in Dry Cargo area. These containers / tank lorries have the potential to mechanical failures & road accidents (within and/ or outside the complex) and tanks in tank farm having potential to mechanical failures, operational failures resulting in the possible scenarios viz. spillage, leakage, fire & explosion that might pose an imminent danger to surrounding populations/area and vehicular traffic (in case of tank lorries) apart from threat to an environment. The plan to deal with such type of emergencies involving hazardous material may be divided in following stages:

Besides involvement of hazardous goods, the vehicular accidents can also lead to serious consequence. This also can lead to serious injuries, traffic issues. The emergency handling during Vehicular incident also requires dealing with Medical emergencies and rescue operations.

Action By	Activity
Planning & Preparedness	

Port Key Person – HOD of Operation – till the vehicle is inside	▪ Constitute Emergency Response Team(s) comprising of at least:
	  ○ Port Engineer / In charge (01), Fire Team Member (01), Port Operators (02), Electrician (01).
	▪ Maintain inventory of emergency items (Hardware) & supplies as necessary
	▪ Collect information about the product and specification/ design of the tanker for the product/vehicle.
	▪ Material Safety Data Sheet to be referred.
	▪ Liaise with HOD – Security for:
	  ○ Ensuring safety equipment & fitness certificates are valid.
	  ○ Auditing the tankers.
	  ○ Awareness program for transporters, drivers etc.

Action During Effective Period	
Emergency Response Team	Liaise with HOD – Security/ Driver/ Transporter to: During an emergency of particular nature Fire, Leak, Explosion, Medical emergency– refer the plan above ▪ Ascertain extent of damage and impact. ▪ Control, block or contain leakage. ▪ Inform various agencies. ▪ Request for assistance. ▪ Restrict movement in the affected area.
Action After Effective Period	
Emergency Response Team	▪ Assess damage. ▪ Undertake restorative measures & repairs. ▪ Liaise with HOS – Occupational Health Services to follow up on causalities

7.2.14 Medical Emergencies & Response

7.2.14.1 Medical facilities

- Ambulance service shall be provided within the port premises round the clock to provide medical assistance and help to the employees and contractors workmen receiving major injuries at work or illness that cannot move and need assistance to reach site OHC or to the hospital for medical attention.
- However, first aid facilities (first aid box) are available to each of the Terminals as well as in the Marine Control Room for providing immediate first aid by a trained person for minor injuries.
- A well-equipped Occupational Health Center (OHC) is established centrally inside the MIDPL premises at Kattupalli to provide first aid, medical assistance and implementing occupational health programs for employees and the contractors. The OHC is managed by a qualified male nurse / paramedical staff. An ambulance facility is available at MIDPL for emergency, on call (Intercom No. 69156; Firefighting services at site available on call at Intercom No. 69155).

7.2.14.2 Accident Reporting

- As per the Port policy all injuries/dangerous occurrences/incident are to be reported and recorded. An accident investigation procedure will be followed and training will be delivered to the site supervision in support of it. The procedure and protocol developed shall include the following:-
- Marine Control, Security Control, Concerned Engineer, Safety Department must be informed immediately (by telephone) in the event of an accident/ emergency.
- In case of an injured person is unable to move, the site medical Centre should be contacted for ambulance and on the spot Medical Assistance.
- First aid training will be given on site and a register of training maintained, personnel trained in first aid will be available throughout the site for any emergency purposes.
- All injuries including medical treatments and first aid cases will be recorded and detailed records will be sent to the Management (weekly /monthly reports).
- Government regulations concerning notification of any serious incident/fatality etc. should be followed as per the statutory requirement/ local regulations and will be dealt with as per the MIDPL policy/procedure.

Action By	Activity
Planning & Preparedness	
Port Key Person	• Constitute Emergency Response Team(s) comprising of at least: ○ Port Engineer (01), First Aider (01), Fire Team Member (01), Safety Personnel (01), Security Personnel (01). • Maintain inventory of emergency items (Hardware) & supplies as necessary
Action During Effective Period	
Emergency Response Team – HOD/ Area personnel	▪ Liaise with Occupational Health personnel / Doctor /Male Nurse, Area personnel and HOD – Security/ HSEF: ▪ Get the information on extent of injury and action taken for First Aid to injured person. ▪ Ensure that the injured person gets immediate Medical attention. ▪ If required, ensure that the injured person sent to hospital for further treatment. ▪ Ensure that the affected area is barricaded and hazards are well taken care of to avoid further injuries ▪ Inform concerned department to initiate the repair / restoration. ▪ Request for assistance.

Action By	Activity
	▪ Restrict movement in the affected area.
Individual	Accident: If you witness an incident or dangerous occurrence (Major Injury due to fall from height, Physical contact with moving machineries / vehicle, Burn, Electrocution, Drowning or Occupational & Personnel Disease etc.): ▪ Contact Occupational Health Centre (OHC) on Intercom No.69156 Telephone No. or Marine Control Room on Intercom 69050, Tel. No. 7823941713 ▪ Contact Security Control Room on Telephone No. 69065 / 7823941712 and Fire Control Room on 69155 or 7823941711 for any help. ▪ Give your Location, Name and ID No. / E.C. No. when giving some information. ▪ State the nature of the accident or incident. It is important to report even when there are no injuries or damage. ▪ Provide relevant First Aid if competent to do so /or Rush the victim to the Occupational Health Centre at site ▪ Stay with the injured person until Medical Assistance arrive and a report of the circumstances has been taken
Action After Effective Period	
Emergency Response Team	▪ Assess / investigate the incident. ▪ Undertake restorative measures & repairs. ▪ Investigate / analysis the incident to prevent reoccurrence. ▪ Liaise with HOS – Occupational Health Services to follow up on causalities

7.2.15 Marine Emergency

Marine- HOD is the Site Incident Controller and will be leading the response team until the emergency is totally brought under control or he is substituted under ERC instruction. This is irrespective of the time taken to control the emergency. The following action plans for emergencies are defined in this plan.

7.2.15.1 Emergency Alert Ship's Engine failure

Key Person	Action
Master of vessel	• Inform Port Control room on VHF • Inform Pilot • Activate Ship Emergency Response Plan

Pilot	• Inform MIDPL control Room
	• Review Vessel's position
	• Tugs/Mooring boats standby for use
	• If engine failure during approach, ready anchors and consider using anchors
	  o Use tugs
	  o Abort approach, turn to sea
	  o Tow the vessel to safety
	• If engine failure after abort point, ready anchors and consider using anchors
	  o Use tugs
	  o Enter turning basin and drop anchor
	• If engine failure at berth ,while unberthing
	  o Stay at berth

MIDPL Control Room	• Inform LTSB Control • Inform Marine HOD • Inform Port tugs/ crafts and activate other tugs • Navigational warnings • Monitor and log communications
HOD –Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot. • Assess damage caused to port property and notify the agent accordingly for damage claims

7.2.15.2 Vessel's grounding in approaches to port

Key Person	Action
Master of vessel	• Inform Port Control room on VHF • Inform Pilot • Activate Ship Emergency Response Plan • Assess situation and damage/possibility of damage to environment; render damage control assistance as required. • Consider re-floating options
Pilot	• Inform Port control Room • Review Vessel's position • Call additional Tugs/Mooring boats for use • Assess damage to ship. Do not attempt immediate re-floating using ships engines • Arrange tugs/mooring boats/ firefighting assistance as required • Ensure personnel are safe/ consider evacuation • Activate oil spill response (if required) • Consider re-floating options • -
MIDPL Control Room	• Inform LTSB / KPL Marine Control • Inform Marine HOD • Inform Port tugs/ crafts and activate other tugs • Navigational warnings • Monitor and log communications
HOD -Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot. • Assess damage caused to port property and notify the agent accordingly for damage claims

7.2.15.3 Collision between Ships in Approaches to Kattupalli/ Ennore port channel

Key Person	Action
Master of vessel	• Inform Port Control room on VHF • Activate Ship Emergency Response Plan • Activate Ship Damage Control Plans • Activate Oil Spill Response, as required
Pilot	• Inform MIDPL Port control Room • Review ship position • Tugs/mooring boats • Liaise with Masters, monitor situation • Abort approach, turn to sea • Tow the vessel to safety, if required • Evacuation, if require
MIDPL Control Room	• Inform LTSB Marine Control / KPL • Inform Marine HOD • Inform Port tugs/ crafts/ diving support • Issue Navigational warnings • Inform medical / Clinic • Monitor and log communication
HOD –Marine (**Site Incident Controller)**	• Standby on VHF and maintain contact pilot. • Assess damage caused to port property and notify the agent accordingly for damage claims

7.2.15.4 Vessel contact with jetty Structure

Key Person	Action
Master of vessel	• Inform Port Control room on VHF • Inform Pilot • Activate Ship Emergency Response Plan

Key Person	Action
	• Activate Ship Damage Control Plans • Activate Oil Spill Response, as required
Pilot	• Inform MIDPL Port control Room • Pull Ship away from the berth • Assess damage to ship and jetty • Consider re-berthing or abort approach and proceed to sea
MIDPL Control Room	• Inform LTSB / KPL Control • Inform Marine HOD • Inform Engineering Services In charge to make assessment of Jetty damage • Monitor and log communications • Take photographic evidence
HOD -Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot. • Assess damage caused to port property and notify the agent accordingly for damage claims
Security	Isolate Jetty

7.2.15.5 Ship at berth mooring failure

Key Person	Action
Master of vessel	• Stop all cargo operations • Commence heaving ship's gangway or assist • Inform Port Control room on VHF • Inform Pilot • Activate Ship Emergency Response Plan
MIDPL Control Room	• Inform Port tugs to start engines and approach the vessel • Instruct Jetty Supervisor to reach the berth, see the possibility of receiving mooring lines. • Call Pilot • Inform LTSB / KPL Control • Inform Marine HOD • Inform Engineering Services In charge to make assessment of Jetty damage • Monitor and log communications
Pilot	• Approach the vessel on tug • Establish contact with the Master for planning and boarding • Ships engines to immediate readiness • Use stand by tug • Arrange tugs/mooring boats/ firefighting assistance as required • Analyse cause
HOD -Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot • Consider re-berthing option or proceed to sea • Assess damage caused to port property and notify the agent accordingly for damage claims

7.2.15.6 Fire/Explosion on board any vessel in port

Key Person	Action
Master of vessel	• Stop all cargo operations • Inform Port Control room on VHF • Activate Ship Emergency Response Plan
MIDPL Control Room	• Inform Port tugs to start engines and approach the vessel, with fire pumps and Fi Fi on stand by and assist if required. • Inform Fire Dept. • Inform Marine HOD • Call Pilot • Inform LTSB / KPL Control • Inform Safety Dept.

Key Person	Action
	• Inform Medical Cell • Inform Security • Monitor and log communications
HOD -Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot • Ensure safety of all personnel / treatment to injured/ evacuation • Consider, pulling out the vessel to safe berth / anchorage • Proceed to safe position/anchorage off port • Assess damage caused to port property and notify the agent accordingly for damage claims
Pilot	• Approach the vessel on tug in case planned to remove to safe berth/anchorage • Establish contact with the Master for planning and boarding • Ships engines to immediate readiness • Use stand by tug
Medical Team	Stand by on Jetty
Fire Squad	Stand by on Jetty
Security Team	Isolate Jetty and remove unnecessary personnel

7.2.15.7 Man over board from ships/tug/Jetty

Key Person	Action
Master of vessel/Observer	• Inform Port Control room on VHF • Activate Ship Emergency Response Plan
MIDPL Control Room	• Inform HOD Marine • Inform Pilot / Port tugs/ crafts • Mobilize Rescue Boats, Life Saving Appliances, Lights, Lookout • Monitor and log Communications • Confirm Navigational Warning issued by Port Control
HOD -Marine(**Site Incident Controller)**	• Standby on VHF and maintain contact with Master / Pilot • Assemble Emergency Response Team • Assess situation
Medical Team	Stand by on Jetty for Medical Assistance

7.2.15.8 Oil Spill during re-fuelling of port tugs/crafts

Key Person	Action
Master of vessel	• Inform MIDPL Port Control room on VHF • Stop bunkering & close all valves • Activate Ship Emergency Response Plan
MIDPL Control Room	• Inform LTSB / KPL control room • Inform Harbour tugs/ crafts • Monitor and log communications • Ensure Oil Spill Gear Readiness and shifting to site
HOD -Marine(**Site Incident Controller)**	• Maintain VHF contact with re-fuelling tug / craft • Maintain VHF contact with Port Control • Assess situation • Activate Oil Spill Response Plan (see section 6,7 & 8) • Inform Coast Guard • Inform DG Shipping • Assess damage caused to port property and notify the agent accordingly for damage claims
Fire Team	Stand by for any fire outbreak

7.2.15.9 Medical Emergency offshore (Ship/Harbour craft)

Key Person	Action
Master of vessel/harbour craft	• Inform Port Control room on VHF • Request nature of assistance required
MIDPL Control Room	• Inform Port Medical • Inform LTSB / KPL control Room • Inform Marine HOD • Port tug / craft standby for evacuation • Monitor / log communication
HOD -Marine(**Site Incident Controller)**	• To be in VHF contact with Ship / Craft • Assess situation • Assess damage caused to port property and notify the agent accordingly for damage claims
Medical Team	• Standby for Medical Assistance • Call Company doctor for advise • Provide Advanced First Aid • Evacuation to Hospital

7.2.15.10 Ship's Security Alert System Activation

Key Person	Action
Master of vessel	• Stop all cargo operations • Inform Port Control room on VHF • Activate Ship Security Plan
MIDPL Control Room	• Inform PFSO/ DY PFSO • Inform Security • Inform Port tugs to start engines and approach the vessel, with fire pumps and Fi Fi on stand by and assist if required. & patrol on the sea side • Inform Fire Dept. • Inform Marine HOD • Call Pilot • Inform LTSB / KPL Control • Inform Safety Dept. • Inform Medical Cell • Monitor and log communications
HOD –Marine/ Dy PFSO(**Site Incident Controller)**	• Standby on VHF and maintain contact pilot • Ensure safety of all personnel / treatment to injured/ evacuation • Consider, pulling out the vessel to safe berth / anchorage • Inform DG Command Centre in consultation with the PFSO
Security Team	• Isolate Jetty / vessel and remove unnecessary personnel • Remove gangway
	• Approach the vessel on tug in case planned to remove to safe berth/anchorage • Establish contact with the Master for planning and boarding • Ships engines to immediate readiness • Use stand by tug
Medical Team	Stand by on Jetty
Fire Squad	Stand by on Jetty

7.2.15.11 Hostage Situation

Key Person	Action
MIDPL Control Room	• Inform PFSO/ DY PFSO • Inform Security • Inform Fire Dept. • Inform Marine HOD • Call Pilot

Key Person	Action
	• Inform LTSB / KPL Control • Inform Safety Dept. • Inform Medical Cell • Monitor and log communications
Security Team	• Isolate Jetty / vessel and remove unnecessary personnel • Stand by for any escalation • Inform Police
HOD –Marine/ Dy PFSO(**Site Incident Controller)**	• Plan out means to contact the belligerent parties for understanding reason for hostage situation • Ensure safety of all personnel / treatment to injured/ evacuation • Consider, pulling out the vessel to safe berth / anchorage • Inform DG Command Centre in consultation with the PFSO
Medical Team	Stand by
Fire Squad	Stand by

7.2.16 Action Plan for Off Site Emergency

When the industrial disaster cannot be controlled by using unit's own resources, then it is necessary to involve outside resources to control such emergency. Even when Industrial disaster spread outside its premises and likely to affect or affect surrounding population, other industries, etc. then also outside resources needed to control it. This emergency called as Off Site Emergency & it will be controlled by either local or district authority.

The emergency location will not change but the line of actions will govern by crisis group instead of units' authorities. The unit own Authority has to extend facilities, liaison, and coordination to the local crisis group or district crisis group as per requirement or situation.

7.2.16.1 Probability of Off-Site Emergency

The Fire/Explosion incidents at Tank farm may not create situation which requires Off Site Emergency from On Site Emergency. The spread of emergency created at other industries by handling and storing activities in the premise would be within Kattupalli area and can be tackled by own resources. But transportation of hazardous material by Tanker or Transportation through pipe line may create situation requires Off Site Emergency.

7.2.16.2 Outside Participation

In off-site actions, the local participants particularly the administration, fire & police play the dominant role. Industrial management has a limited and comparatively submissive role. The diversities of the problems and response are bigger and Humanitarian work assumes more importance.

The correct management strategy in this situation will be to involve the local participants/stakeholders fully in emergency operation and provide necessary technical and financial support to them to manage the emergency..

7.2.16.3 Mutual Aid and Interaction

The benefits from mutual help will in term of: -

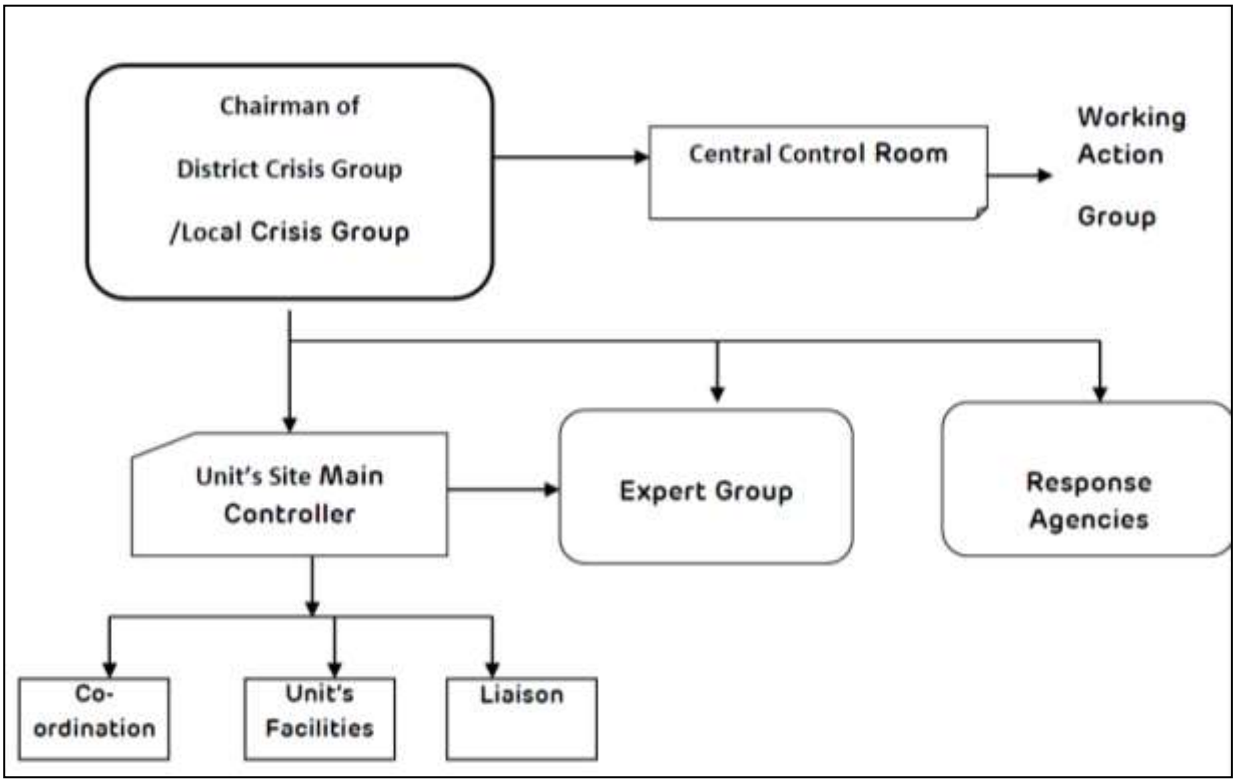
- Availability of more numbers of technical persons in time of need.
- Gains from sharing of experience.
- Resources like cars, rescue equipment's, protective equipment's and tools to meet the emergency can be pooled.

- Facilities of first aid, and services of medical officers and pare-medical staff in all units available for use for the unit in distress.
- In drafting the Off-Site Program all units can work together and evolve a common plan with participation of all units.
- In terms of communication with other local participants and giving information to public, a joint approach will be more successful.
- In case of emergencies involving the community, the workload in connection with rescue, relief and medical aid can be shared.
- MIDPL is a member of the Kattupalli Area Industrial Association (KAIA)
- During the unexpected emergency will inform the concerned authority

In order to derive maximum benefit from mutual help it will be necessary for all the participating units to interact with each other, share information and experience and also establish reliable communication links. Apart from facilities like communication facilities and codes for priority in calling during emergencies, methods of contact and nodal persons for contact should be decided in advance.

7.2.16.4 Action by SMC & IC during Offsite Emergency

During off site emergency, Duties and responsibility of unit's Site Main Controller and Incident Controller will be different from onsite emergency plan. In offsite emergency plan, Government Authority (Chairman of District Crisis Group/Local Crisis Group) will take charge of disaster and now he will be site main controller for Off Site Emergency plan.



7.2.17 Withdrawal of emergency (Calling off Emergency)

The emergency declared both within the works and the community should be called off only after making sure that the incident is brought under control and that no further dangers are possible to property or life. The Site Main controller, Govt. Authority in consultation with the work groups concerned, should take a decision to this effect.

7.2.18 Tentative Evacuation plan for Emergency and Assembly Points

General plant layout showing emergency escape route and assembly points for existing Kattupalli Port are given in **Figure 7-5** and for Proposed development are given in **Figure 7-6**. The details of Safe Assembly Points and Shelter en-route are mentioned in

Table 7-28: Details of Alternate Shelter

Sr. No. of Assembly point	Location	Accommodation Capacity	At the time of emergency	
			Person in charge	Phone number
1.	In front of Site office – Near Office Gate	100 no.s	Head - Security	8980016218
2.	Near Container Yard	100 no.s	Incharge – Container operations	8939992949
3.	Near Custom Office Crossing	150 no.s	Incharge – Container operations	8939992949
4.	Near Port Gate House Complex	150 no.s	Head - Security	8980016218

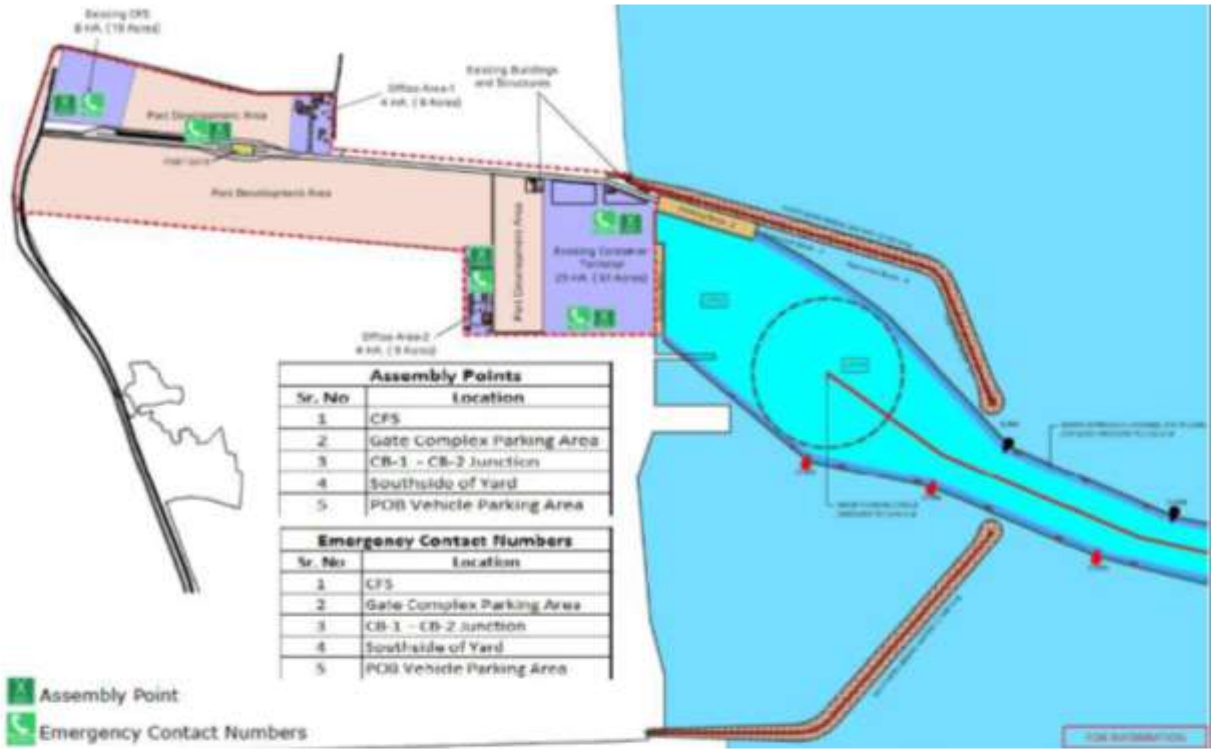


Figure 7-5: Emergency Assembly Points for Existing Kattupalli Port

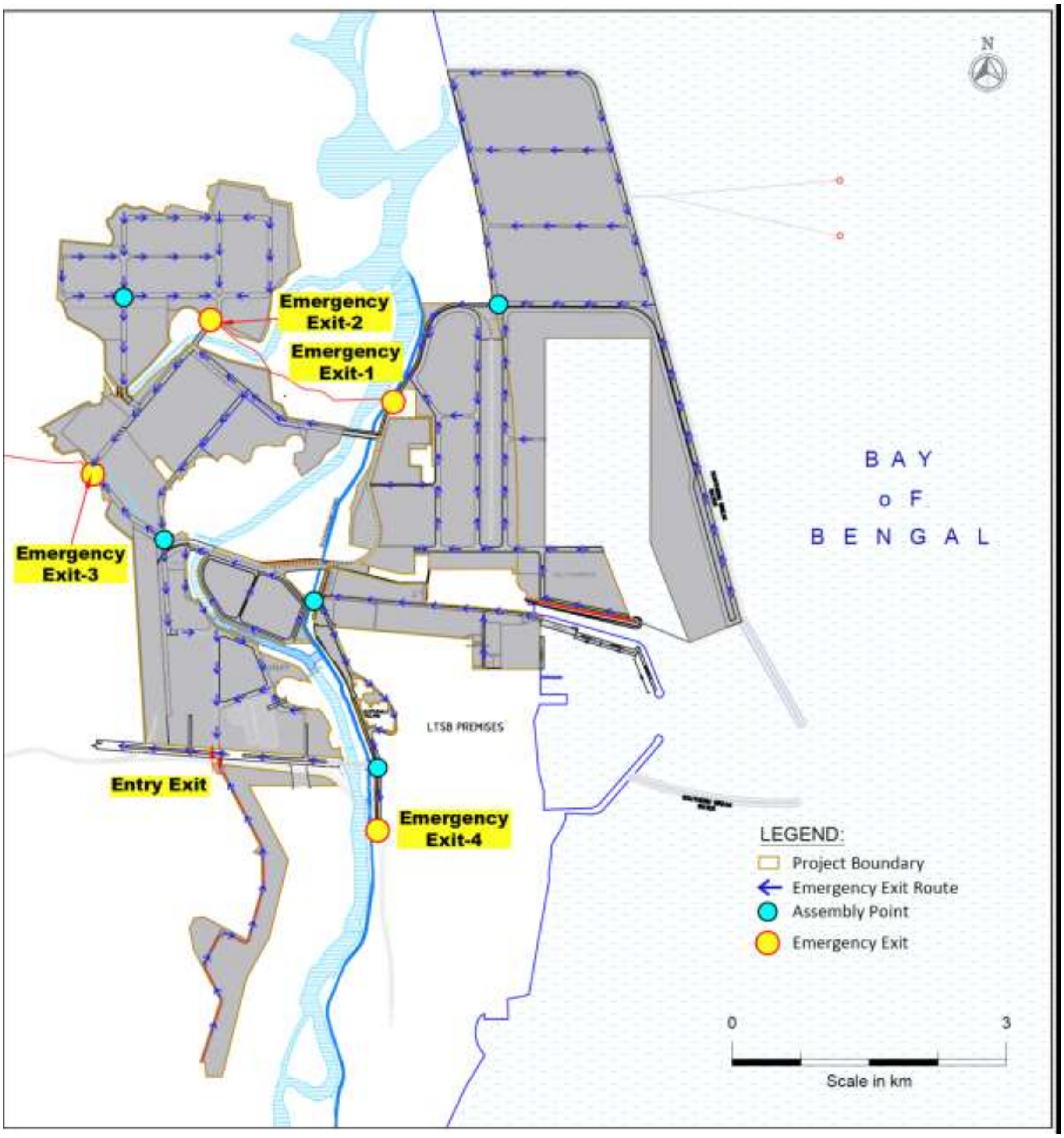


Figure 7-6: Emergency evacuation plan for RMP

The existing DMP do recognise the continuous improvement of different strengths and capacities that different groups use to prepare for, cope with and respond to a disaster. The existing DMP shall be revised considerably by improving, strengthening and upgrading the approach (including facilities) and adding new dimensions to be more useful and effective in addressing the difficult challenges of disaster risk reduction requirements of proposed RMP.

7.3 Flood Model Study

Preliminary modelling studies indicate that the raising of backup area of the port to +5m CD is effective in protecting the port infrastructure from the overtopping of the river during a 100-year rainfall event of 24-hour duration.

Detailed bathymetry of the Kosasthalaiyar backwater river from Ennore creek up to Pulicat lake is required, in addition to any available calibration data, for obtaining conclusive results in terms of the exact HFL that can be expected near the port. Detailed bathymetric survey of Buckingham canal in this area is also crucial since the storage capacity and conveyance of the canal can reduce flooding in the area.

The flood protection of the area may be improved by carrying out de-silting of Buckingham canal and the Backwater Rivers. Locations where the embankments of the Kosasthalaiyar Backwater River and B-canal damages must be identified and strengthened to reduce overtopping from the banks.

A coupled 1D & 2D model is applied to understand the hydraulic behaviour of the Kosasthalaiyar River, Ennore Creek and their floodplains, to determine the flood paths along the proposed Kattupalli port expansion area.

The baseline scenario represents the current condition and the future scenario represents proposed expansion of Kattupalli port with increase in the ground elevation. These two scenarios are simulated for peak flood event combined with tidal variations in the vicinity of project area.

7.3.1 1D River Model

MIKE Hydro River is a model system for one-dimensional (1D) networks such as river and channel networks. Inputs for the one-dimensional model include rainfall, cross-sections in rivers and channels, upstream- and downstream boundary conditions (water level or discharge time series) and structures. The output of the model gives the details about the water level, velocity, and discharge at selected points in the network.

Model Setup

The model setup of Kosasthalaiyar River and Ennore creek is developed using MIKE HYDRO RIVER (One dimensional) to simulate flow and water level along its length. The key components the hydraulic model is:

1 River alignment (.shp format)
2 River cross sections at various chainages (surveyed cross sections for baseline, and designed cross sections for proposed scenarios)
3 Boundary conditions (a) discharge entering the rivers and (b) tidal water level at the mouth
4 Roughness coefficient

River network and cross sections

The river network was setup using the river drainage patterns of Gummidipoondi, Araniyar, and Kosasthalaiyar rivers. These rivers are selected for the modelling since they all drain into the sea viz. Ennore Creek and therefore can impact flooding around the port area. Buckingham canal has also been included starting from the emergence of the canal near the outflow point of Pulicat lake until the confluence of the canal with Cooum river at the southern boundary of the model.

Gummidipoondi River drains into Pulicat Lake. Araniyar river drains into the southern end of Pulicat lake and joins a stream which connects Pulicat Lake with Ennore Creek. The port lies beside this stream and this stream is crucial to the flood scenario around the port area.

Buckingham canal flows parallel to this stream (between the stream and the coast) until Ennore Creek where it merges with the sea. South of the creek, Buckingham canal re-emerges from Kosasthalaiyar river and continues to traverse south parallel to the coast until it meets Cooum river.

The entire canal extends from Kakinada in Andhra Pradesh to Villupuram district of Tamil Nadu over a distance of 797 km.

The cross sections of the river have been extracted using Digital Elevation Models (DEM) from 2 sources:

- For the area close to the creek, 10m resolution CARTOSAT DEM was purchased from National Remote Sensing Centre (NRSC) and used. The extent of the 10m CARTOSAT DEM with respect to the river network can be seen in **Figure 7-7**.
- For all the remaining areas, 30m SRTM DEM was obtained from United States Geological Survey (USGS) where it is publicly available for download.

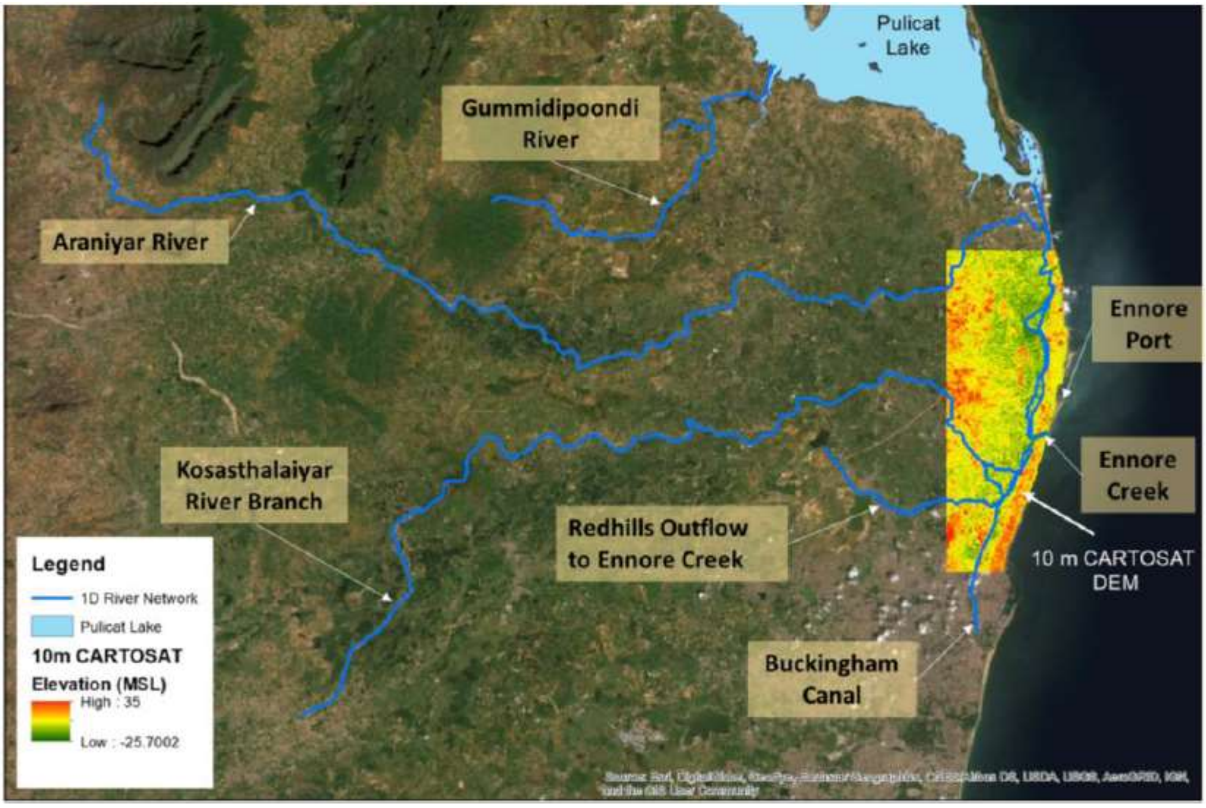


Figure 7-7: River network with 10m CARTOSAT DEM. Remaining areas with 30m SRTM DEM

Boundary conditions

Boundary conditions are applied into the river to account for dam releases along the river and catchment runoff entering the river. At the downstream end, Gummidipoondi river freely discharges into Pulicat lake. A tidal boundary is applied at Ennore creek and at the confluence of B-canal with Cooum river in the southern boundary of the model. The excess water from Pulicat lake flows into a stream which connects Araniyar river to Ennore creek.

Figure 7-8 shows the locations where the boundary conditions are applied with ID numbers from 1 to 8. **Table 7-29** presents details about the boundaries marked in the figure using the same ID numbers.

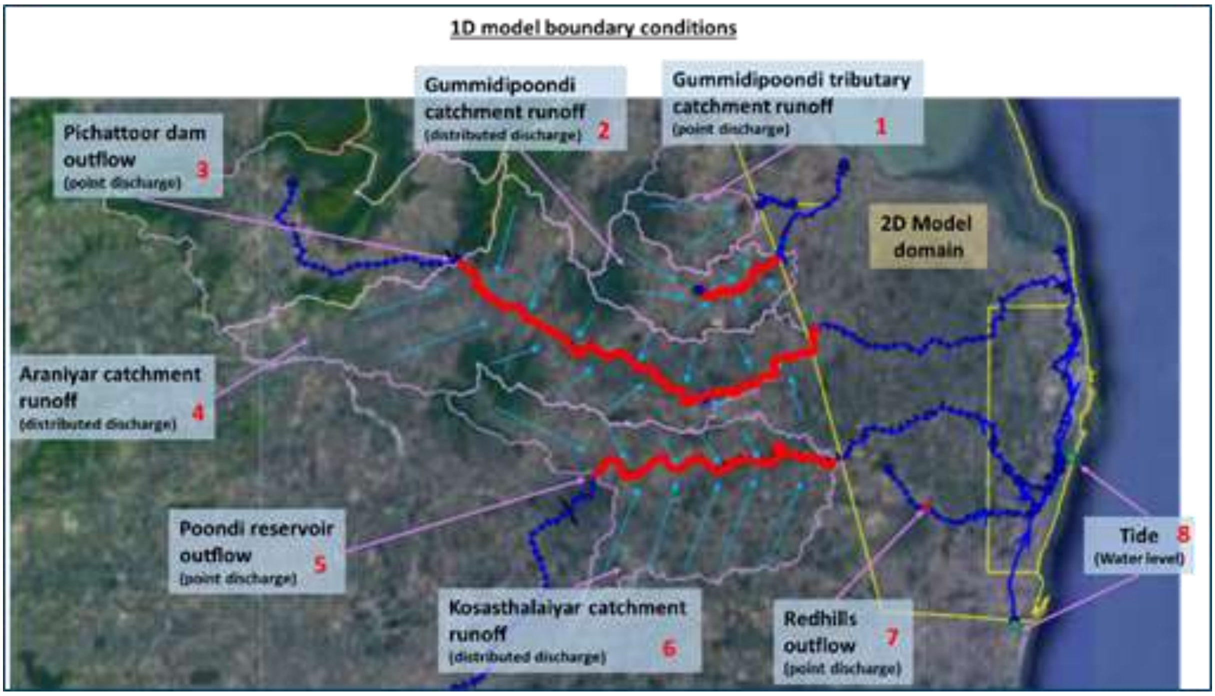


Figure 7-8: 1D model boundary conditions (light blue line= flow direction; red line = distributed catchment runoff boundaries; pink polygons = NAM catchments; yellow polygon = 2D model domain)

Table 7-29: Details of boundary conditions

Boundary ID	River/Location	Description	Boundary type	Reference
1.	Gummidipoondi Tributary	Catchment runoff (till 2D model domain)	Point discharge	Obtained from NAM (rainfall-runoff) model
2.	Gummidipoondi river	Catchment runoff (till 2D model domain)	Distributed discharge	Obtained from NAM model
3.	Araniyar	Outflow from Pichatur	Dam Point discharge	Newspaper article (Thanthi News, 2015)
4.	Araniyar	Catchment runoff (downstream of reservoir till 2D model domain)	Distributed discharge	Obtained from NAM model
5.	Kosasthalaiyar	Poondi Reservoir Outflow	Point discharge	DHI Library and 2015 flood assessment report (IISc, 2016)
6.	Kosasthalaiyar	Catchment runoff (downstream of reservoir till 2D model domain)	Distributed discharge	Obtained from NAM model
7.	Kosasthalaiyar	Redhills reservoir outflow to Ennore Creek	Point discharge	DHI Library and 2015 flood assessment report (IISc, 2016)
8.	Ennore Creek C-	Tide	Water level	MAP data from MADRAS
	B-canal southern limit in model	Tide (since it is merging with Cooum river near the mouth)	Water level	C-MAP data from MADRAS

Gummidipoondi

The discharge hydrograph for Gummidipoondi river and its tributary were obtained by simulating a rainfall runoff model (NAM). The hydrographs for the tributary and main river (numbers 1 and 2 are shown in **Figure 7-8** and **Figure 7-9**.

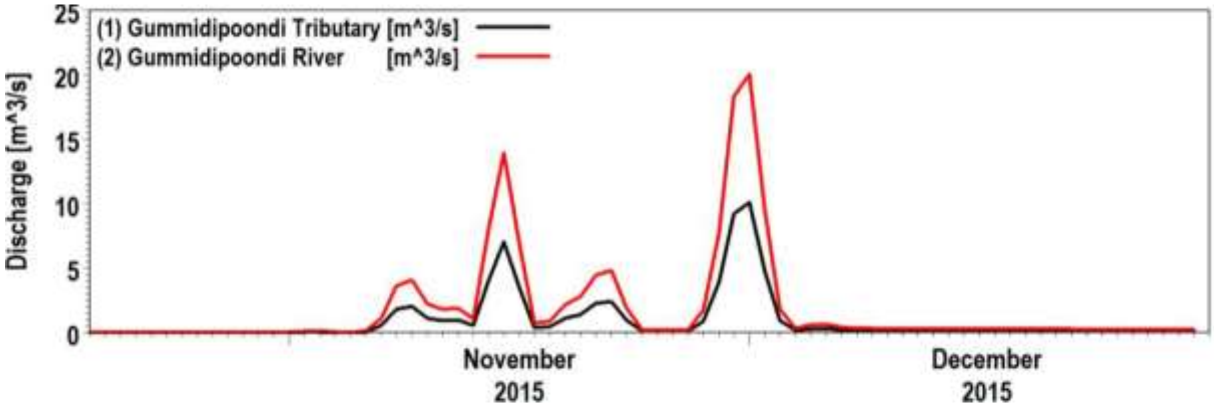


Figure 7-9: Discharge (m^3/s) for Gummidipoondi Tributary and River catchment runoff

Araniyar River

The discharge data from Pichatur dam (boundary ID 3, **Figure 7-8** for 2 days during 2015 flood were obtained from published sources (Thanthi, 2015). The normal discharge from this dam for remaining days was set to 2 m^3/s^2.

The discharge hydrograph for Arani river catchment runoff (boundary ID 4, **Figure 7-8**) were obtained by running a rainfall runoff model (NAM). The catchment used for the NAM model is the intermediary catchment downstream of Pichatur dam and until the 2D model domain.

The two hydrographs for Arani river are shown in **Figure 7-10**.

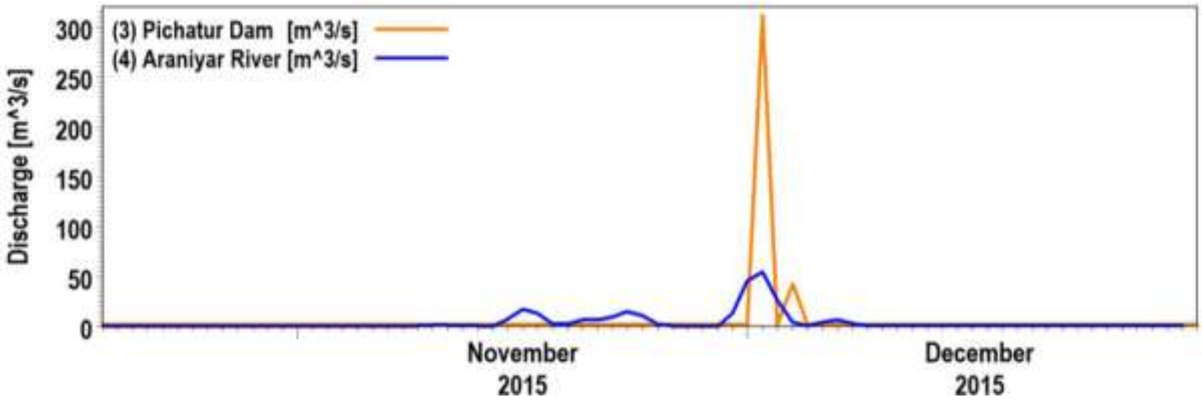


Figure 7-10: Discharge (m^3/s) at Pichatur Dam outflow and Araniyar River catchment runoff

Kosasthalaiyar

Three boundary conditions were added into Kosasthalaiyar river:

- Poondi reservoir outflow (boundary ID 5, **Figure 7-8**)
- Kosasthalaiyar river catchment runoff for the intermediary catchment from downstream of Poondi till the 2D model domain (boundary ID 6, **Figure 7-8**)
- Redhills reservoir outflow (boundary ID 7, **Figure 7-8**)

The three hydrographs are plotted in **Figure 7-11**.

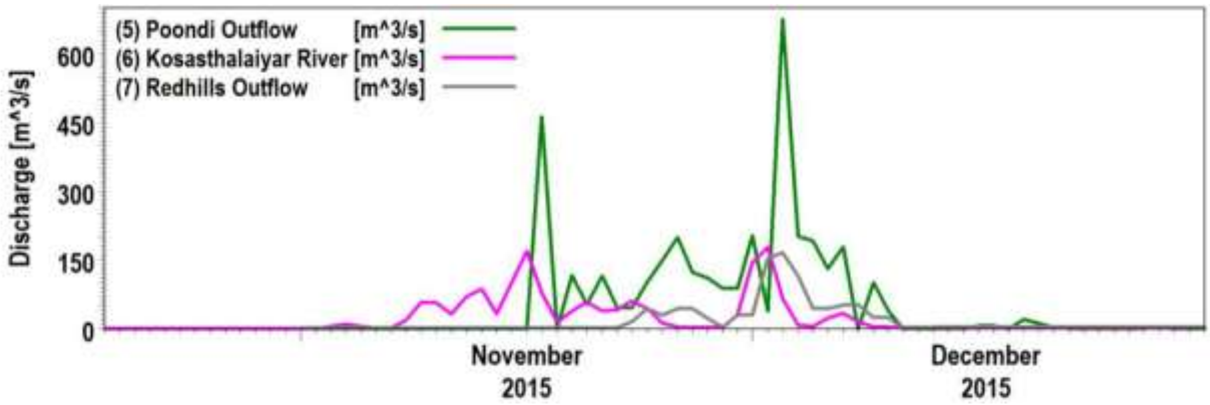


Figure 7-11: Discharge (m^3/s) for Poondi Reservoir outflow; Kosasthalaiyar River catchment runoff and Redhills outflow to Ennore

Tide

The tidal boundary condition (marked as ID 8 in **Figure 7-8**) is applied at Ennore creek and Buckingham canal at the confluence with Cooum river mouth.

For this purpose, the tidal water levels from the closest C-MAP station – MADRAS – were downloaded for November and December 2015. The tidal boundary time series is as shown in **Figure 7-12**. The tide ranges from 0.8m to -0.45m with respect to sea level.

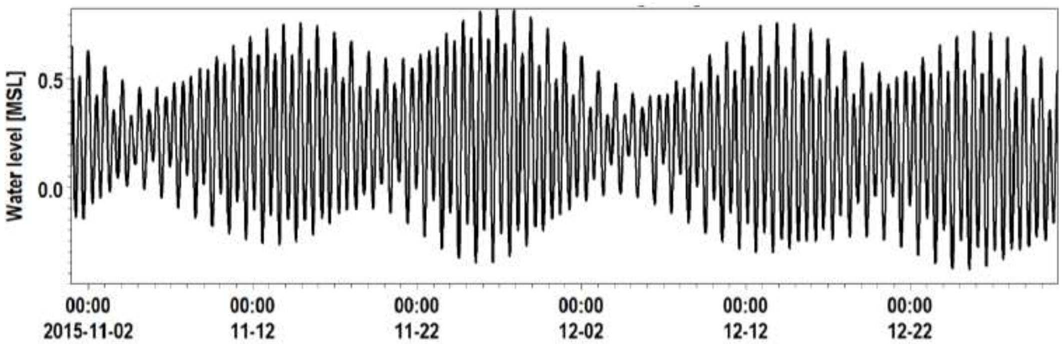


Figure 7-12: Tide water level boundary with respect to Mean Sea Level (MSL)

7.3.1.1 Roughness coefficient

The resistance to the flow in the river is typically estimated by calibration with the observed discharge and water level data available between the model stretch, i.e. reservoir water spread length. Since no such intermediate data is available to calibrate the model, standard values from the literature have been used. The roughness values that have been used in the model based on the type of land-use or channel lining material are listed in **Table 7-30**.

Table 7-30: Roughness coefficients used in the model (USACE, 1995)

Type of channel	Manning's 'n' value	Manning's 'M' value
Natural channels with no boulders and scattered bush with weeds	0.03	33.33
Floodplains with mature row crops	0.035	28.57
Floodplains with mature field crops	0.04	25
Channel with dry rubble or riprap or stone-pitching on one side	0.022	45.45
Concrete lined channel	0.018	55.56

7.3.2 2D Surface Model

The 2D modelling is carried out using MIKE 21 Flow Model FM, which is modelling software based on a flexible mesh approach. It is used for flood modelling, estimating the flood depths in the study area. The Hydrodynamic Module used for flood modelling is based on the numerical solution of the shallow water equations - the depth-integrated incompressible Reynolds averaged Navier-Stokes equations. Thus, the model consists of continuity, momentum, temperature, salinity, and density equations. In the horizontal domain both Cartesian and spherical coordinates can be used. The spatial discretization of the primitive equations is performed using a cell centred finite volume method. The spatial domain is discretized by subdivision of the continuum into non-overlapping element/cells. In the horizontal plane an unstructured grid is used comprising of triangles or quadrilateral element. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible to handle discontinuous solutions. For the time integration an explicit scheme is used.

Model setup

The 2D model setup mainly consists of a Digital Elevation Model (DEM) in the study area. 10m CARTOSAT DEM from NRSC is used for 239 km2 in the vicinity of the port area (refer Figure 11-3 for extent of DEM) and 30m SRTM DEM from USGS is used for the remaining area. A flexible triangular, computational mesh is created for the model domain, which is shown in **Figure 7-13**.

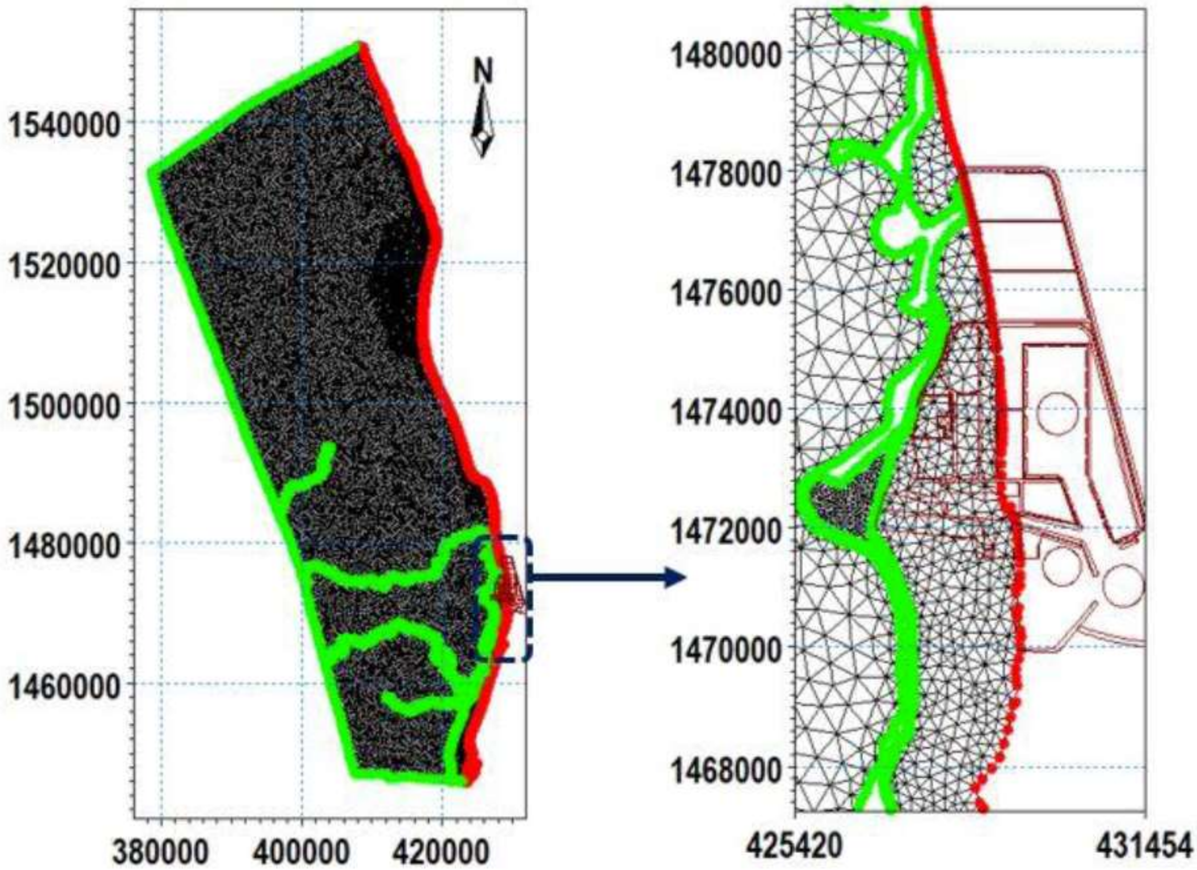


Figure 7-13: Flexible mesh used for model domain

7.3.2.1 Initial conditions and boundary conditions

The Surface Elevations (SE) with 0m total water depth or dry throughout the model domain is considered as the initial condition for the hydrodynamic flow model which is shown in **Figure 7-14**. The Land boundary condition on the north, south and west side of the model domain assumes zero flow condition. The uniform Manning number of 28.57 is used for the entire domain (refer **Table 7-30**).

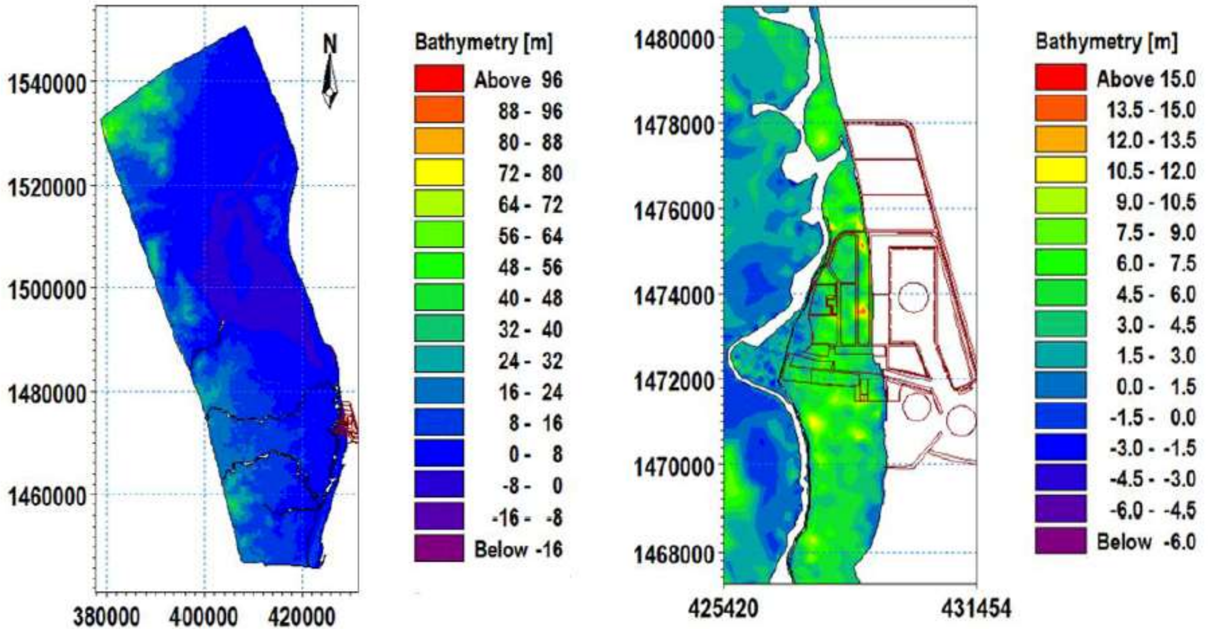


Figure 7-14: Surface Elevation (SE) as the initial condition for the Hydrodynamic flow model

As the storm intensity of 2015 flood event is greater than 24 hour-100 year return period storm intensity, modelling is carried out for 2015 flood event to estimate the maximum flooding depths in the port area.

7.3.3 Coupled Flood Model (1D & 2D)

MIKE FLOOD is a product that integrates the 1-dimensional model MIKE HYDRO River, MIKE 11, MIKE URBAN (MOUSE) and the 2-dimensional model MIKE 21 into a single, dynamically coupled modelling system.

Using a coupled approach enables the best features of both the 1-dimensional and the 2-dimensional models to be utilised, whilst at the same time avoiding many of the limitations of resolution and accuracy encountered when using 1D or 2D separately.

In the present case, MIKE FLOOD is used to couple the 1D MIKE HYDRO RIVER and the 2D MIKE 21FM models.

Model Setup

The 1D model (MIKE HYDRO River) and the 2D model (MIKE 21 FM) are coupled using MIKE FLOOD. MIKE FLOOD has several types of links to couple the 1D and 2D. In this case, lateral links are used to couple the left and right banks of the 1D river to the 2D surface. A lateral link allows a string of MIKE 21 cells/elements to be laterally linked to a given reach in MIKE HYDRO River, either a section of a branch or an entire branch. Flow through the lateral link is calculated using a structure (weir) equation. This type of link is particularly useful for simulating overflow from a river channel onto a flood plain. Figure 11-12 shows the application of lateral links.

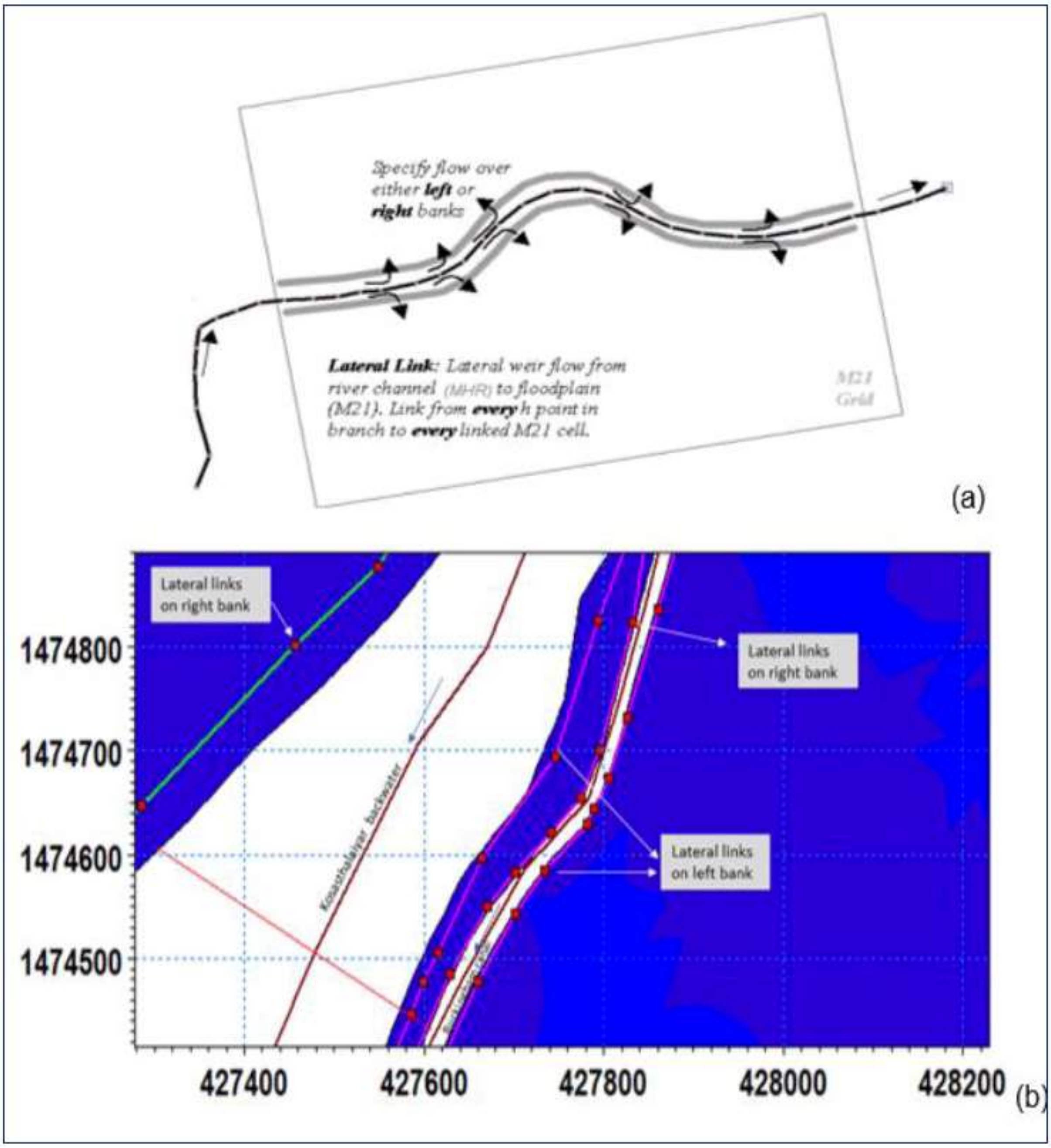


Figure 7-15: a) Application of lateral links b) Lateral links of zoomed area near port

Figure 7-16 shows the entire MIKE Flood model extent and sub-set of study area developed using two way coupling and the lateral links used to couple the 1D and 2D.

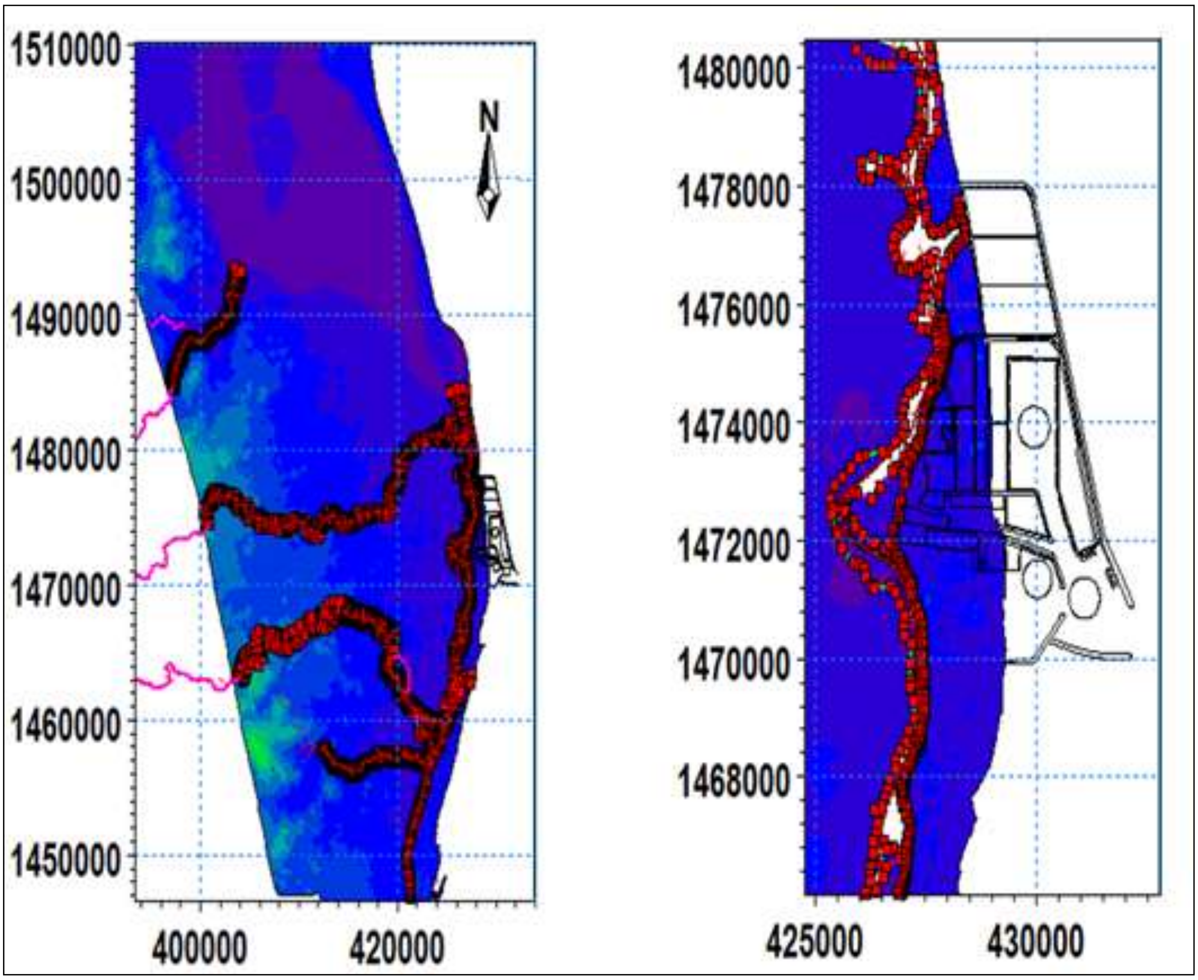


Figure 7-16: MIKE FLOOD two way coupling setup showing lateral links a) Entire Model domain; b) Zoomed to port area

7.3.3.1 Model Scenarios

The flood model is carried out for baseline condition and future scenario for 4 days from 14 Nov to 18 Nov 2015. Baseline model is performed by considering the existing ground condition and future scenario includes the development activities in the port area. The model setup for both is same. Bathymetry for the 2D model is updated to incorporate the port plan as provided by the client for future scenario.

Baseline

CARTOSAT DEM values are used as surface elevation in the port area. The maximum elevation in the port area is 15.78 m. Kosasthalaiyar backwater and north Buckingham canal passes through this area. The flood plain on the left bank (western part of the Port) has lower elevation compared to the right bank.

Future scenario

The future scenario considers the situation where the land elevation in the port backup area is raised to +4.4 m with respect to MSL, as per the requirement of the client. The comparison of surface elevation for baseline condition and future scenario is shown in **Figure 7-17**.

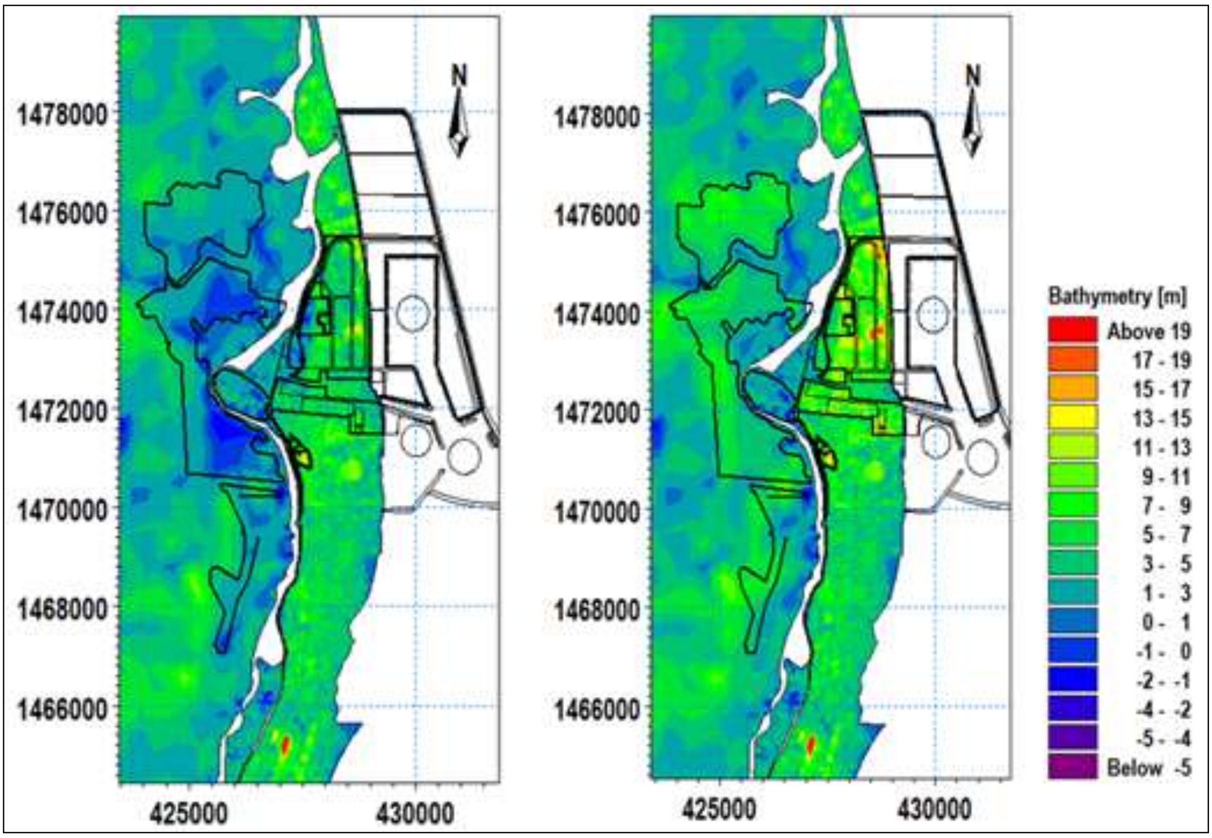


Figure 7-17: Surface elevation in the port area for baseline and future scenario

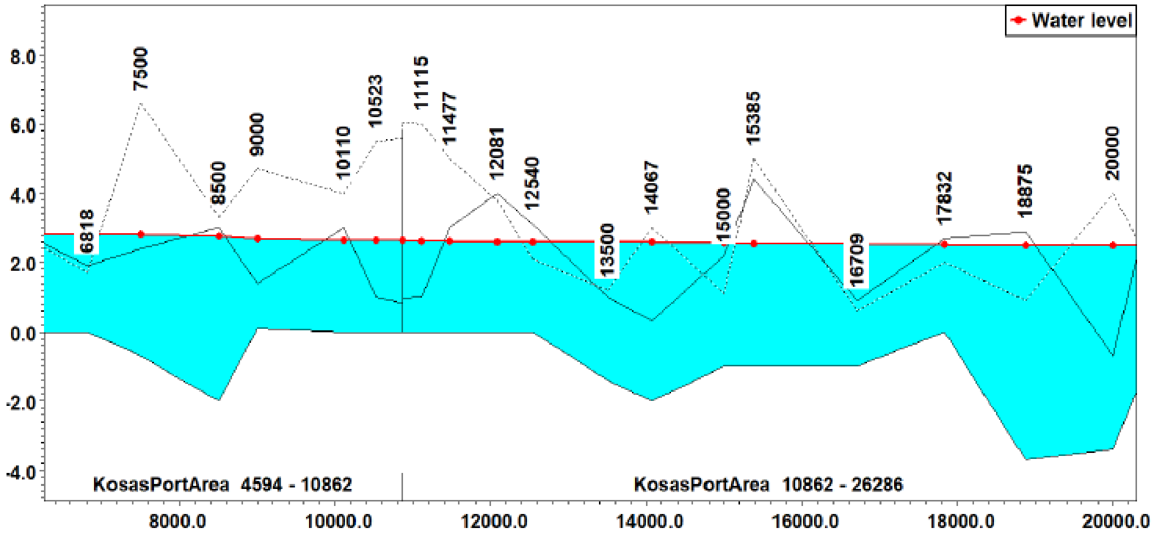
7.3.3.2 Coupled Model Results

The coupled (1D & 2D) model results provide the inundation depth and extent of flood in the port area, and flood level in the river. High flood level in the river means that the water continues to flow out of the river which induces flooding in the flood plain.

Baseline Scenario

The simulated maximum water level profile i.e., High Flood Level (HFL) along the Kosasthalaiyar backwater river and Buckingham canal in the port area is shown in **Figure 7-18** for baseline condition. This shows that the water level in the channel is higher than the existing bank level. When this occurs, the flood water from the river will flow laterally onto the floodplain following the gradient of the DEM and result in inundation of the floodplain.

Note: It is assumed that flow direction is from Pulicat lake to Ennore creek. Dotted black line = left riverbank; Solid black line = right bank; Blue shaded area = maximum water level condition



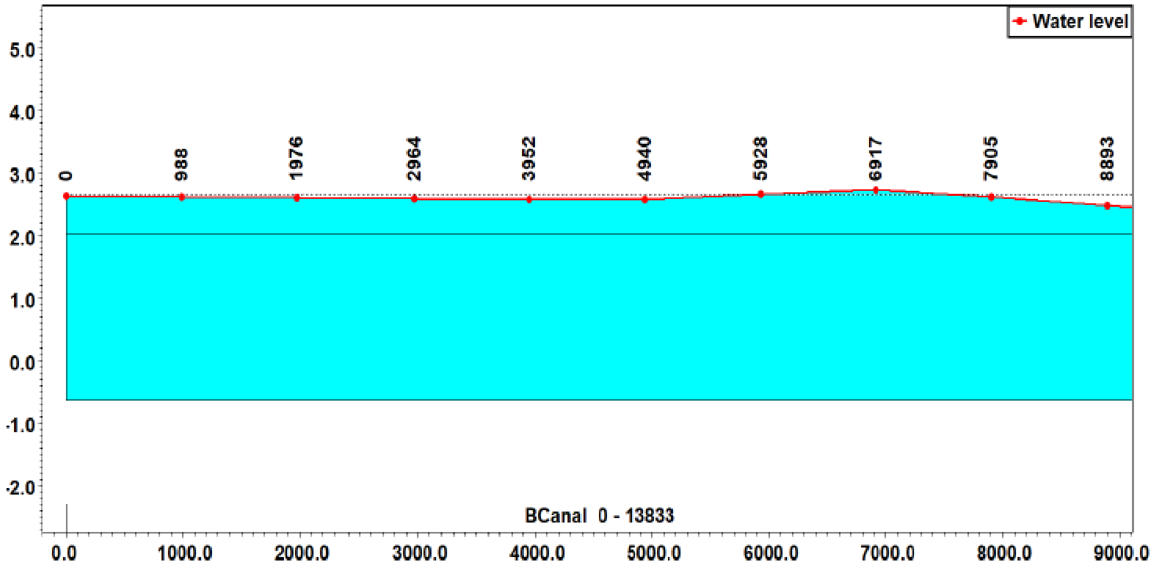


Figure 7-18: Water level profile of Kosasthalaiyar and Buckingham canal-Baseline condition

The inundation depth and current speed in the vicinity of the port area induced by the 2015 flood event with baseline configuration is shown in **Figure 7-19** and **Figure 7-20**. It is observed from the model that the maximum water depth is 3.5 m near the meandering area of the Kosasthalaiyar river where multipurpose area for the port is expected. The west side of the port (right bank of the river) is heavily flooded, where depth is varying between 1.8m and 3.5 m. Because of the existing high ground elevation, flooding has minimal impact on the eastern part of the port (left bank of the river) compared to other area.

The current speeds are low in these area, less than 0.2 m/s, presumably due to the flat terrain.

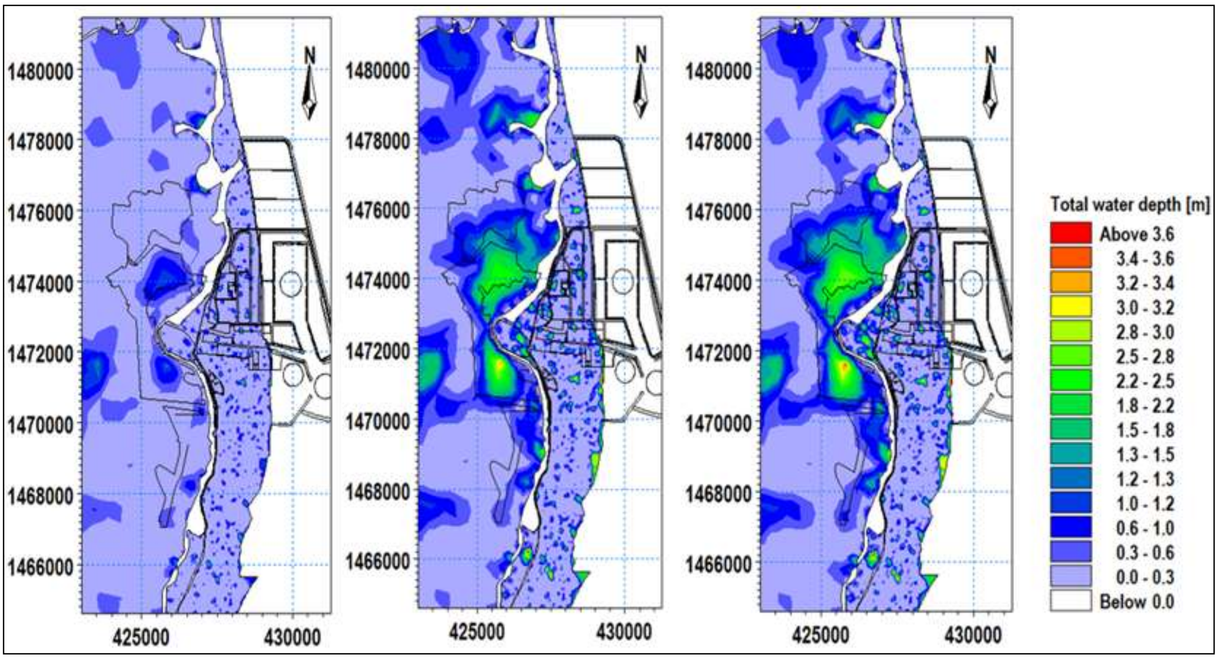


Figure 7-19: Flood inundation depth from 16 Nov 2015 to 18 Nov 2015 - Baseline condition

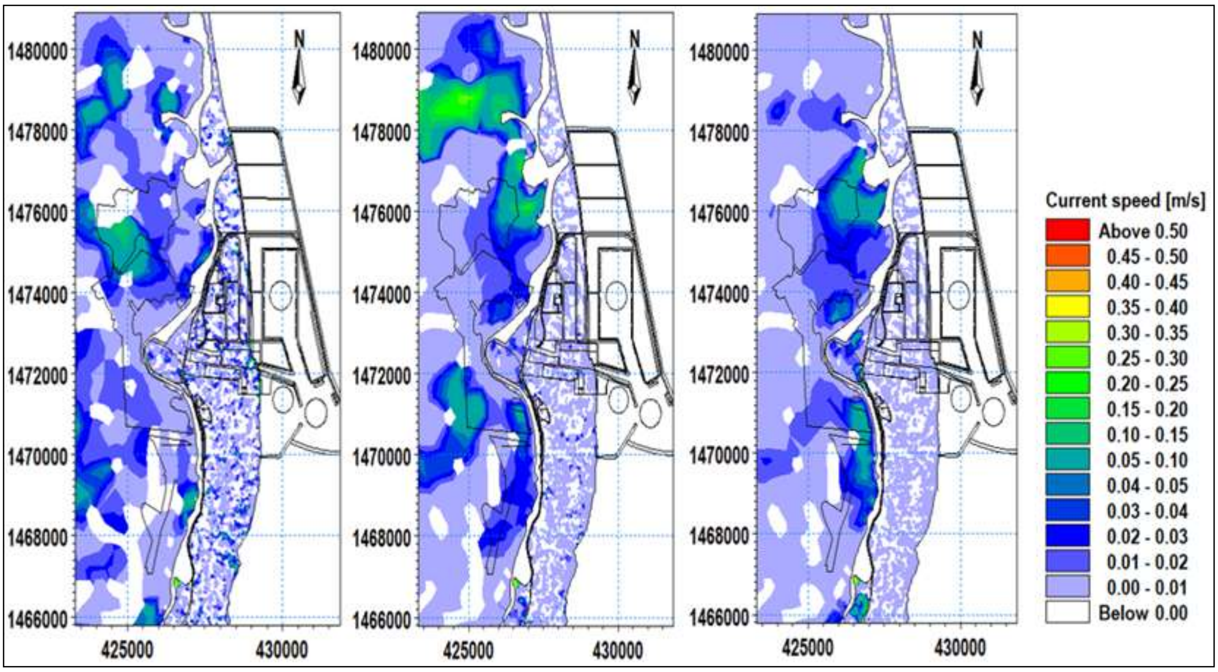


Figure 7-20: Current speed from 16 Nov 2015 to 18 Nov 2015 - Baseline condition

Future Scenario

The simulated maximum water level profile i.e., High Flood Level (HFL) along the Kosasthalaiyar backwater river and Buckingham canal is given in **Figure 7-21** for future scenario. The inundation depth and current speed with the proposed development of the port area is shown in **Figure 7-22** and **Figure 7-23**.

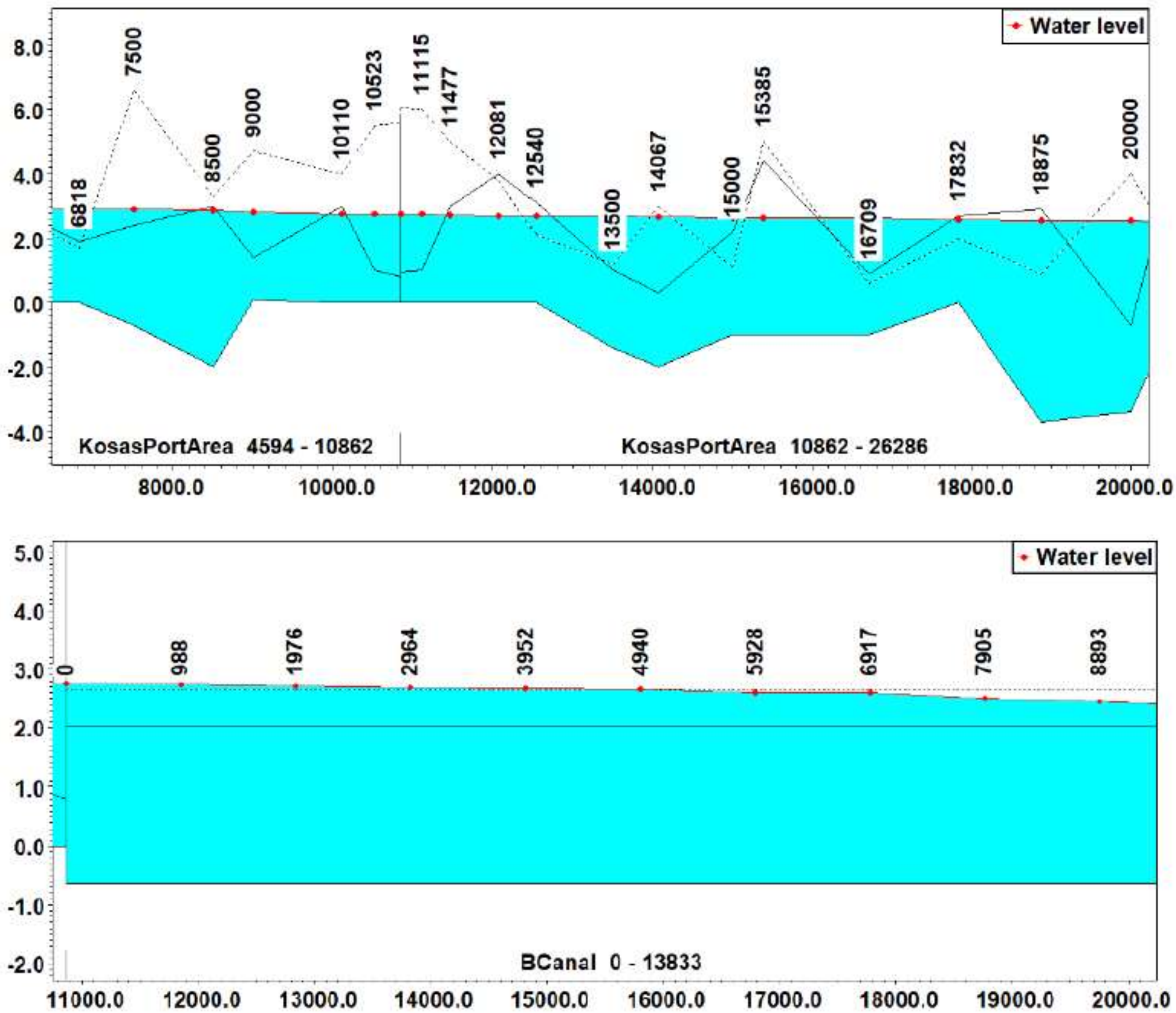


Figure 7-21: Water level profile of Kosasthalaiyar and Buckingham canal – Future Scenario

Note: Assuming that flow direction is from Pulicat lake to Ennore creek. Dotted black line = left riverbank; Solid black line = right bank; Blue shaded area = maximum water level condition

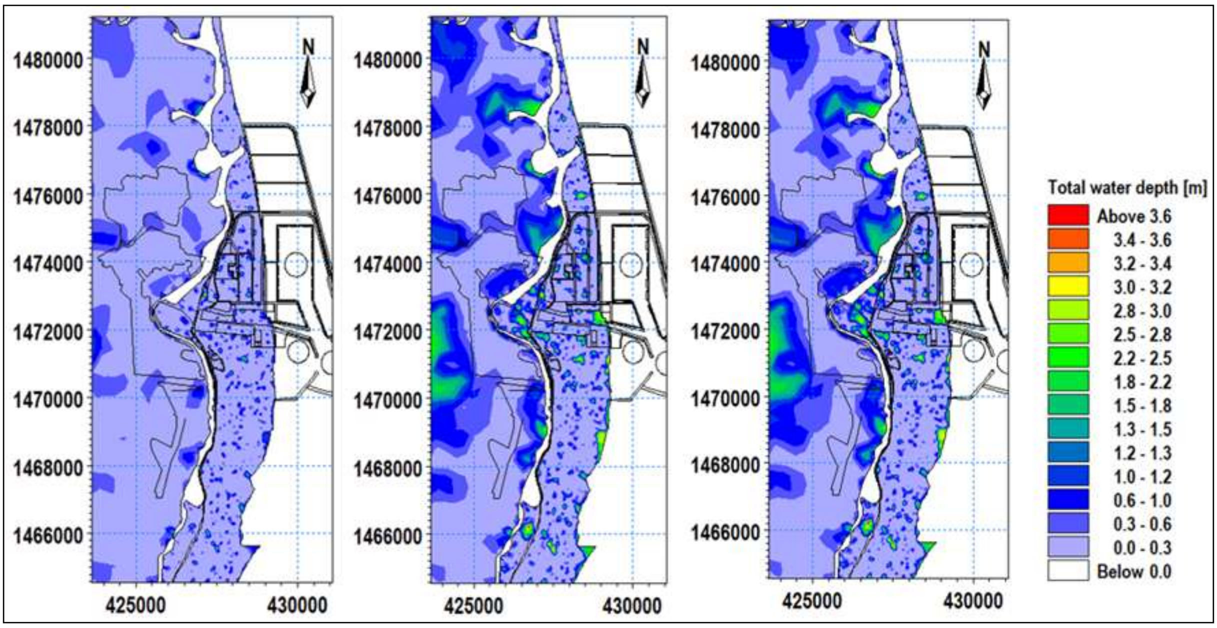


Figure 7-22: Flood inundation depth from 16 Nov 2015 to 18 Nov 2015 – Future Scenario condition

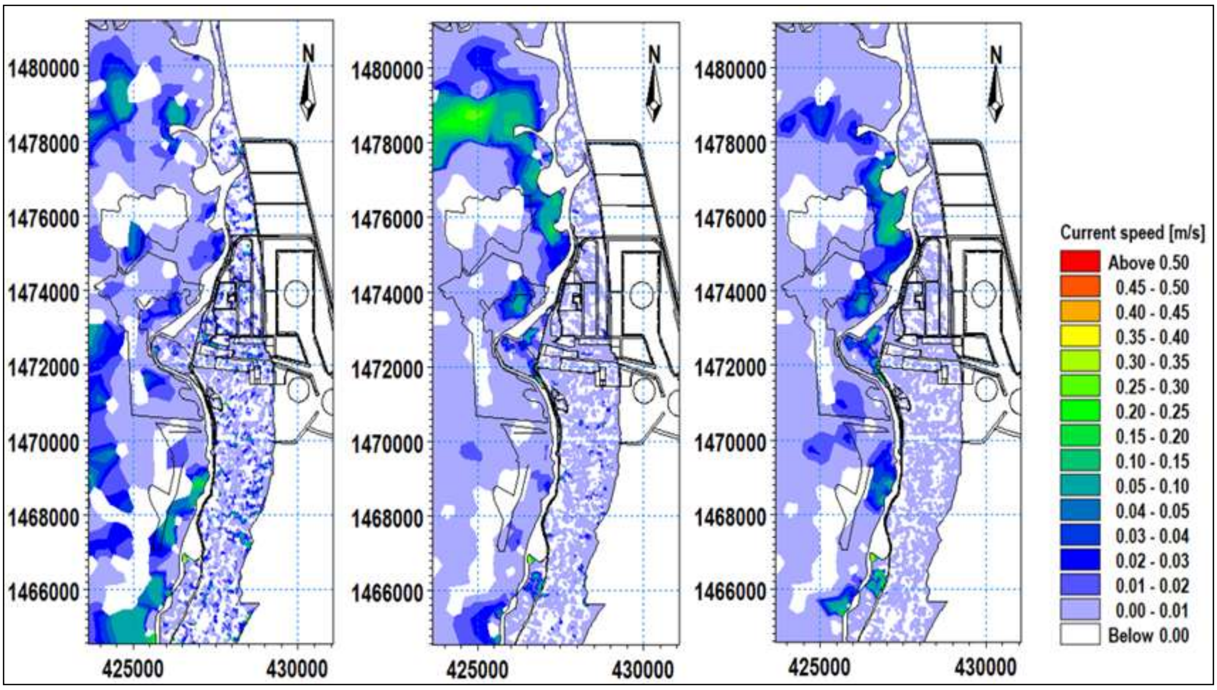


Figure 7-23: Current speed from 16 Nov 2015 to 18 Nov 2015 – Future Scenario condition

The comparison of the flood inundation depth between baseline and future scenario is shown in **Figure 7-24** for the 2015 event.

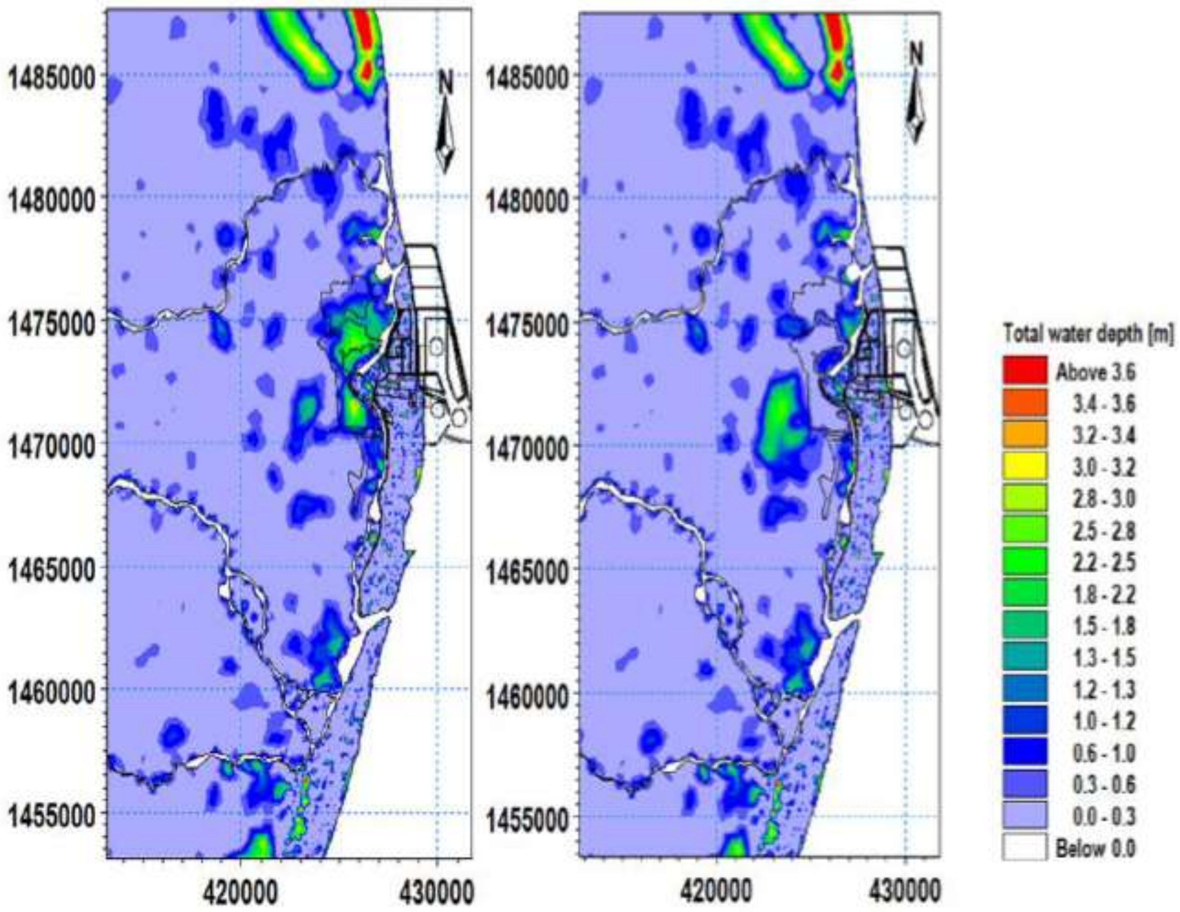


Figure 7-24: Comparison of flood extent between baseline and future scenario

As seen in **Figure 7-18**, the HFL in the Kosasthalaiyar River and B-canal in the vicinity of the port backup area is approximately 3 m with respect to MSL. Based on CARTOSAT elevation data, the port backup area alongside the river has a low elevation ranging from - 2 to +3 m with respect to MSL (**Figure 7-17**). Thus it seen that the inundation depth with the baseline scenario reaching up to 3.6 m above MSL particularly along the banks of the river as seen in **Figure 7-19**. The inundation is severe around the meandering portion of the river. Current speeds are low in these area, less than 0.2 m/s, presumably due to the flat terrain. These values may change once the modelling is carried out with detailed surveyed bathymetry of the area.

For the future scenario, the elevation of the port backup area is raised to +4.4 m above mean sea level. The HFL in Buckingham canal is slightly higher in the future scenario than the baseline scenario. The raising of the port backup area is seen to be effective since the flooding of the backup area along the river banks reduces significantly and flood depths are reduced to under 0.3 m (**Figure 7-22**).

Thus, the preliminary modelling study carried out shows that raising the port backup area along to riverbanks to the proposed +4.4 m MSL (which is equal to +5 CD) would be an effective measure to protect the backup area from flooding. However, as seen in **Figure 7-24**, the flooding increases in the area just west of the elevated backup area.

7.3.4 Storm Water Management Plan

Natural drainage of the surrounding area of Kattupalli Port shall be diverted through river/B'canal to Ennore creek. Kattupalli port back up area shall be divided into sub catchment area and different outfalls at nearest point into the River/Creek. Based on the sub catchment area, outfall drains are proposed to carry storm water discharge from port area and discharging into sea.

7.3.4.1 Assumptions

The following are the assumptions considered for the storm water design:

- Rainfall intensity is considered as 35 mm/hr based on IRC- SP-13, for Chennai
- The port development is at raised level as per flood modelling report
- Diversion of outside natural streams (i.e. River/Creek) is not considered in internal storm water drainage system
- Final outfall shall be discharged into the Sea / creek
- Outfalls will be constructed in phased manner as per development of internal plots
- External main storm water drains shall be proposed along main roads
- Main drain from sub-catchment area shall be connected to final outfall and lateral shall be connected to main drain

7.3.4.2 Drainage Pattern and Catchment Area Analysis of Port Backup Area

The masterplan of the proposed Kattupalli Port has been divided into 15 sub-catchments to lay out a storm water drainage plan for the area as shown in **Figure 7-25**.

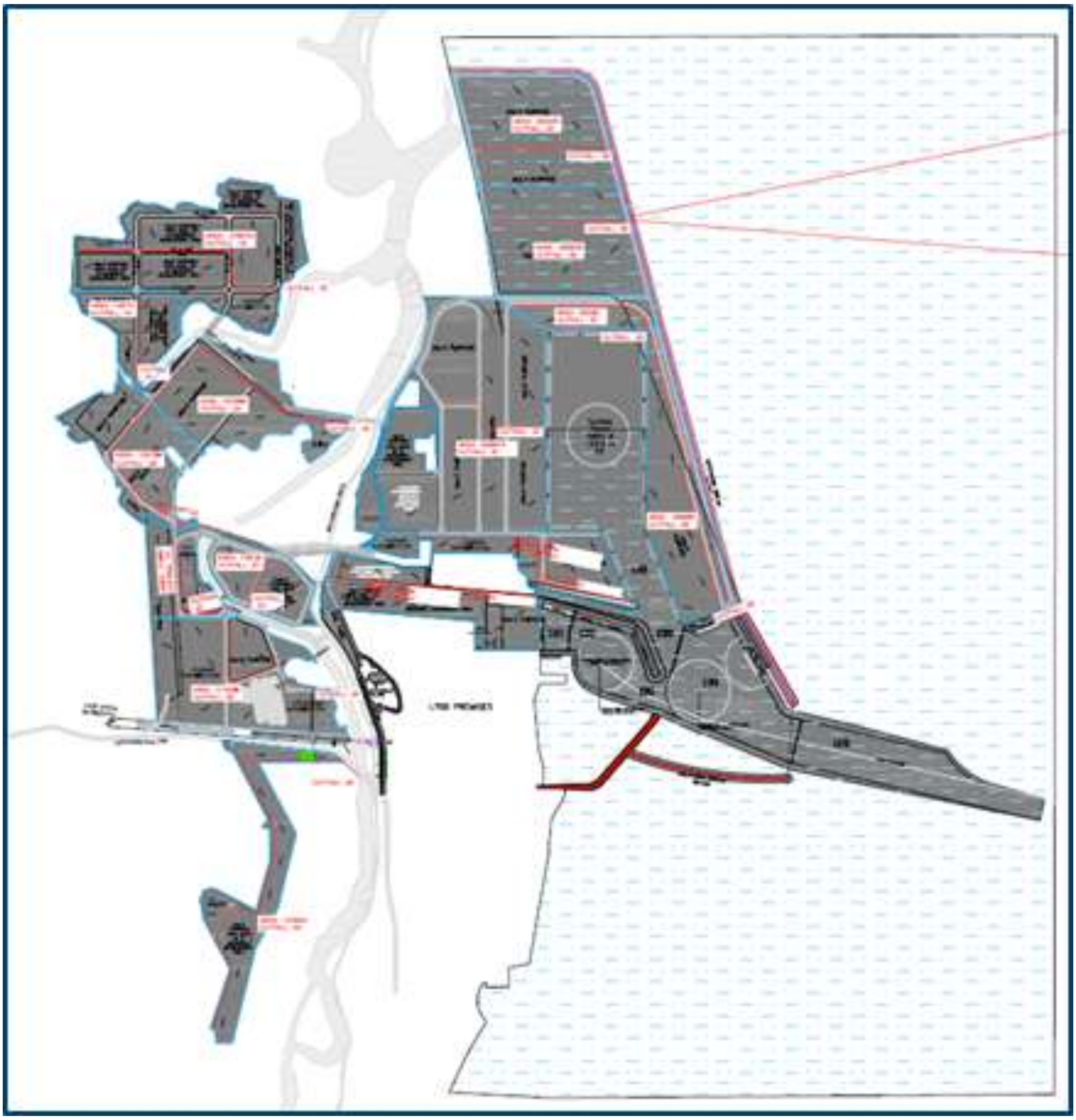


Figure 7-25: Masterplan showing flow-directions (black arrows) and storm water drains (red lines)

The outlets drain the storm water from the proposed backup area either into the river (for port area on the west of the river) or directly into the sea (for port areas east of the river).

Based on the type of land use, runoff coefficient is decided. A summary of the sub-catchment areas, their runoff coefficients and design runoff are given in **Table 7-31**.

Table 7-31: Sub-catchment area and storm water flow calculation

Area description	Tributary Area on section		Net Tributary Area		Intensity of storm (mm/h)	Design runoff (m3/s)	Outfall Description
	Type 1 (Ha)	"C" Coefficient	Section (Ha)	Cumulative (Ha)			
Area 1A	74.68	0.75	56.01	56.01	35.00	5.45	Outfall-1A in the River
Area 1B	276.67	0.75	207.50	207.50	35.00	20.17	Outfall-1B in the River
Area 2A	167.40	0.75	125.55	125.55	35.00	12.21	Outfall-2A in the River
Area 2B	130.73	0.75	98.05	98.05	35.00	9.53	Outfall-2B in the River
Area 2C	71.96	0.75	53.97	53.97	35.00	5.25	Outfall-2C in the River

Area description	Tributary Area on section		Net Tributary Area		Intensity of storm (mm/h)	Design runoff (m3/s)	Outfall Description
	Type 1 (Ha)	"C" Coefficient	Section (Ha)	Cumulative (Ha)			
Area 2D	75.81	0.75	56.86	56.86	35.00	5.53	Outfall-2D in the River
Area 2E	211.63	0.75	158.72	158.72	35.00	15.43	Outfall-2E in the River
Area 3A	203.23	0.75	152.42	152.42	35.00	14.82	Outfall-3A in the River
Area 3B	206.95	0.75	155.21	155.21	35.00	15.09	Outfall-3B in the River
Area 3C	435.88	0.75	326.91	326.91	35.00	31.78	Outfall-3C in the River
Area 3D	60.24	0.75	45.18	45.18	35.00	4.39	Outfall-3D in the River
Area 3E	169.50	0.75	127.12	127.12	35.00	12.36	Outfall-3E in the River
Area 3F	114.15	0.75	85.61	85.61	35.00	8.32	Outfall-3F in the River
Area 3G	177.51	0.75	133.13	133.13	35.00	12.94	Outfall-3G in the River
Area 4A	121.94	0.75	91.46	91.46	35.00	8.89	Outfall-4A in the River
Area 1A	74.68	0.75	56.01	56.01	35.00	5.45	Outfall-1A in the River

Port back up yard storm water drains are of RCC channel with minimum of 600 mm to maximum shall be as per design flow and 1:500 longitudinal slopes. Roadside drains are provided within utility corridor on road. Minimum velocity 0.60 m/s and maximum velocity 2.5 m/s shall be considered in design of the drains. The road crossing shall be proposed by RCC box drain or RCC Hume pipes.

During construction of the port, for temporary drainage and ease movement, temporary storm water drains, and culverts are proposed. These drains will be stone pitched drains with bottom width of 0.5m. A typical section of a pitched drain is shown in **Figure 7-26**.

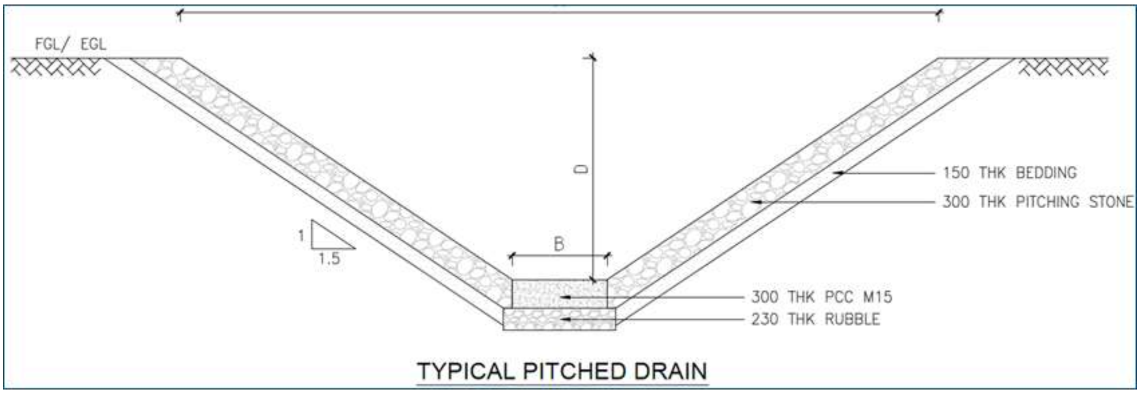


Figure 7-26: Typical cross section of a pitched drain

7.3.4.3 Drainage Pattern and Catchment Area Analysis on Westside of Port Backup Area

The alignment of the drain is shown in **Figure 7-27**. **Figure 7-28** shows the alignment of the identified drain with respect to drainage pattern lines (from the drainage pattern study) and baseline/layout inundation results.

Figure 7-27: Existing drainage canal alignment (red line) with respect to port boundary (black line)

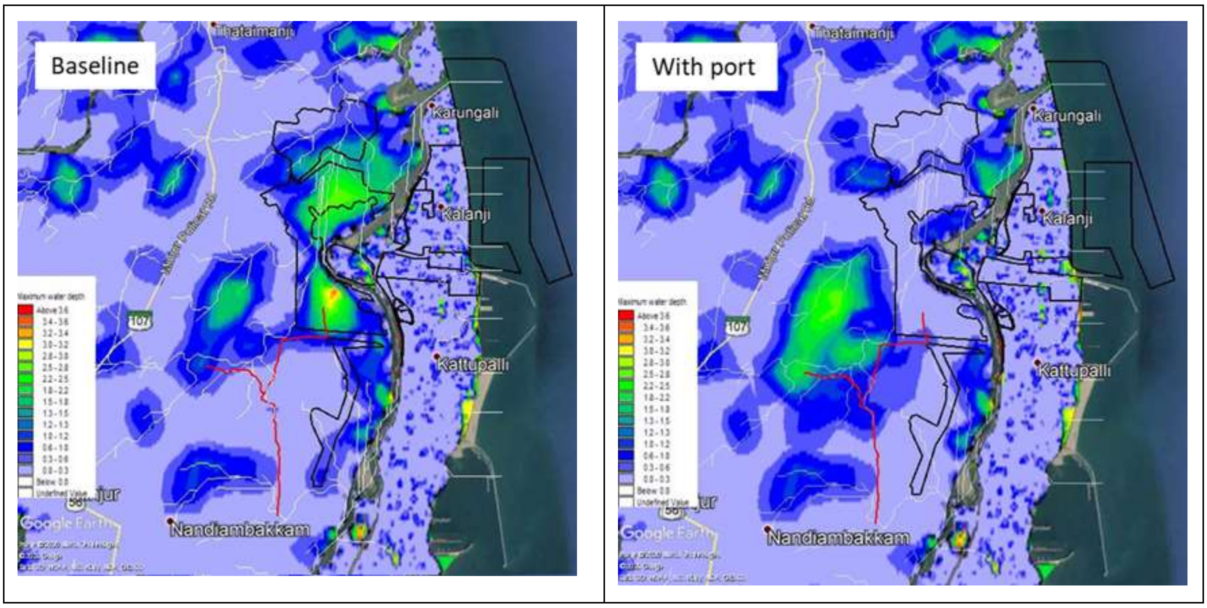


Figure 7-28: Existing drainage canal alignment (red lines), drainage pattern (white lines) with respect to port boundary (black line) and model inundation extent

The existing drain alignment falls within the natural drainage pattern of the flood waters in this area and as such it is recommended that drain should be retained for management of inundation along the western periphery of the port.

It is further recommended that the open drain channel must be extended until the river along the main road which passes through the port backup area as shown in **Figure 7-29**. The canal segment which enters the backup area must be integrated with the storm water drainage network of the port.

Figure 7-29: Open channel extension (yellow line) to the river along the road

7.3.4.4 Recommendations

Flood model studies indicate that the raising of proposed Master Plan backup area of the port to +5m CD is effective in protecting the port infrastructure from the overtopping of the river during a 100-year rainfall event of 24-hour duration.

Locations where the embankments of the Kosasthalaiyar Backwater River and B-canal are damaged must be identified and strengthened to reduce overtopping from the banks.

Locations where the banks are not continuous or have breaches/gaps must also be identified and continuous embankments of the river and B-canal must be ensured.

The proposed Master Plan development area has been divided into 15 sub-catchments and a Storm Water Drainage network plan has to be laid out to drain the storm water from the port area into the river/canal or the sea. The port backup area will be raised, and the flow directions will be ensured into the drains.

The existing open channel towards the western side and periphery of the port backup is recommended to be retained for mitigation of flooding in this area. The de-silting of this canal is important to have a quick recession of flood water. The open channel must also be extended as suggested in the previous section and integrated with the Storm Water Drainage network of the port area.

7.4 Tsunami Modelling

Three historical tsunamis generated in Bay of Bengal are simulated to predict the water levels and currents at the proposed port development. For the tsunami model, the static vertical tectonic displacement is used to model initial wave heights (Synolakis, 2003). Tsunami models assume that water motion occurs instantaneously. In other words, the initial tsunami wave is assumed to be of the same shape as the seafloor deformation (Synolakis, 2003).

Earthquake Parameters

For calculating the initial vertical displacement due to the earthquake various earthquake parameters was considered such as the initial rupture time, dip angle, strike angle, slip angle, latitude and longitude and most importantly the moment magnitude of the earthquake and the type of fault mechanism.

However, in this study, the fault parameters of the earthquakes considered for the generation of 2004 Sumatra Tsunami is from the journal “Source Constraints and Model Simulation of the December 26, 2004, Indian Ocean Tsunami”, Similarly fault parameters for 1881 and 1941 earthquakes are from the journal “Tsunami vulnerability assessment in urban areas using numerical model and GIS” respectively. The fault parameters are listed in **Table 7-32**.

Table 7-32: Fault parameters for 1881, 1941 and 2004 Earthquakes in the Bay of Bengal

Parameters	1881 Car Nicobar	1941 Andaman	2004 Sumatra				
			Fault-1	Fault-2	Fault-3	Fault-4	Fault-5
Longitude [Deg]	92.43	92.5	95.10	93.90	93.41	92.10	92
Latitude [Deg]	8.52	12.1	2.50	4.33	5.80	9.10	10.50
Magnitude [Mw]	7.9	7.7	9.3				
Slip [m]	5	5	18	23	12	12	12
Fault length [km]	200	200	220	150	390	150	350
Fault width [km]	80	80	130	130	120	95	95
Strike angle [Deg]	350	20	323	348	338	356	10
Dip angle [Deg]	25	20	12	12	12	12	12
Rake angle [Deg]	90	90	90	90	90	90	90
Focal depth [km]	15	30	25	25	25	25	25

Model Setup

Bathymetry

The model that covers Bay of Bengal, Andaman Sea, and Laccadive sea has been used in the study. The model covers tsunami generation and propagation area. The dedicated model coverage is shown in **Section 2.3.1** of **Chapter 2**. About 147801 elements with various mesh resolutions have been produced. The resolution of the bathymetries is varied from 100m to 25km respectively.

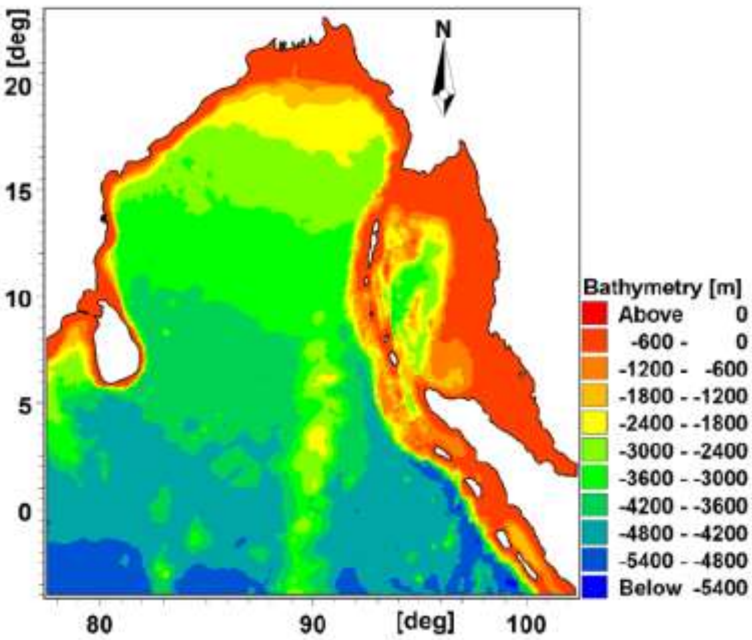


Table 7-33: Domain used for Tsunami Modelling

Initial Water Elevation

Tsunami is caused by the vertical displacement of the water column along the fault line. The elevated water was subjected to the action of gravity, which induces a series of waves (collectively known as the tsunami). The resulting wave train travelled away from the source at a given speed, which in general, is determined by the length of the waves and the local water depth.

The initial surface elevation along the fault (responsible for the onset of the tsunami wave train), constitute the main input to the MIKE21 HDFM. The initial surface elevation was generated by MIKE21 Bathymetry Adjustment Tool.

Results

The model results show the generation and propagation of the tsunamis considered. The total duration of all simulations was considered 5 hours from the initial rupture time. **Figure 7-30** shows the 2004 Sumatra tsunami propagation after 30min, 60min and 120min from the initial rupture. **Figure 7-31** shows the predicted maximum surface elevation and current speed at Kattupalli region due to 2004 tsunami.

Further, water levels and current speeds were extracted at Kattupalli port entrance, Ennore and Pulicat creek entrance as shown in **Figure 7-32** and **Figure 7-33**. The maximum water level predicted at Port entrance is about 2.18m due to 2004 Sumatra tsunami. The corresponding current speed at Port entrance is estimated about 2.8m/s at Kattupalli Port entrance.

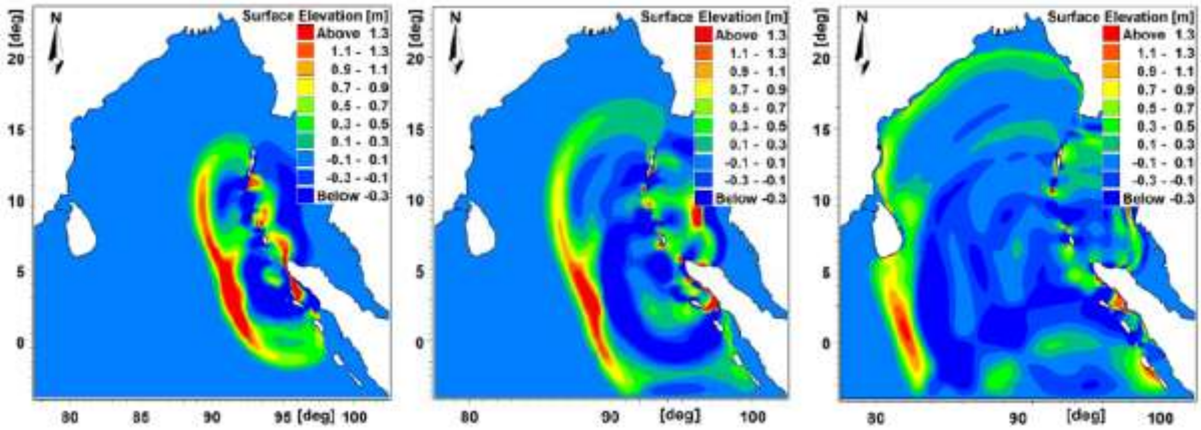


Figure 7-30: 2004 Sumatra Tsunami propagation after 30, 60, and 120 minutes from origin

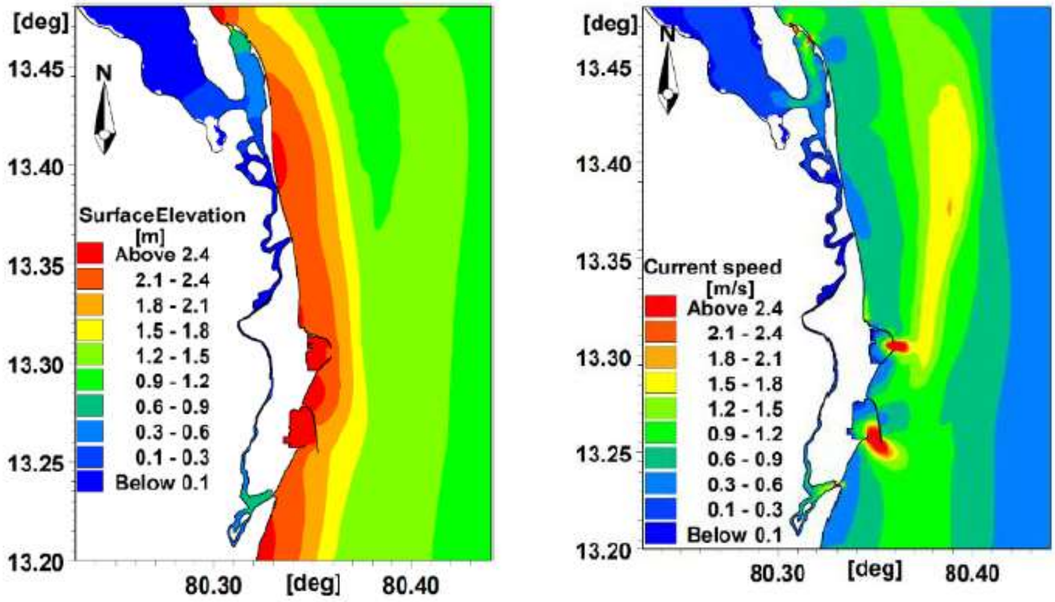


Figure 7-31: Water level and current speed induced by 2004 tsunami along study area

The maximum water elevation and current speed from the model at different extraction locations along the study area are listed in **Table 7-34** and **Table 7-35**.

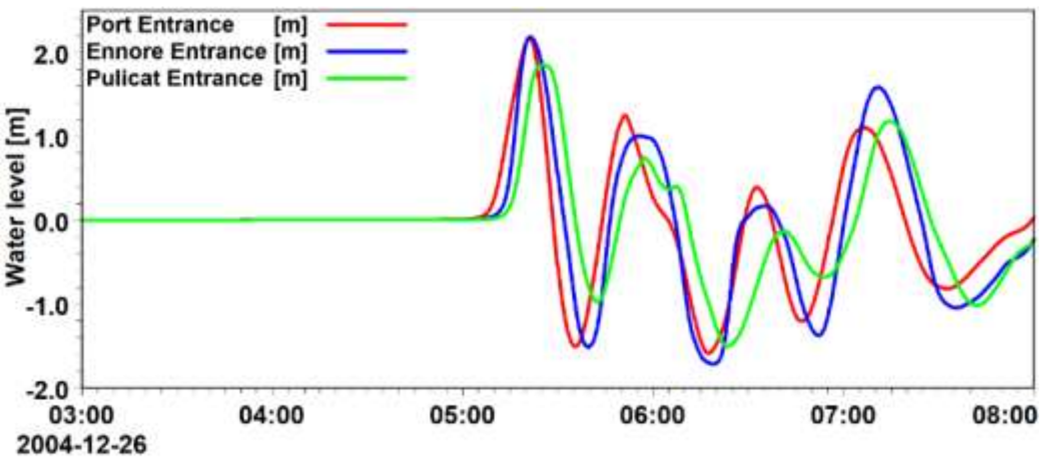


Figure 7-32: Tsunami induced surface elevation along the study area from 2004 Sumatra Tsunami

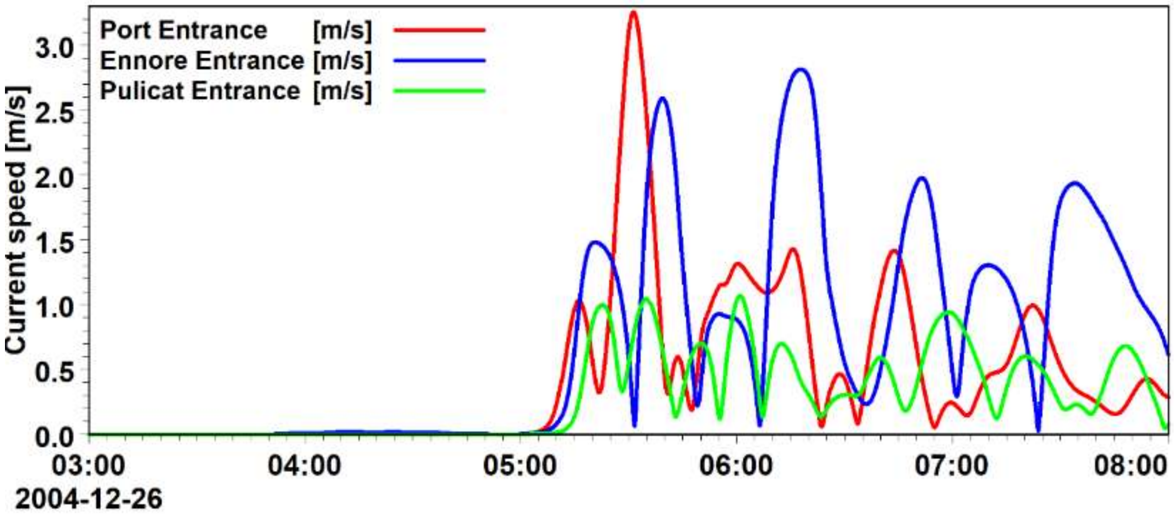


Figure 7-33: Tsunami induced current speed along the study area from 2004 Sumatra Tsunami

Table 7-34: Location details and surface elevation for selected points

Location			Surface Elevation[m]		
Name	Long [Deg]	Lat [Deg]	1881 Car Nicobar	1941 Andaman	2004 Sumatra
Ennore Creek Entrance	80.362	13.305	0.44	0.22	2.18
Kattupalli Port Entrance	80.331	13.233	0.47	0.21	2.18
Pullicat Lake Entrance	80.317	13.474	0.41	0.23	1.85

Table 7-35: Location details and current speed for selected points

Location			Current Speed [m/s]		
Name	Long [Deg]	Lat [Deg]	1881 Car Nicobar	1941 Andaman	2004 Sumatra
Ennore Creek Entrance	80.362	13.305	0.6	0.18	3.26
Kattupalli Port Entrance	80.331	13.233	1.0	0.46	2.81
Pullicat Lake Entrance	80.317	13.474	0.4	0.14	1.07

7.5 Oil Spill Contingency Plan

An oil spill contingency plan is a detailed oil spill response and removal plan that addresses controlling, containing, and recovering an oil discharge in quantities that may be harmful to navigable waters or adjoining shorelines..

The elements of the oil spill contingency plan are

- Definition of the authorities, responsibilities, and duties of all entities involved in oil removal operations;
- Procedures for early detection and timely notification of an oil discharge;
- Assurance that full resource capability is known and can be committed following a discharge;
- Actions for after discovery and notification of a discharge;
- Procedures to facilitate recovery of damages and enforcement measures.

7.5.1 Facility Level Oil Spill Disaster Contingency Plan for Existing Kattupalli Port

The Facility Level Oil Spill Disaster Contingency Plan for the Kattupalli Port has been prepared with essential studies for meeting the requirement of a Category B Port in line with the latest Indian Coast Guard (ICG) guidelines in order to respond to oil spill efficiently and submitted to the Commandant (for District Operational and Plans Officer), Coast Guard District, Tamil Nadu.

The primary objectives of Kattupalli Port Oil Spill Contingency Plan is to be part of National Oil Spill Contingency Plan hierarchy outlined NOSDCP at the apex level to coordinate significant or disaster type spills, the Regional Oil Spill Disaster Contingency Plan (ROSDCP) to coordinate spill in the Eastern seaboard, utilizing the resources available within the region. The District Oil Spill Disaster Contingency Plan (DOSDCP) coordinates minor oil spills that affect maritime area within the coastal state limits. The Kattupalli Ports Oil Spill contingency Plans is integrated with respective DOSDCP so that a combined effort is made for oil spill response with aim to develop

a. To develop appropriate and effective systems for the detection and reporting of spillage of oil.

b. To ensure prompt response to prevent, control and combat oil pollution.

c. To ensure that adequate protection is provided to the public health and welfare, and the marine environment.

The OSCP shall be reviewed after each spill incident or every six (6) months / one (1) year and an assets holding update every three (3) months. This will include:

a. Checking telephones and fax numbers

b. Checking names of office holders

c. Changes to response action thought necessary on the basis of training and spill response

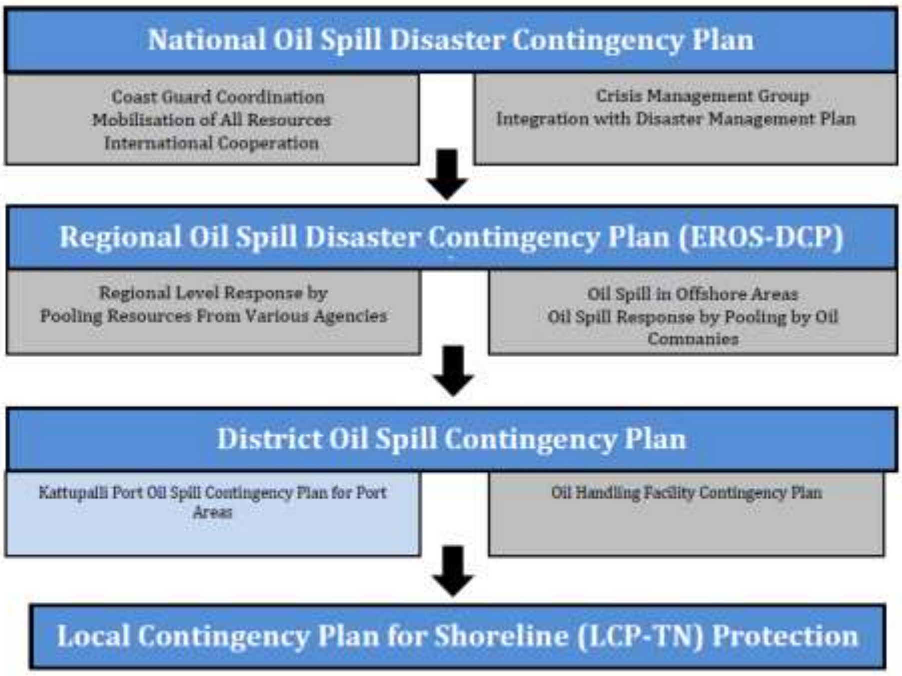


Figure 7-34: Contingency Plan Hierarchy

The Facility Level Oil Spill Disaster Contingency Plan for the Kattupalli Port is being prepared with essential studies for meeting the requirement of a Category B Port in line with the latest Indian Coast Guard (ICG) guidelines in order to respond to oil spill efficiently.

7.5.2 Oil Spill Classification and Tiered Response

7.5.2.1 Authorities and Responsibilities

The National Oil Spill Disaster Contingency Plan (NOS-DCP) is the national plan dealing with oil spill response, which delineates the responsibilities of various resource and oil handling agencies beside the Government agencies for offshore oil spill response. The NOS-DCP stipulates the organizational and operational details to effectively combat a national oil spill contingency. As per the operational pattern, Ministry of Defence (MoD) has been given the overall responsibility to co-ordinate among all stakeholders at the centre on the implementation issues arising from NOS-DCP.

The NOS-DCP envisages that the Director General of Indian Coast Guard (DGICG) as the Central Coordinating Authority (CCA) for enforcing the provisions of the NOS-DCP in the maritime zones of India and delineates the duties and responsibilities of each participating agencies identified in the plan. Keeping the operational flexibility requirement for effective response activities, escalation of activities are planned from facility level operation to regional level stakeholder operation through mutual aid activities and then further escalating with availing assistance from national plan or international plan stakeholders. For Kattupalli Port, the authorities and responsibilities as per NOS- DCP is as presented in

Table 7-36: Statutory and Combat Agencies for Kattupalli Port as per NOS-DCP guidelines

Responsibilities	
Statutory Agency Tamil Nadu Maritime Board (TNMB)	Statutory Agency Tamil Nadu Maritime Board (TNMB)
Combat Operations Responsibility for Oil Spills	
Combat agency within Kattupalli Port Limit	MIDPL with response assistance from other national plan Stakeholders as required.
Within shoreline and intertidal zones outside Port Limit	Government of Tamil Nadu (GoTN) with response assistance from other national plan stake holders.
For Hazardous and Noxious Substances Incidents in Ports	The chemical industry/exporter/importer/polluter through a tie up with combat agencies and the relevant port as specified in the relevant contingency plan with response assistance from other national plan stakeholders as required.
Within shoreline and intertidal zones	The relevant chemical company or terminal operator under industry arrangements/polluter, under the provisions of National Disaster Management Authority guideline or under the provision of the Chemical Accident Rules, 1996 established by the Ministry of Environment, Forest and Climate Change (MoEF&CC). The polluter and the response state/UT Statutory agency with response assistance from other national plan stakeholders as required.

As per the oil spill organogram of NOS-DCP, Crisis Management Group (CMG) for oil spill at National, State, District and Local level will support for managerial aspects, review, approval, updating of contingency plans etc., whereas coordination to oil spill response operations are entrusted with ICG and which is in line with the provision of escalations from Tier 1 to Tier 2 and Tier 3. Oil spill organogram is presented in **Figure 7-35**.

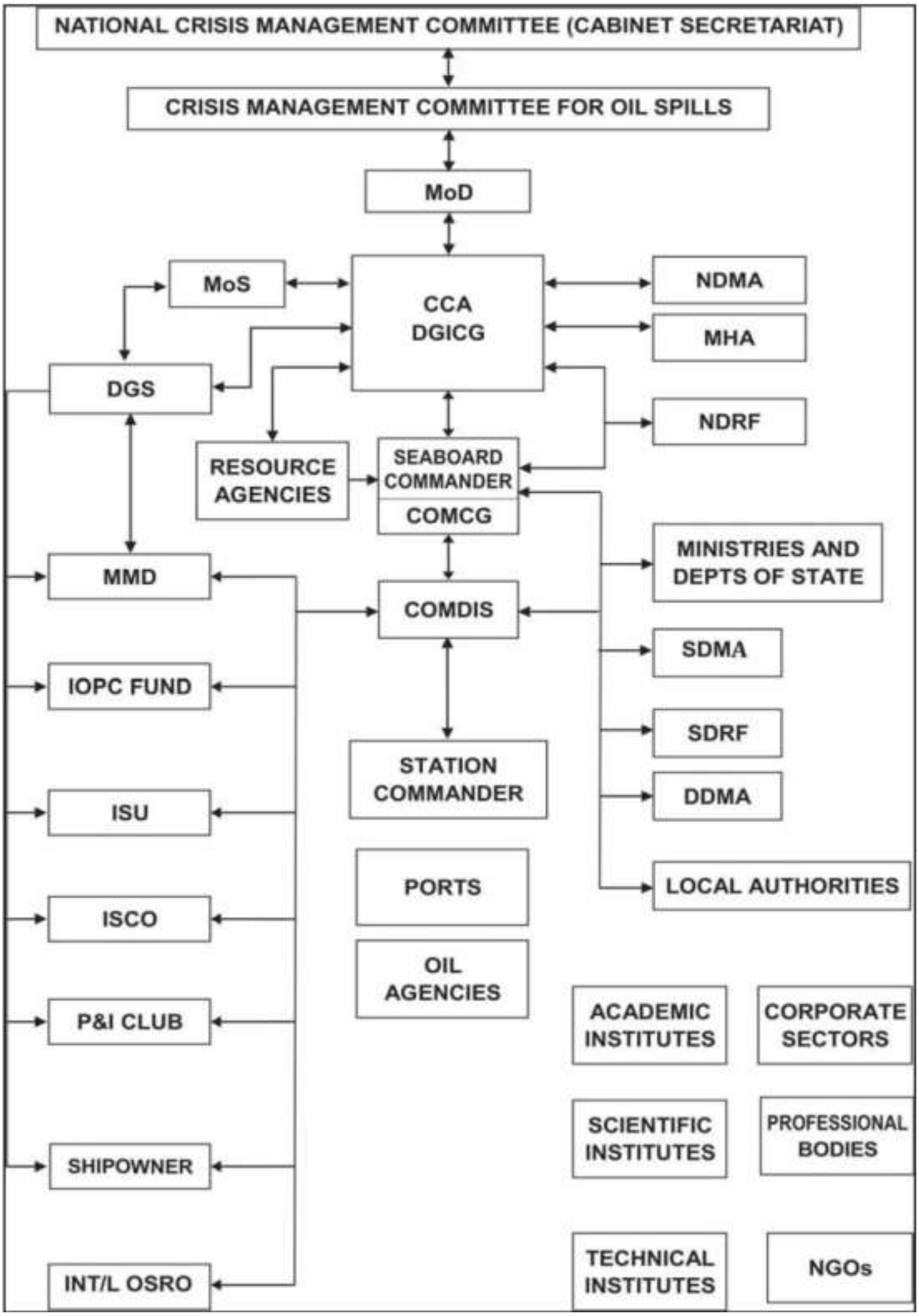


Figure 7-35: Oil Spill Organogram

In case of a Tier 1 spill within port limit, the in house Emergency Response Unit (ERU) and attached Incident Management Team (IMT) of Kattupalli Port would be mobilised for response operation while ICG (E) Region and the ICG District unit of Tamil Nadu would be directly overseeing the activities in case of escalation to Tier 2 or Tier 3. Oil Spill organogram specific to Kattupalli Port connecting to State and National Oil Spill Structure as per the NOSDCP requirement is presented in **Figure 7-36**.

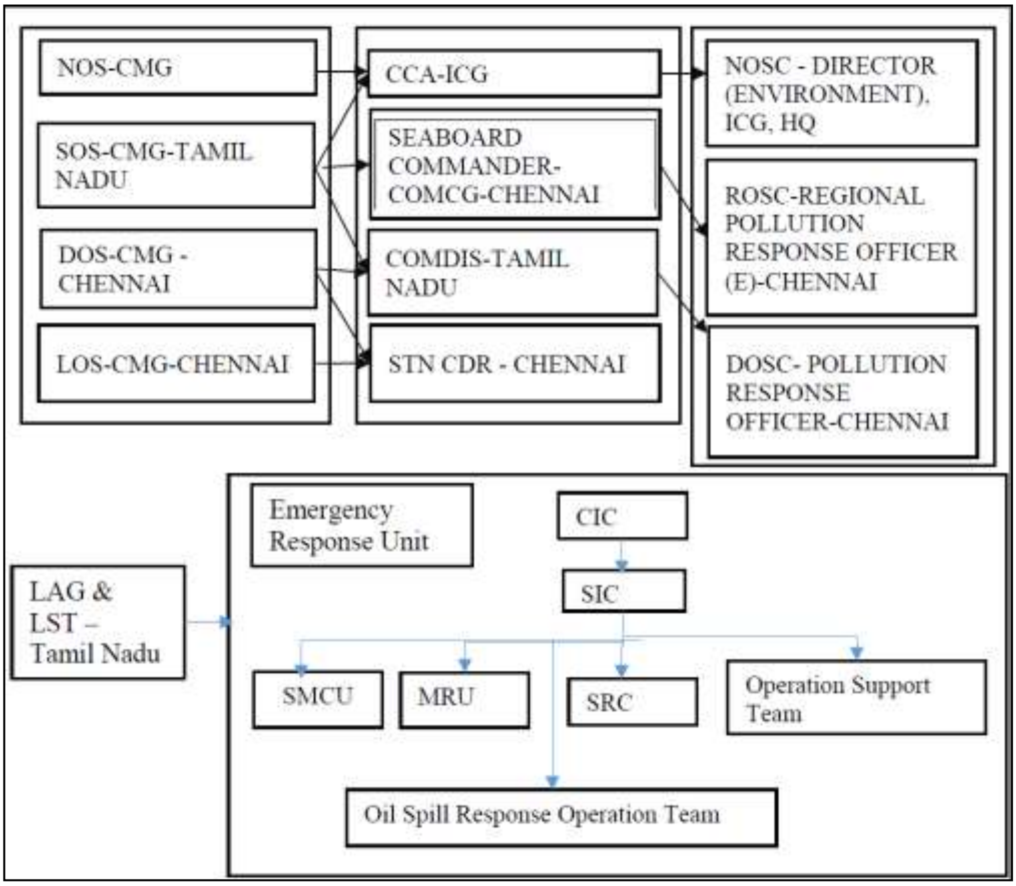
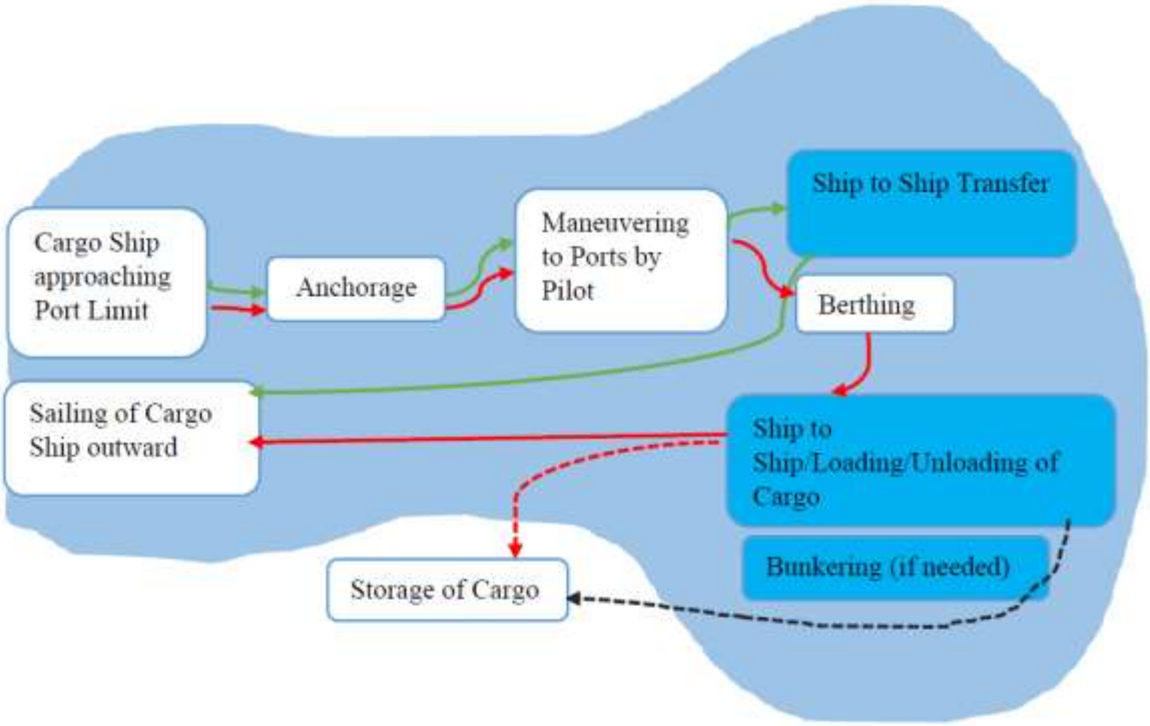


Figure 7-36: Oil Spill Organogram for Kattupalli Port connecting to NOS-DCP Structure

7.5.2.1.1 Identification of Activities and Risks

Operational activities planned for Kattupalli Port which may contribute to the oil spill incidents within the harbour water were systematically analysed. This include mechanical operation such as vessel movement, berthing, loading-unloading, storage, etc., Operational aspects that are analysed in the Risk Assessment study include vessel operation and Cargo transfer operation as presented in **Figure 7-37**.



Note:
Continuous line indicates operation within water
Dotted line indicates cargo handling operation connecting water to land

Figure 7-37: Operational Aspects of Kattupalli port

7.5.2.2 Type of oil Likely to be Spilled

Kattupalli Port would be equipped to handle all type of cargo including container, general, bulk/break bulk cargo, oil and chemicals of hazardous nature. NOS-DCP guidelines defines oils and HNS as below for which the Contingency Plan shall be prepared as per the ICG guidelines.

- "Oil" means petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products, other than petrochemicals subject to the provisions of Annex II of MARPOL 73/78 and includes the substances listed in Appendix I to Annex I of MARPOL73/78 as amended.
- "Hazardous and Noxious Substance" as defined in the IMO OPRC-HNS Protocol means any substance other than oil which, if introduced into the marine environment is likely to create hazards to human health, harm living resources and marine life, damage amenities or interfere with other legitimate uses of the sea.

7.5.3 Probable Fate of Spilled Oil/Liquid Cargo

Fate of oil handled at Kattupalli Port was determined by the chemical characteristics of oil spilled and marine conditions prevailing in the area. The fate of oil handled at Kattupalli Port was analysed with respect to the various chemical characteristics which will determine their weathering process. While for the persistent oil, response operation to be immediately initiated, for the non-persistent oil types, monitoring of the spill is the major activity to be followed due to inherent capacity for natural processes such as evaporation and dissolution.

Comparing with the persistent and non-persistent nature of the oil, the response operation requirements are also duly summarized in **Table 7-37**.

Table 7-37: Fate of Oils handled at Kattupalli port

Sl.No	Cargo	Persistency	Fate	Response Requirements
1	Alphaplus - C-18	Persistent	Evaporate/Dissolve	Spill Monitoring
2	Alphaplus C-20/24	Persistent	Evaporate/Dissolve	Spill Monitoring
3	Aromatic Solvent Naptha K- 150	Non Persistent	Evaporate/Dissolve	Spill Monitoring
4	Aromatic Solvent Naptha K- 175	Non Persistent	Evaporate/Dissolve	Spill Monitoring
5	Aromatic Solvent Naptha K- 200	Non Persistent	Evaporate/Dissolve	Spill Monitoring
6	Aromatic Solvent Naptha Kesol 100	Non Persistent	Evaporate/Dissolve	Spill Monitoring
7	Base Oil	Persistent	Evaporate/Dissolve	Response Operation
8	Base Oil 3043	Persistent	Evaporate/Dissolve	Response Operation
9	Base Oil 3080	Persistent	Evaporate/Dissolve	Response Operation
10	Base Oil SN 150	Persistent	Evaporate/Dissolve	Response Operation
11	Base Oil SN 500	Persistent	Evaporate/Dissolve	Response Operation
12	Base Oil SN 650	Persistent	Evaporate/Dissolve	Response Operation
13	Bitumen / Asphalt	Persistent	Sink	Response Operation
14	Butane	Non-Persistent	Evaporate	Spill Monitoring
15	Carbon Black Feedstock (CBFS)	persistent	Sink	Response Operation
16	Carbon Black Oil	Persistent	Float	Response Operation
17	Condensate Oil	Non-Persistent	Evaporate/Dissolve/Float	Spill Monitoring
18	Crude Mineral Oil	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
19	Decant Oil	Persistent	Sink	Response Operation
20	Furance Oil	Persistent	Float	Response Operation
21	Gas Condensate Oil	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
22	Heavy Aromatics	Persistent	Float	Spill Monitoring
23	Heavy White Oil	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
24	Hexane	Non-Persistent		
25	High Speed Diesel (Gas Oil)	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
26	Kerosene	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
27	Liquid Paraffin-H	Persistent		

Sl.No	Cargo	Persistency	Fate	Response Requirements
28	Liquid Paraffins-B	Persistent		
29	Liquid Paraffins-K	Persistent		
30	Liquid Paraffins-LF	Persistent		
31	LNG	Non-Persistent	Release to air	
32	Low Aromatic White Spirit	Persistent		
33	Low Sulfphur Heavy Stock	Persistent		
34	LPG	Non-Persistent	Release to air	
35	Lube oil	Persistent		
36	Mix Blend Of C12/C20-24	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
37	Mixed Aromatics-Kemax 65	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
38	Motor Spirit	Non-Persistent	Evaporate/Dissolve	Spill Monitoring
39	N-Alkanes(C10+) Lqd Parafins-L	Persistent		
40	N-Alkanes(C10+)Liquid Paraffins-M	Persistent		
41	Naphtha	Non Persistent	Evaporate/Dissolve	Spill Monitoring
42	N-Hexane	Non Persistent	Evaporate/Dissolve	Spill Monitoring
43	N-Paraffin	Persistent		
44	Pentane	Non Persistent		
45	Propane	Non Persistent		
46	Rubber Process Oil	Persistent	Float	Response Operation
47	Solvent C-9	Non Persistent	Evaporate/Dissolve	Spill Monitoring
48	Superior Kerosene Oil	Non Persistent	Evaporate/Dissolve	Spill Monitoring
49	Waxes (Liquid Paraffins-WR)	Persistent	Float/Sink	Response Operation
50	Waxes(Liquid Paraffin-X50)	Persistent	Float/Sink	Response Operation

7.5.4 Development of oil spill scenarios including worst case discharge

Considering the proposed development plan of Port, the type and size of vessels, cargo types to be handled, marine meteorological conditions of project area and the operational activities within the port water, the credible scenarios have been shortlisted for the Kattupalli Port. Risk level for various shortlisted credible scenarios were determined based on the frequency of their occurrence i.e., likelihood that the event will occur and extent of threat to vulnerable features, i.e., consequences they could cause.

Table 7-38: Basis of Probability and Consequences

Probability – Definitions	Assigned Value
Frequency - Likely to occur often in the life of an item.	5
Probable - Will occur several times in the life of an item.	4
Occasional - Likely to occur sometime in the life of an item.	3
Remote - Unlikely but possible to occur in the life of an item.	2
Improbable - So unlikely, it can be assumed occurrence may not be experienced	1
Consequences – Definitions	**Assigned Value**
Catastrophic - Operating conditions are such that human error, environment, design deficiencies, element, subsystem or component failure, or procedural deficiencies may commonly cause death or major system loss, thereby requiring immediate cessation of the unsafe activity or operation	4
Critical - Operating conditions are such that human error, environment, design deficiencies, element, subsystem or component failure or procedural deficiencies may commonly cause severe injury or illness or major system damage thereby requiring immediate corrective action.	3
Marginal - Operating conditions may commonly cause minor injury or illness or minor systems damage such that human error, environment, design deficiencies, subsystem or component failure or procedural deficiencies can be counteracted or controlled without severe injury, illness or major system damage	2
Negligible - Operating conditions are such that personnel error, environment, design deficiencies, subsystem or component failure or procedural deficiencies will result in no, or less than minor illness, injury or system damage	1

Table 7-39: Representative Risk Matrix

Basic Frequency Classes and Assigned Values	Consequences and Assigned Values			
	Catastrophic (4)	Critical (3)	Marginal (2)	Negligible (1)
Frequent (5)	High-20	High-15	High-10	Medium-5
Probable (4)	High - 16	High - 12	Serious – 8	Medium - 4
Occasional (3)	High - 12	Serious - 9	Medium – 6	Low - 3
Remote (2)	Serious - 8	Medium - 6	Medium – 4	Low - 2
Improbable (1)	Medium - 4	Low - 3	Low - 2	Low - 1

The risk levels of credible scenarios identified are as presented in **Table 7-40**.

Table 7-40: Oil Spill Risk Levels for Credible Scenarios for Kattupalli Port-Worst Case Scenario

S. No	Primary Hazard Location	Location of Hazard	Most Probable Compounds	Hazard Type	Probability	Consequences	Risk Value	Risk Levels
1.	Marine Vessel collision/allusion to other vessel at Anchorage	Anchorage	Combined spillages - Product(LSHS) +FO	Collision	3	4	12.00	High
2.	Grounding of Marine Vessel at the breakwater mouth while maneuvering	Maneuvering	FO	Grounding	4	3	12.00	High
3.	Fire/Explosion while Cargo Handling at Anchorage	Anchorage	Combined spillages - Product(LSHS) +FO	Fire/Explosion	2	4	8.00	Serious
4.	Fire/Explosion while Cargo Handling at Berth	Berth	Combined spillages - Product(LSHS) +FO	Fire/Explosion	2	4	8.00	Serious
5.	Failure in Bunkering at	Berth	FO	Bunkering	3	2	6.00	Medium

S. No	Primary Hazard Location	Location of Hazard	Most Probable Compounds	Hazard Type	Probability	Consequences	Risk Value	Risk Levels
	Berth							
6.	Failure in Bunkering at Anchorage	Anchorage	FO	Bunkering	3	1	3.00	Low
7.	Fire/Explosion While Bunkering at Berth	Berth	Combined spillages - Product(LSHS) +FO	Fire/Explosion	1	4	4.00	Medium
8.	Fire/Explosion While Bunkering at Anchorage	Anchorage	Combined spillages - Product(LSHS) +FO	Fire/Explosion	1	4	4.00	Medium

7.5.5 Shoreline Sensitivity Mapping

Environmental Sensitivity Index (ESI) maps provide a concise summary of coastal resources that are at risk if an oil spill occurs nearby. When an oil spill occurs, ESI maps can help responders meet one of the main response objectives, i.e. prioritizing the resources for protection and reducing the environmental consequences of the spill and the clean-up efforts. Additionally, ESI maps can be used by planners before a spill happens to identify vulnerable locations, establish protection priorities, and identify clean-up strategies.

As per NOS DCP guidelines MIDPL has the responsibility for response operation within declared port limit. However, considering that the spill if happened may travel beyond its limit 10 km radial distance from the Kattupalli Port was studied for the preparation of ESI map effectively covering the immediate surroundings of the port in due consideration of the vessel approach and departures from the Port.

The area studied extended upto Pulicat (13˚23'N and 80˚19'E) at the northern side and Ennore (13˚13'N and 80˚19'E) on the southern side along the coast.

The shoreline characteristics were collected by conducting survey along the coast during the month of July – August, 2019. According to the site visit conducted, it was understood that the shoreline characteristics of the study area belong to mainly 4 categories as follows:

- 1B - Exposed, solid manmade structures
- 3A (E) - Fine to medium grained sand beaches
- 6B – Riprap
- 10D (R)- Mangroves

As indicated in the ESI Map, the most sensitive shoreline classification of the study area is the Category 10 D (R)–mangroves seen at Ennore creek area. The other shoreline features are riprap construction along the coast within the port limits of Kattupalli Port and Kamarajar Port and also within the L&T shipyard and along the Netukuppam, Ennore and Periyakuppam area.

The least sensitive classification in the study area includes the exposed solid manmade structures seen within the port limits of Kattupalli, Thazhankuppam Kamarajar and L& T Shipyard.

The sensitive biological resources of the area that are most likely at risk in the event of an oil spill are depicted on the map. The major categories of biological resources considered were, fish and birds.

Special Local Considerations

Other attributes specific to the project location is the increased beach based tourism activities along the beaches from September–February every year. No other specific local activities are observed within 10 km of Project location.

7.5.6 Philosophy and Objectives

Philosophy of the oil spill contingency plan for Kattupalli Port is to assist MIDPL to understand in detail the oil spill risk associated with the port operation and equip with better preparedness with key principles–prevent, prepare and respond. The contingency plan is flexible for enhancing partnership through tiered response with specific focus given for choosing the people with right skills for oil spill operations and also to include key decision makers in IMT for effective combat operations.

Objective of the oil spill contingency plan is to equip Kattupalli Port with an “Executable Oil Spill Contingency Plan” to implement effective oil spill response operations in emergency with specific emphasis given to the availability and skill of human resources targeting continual improvement through training and exercises and incorporating all aspects of operation-response planning, response operation, post response scenarios including cost and waste management aspects.

7.5.7 Oil Spill Response in Offshore Zones

Since offshore operations are not planned, this is excluded in the facility level plan for existing facility and for proposed RMP ESI mapping due procedures shall be adhered.

7.5.8 Oil Spill in Coastal Zones

Kattupalli Port is prepared for oil spill response operation for the Coastal Zone – both on the marine water and associated shoreline by ensuring the availability of trained resources and appropriate OSR equipment including shoreline response equipment in place. In Coastal waters, the response operations shall include controlling the spreading of the oil with provisions of booms, containment of the oil with oil skimmers and protecting the shorelines through deflective booms and recovering the shorelines with adequate shoreline response operations.

7.5.9 Shoreline/Creek Oil Spill Response

The shoreline response operations are critical as the response techniques vary depending on the shoreline types. Considering the shoreline types of the area in and round the Port, the oil behaviour and response operations requirements are assessed and are given in **Table 7-41**.

Table 7-41: Shoreline/Creek Response requirements within 10km of Kattupalli port

S. No.	Shoreline/Creek Feature	Oil Behaviour	Response Considerations
1.	1B - Exposed, solid Manmade structures	Any oil that is deposited will be rapidly removed from exposed faces, although oil persistence on any specific shoreline is related to the incoming wave energy. The most resistant oil would remain as a patchy band	High-pressure spraying may be required to remove oil for aesthetic reasons and prevent leaching of the oil from the structure. Clean-up crews should make sure to recover all released oil.

S. No.	Shoreline/Creek Feature	Oil Behaviour	Response Considerations
		at or above the high-water line	
2.	3A (E) – Fine to medium grained sand beaches	During small spills, oil will concentrate in a band along the swash line. Maximum penetration of oil into fine-grained sand will be less than 15 cm; penetration into coarse grained sand can reach 25 cm. Burial of oiled layers by clean sand within the first few weeks after the spill will be limited usually to less than 30 cm, whereas burial by up to 60 cm on coarse-grained beaches is possible. Deepest burial will occur if the oil is stranded onshore at the beginning of an accretionary period, such as after a storm. Much of the oil will be removed during the next storm. Heavy accumulations of residual oil can form tar mats. Biological impacts are likely to be low, except for when the beaches are being used by shorebirds for resting and foraging.	Most beaches will require extensive clean-up efforts to remove as much of the oil as possible. Sand removal should be kept to a minimum, to avoid erosional problems. Use of heavy equipment for oiled sediment removal may result in the removal of excessive amounts of sand; manual clean-up may be preferable. All activity through the oiled sand should be limited to prevent mixing the oil deeper into the sediments and contamination of adjacent clean areas. When possible, clean-up crews should wait for all of the oil to come ashore prior to removal of oiled sediment.
3.	6B - Riprap	Deep penetration of oil between the boulders is likely where the riprap is placed at the water line. Oil adheres readily to the rough rock surfaces. If oil is left uncleaned, it may cause chronic leaching until the oil hardens into an asphalt deposit.	When the oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective, making sure to recover all released oil. Heavy and weathered oils are more difficult to remove, requiring scraping and/or hot-water spraying. It may be necessary to replace heavily oiled riprap.
4.	10D (R)– Mangroves	Distribution of deposited oil is typically patchy due to the variability in tidal heights within the mangrove area. If there is a berm or shoreline present, oil tends to concentrate and penetrate into the berm or accumulated detrital wrack–organic material. The oil can penetrate into the soil, particularly through burrows and other voids like those formed by dead mangrove roots. Lighter oils tend to penetrate more deeply into mangroves than heavier and more weathered oils, but will not persist unless they mix into the soil. Crude oils and heavier refined products can pool onto sediment surfaces and can be highly persistent. These heavy oils and emulsified oil can be trapped in thickets of red	**Natural Recovery** Cleanup also is not recommended for small accumulations of oil, regardless of product type. **Barriers/Berms** Sediment berms and dams can be used to temporarily close off the mouths of small inlets where currents and waves are low enough not to wash the sediments away. Manual removal, using hand tools and manual labor, is often conducted to remove bulk oiling by heavier oils, such as crude oil or intermediate fuel oils, stranded in mangroves. Manual removal can help prevent other areas from becoming contaminated as the oil moves around, and helps limit long-term sediment contamination.

S. No.	Shoreline/Creek Feature	Oil Behaviour	Response Considerations
		mangrove prop roots and black mangrove pneumatophores and are likely to adhere to and coat these surfaces, as well as other organic materials. Re-oiling from re-suspended oil, particularly as tides rise and fall, may further injure plants over time.	

The shoreline response also contribute to a major quantity of waste generated including plastic bags, oiled flora and fauna, partially oiled sorbent booms, pads etc.

7.5.10 Storage and Disposal of Oil and Oily Waste

A temporary storage site has been identified in line with the criteria for site selection[2] and has been integrated in the master plan of Port development.

7.5.11 Marine Oil Spill Response Equipment

Marine oil spill response equipment has been proposed in line with the requirement for a Category B Port complying with the guidelines issued by ICG (Ref: EP/0720/Circular No 03/2018 dated 19.12.2018). Minimum OSR equipment shall be stored at FCP and the major portion would be stored at ECC.

7.5.12 Actions and Operations

7.5.12.1 Initial procedures

- Notification of Oil Spill To Concerned Authorities

Oil spill incidents reporting requirements for Kattupalli Port and subsequent actions by MRCC of ICG is presented in **Figure 7-38**.

[2] *Sources: International Petroleum Industry Environmental Conservation Association (IPIECA) and International Maritime Organization (IMO))*

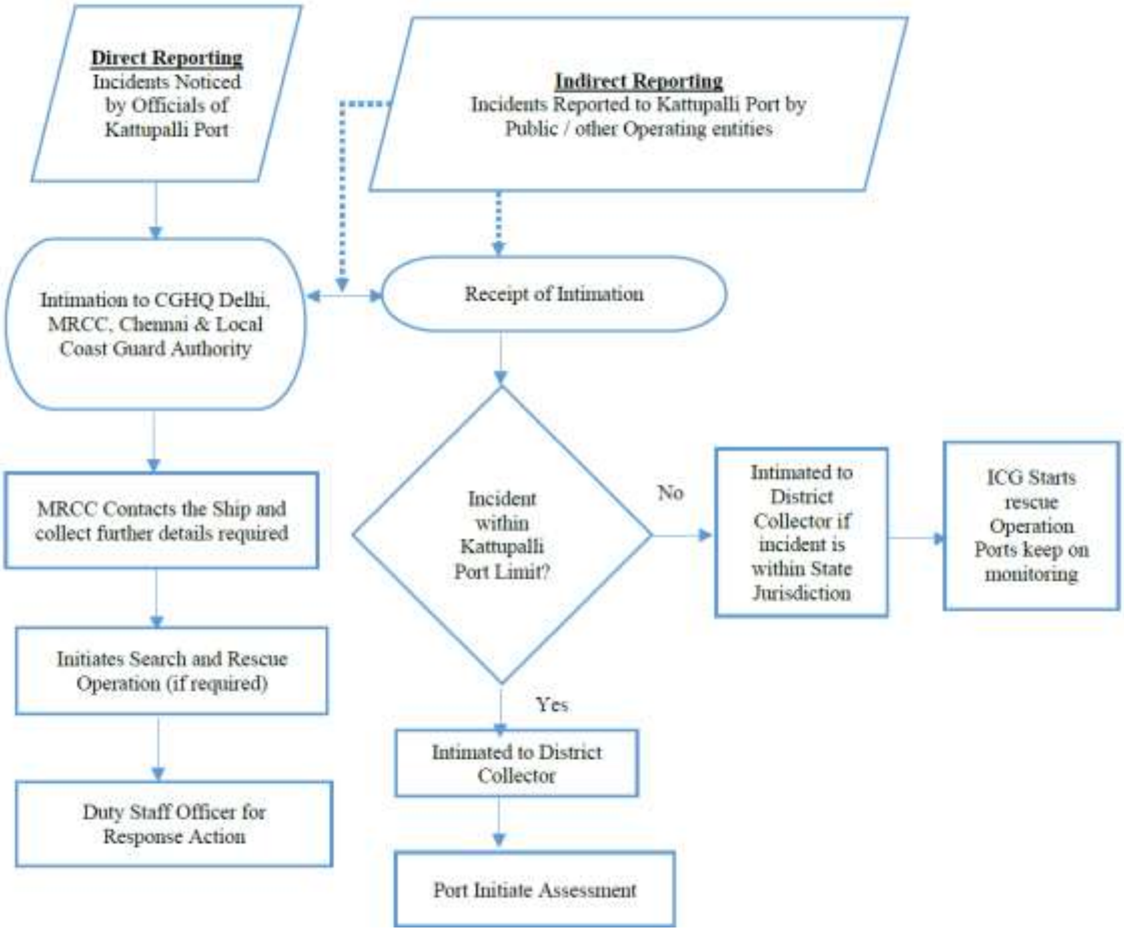


Figure 7-38: Oil Spill Incident Reporting and Immediate Actions

- Preliminary Estimate Of Response Tier

Preliminary estimation of response tier may be made by considering the following inputs received from POLREP (Online pollution reporting system) along with the site specific factors such as

  - Location of Spill
  - Type of oil spill – rate of spillage – oil appearance and approximate thickness
  - Marine Meteorological conditions – Resources at risk
  - Response operation prospects – favouring/challenging – response resources adequate
- Notifying the key Team members & Authorities
- Manning control room
- Collecting Information (Oil type, Sea/Wind Forecast/ Aerial Surveillance, Beach Reports)
- Estimation of fate of Slick (24, 48 and 72 Hours)
- Identifying Resources immediately at Risk, Informing parties

7.5.12.2 Operations Planning

- Assembling of the full Response Team
- Identifying the Immediate Response Priorities
- Mobilizing immediate response
- Media Briefing

- Planning medium Term Operation (24, 48 and 72 Hr)
- Deciding to escalate Response to higher tier
- Mobilizing or placing on standby resources required
- Establishing field command post and communications

7.5.12.3 Control of Operations

- Establishing management team with experts and advisors
- Updating information (sea/wind/weather forecast, aerial surveillance, beach reports)
- Reviewing and planning operation
- Obtaining additional equipment, supplies and manpower
- Preparing daily incident log and management reports
- Preparing operations accounting and financing reports
- Preparing release for public and press conferences
- Brief local and government officials

7.5.12.4 Termination of Operations

- Deciding final and optimal levels of beach clean-up
- Standing-down equipment, cleaning, maintaining, replacing
- Preparing formal detailed report
- Reviewing plans and procedures from lessons learnt

Continuous improvement with different strengths and capacities shall be made to existing OSCP. The existing OSCP shall be revised considerably by improving, strengthening and upgrading the approach (including facilities) and adding new dimensions to be more useful and effective in addressing the requirements and challenges of Proposed RMP.

7.6 Traffic and Transportation Study

The detailed traffic survey was conducted around Kattupalli port in line to ToR requirement for assessment of the cumulative impact of all development and based on the study, traffic management and traffic decongestion plan has been drawn up. The details of the study, outcome and recommendations are presented in following section.

7.6.1 Project Location

Kattupalli is located 30 kilometres towards north of Chennai and has connectivity with hinterland of North Tamil Nadu, Chennai, Bangalore region and South Andhra Pradesh. Two more ports exist in the close vicinity of the existing Kattupalli port viz. Chennai Port and Ennore Port.

The following are the three important National Highways emerging from Kattupalli port:

- NH-16 (Old NH-5) connecting Chennai and Kolkata and passing through major cities such as Vijayawada, Visakhapatnam and Cuttack
- NH-48 (Old NH-4) linking Chennai and Mumbai passing through Bangalore and Pune
- NH-32 & NH-38 (Old NH-45) linking Chennai and Madurai and connecting the southern parts of Tamil Nadu

7.6.2 Traffic Surveys

An accurate assessment of the traffic that is likely to use the roads has an important bearing on the project potential, as it forms the basic input in planning, design, operation and financing. A thorough knowledge of the travel characteristics of the traffic, likely to use the major roads in the influence area of the study corridor is essential for future traffic estimation. Hence, traffic surveys were carried out to assess the baseline traffic characteristics on the roads in study area.

7.6.2.1 Classified Traffic Volume Count

Classified Traffic Volume Count surveys were conducted at 5 strategic points i.e. at on Port Access Road (Between KPL Main Gate and KPL Gate No.2), Chettinad International Coal Terminal (CICT) Road, Near Vinay Nagar Temple on SH-56, Near Thiruvellavoyal SH-107 and Near Pulicat Check Post on SH-104 of Thiruvallur district for a period of 24 hours to assess traffic intensity on existing road network in the site vicinity.

7.6.2.2 Turning Movement Count (TMC) Survey

Turning Movement Count Survey was conducted at three locations i.e. at Near L&T Modular Fabrication Facility (MFF), Near Kamarajar Port Ltd Main Gate and Near North Chennai Thermal Power Station (NCTPS) for a period of 24 hours. This survey is to analyse turning movements/ diversions at the junction and identify / suggest any improvement measures to reduce the conflicts or ensure free flow of the major traffic movement at the junctions.

7.6.2.3 Entry Exit Count Survey

Entry Exit Count Survey was conducted at three locations i.e. at Kattupalli Port Main Gate, Kamarajar Port Ltd Gate No.-2 and Kamarajar Port Ltd Main Gate for a period of 24 hours.

The details of the traffic surveys conducted are given in **Table 7-42** and shown in **Figure 7-39**.

Table 7-42: Details of Traffic Surveys

Location Code	Type of Survey	Location	Duration of Survey
CTVC-1	Classified Traffic Volume Count	On Port Access Road (Between KPL Main Gate and KPL Gate No.2)	24 hours
CTVC-2		Chettinad International Coal Terminal (CICT) Road	
CTVC-3		Near Vinay Nagar Temple on SH-56	
CTVC-4		Near Thiruvellavoyal SH-107	
CTVC-5		Near Pulicat Check Post on SH-104	
TMC-1	Turning Movement Count	Near L&T Modular Fabrication Facility (MFF)	
TMC-2		Near Kamarajar Port Ltd Main Gate	
TMC-3		Near North Chennai Thermal Power Station (NCTPS)	
EE-1	Entry Exit Count Survey	At Katupalli Port Main Gate	
EE-2		Kamarajar Port Ltd Gate No.-2	
EE-3		Kamarajar Port Ltd Main Gate	

Legend:
Turning Movement Count (TMC)
- TMC-1: Near L&T Modular Fabrication Facility (MFF)
- TMC-2: Near Kamarajar Port Ltd Main Gate
- TMC-3: Near North Chennai Thermal Power Station (NCTPS)

Classified Traffic Volume Count (CTVC)
- CTVC-1: On Port Access Road (Between KPL Main Gate and KPL Gate No.2)
- CTVC-2: Chettinad International Coal Terminal (CICT) Road
- CTVC-3: Near Vinay Nagar Temple on SH-56
- CTVC-4: Near Thiruvellavoyal SH-107
- CTVC-5: Near Pulicat Check Post on SH-104

Entry- Exit (EE) Count Survey
- EE-1: At Katupalli Port Main Gate
- EE-2: Kamarajar Port Ltd Gate No.-2
- EE-3: Kamarajar Port Ltd Main Gate

Figure 7-39: Location of Traffic Surveys

7.6.3 Traffic Survey Analysis

Traffic assessment includes both internal as well as external traffic assessment. Internal traffic assessment is required to assess the transport network within the development and external traffic analysis is required to assess the adequacy of the existing transport network to cater to the future traffic.

Internal traffic analysis includes the estimation of generated traffic (trip generation) from the proposed development and lane capacity assessment of the road infrastructure proposed within the development.

7.6.3.1 Average Daily Traffic (ADT)

The traffic volume data collected (for 24 hours) has been analysed to assess the volume of traffic, composition, hourly variation of traffic for the day at each surveyed location. The summary of ADT in terms of vehicles and PCUs is given in **Table 7-43**.

Table 7-43: Average Daily Traffic (ADT) observed at survey locations

Location ID	CTVC-1	CTVC-2	CTVC-3	CTVC-4	CTVC-5
Location Name	Port Access Road	CICT Road	Vinay Nagar Temple on SH-56	Thiruvellavoyal SH 107	Pulicat Check Post
Car/Jeep/Van	1019	113	1609	290	284
School Bus	-	-	-	0	0
Mini Bus	99	49	99	56	96

L&T Infra Engineering

Location ID	CTVC-1	CTVC-2	CTVC-3	CTVC-4	CTVC-5
Government Bus	-	2	168	44	162
Private Bus	124	9	90	22	72
Goods Carrier - 4W	359	59	452	129	64
LCV	64	19	592	12	45
2 Axle	255	35	1035	14	8
3 Axle	642	250	1918	1	1
MAV (4-6 Axle)	2877	761	5215	2	3
> 6 Axles	1	-	-	0	0
HCM/EME	4	13	5	1	0
Two Wheeler	2186	543	7171	3544	2035
Auto Rickshaw - 3W	128	9	497	517	73
Auto Rickshaw -6 Seater	-	-	-	0	0
Goods Auto Rickshaw - 3W	-	-	-	0	0
Tractor+ Trailer	6	17	5	0	4
Tractor	4	35	1	47	15
Cycle	-	9	10	40	0
Animal Drawn	1	-	-	3	0
Total Vehicles	**7769**	**1923**	**18867**	**4722**	**2862**
Total PCUs	18916	5063	40335	3176	2435

Observations:

1. At CTVC-1, CTVC-2, and CTVC-3, the number of PCUs are significantly higher than the number of vehicles indicating that the proportion of MAV on the road is high which can be attributed to the fact that most of traffic originated and destined to port comprises of MAV.
2. At CTVC-4 and CTVC-5, the numbers of PCUs are significantly lower than the number of vehicles which indicates that the proportion of two wheelers and cars on the road stretch is high. These routes are not being used by port bound traffic.

7.6.3.2 Traffic Composition

The traffic composition at count locations is given in **Table 7-44** and Vehicular composition distribution is presented from **Figure 7-40** to **Figure 7-42**.

Table 7-44: Traffic composition at count locations

Mode	CTVC-1	CTVC-2	CTVC-3	CTVC-4	CTVC-5
Two Wheeler	28%	28%	38%	76%	71%
Passenger Auto	2%	0%	3%	11%	3%
Car/Jeep/Van	13%	6%	9%	6%	10%
Mini Bus	1%	2%	1%	1%	3%
Bus	2%	1%	1%	2%	8%
Goods Carrier - 4W	5%	3%	2%	3%	2%
Auto/Mini LCV	0%	0%	0%	0%	0%
LCV	1%	1%	3%	0%	2%
2 Axle	3%	2%	5%	0%	0%
3 Axle	0%	0%	0%	0%	0%
MAV (4-6 Axle)	45%	54%	38%	0%	0%
Tractor	0%	3%	0%	1%	1%
Non-motorized Vehicles	0%	0%	0%	0%	0%
Total Vehicles	**100%**	**100%**	**100%**	**100%**	**100%**

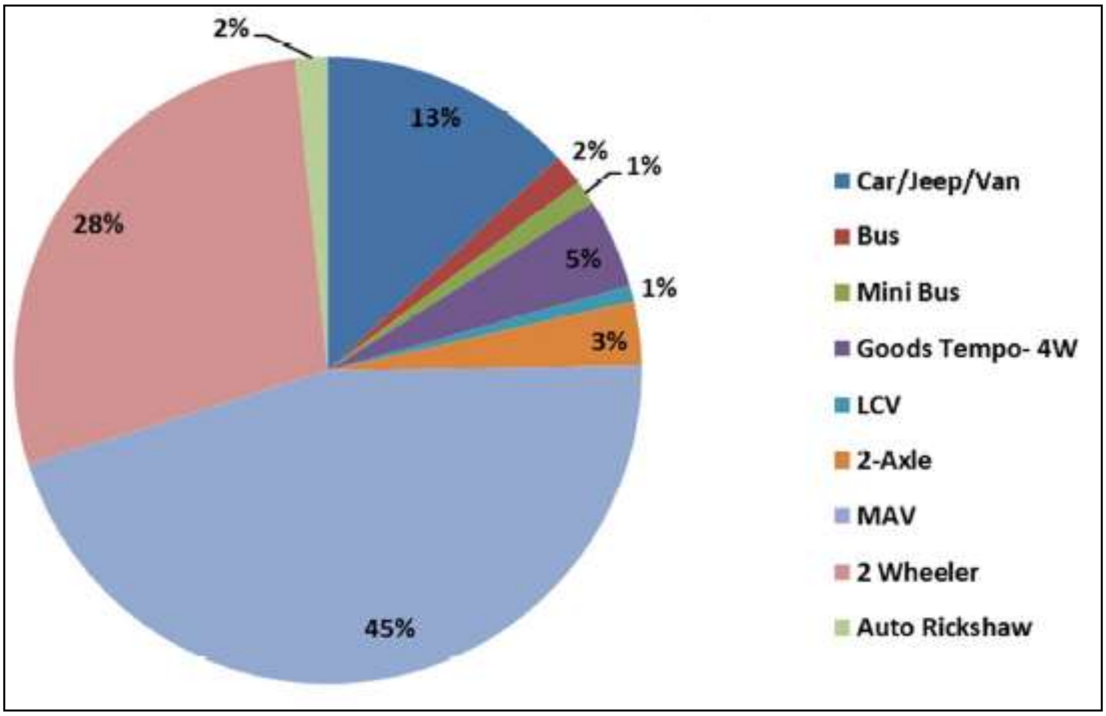


Figure 7-40: Vehicle composition distribution at CTVC-1

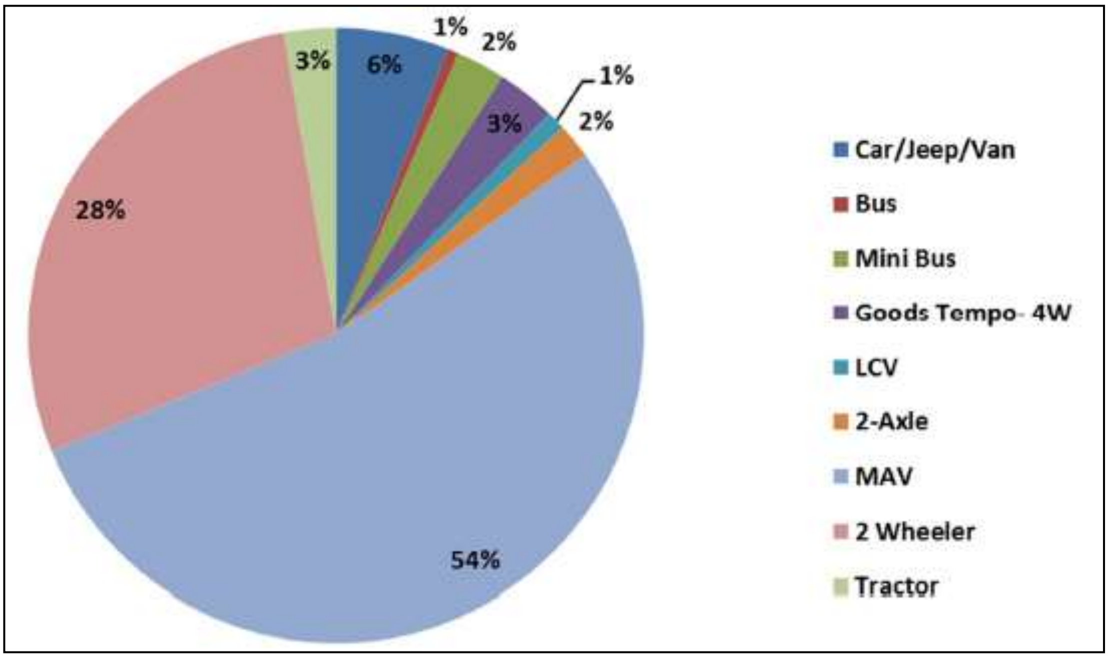


Figure 7-41: Vehicle composition distribution at CTVC-2

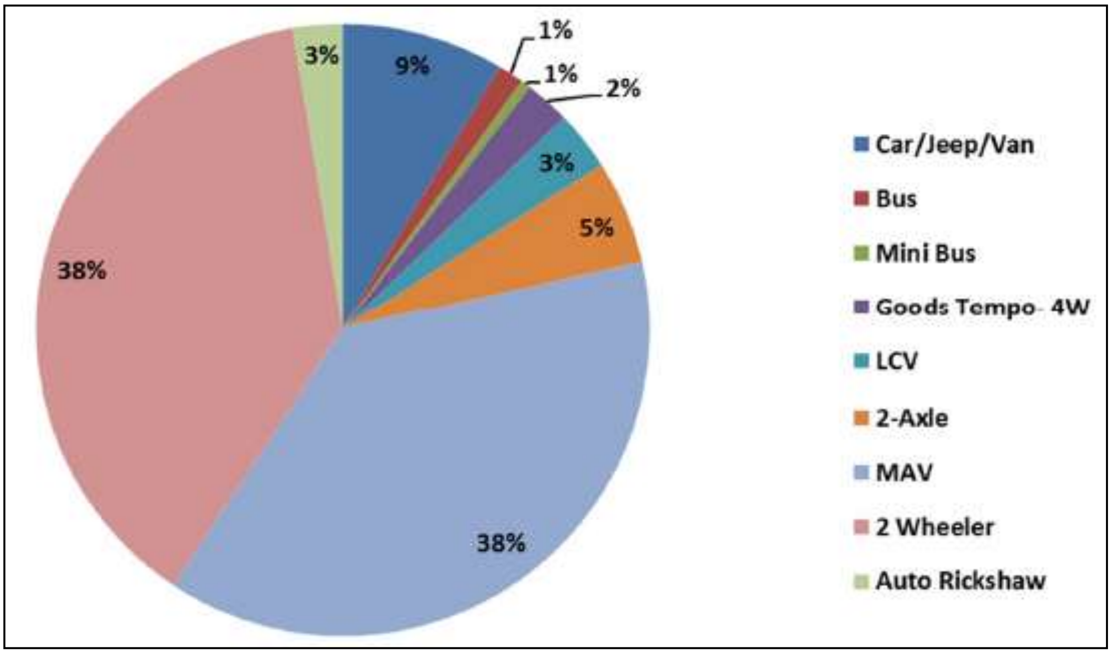


Figure 7-42: Vehicle composition distribution at CTVC-3

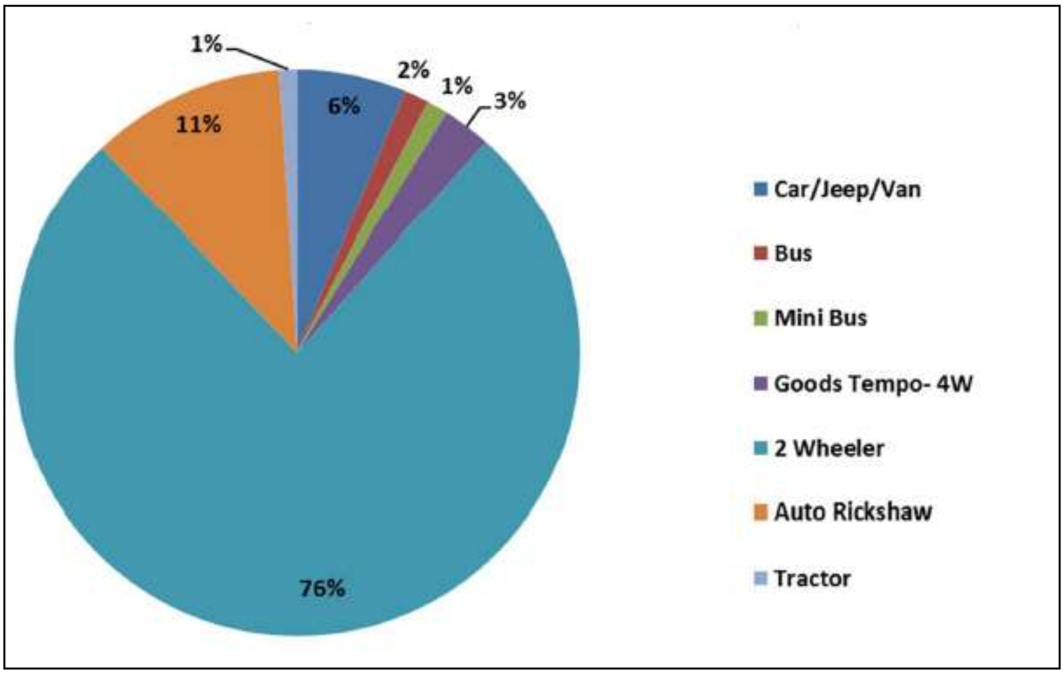


Figure 7-43: Vehicle composition distribution at CTVC-4

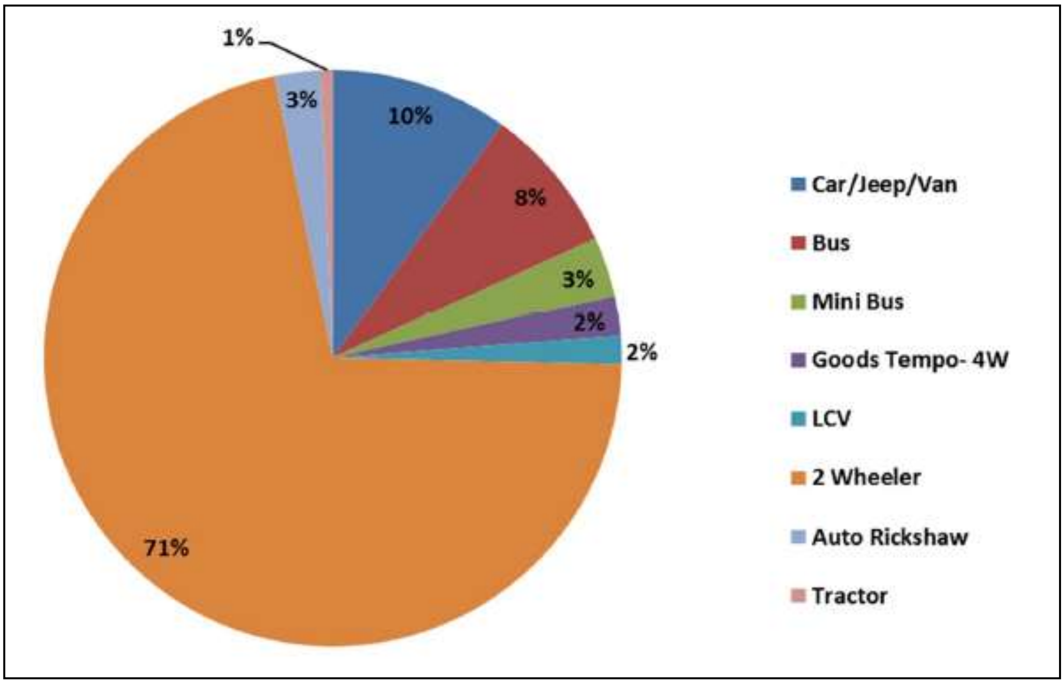


Figure 7-44: Vehicle composition distribution at CTVC-5

Observations:

- At CTVC-1, high PCU is due to more proportion of MAV's (45%), followed by two wheelers (28%), Cars (13%) of the traffic. Goods vehicles and Passenger vehicles comprise 54% and 46% of total traffic respectively.
- At CTVC-2, most of the traffic is multi-axle trucks (about 54%), followed by two wheelers (28%), Cars (6%). Goods vehicles and Passenger vehicles comprise 62% and 38% of the total traffic respectively.
- At CTVC-3, this road acts as the main access road for port bound/originated traffic. The traffic majorly comprises MAV in the Goods Vehicle category (38%) and two wheelers (38%) in passenger vehicle category which is followed by cars (9%). Goods vehicles and Passenger vehicles comprise about 49% and 51% of the total traffic respectively.
- At CTVC-4 and CTVC-5, Majority of traffic consists of two wheelers and followed by Auto Rickshaws and Cars of total traffic. Goods vehicles and Passenger vehicles comprise 4% and 96% of the total traffic respectively. Non- Motorized Vehicles form 1% of the traffic is at CTVC-4 only. This indicates that currently, these routes are not being used by port bound traffic.

7.6.3.3 Entry-Exit Count Analysis

7.6.3.3.1 Entry-Exit – 1

Traffic Volume Count Data collected at Location EE-1 was analysed and summarized in **Table 7-45**.

Table 7-45: Total Traffic Volume at Location EE-1

No. of Vehicles		Total (Vehicles)	Total (PCUs)
Kattupalli Port - Entry	Kattupalli Port - Exit		
3242	3211	6453	16364

The hourly variations of the traffic at Location EE-1 are shown in **Figure 7-45**.

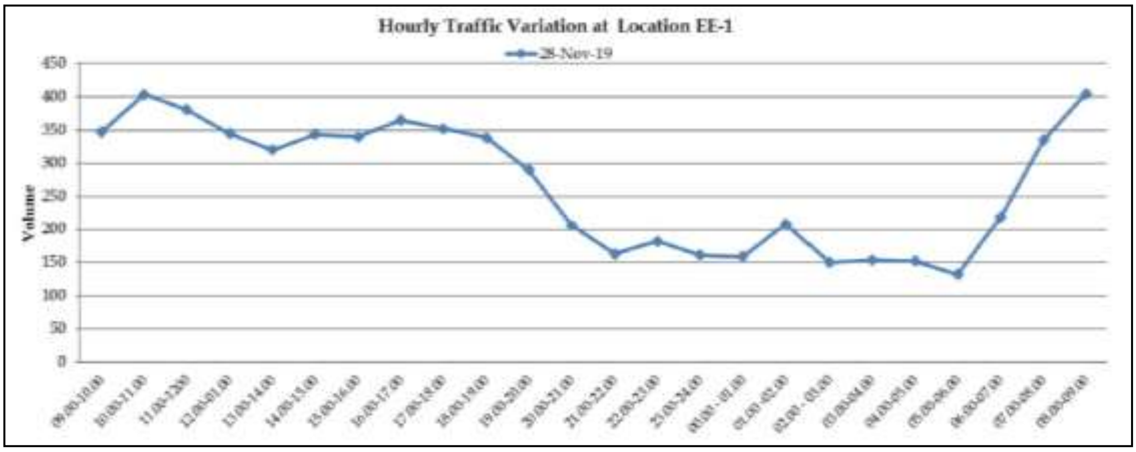


Figure 7-45: Hourly Variation of Traffic (Vehicles) at Location EE-1

It can be observed from the above chart that the traffic volume at Kattupalli Port Gate during the day starts increasing at about 6.00 hours till 9:00 hours, and after peaking between 8:00 hours and 9:00 hours decreases and becomes almost constant till 20:00 hours after which it starts declining rapidly. An insignificant secondary peak is observed between 1:00 hours and 2:00 hours.

7.6.3.3.2 Entry-Exit – 2

Traffic Volume Count Data collected at Location EE-2 was analysed and summarized in **Table 7-46**.

Table 7-46: Total Traffic Volume at Location EE-2

No. of Vehicles		Total (Vehicles)	Total (PCUs)
KPL West Gate - Entry	KPL West Gate - Exit		
689	186	875	2600

The hourly variations of the traffic at Location EE-2 are shown in **Figure 7-46**.

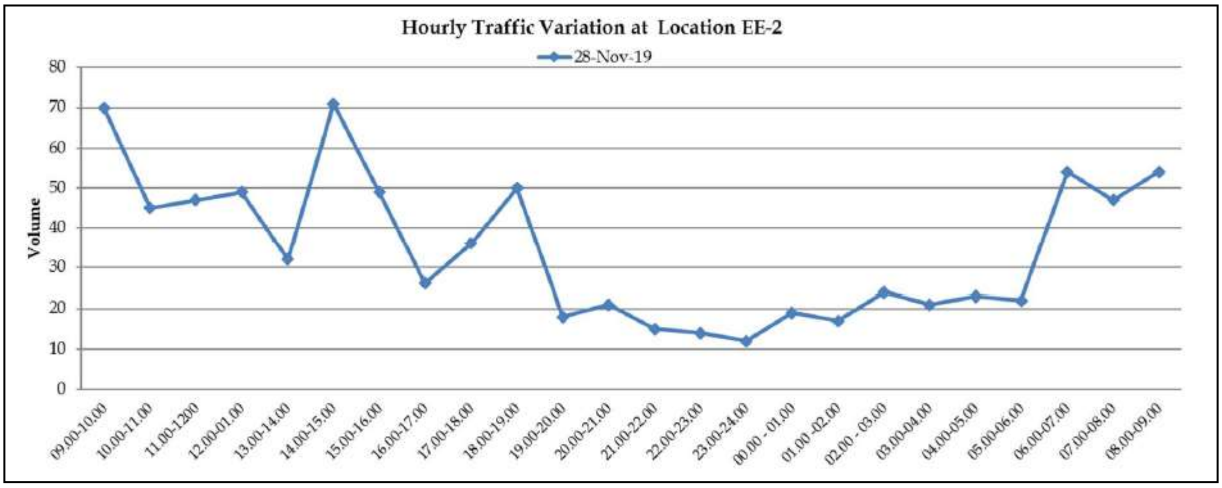


Figure 7-46: Hourly Variation of Traffic (Vehicles) at Location EE-2

It can be observed from the above chart that the traffic volume during the day starts increasing at about 6.00 hours till 9:00 hours, and after peaking between 8:00 hours and 9:00 hours and shows random intermittent peaks till 20:00 hours. After this duration, it starts declining rapidly and shows almost similar trend till 6:00 hours after which it starts increasing again.

7.6.3.3.3 Entry-Exit – 3

Traffic Volume Count Data collected at Location EE-3 was analysed and summarized in **Table 7-47**.

Table 7-47: Total Traffic Volume at Location EE-3

No. of Vehicles		Total (Vehicles)	Total (PCUs)
KPL Main Gate - Entry	KPL Main Gate - Exit		
1079	1163	2242	4909

The hourly variations of the traffic at Location EE-3 are shown in **Figure 7-47**.

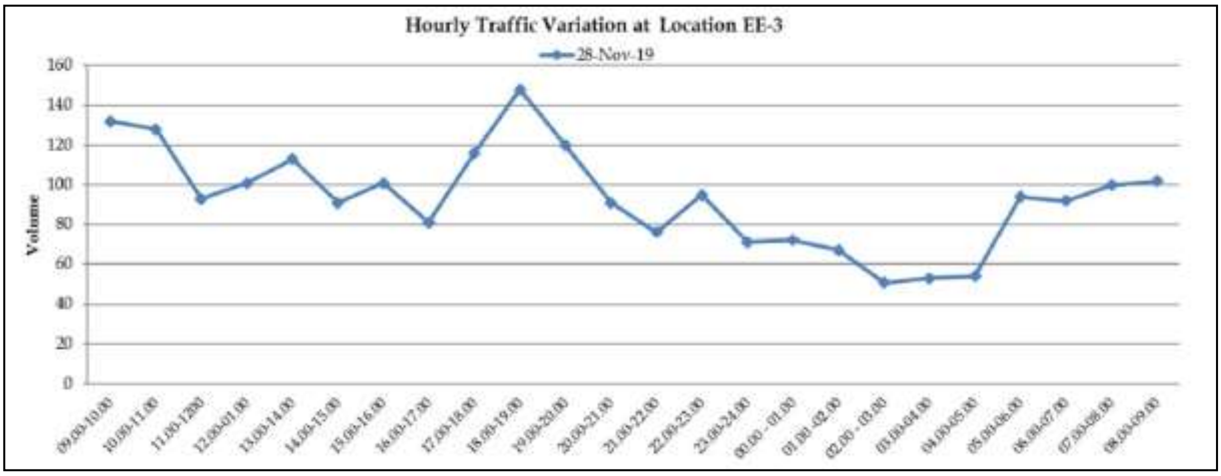


Figure 7-47: Hourly Variation of Traffic (Vehicles) at Location EE-3

In line with the trend observed at other locations, it can be observed from the above chart that the traffic volume during the day starts increasing at about 6.00 hours till 9:00 hours. It shows random peaks through the day and peaking between 18:00 hours and 19:00 hours after which, the traffic declines rapidly. Thereafter, at 6:00 hours, the next day, it starts increasing again.

7.6.3.4 Turning Movement Count Analysis

7.6.3.4.1 Turning Movement Count -1

The general arrangement of the junction is shown in **Figure 7-48**. Since the Kattupalli Village Road and Appollo Road are minor roads and the traffic movement is very less, therefore junction is analysed as a 3 arm Junction and the traffic on these two roads was counted separately.

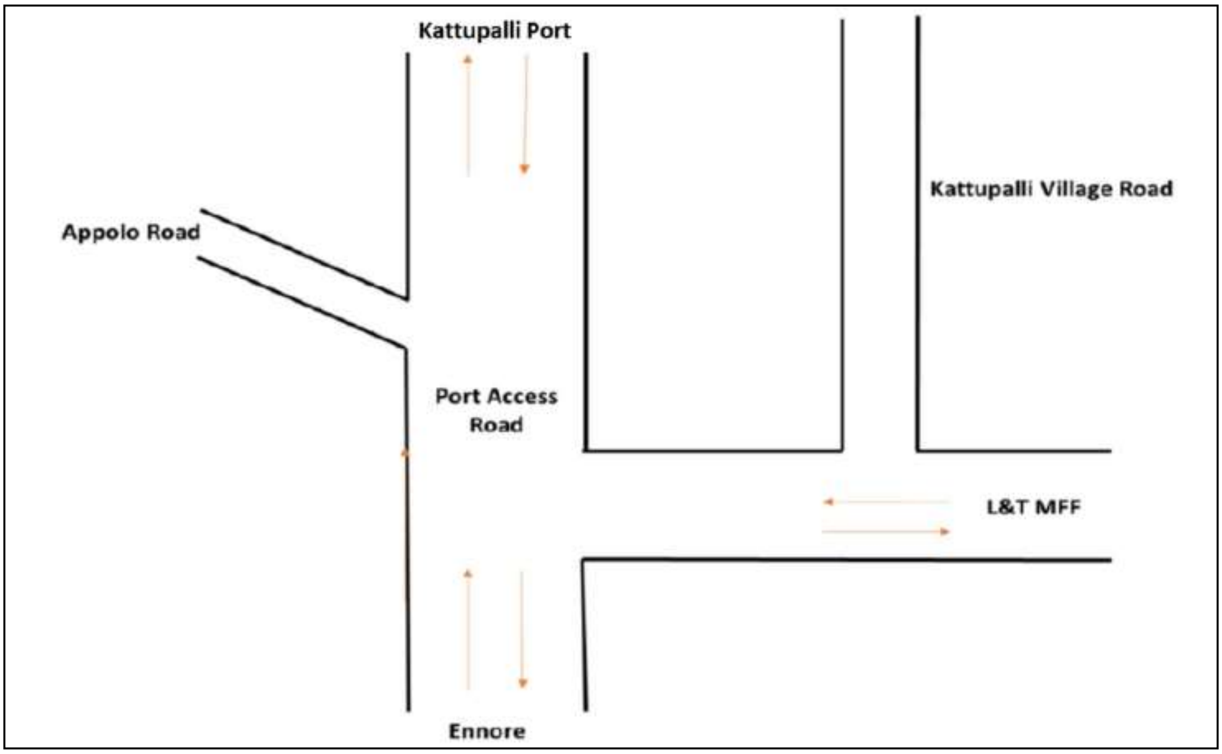


Figure 7-48: General Arrangement of TMC-1 Junction

The peak hour traffic at the Junction is 1437 PCU between 8AM and 9 AM and the total junction traffic is 20816 PCU for the day. The arm wise traffic movement in PCU for peak hour and Total Junction Traffic is shown in **Figure 7-49** and **Figure 7-50**. The total traffic observed for one day on Kattupalli Village Road and Appollo Road is 601 PCU and 1897 PCU respectively.

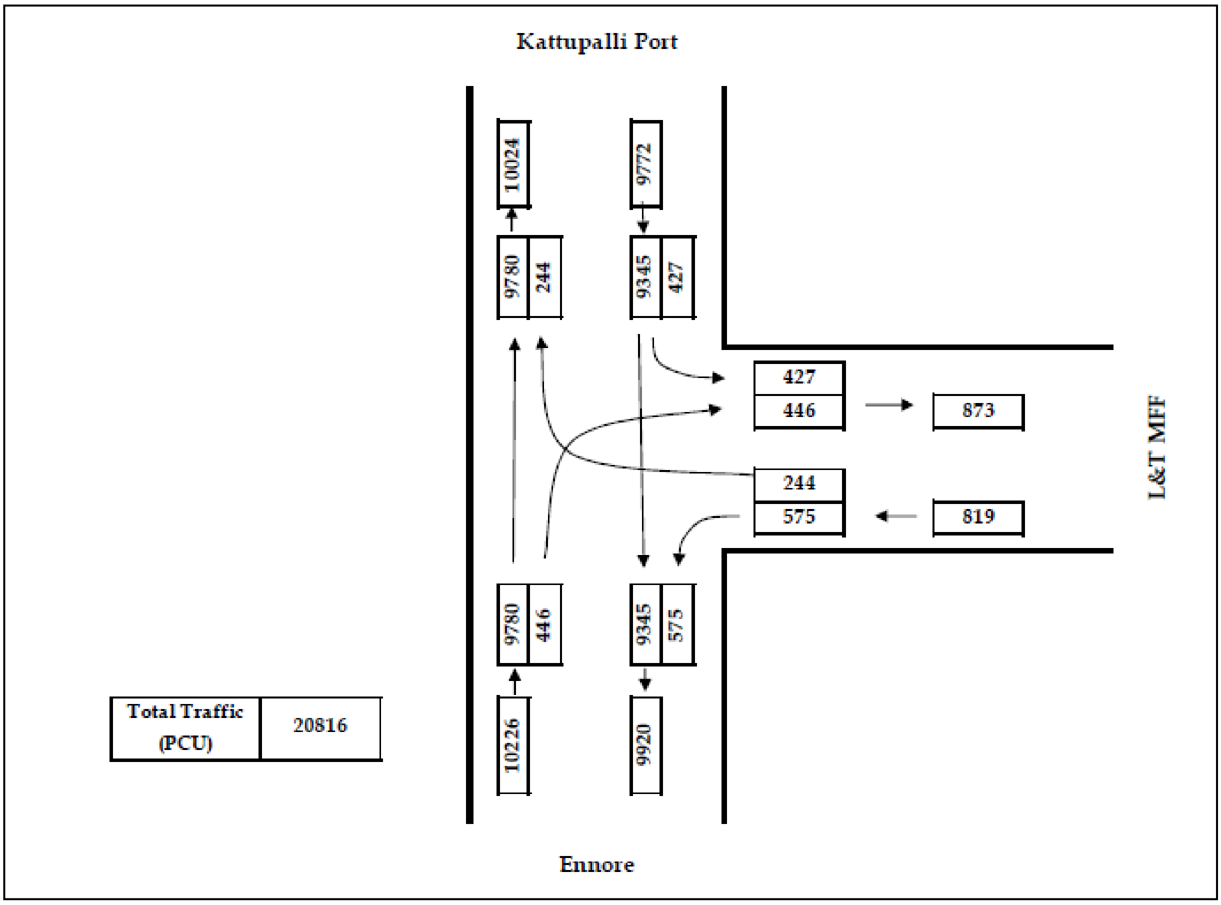


Figure 7-49: Peak Hour Traffic (PCU) at TMC-1 Junction

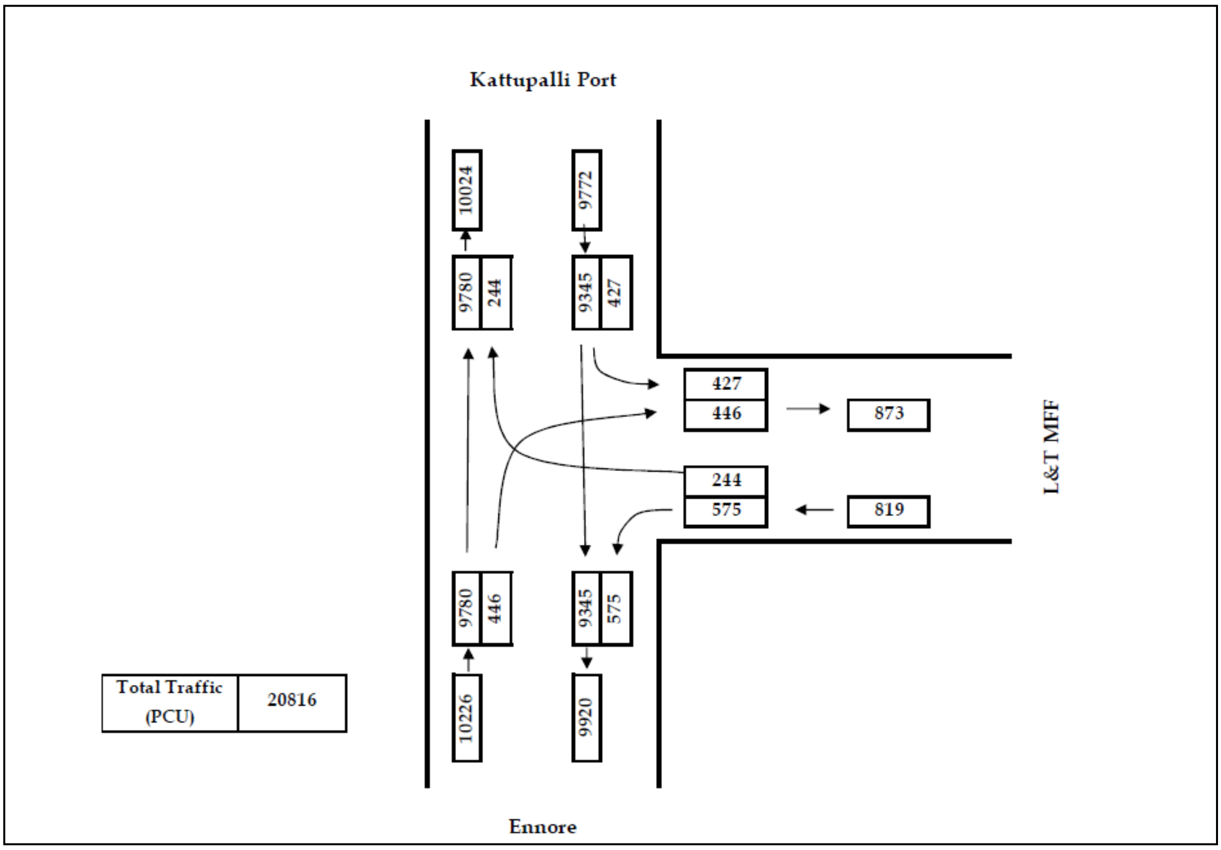


Figure 7-50: Total Traffic Flow (PCU) at TMC-1 Junction

7.6.3.4.2 Turning Movement Count -2

The general arrangement of the junction is shown in the Figure 3-22

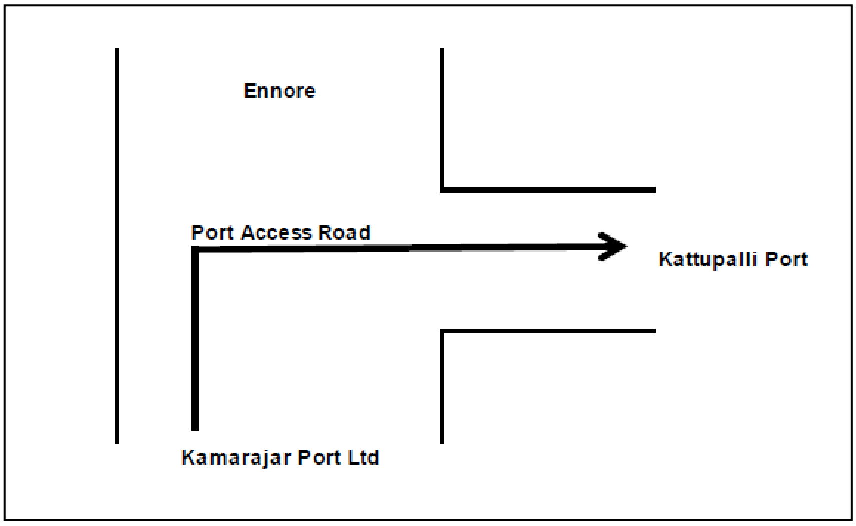


Figure 7-51: General Arrangement of TMC-2 Junction

The peak hour traffic at the Junction is 1173 PCU between 8AM and 9 AM and the total junction traffic is 20469 PCU for the day. The arm wise traffic movement in PCU for peak hour and Total Junction Traffic is shown in **Figure 7-52** and **Figure 7-53**.

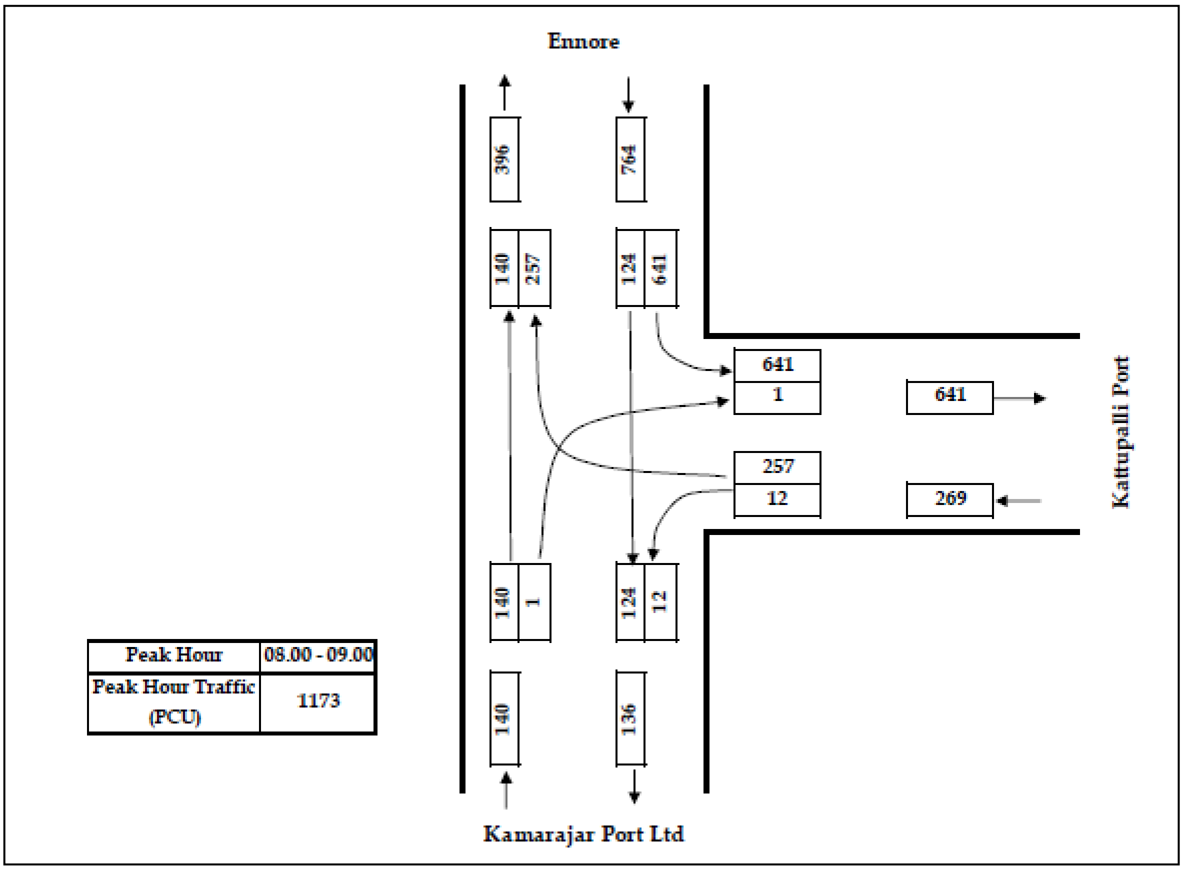


Figure 7-52: Peak Hour Traffic (PCU) at TMC-2 Junction

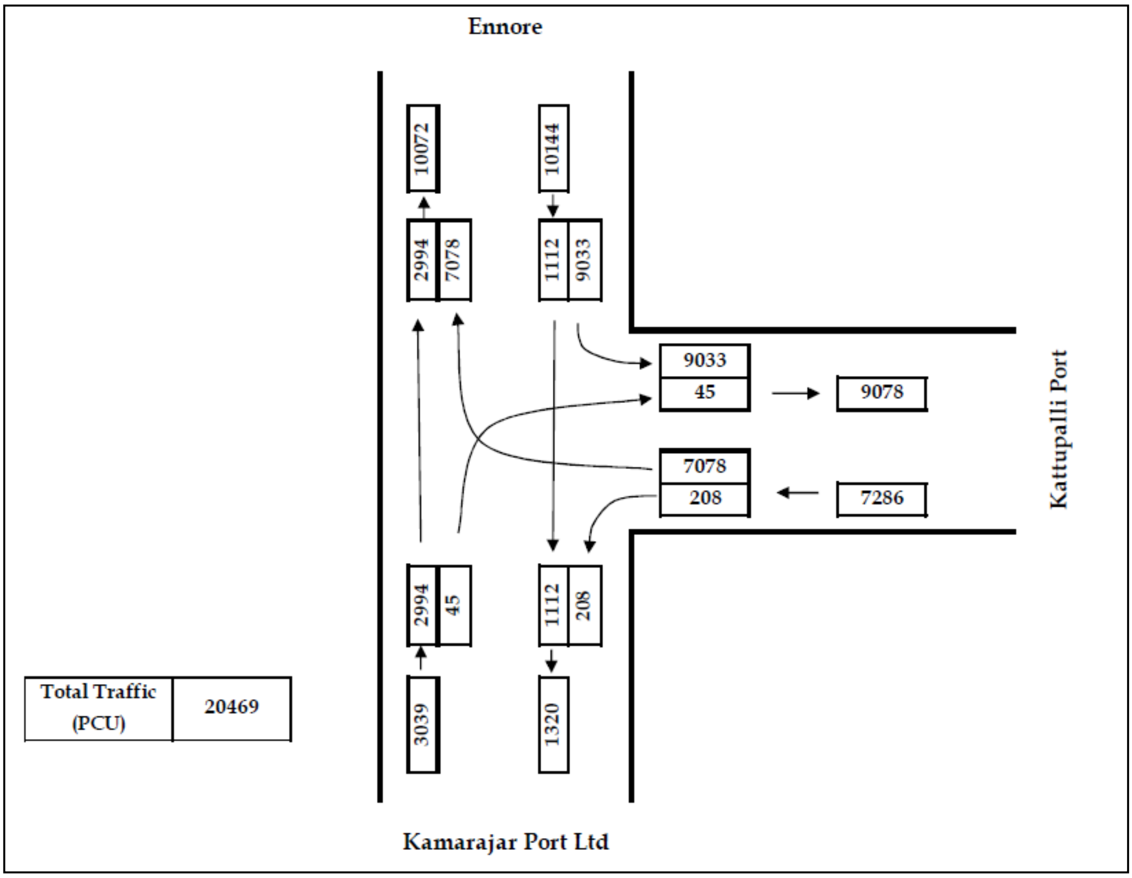


Figure 7-53: Total Traffic Flow (PCU) at TMC-2 Junction

7.6.3.4.3 Turning Movement Count -3

The general arrangement of the junction is shown in the **Figure 7-54.**

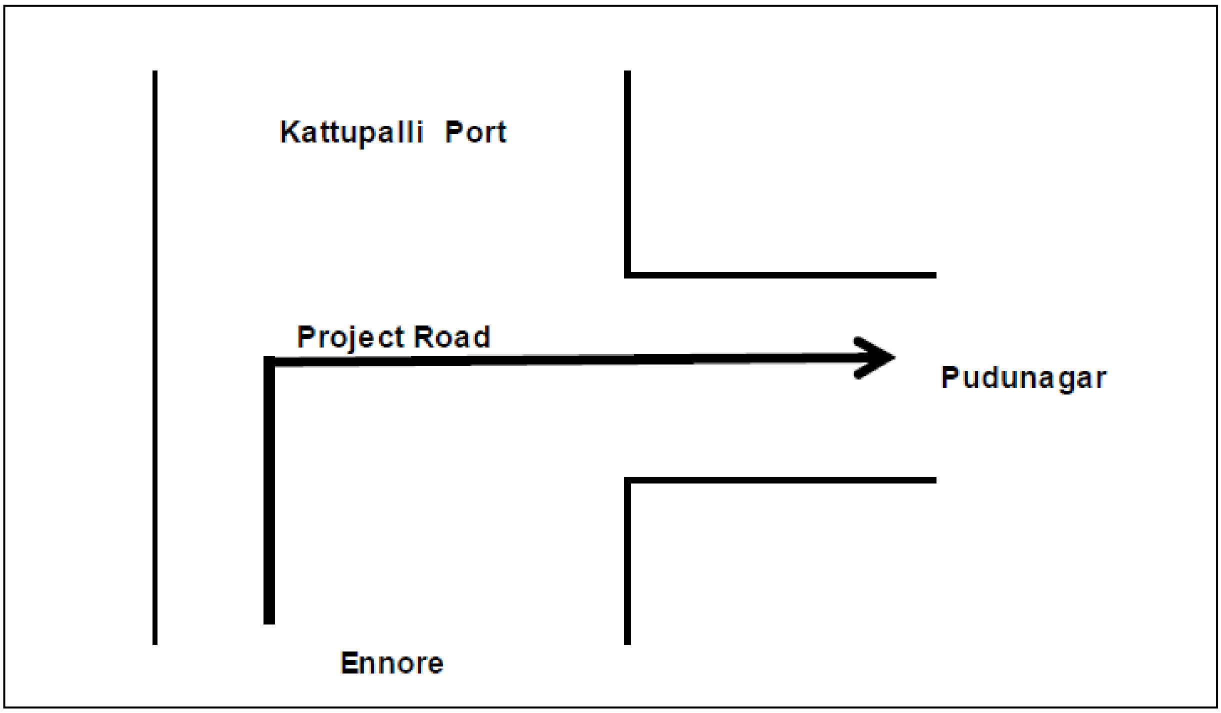


Figure 7-54: General Arrangement of TMC-3 Junction

The peak hour traffic at the Junction is 1581 PCU between 10AM and 11 AM and the total junction traffic is 26915 PCU for the day. The arm wise traffic movement in PCU for peak hour and Total Junction Traffic is shown in **Figure 7-55** and **Figure 7-56.**

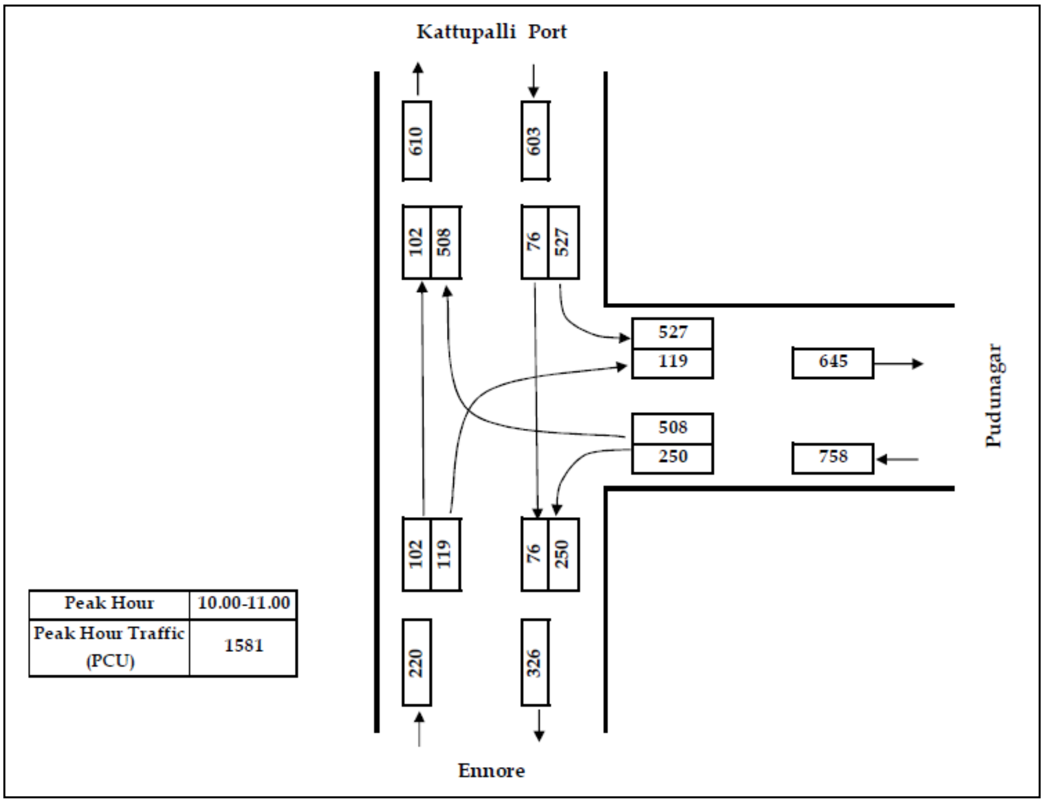


Figure 7-55: Peak Hour Traffic (PCU) at TMC-3 Junction

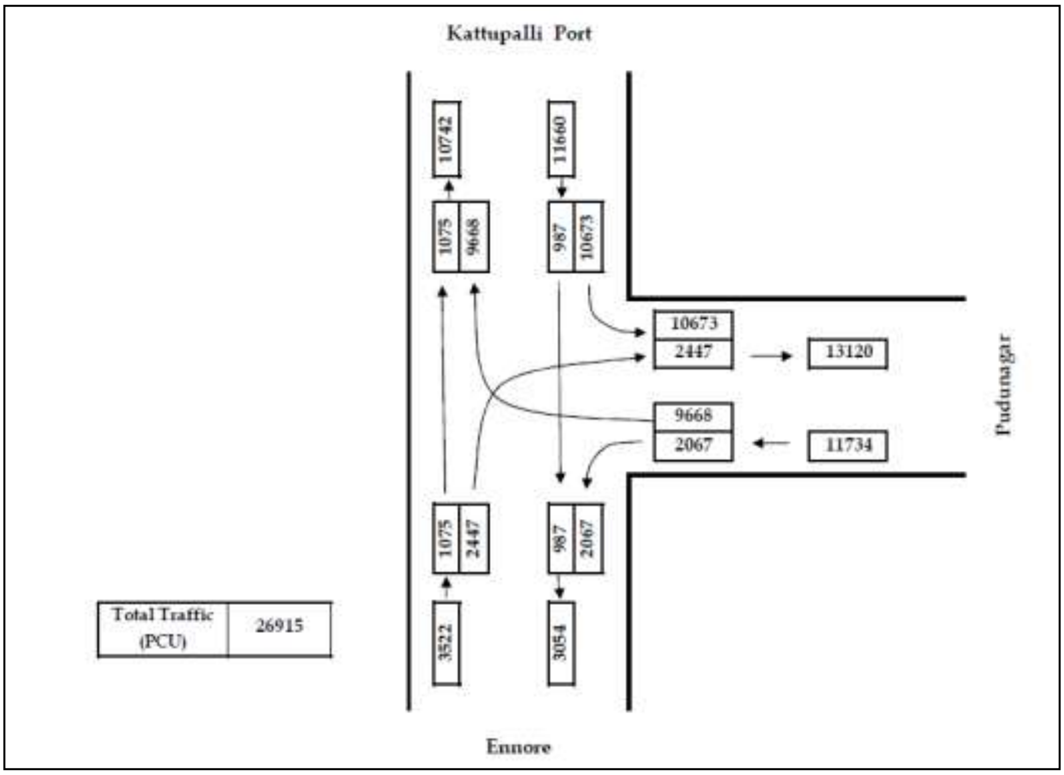


Figure 7-56: Total Traffic Flow (PCU) at TMC-3 Junction

7.6.3.5 Annual Average Daily Traffic (AADT)

The seasonal factor is a measure of the variation that occurs in daily traffic flows throughout the year. Seasonality Correction Factor (SCF) is the ratio of Annual Average Traffic for the 12 months to the Average traffic of that month. To establish seasonality correction factor for the traffic plying on the project roads, fuel sales data collected from the Fuel stations in the project influence area is used. A seasonality correction factor value of more than 1 indicates that the traffic in that month is less compared to the AADT. The seasonality correction factor arrived for the month of November from the fuel sales data is presented in **Table 7-48**.

Table 7-48: Adopted Seasonal Correction Factor

Vehicle Type	SCF
Car/Jeep/Van/Taxi	1.01
School Bus	1.10
Mini bus	1.10
Govt. Bus	1.10
Private Bus	1.10
Goods Carrier-4W	1.01
LCV	1.10
2-Axle	1.10
3-Axle	1.10
4-6 Axle	1.10
> 6 Axles	1.10
HCM/EME	1.10
2-Wheeler	1.00
Auto Rickshaw- 3-Seater	1.00
Auto Rickshaw- 6-Seater	1.00
Goods Carrier-3W	1.00
Tractor + Trailer	1.00
Tractor	1.00
Cycle	1.00
Animal Drawn	1.00

It is seen that the SCF for the month of November for both passenger traffic and goods traffic (except those plying mostly within city limits) is more than 1, which indicates that the traffic in the month of November is lesser than the yearly average traffic for Car, LCV, Bus/Truck and MAV.
The base traffic (AADT) for projection is arrived at by multiplying the seasonality factor for the month of November with the traffic obtained from traffic volume count. The AADT estimated for the various roads is summarized in **Table 7-49**.

Table 7-49: Annual Average Daily Traffic (AADT)

Location ID	CTVC-1	CTVC-2	CTVC-3	CTVC-4	CTVC-5
Location Name	Port Access Road	CICT Road	Vinay Nagar Temple on SH-56	Thiruvellavoyal SH-107	Pulicat Check Post
Car/Jeep/Van	1029	114	1625	293	287
School Bus	0	0	0	0	0
Mini Bus	109	54	109	62	106
Government Bus	0	2	185	48	178
Private Bus	136	10	99	24	79
Goods Carrier - 4W	363	60	457	130	65
LCV	70	21	651	13	50
2 Axle	281	39	1139	15	9
3 Axle	706	275	2110	1	1
MAV (4-6 Axle)	3165	837	5737	2	3
> 6 Axles	1	0	0	0	0
HCM/EME	4	14	6	1	0

Location ID	CTVC-1	CTVC-2	CTVC-3	CTVC-4	CTVC-5
Location Name	Port Access Road	CICT Road	Vinay Nagar Temple on SH-56	Thiruvellavoyal SH-107	Pulicat Check Post
Two Wheeler	2186	543	7171	3544	2035
Auto Rickshaw - 3W	128	9	497	517	73
Auto Rickshaw-6-Seater	0	0	0	0	0
Goods Carrier - 3W	0	0	0	0	0
Tractor+ Trailer	6	17	5	0	4
Tractor	4	35	1	47	15
Cycle	0	9	10	40	0
Animal Drawn	1	0	0	3	0
Total AADT (Vehicles)	**8189**	**2039**	**19800**	**4741**	**2904**
Total AADT (PCU)	**20558**	**5512**	**43772**	**3216**	**2534**

7.6.4 Traffic Growth Rate Analysis

Future traffic forms the basis for the design of the transportation infrastructure facility. Also, to understand the impact of traffic on the surrounding network it becomes necessary to estimate the future traffic. The traffic impact assessment due to the future expansion of Kattupalli Port will require an estimated future traffic on the surrounding network especially within 5 Km radius of Kattupalli port.

The cargo share by road was segregated and total trucks per day were calculated for current year (2019) and horizon year (2035). The CAGR of Trucks from current to horizon year is shown in **Table 7-50.** The truck growth rate is based on the expansion capacity of port.

Table 7-50: Future Port Traffic Growth (Trucks/day)

	Present Traffic (2019)	Horizon year Traffic (2050)	CAGR
Kattupalli Port	1193	14674	8.43%

As per the above data the MAV traffic from current year to horizon is expected to grow at a CAGR of 8.43%.

7.6.5 Estimated Growth Rates

Judicious considerations of the various parameters are involved in the estimated growth rates for all types of modes as tabulated in **Table 7-51**.

In order to provide realistic growth rates, the possible shift in modal choice, such as a preference change from 2 Axle to MAV, are considered. The growth rate of 2-Axle trucks is considered as 2%, given the fact that the same show a declining usage trend all over the country.

Table 7-51: Estimated Traffic Growth Rates

Vehicle Type	Estimated Growth Rates
Car/Jeep/Van/Taxi	5%
Bus	5%
Mini bus	5%
Goods Carrier- 4W	5%
LCV	5%
2-Axle	2%
3 Axle	7%
4-6 Axle	7%
> 6 Axles	7%
HCM/EME	5%

Vehicle Type	Estimated Growth Rates
2-Wheeler	5%
Auto Rickshaw	5%
Goods Carrier- 3W	5%
Tractor + Trailer	5%
Cycle	5%
Animal Drawn	5%

The Destination of goods vehicle movement in the external network is shown in **Table 7-52.**

Table 7-52: Distribution of Goods vehicles for Future years

Destination	2Axle/3 Axle	MAV
South of Kattupalli Port (i.e. Towards Chennai)	80%	80%
North of Kattupalli Port (i.e. Towards Vijayawada)	5%	5%
West of Kattupalli Port (i.e. Towards Bengaluru)	15%	15%
Total	100%	100%

7.6.5.1 Estimation of Number of Goods Vehicle due to Port Expansion

The numbers of goods vehicles are estimated based on the proposed port expansion plans and the share of road transport. The data given in **Table 7-53** is utilized to estimate the same based on the port and type of cargo.

Table 7-53: Details of Proposed Ennore/ Kamarajar Port Capacity[3]

Cargo Handled (MTPA)	Current Capacity	Capacity Augmentation Required over current		
		2020	2025	2030
Coal	54	0	0	24.1
Crude/ POL	11	0	2.5	4.5
Container	27	0	0	7.7
Other	4	0.2	1	5.2
Total	96	0.2	3.5	41.5

Since the previous year target demands have not been achieved as per projections, a growth rate of about 5% per annum would be considered as reasonable in the initial period.

Heavy Goods Vehicles (HGV):

Kattupalli and Ennore Ports are the two major traffic generators for Goods vehicles. The existing and future expansion of port capacity is shown in **Table 7-54**.

Table 7-54: Existing & Future Port Capacity

Port	Port Capacity (in MTPA)		
Kattupalli Port	Existing Capacity	Future Capacity Expansion	Total Capacity
	24.65	295.35	320

The future traffic generation is estimated by applying suitable road share and average truck load carrying capacity. The truck traffic for future development has been presented in **Table 7-55.**

[3] *SAGARMALA: Master Plan for Kamarajar (Ennore) Port*

Table 7-55: Kattupalli Port Master Plan – Berth capacity and Traffic Share

S. No	Description	Capacity of Berths in MTPA	Road Share (%)	Road Share	MT or TEU[4] / Day	Trucks / Day	Trucks / Hr	Rail Share (%)	Rail Share (MTPA)	Pipeline Share (%)	Pipeline Share (MTPA)
1	**Container Cargo**				**350 Days / Yr.**	**2 TEU / Truck**	**22Hrs / Day**				
a.	Berth 1	12.6	60%	7.56	1543	454	20.6	40%	5.04	0%	0.000
b.	Berth 2	12.6	60%	7.56	1543	454	20.6	40%	5.04	0%	0.000
c.	Berth 11	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
d.	Berth 12	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
e.	Berth 13	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
f.	Berth 14	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
g.	Berth 15	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
h.	Berth 16	11.48	60%	6.888	1406	413	18.8	40%	4.59	0%	0.000
	Total	**94.08**		**4.03**	**11522**	**3386**	**154**		**37.63**		
2	**Multipurpose/ General Cargo**					**20 MT / Truck**					
a.	Berth 6	12	70%	8.4	24000	1200	55	30%	3.60	0%	0.000
b.	Berth 7	12	70%	8.4	24000	1200	55	30%	3.60	0%	0.000
c.	Berth 8	12	70%	8.4	24000	1200	55	30%	3.60	0%	0.000
d.	Berth 9	12	70%	8.4	24000	1200	55	30%	3.60	0%	0.000
e.	Berth 10	12	70%	8.4	24000	1200	55	30%	3.60	0%	0.000
	Total	**60.00**		**42.00**	**120000**	**6000**	**275**		**18.00**		
3	**Bulk Cargo**					**20 MT / Truck**					
a.	Berth 17	17	20%	3.4	9714	486	22	80%	13.60	0%	0.000
b.	Berth 18	17	20%	3.4	9714	486	22	80%	13.60	0%	0.000
c.	Berth 19	17	20%	3.4	9714	486	22	80%	13.60	0%	0.000
d.	Berth 20	17	20%	3.4	9714	486	22	80%	13.60	0%	0.000
e.	Berth 21	17	20%	3.4	9714	486	22	80%	13.60	0%	0.000
	Total	**85.00**		**17.00**	**48570**	**2430**	**110**		**68.00**		
4	**LNG / LPG Cargo**										
a.	Berth 5	5	10%	0.5	1429	71	3	0%	0.0	90%	4.5
b.	Berth 29	5	10%	0.5	1429	71	3	0%	0.0	90%	4.5
c.	Berth 30	10	10%	1	2857	143	6	0%	0.0	90%	9
	Total	**20.00**		**2.00**	**5715**	**285**	**12**				**18.0**
5	**Liquid Cargo / Multipurpose**										
a.	Berth 3	5	40%	2	5714	286	13	10%	0.5	50%	2.5
b.	Berth 4	5	40%	2	5714	286	13	10%	0.5	50%	2.5
c.	Berth 22	5	40%	2	5714	286	13	10%	0.5	50%	2.5
d.	Berth 23	5	40%	2	5714	286	13	10%	0.5	50%	2.5
e.	Berth 24	5	40%	2	5714	286	13	10%	0.5	50%	2.5
f.	Berth 25	5	40%	2	5714	286	13	10%	0.5	50%	2.5
g.	Berth 26	5	40%	2	5714	286	13	10%	0.5	50%	2.5
h.	Berth 27	5	40%	2	5714	286	13	10%	0.5	50%	2.5
i.	Berth 28	5	40%	2	5714	286	13	10%	0.5	50%	2.5
	Total	**45.00**		**18**	**51426**	**2574**	**117**		**4.5**		**22.5**

[4] *1 TEU = 14 MTPA*

S. No	Description	Capacity of Berths in MTPA	Road Share (%)	Road Share	MT or TEU[4] / Day	Trucks / Day	Trucks / Hr	Rail Share (%)	Rail Share (MTPA)	Pipeline Share (%)	Pipeline Share (MTPA)
6	**Trans loading**	3									
Total		**3**									
7	**Barge Handling**	12									
	Total	**12.00**									
Total Capacity of Port		**319.08**		**135.4**	**237233**	**14675**	**667**		**128.13**		**40.5**

The existing CTVC survey at various locations captures the HGV traffic due to current port activities. Hence, only the increase in truck traffic from existing port activities to future port capacity is used for assigning the future traffic transportation software VISUM.

Traffic Scenario:

The following scenarios are considered based on the phase wise development of Kattupalli port and development of surrounding roads. The different scenarios are as follows:

1. Scenario 1: Existing Network with Existing Traffic Demand
2. Scenario 2: Future Network with Future Traffic Demand of Year 2030
    a. Kattupalli 50% of proposed future capacity
    b. Ennore Port growth @5% traffic compounded annually
3. Scenario 3: Future Network with Future Traffic Demand of Year 2040
    a. Kattupalli 100% of proposed future capacity
    b. Ennore Port growth @5% traffic compounded annually

The capacities of road for different level of services based on IRC 64-1990, IRC SP 73-2018, IRC SP 84- 2019 are presented in **Table 7-56**.

Table 7-56: Capacities of Highway for different Level of Service

Lane Configuration	Capacity @ LOS B (PCU/day)	Capacity @ LOS C (PCU/day)
2 Lane Highway	10000	14000
4 Lane Divided Highway (2+2)	40000	60000
6 Lane Divided Highway (3+3)*	60000	90000
8 Lane Divided Highway (4+4)*	80000	120000
10 Lanes Divided Highway (5+5)*	100000	150000

*Assumed based on per lane capacity of 2+2 lane road i.e. 10000 PCU/lane/day for LOS B & 15000 PCU/lane/day for LOS C.

Based on the arrived growth rate and estimated generated traffic from the development of Kattupalli port and development of surrounding roads, traffic forecast for the three scenarios has been carried out for the external roads and the same is presented in **Table 7-57**.

Note: In scenario 2, the existing traffic is projected by applying mode wise (except heavy goods vehicles) growth rate every year till 2030. The heavy goods vehicle numbers as worked out due to 50% expansion of port after Year FY 2019-20 is assigned directly.

In scenario 3, the existing traffic is projected by applying the growth rate every year till 2040 for each mode (except Heavy Goods vehicles)[5] and the Heavy goods vehicles generated from the expansion is assigned in the modelling.

[5] *Source: Traffic Impact assessment report of Kattupalli port prepared by FP Project Management-June 2020*

Table 7-57: Traffic forecast on external roads and Lane Requirement for Different Scenarios

Location No.	Road Name	Existing Lane Configuration	Scenario 1 (Existing)		Scenario 2 (2030)		Scenario 3 (2040)	
			Volume (PCU/ Day)	Lane Required	Volume (PCU/ Day)	Lane Required	Volume (PCU/Day)	Lane Required
1.	CTVC-1: Port Access Road (Between KPL Main Gate and KPL Gate No.2)	2	18057	2+2	8821	2+2	16201	2+2
2.	CTVC-2: CICT Road (Near Chettinad International Coal Terminal Ltd)	2	5725	2	3985	2	7506	2
3.	CTVC-3: Near Vinay Nagar Temple on SH-56	2+2	38992	2+2	38273	2+2	54864	3+3
4.	CTVC-4: Near Thiruvellavoyal SH- 107	2	3773	2	7233	2	12633	2+2
5.	CTVC-5: Near Pulicat Check Post on SH-104	2	2514	2	4101	2	6687	2
6.	Proposed Peripheral Ring Road	-	-	-	48439	3+3	95171	5+5
7.	Athipattu Main Road	3	17264	2+2	9166	3	15997	2+2

*Lane configuration at Level of Service B for External Roads

Observations:

Scenario 1: It can be observed from the above table that Port Access Road (Location 1), SH-56 as well as Athipattu Main Road are already saturated and require immediate capacity augmentation. Other locations have a better LOS.

Scenario 2: As compared to Scenario 1, the level of service at Locations 3 and 6 are likely to remain fully occupied despite additional access through the peripheral ring road. Hence it is recommended to review the situation at an appropriate time for further capacity augmentation of the main access road/ alternate alignments, for example to the north of Kattupalli port. The other locations have a reasonable LOS at this stage.

Scenario 3: As compared to the Scenario 2, as expected, the volume/capacity ratio has increased i.e. the residual capacity has reduced. However, all the roads (except Location 3, Location 6 and Location 7) are within LOS C. The roads at Location 3 and Location 6 will require capacity augmentation before 2040. Alternately other routes may be developed in order to ease out the same.

The Traffic flow on the surrounding network Scenario-3 at the end of the Year 2040 is presented in **Figure 7-57**.

Figure 7-57: Traffic Flow on the Surrounding Network Scenario 3-Year 2040

7.6.6 Proposed Internal Roads

Based on the arrived growth rate and estimated generated traffic from the development of Kattupalli port, Internal roads have been assessed for lane requirements and the main internal roads of the future year masterplan has been highlighted in **Figure 7-58**.

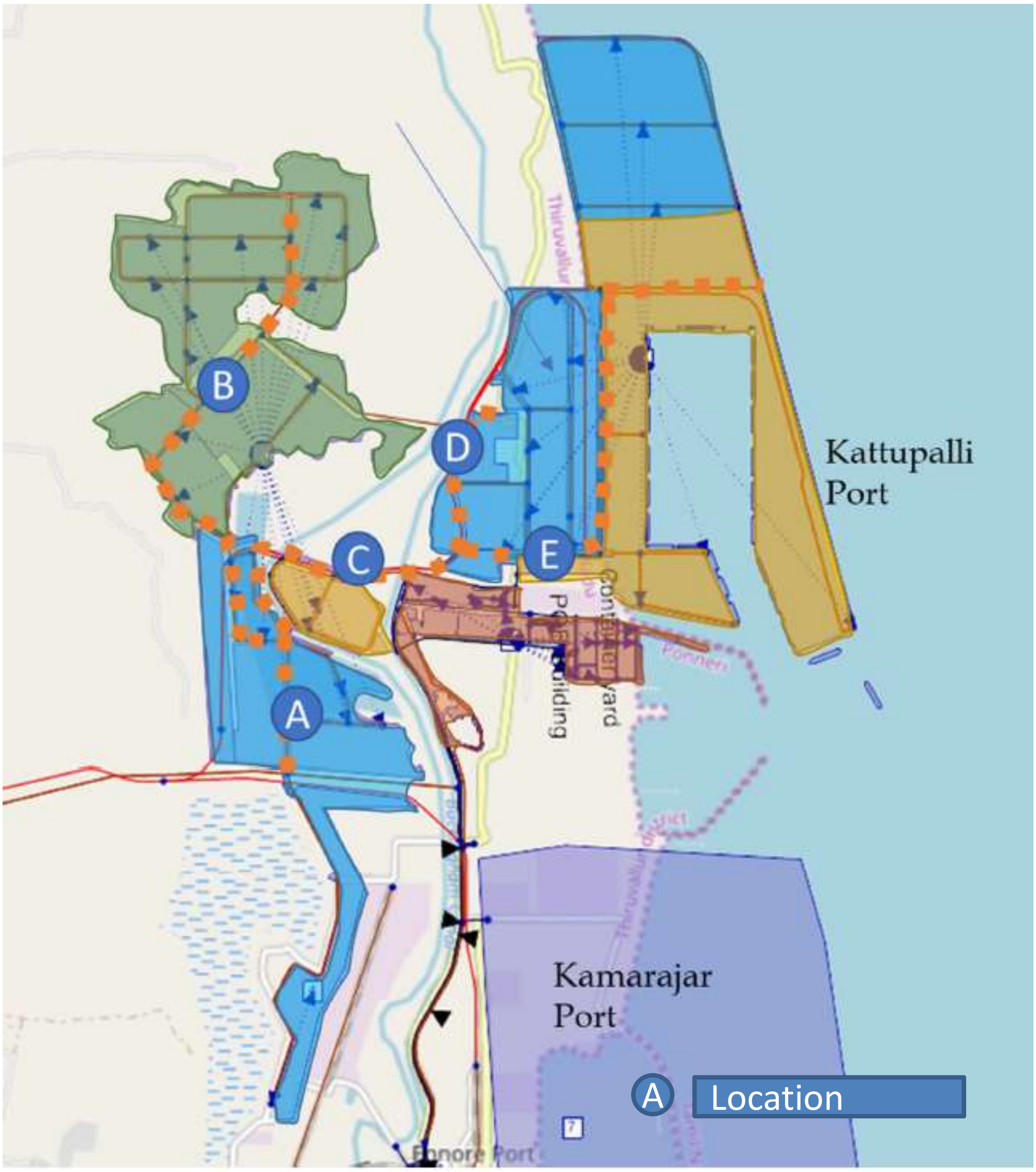


Figure 7-58: Proposed Main internal Roads for Future Year

The Internal Lane requirement for different scenarios has been presented in **Table 7-58**.

Table 7-58: Internal Lane Requirement for Different Scenarios

Location No.	Location Name	Scenario 2 (2030)		Scenario 3 (2040)	
		Volume (PCU/Day)	Lane Required	Volume (PCU/Day)	Lane Required
1.	Location A	41,256	2+2	82,512	3+3
2.	Location B	18,000	2+2	36,000	2+2
3.	Location C	14,472	2+2	28,941	2+2
4.	Location D	3,000	2	5,997	2
5.	Location E	11.16	2+2	22,320	2+2

*Lane configuration for internal roads at Level of Service C (LOS C)

7.6.7 Traffic Management Plan

In future, roads and junctions will require capacity augmentation due to increase in traffic. However, this effect/impact can be mitigated with the development of additional links, capacity augmentation (widening) in the close vicinity of the port. An integrated approach may help develop an efficient transportation network for port access and overcome the problems that currently exist/anticipated in future years.

Traffic Management Measures have been devised in order to improve port access, traffic routing and management through capacity augmentation measures for efficient movement of cargo/goods and passenger/employees. The Traffic Management Plan has been devised with the following principles in mind:

1. Capacity augmentation and Traffic management for the entire area.
2. Implementability

Capacity augmentation and Traffic management for the entire area:

The existing roads may not be able to cater to the additional traffic in the future years due to increased traffic. In such a scenario, it is imperative to enhance the capacity of the overall network. The phase wise lane requirement of the roads surrounding the Kattupalli port is presented in **Table 7-57**.

Figure 7-59: Proposal for Future Roads widening and New Links in Future Years

7.6.8 Proposal of Parking

A provision of 6-8 Trucks per MTPA is a sufficient provision. The area requirements have been calculated based on an average area of 200sq.m per parking lot. Thus, the phase wise recommendations for provision of Parking for Kattupalli Port are given in **Table 7-59**.

Table 7-59: Phase wise Parking Requirement for Kattupalli Port

Scenario	Capacity	Parking Requirement (Numbers)	Area Requirement (ha)
1	24.75 MTPA	174	2.61
2	160 MTPA	1120	16.8
3	320 MTPA	2240	33.6

7.7 Social Impact Assessment

7.7.1 Social Impacts during Construction Phase

7.7.1.1 Land Acquisition

The proposed Plan of Port Expansion and Revised Master Plan Development of Kattupalli Port will be carried out in total area of **2472.85 hectares** which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 hectares including basin all developable area.

The proposed development will consist of material handling area, cargo storage/backup area, operational and utility area, internal connectivity, drainage, greenbelt and buildings etc. The village wise land bifurcation of Kattupalli port master plan land is given **Table 7-60** and **Table 7-61**.

Table 7-60: Required of Land for Port Development

Sl. No	Name of the Village	Private Land (in Ha)	Government Land (in Ha)	Total (in Ha)
1	Ebrahamapuram	33.09	0.44	33.52
2	Kattur	70.11	182.69	252.79
3	Voyalur	90.55	566.20	656.75
4	Puzhdivakkam	-	121.46	121.46
5	Kallanji	210.42	796.15	1,006.57
6	Kattupalli	209.15	192.62	401.77
	Total	**613.31**	**1,859.54**	**2,472.85**

Table 7-61: Village-Wise Land Details

Sl. No.	Name of the Village	Private Land (in Ha)	Government Land (in Ha)	Total (in Ha)
1	Ebrahamapuram	33.09	0.44	33.52
2	Kattur	70.11	182.69	252.79
3	Voyalur	90.55	528.12	618.67
4	Puzhdivakkam	-	121.46	121.46
5	Kallanji	158.74	-	158.74
6	Kattupalli	153.32	33.52	186.84
7	Voyalur & Kattupalli	-	38.08	38.08
9	Kallanji	51.69	-	51.69
10	Kattupalli	55.84	-	55.84
11	Kattupalli (existing Port area)	-	130.27	130.27
12	Kattupalli (coastal land by TNMB)	-	6.08	6.08
13	Kattupalli	-	22.73	22.73
14	Kattupalli	-	0.03	0.03
15	Kallanji & Kattupalli (Sea Reclamation area from TNMB)	-	796.15	796.15
	Total	**613.31**	**1,859.54**	**2,472.85**

Source: Land Acquisition Officer, MIDPL

7.7.1.2 Land Acquisition Status

As per revised Master Plan Development of Kattupalli Port will be carried out in total area of **2472.85 ha** out of which 53.34 ha of government land and 107.52 private land is in possession and 136.28 ha of land is existing port area and 1669.92 ha of government land (which includes reclamation area of 796.15 ha) and 505.79 ha private land to be handed over on payment of compensation. The land acquisition status is given in **Table 7-62**.

Table 7-62: Land Acquisition Status

Particulars	Land possession with MIDPL	Possession to be handed over on Payment of Ex-gratia / Compensation	Total
Govt. Land	189.618	1,669.925	1,859.543
Patta Land	107.520	505.790	613.310
Total	**297.138**	**2175.715**	**2,472.853**

7.7.1.3 Impact on Families

There are no settlements in the project site and project doesn't attract resettlement and rehabilitation (R&R).

7.7.1.4 Loss of Livelihood

Development of Kattupalli Port may affect the bio-diversity of Pulicat Lake and the canal, which in turn will impact the livelihood of the fishing community.

7.7.1.5 Impact Due to Change in Land Use

Due to proposed development and change in land use to constructional development, people in the region will be beneficial in terms of creation of employment, increase in infrastructure facilities and improved socio-economic conditions for far extent.

7.7.1.6 Construction Workers Camp

Construction phase requires a good workforce. To ensure that there is no strain on the existing infrastructure; worker camps will be self-sufficient and would not rely on a local resource of surrounding existing villages and hamlets. This would also ensure that there will be no conflict with the local population. Further, the worker camp will be located well within the project boundary. The basic infrastructure facilities like water supply, sanitation, power supply etc., will be provided in the workers camp.

7.7.1.7 Impact on Nearby Settlements

During construction and expansion of Port work, the anticipated impact on nearby settlements during the construction phase will be due to air pollution and the noise-generating activities. The dust suppression measures and enclosures around the high noise generating areas will be provided.

The noise generating equipment will be provided with enclosures such that cumulative noise will be within permissible limits.

However, the activities are limited to the construction/expansion phase and will cease upon completion of the construction. Hence, this impact is insignificant.

Dust suppression measures and enclosures around the high noise generating areas within the construction area will be provided. And a time to time monitoring has to be done with coordination of TNPCB.

Ambient noise levels will be monitored at regular intervals. Noise generating equipment will be provided with suitable enclosures such that cumulative noise will be within permissible limits. Operation of vehicles shall be carried out only during non-peak hours and Speed limits shall be restricted and will be within limits. Noise and pollution generated from construction activities will be predominantly confined within the project site. Impacts due to these activities would be short-term in nature and localised.

7.7.1.8 Fishing Activity

As per studies, it was observed (**Section 3.14.6**) that there are 7 notified fishing villages and 12 notified landing centres are falling in the studies area. The certain activities will be disturbed during construction and expansion of port work. No R&R is envisaged for the expansion of Kattupalli port. Development of Revised Master Plan will neither affect the fishing activities nor restrict the movement of local fishermen and boats.

- To avoid any disturbance to the fishermen movement, signboards will be placed at the construction activities to make fishermen aware of the ongoing activities.
- For declaring the channel area, necessary marker buoys shall be installed. Interactions shall be continued with the fishing community about the marker buoys indicating the areas of operation so that they may avoid those areas during the construction period. Hence, no hindrance of fishing activity is anticipated during the construction phase of the Kattupalli port expansion.
- Proper Planning execution of offshore construction activities to ensure completion of the construction as per schedule
- Slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste during construction Phase
- All the discharges and Air Emissions will be maintained within the stipulated standards by adopting appropriate methods as committed.
- All the motorised crafts using the fishing harbour go deeper into the sea, however, port operational activities are restricted to maximum depth.
- No fishing grounds are reported in the proposed areas for revised master Plan development.
- Changes in the sedimentation processes were localized due to proposed developments and no impact on the other than development area.
- Minimal Erosion and accretion on the study area are reported and which can be taken care of by implementing proper mitigation measures (**Section 4.2.3.5 & 4.2.3.6**).
- The simulation of the dispersion pattern of the return cold water discharges from LNG/LPG Plant indicates that no significant change in the ambient qualities of the surrounding waters was predicted beyond a maximum distance from the point of disposal.

Positive Impacts

As a part of Corporate Social Responsibility (CSR), MIDPL has taken several activities to achieve its objectives of growth with goodness in the areas of Education, Community Health, Sustainable Livelihood Development and Community Development. The same is discussed in the CSR activities being carried out and planned by MIDPL, elaborated in detail as part of **Section 8.4**.

7.7.1.9 Employment Potential

During the construction phase, approximately 500 -1000 workers will be employed respectively.

The project when fully operational also brings direct employment potential of about 1500 nos. and indirect employment about 4500 people.

7.7.1.10 Fishing Activity

In addition to the discussion of section **7.7.1.8** above, safe navigation routes shall be earmarked for movement of fishing vessels. However, the port activities involved in the operation phase will be confined to the project area All Appropriate measures will be taken to minimize the hindrance to fishing activity during construction & operation phase. The port management will conduct regular consultation with fishermen associations reading safe navigation. Conflicts, if any, with fishing community will be amicably resolved in all cases.

Employment Potential

There will be a huge demand for skilled, semi-skilled and unskilled workforce during the operation phase of the Port and most local people must be employed based on their skills and educational qualification.

Proposed development of **2,472.85 ha** is likely to generate direct and indirect employment in and around the project villages. The project when fully operational also brings direct employment potential of about 1500 nos. hereby opening up employment opportunities for the youth in the catchment region. Additionally, the induced development due to the Port Expansion can bring indirect employment about 4500 people.

7.7.1.11 Public Health and Safety

The industries proposed to be developed in the Industrial Park area to be upcoming which are to be suitable and non-polluting i.e. automobiles and its ancillary etc. Suitable safety/mitigation measures and procedures will be followed during the operation of these industries.

Industrial wastewater shall be treated within industry premise and treated wastewater will be reused within the industry. Air pollution generating industries shall be using the air pollution control equipment and the pollution level shall be monitored by TNPCB or appropriate authority or government-appointed authorised agencies. Compliance report shall be sent to TNPCB/Government regularly to check and may suggest suitable measures. The solid waste generated from the proposed project will be segregated as Municipal waste, Hazardous waste & E-Waste. Municipal waste generated will be disposed to local bins for further treatment and disposal. hazardous waste generated shall be sent through authorized waste handler for further treatment and disposal. E-Waste generated will be collected, stored and transported to authorised recyclers.

An effective Disaster Management Plan (DMP) which includes Onsite and Offsite emergency plan shall also be prepared and will be followed to minimize the probability of occurrence of emergencies and mitigate the impacts.

7.7.2 Stakeholder Consultation

In addition to Socio Economic Study conducted (based on Primary & Secondary data analysis), ongoing community interaction/consultations as part of MIDPL ongoing CSR activities; Need based Assessment has also been carried out through the Madras School of Social Work (**Chapter 8**) as per ToR requirement. As part of the study several community consultations/focussed group discussion were undertaken to understand the people’s perception related to the project as well as the impacts they perceived. This was also to understand and facilitate appropriate CSR intervention going forward. The study highlights the socio-economic status and future needs of the forty six areas located around Kattupalli Port, Thiruvallur District, Tamilnadu.

The brief details of stakeholder consultation carried out are given below.

Stakeholder Identified:

The stakeholders identified are as follows:

- Land Affected Persons
- Settlements within the project site
- Social & Economic Vulnerable affected such as women, children, handicapped, BPL etc.
- Local Governance, Hospitals, Schools and Panchayats
- Fishing Community

The Stakeholder consultation was done by the external agencies i.e. Madras School of Social Work, Chennai is provided below **Exhibit 7-7** to **Exhibit 7-12**. The detailed outcome of the need based assessment/stakeholder consultation/focussed group discussions are discussed in **Table 7-63**.

Exhibit 7-7: Stakeholder Consultation Government Hr. Sec. School, Pazhaverkadu

Exhibit 7-8: Public Consultation Thangalperungulam Hamlet

Exhibit 7-9: Irular colony at Nandhiyambakkam

Exhibit 7-10: Ornambedu

Exhibit 7-11: Women Consultation

Exhibit 7-12: Irular Colony in Nandiambakkam

Table 7-63: Outcome of Need-Based Assessment

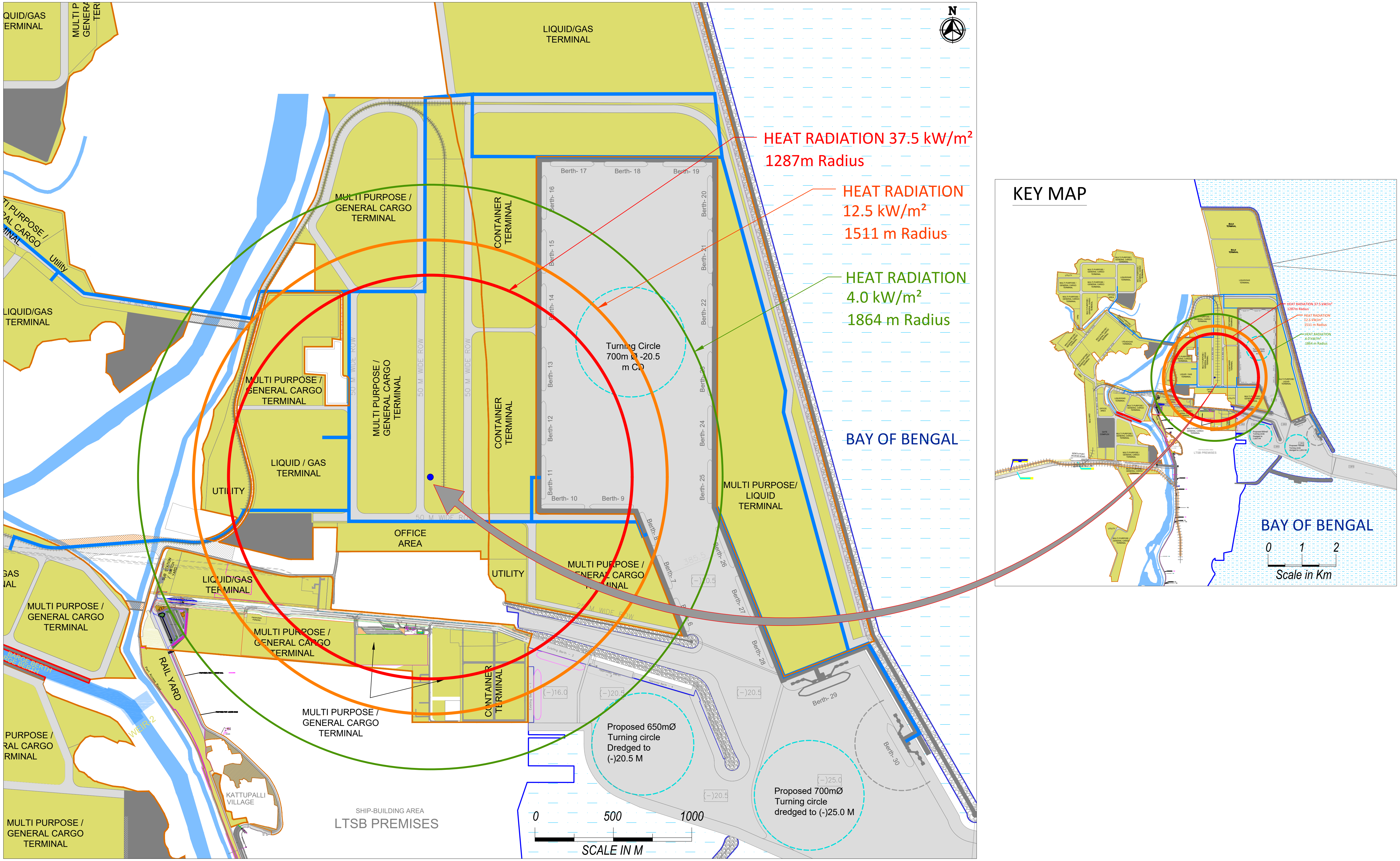
Sl No	Panchayat	Name of the Village	Request from Panchayath Samities and Community Leaders
1	Kattupalli	Kattupalli village (general) Kattupalli colony & Anna Nagar (SC&ST) Puzhudhivakkam (Cheppakkam) Kaalanji R&R Kuppam alias Kattupalli Kuppam	Individual & Community toilets School toilets, furniture and fixtures, Kitchen with meals serving facility. High Mast Lights in 5 villages Skill Training on Sewing & Sewing centres Fitness centre and equipment's Hand Water Pumps at major locations Sports kits to clubs RO plant in villages and PHC Two Library buildings Proper Drainage Facilities Tree Plantation Campaigns Bus bays and Shelter facilities Road & Transportation facilities
2	Kattur	Kattur village Kattur colony Abiramapuram (SC) Lakshmi Amman Nagar (ST)	Infra support to Kattur PHC along with solar water heater, solar power generator for upgrading to Mini hospital. Desiltation of farm pond – 6 nos High Mast light – 3 nos Bus shelter – two numbers Concretised/Bitumen Road in all hamlets Individual and community toilet facilities Ground-level & Over Head Water tanks in all villages Skill Development & Livelihood development centres Livelihood enhancement including Prawn/fish development in natural ponds. School Building infra support and toilet facilities Individual/Community toilets in all villages
3	Voyalur	Voyalur Village Voyalur Kuppam Senghazhanirmedu Senghazhanirmedu Colony Ornambedu Ornambedu colony Kokkumedu Ramanathapuram Rajan Thoppu	Smart school facilities (Computer, TV and RO in school) School -toilet facilities Health camps High mast light - 9nos School building infra support Agri & horticulture support - Vet. Camp, Watermelon cultivation Community Hall Education Quality Enhancement. Pathways in the interior villages Drinking-Water Facilities (presently from 20km away) Village sanitation facilities

Sl No	Panchayat	Name of the Village	Request from Panchayath Samities and Community Leaders
4	Neidhavayal	Neidhavayal village Neidhavayal colony Saanar Kuppam KR Palayam Mouthambedu	Smart classroom facilities needed Building for Ration Shop (PDS) Individual & Community toilet Soak pit Playground Livelihood & skill development
5	Thiruvella Voyal	Thiruvellavoyal Thiruvellavoyal colony Madha Koil village	Skill development & Livelihood development Centres Fitness centre and equipment 50 Individual Household Toilet & one community toilet, Safe drinking water - RO plant High Mast light & Solar light, Infra Support to Community Hall Restoration of water bodies – 2 nos
6	Thangal Perungbulam	Thangal Perungbulam Korai Kuppam Karungkali Kadal Kanniyur Edayan Kulam Saathang Kuppam	Waste Management - Tractors Education Quality Improvement Programme Water tank Icebox 100lit for 163 families Cement road Community Hall at Korai Kuppam Fishing Net storage building, Public toilet & individual School Infra Support – new building 70 nos.–100ltr Insulated Iceboxes 30 feet height High Mast Light for safeguarding fishing net Restoration of Boat parking canal to avoid collision between boats, Community hall to avoid travelling to Ponneri
7	Velur	Velur Velur colony	RO Plant & Water tank, Community Hall Community toilet Agriculture and animal husbandry Smart school facilities
8	Nandhiyam Bakkam	Nandhiyambakkam Irula community	Education infra & quality enhancement Anganwadi infra support Livelihood support Drinking water facility Sanitation facilities Road connectivity
9	Kottai Kuppam	Kottai Kuppam Naduvur Madha Kuppam Andi Kuppam Ambetkar Nagar (SC) Senjiyamman Nagar (ST) MGR Nagar Dhoni rev Kiramam Jamila Bath	School support (Benches and Desks (20 Sets), Uniforms) Community Hall @ Dhonirev Kiramam village Concrete road Fish netting and repair centre SWM facility Sanitation & drainage facilities Livelihood support High mast light Skill Development Mangrove afforestation Desiltation in boat parking areas Protection of Biodiversity Restoration of water bodies
10	Light House Kuppam	Light House Kuppam Thirumalai nagar Sembasi kuppam Arangam kuppam Karimanal Vairavan Kuppam Gunan Kuppam	Bar mouth restoration-permanent solution School infra support Concrete road connectivity Sanitation & drainage facilities Livelihood & Skill Development Artificial reef

Sl No	Panchayat	Name of the Village	Request from Panchayath Samities and Community Leaders
11	Pulicat	Pulicat Pasiyavara kuppam Kulathumedu Periya street Bhoomi Kottai Bajanai kovil street/Palayakar street Karayan Kuppam Adhinarayana Kovil street Edamany colony/ Pachiyavar kuppam	RO water plant & Over Head Tank (60kL), High Mast Light Retiring room in Government Hospital, Pulicat Tractor for Garbage management Skill Development Education infra support Quality enhancement programme Individual and community toilets
12	Kalpakkam	Kalappakkam Siru pazhaverkadu Aandarmadam Kadapakkam mel colony Abiramapuram (ST)	Skill development & Livelihood Enhancement Livestock support
13	Kadapakkam	Kadapakkam Siru pazhaverkadu Aandarmadam Kadapakkammel colony Abiramapuram (ST)	Education infra support RO Plant Road and drainage, High mast light Agriculture and Animal husbandry Youth skilling Sanitation
14	Athipattu	16 Hamlets/Villages	High mast light Road connectivity Waste management Sanitation & drainage facilities Skilling youth Quality education enhancement

Source: Data provided by the Client and Studied by MSSW, Chennai appointed by MIDPL

Figures



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PROJECT:	CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS
TITLE:	HRDD FOR CATASTRPOHIC FAILURE OF EPICHLOROHYDRIN MARINE UNLOADING ARM
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.

PROJECT NO: C1201302
DATE: 07.12.2020
MADE: BNK
FIGURE NO: FD0701
REV: A

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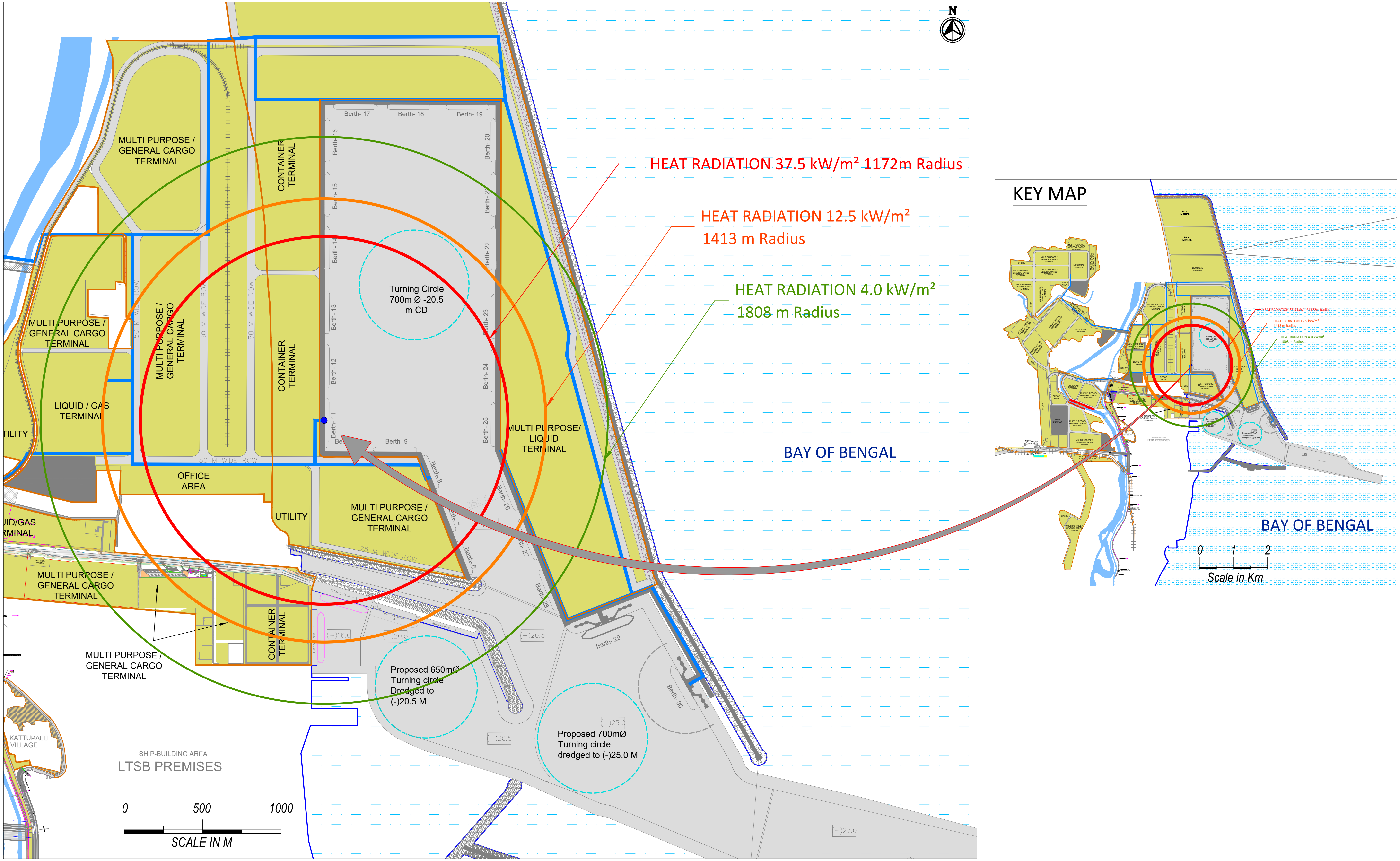

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PROJECT: CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS	PROJECT NO: C1201302
TITLE: HRDD FOR CATASTRPOHIC FAILURE OF LPG MARINE UNLOADING ARM	DATE: 07.12.2020
	MADE: BNK
L&T Infra Engineering — L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0702 · REV: A

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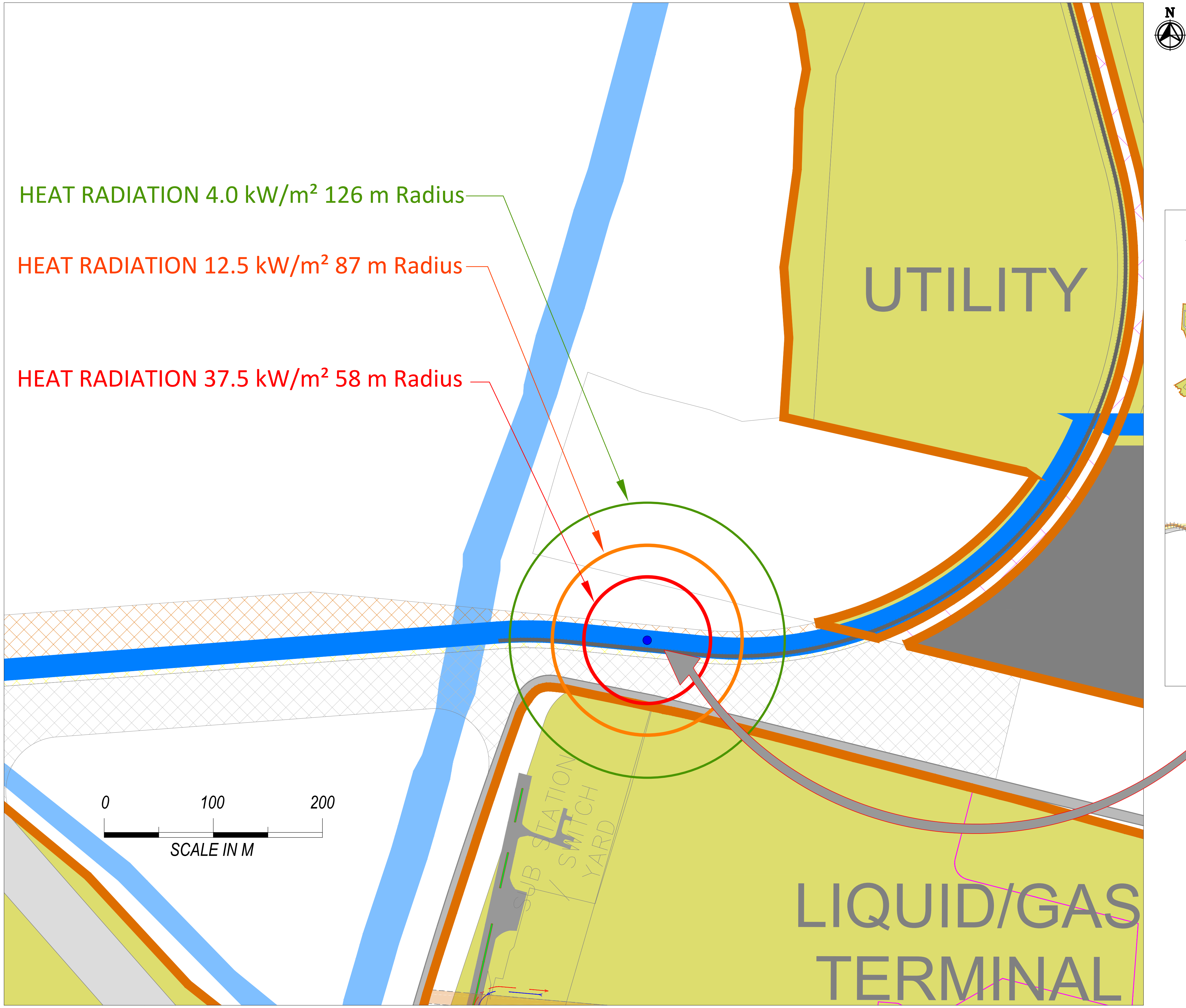

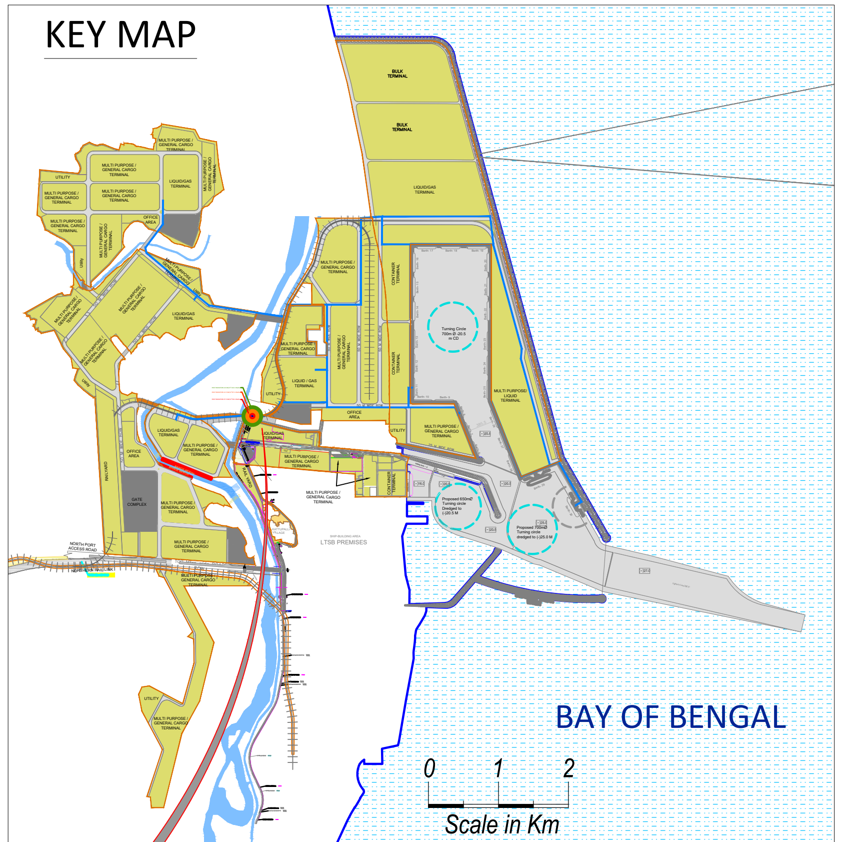

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PROJECT:	CEIA KATUPALLI PORT EXPANSION – RISK ASSESSMENT FOR REVISED CARGO PARAMETERS
TITLE:	HRDD FOR 25MM LEAK OF 18" ACRYLONITRILE PIPELINE FROM JETTY TO TFA
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.

PROJECT NO: C1201302

DATE: 07.12.2020

MADE: BNK

FIGURE NO: FD0703

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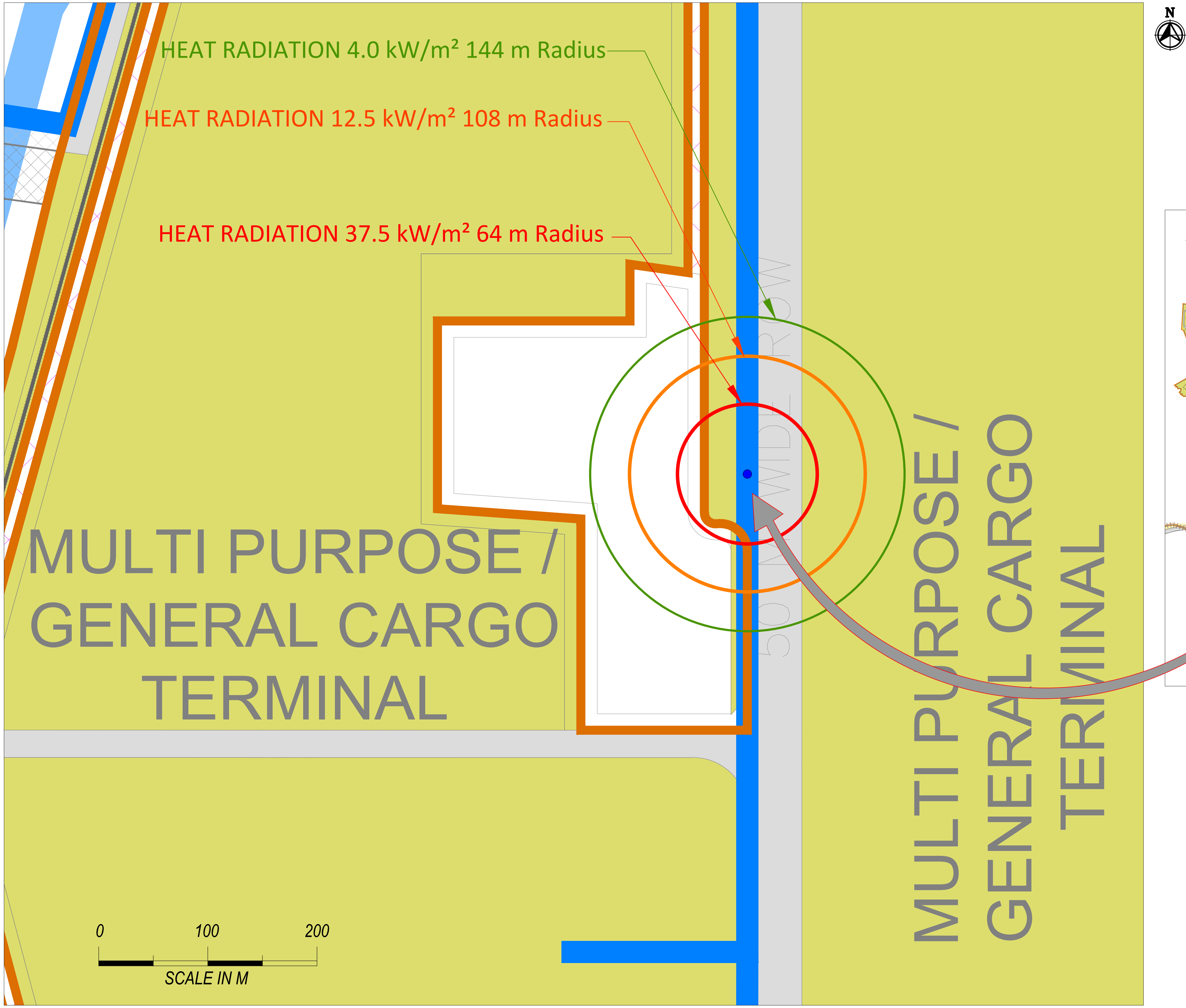

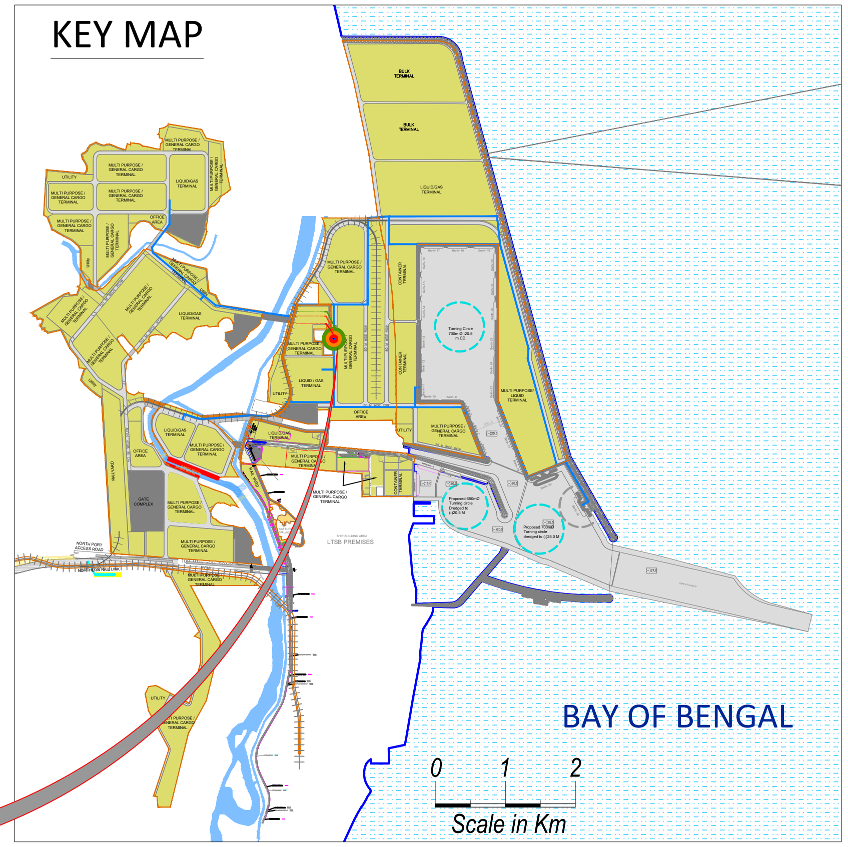

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PROJECT: CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS	PROJECT NO: C1201302
TITLE: HRDD FOR 25MM LEAK OF 18" EPICHLOROHYDRIN PIPELINE FROM JETTY TO TFA	DATE: 07.12.2020
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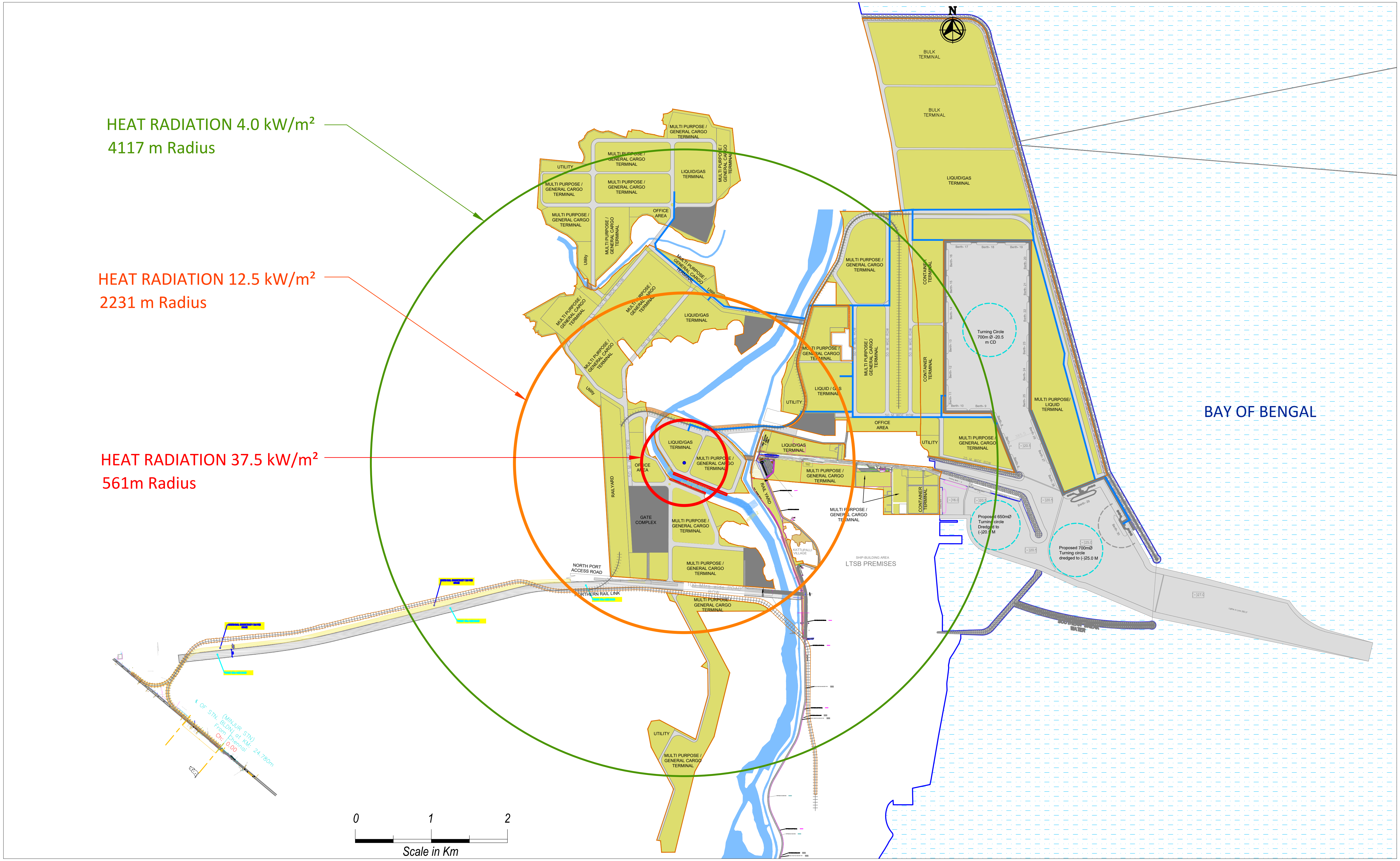
L&T Infra Engineering — **L&T Infrastructure Engineering Ltd.**	FIGURE NO: FD0704 — REV: A



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TITLE: HRDD FOR CATASTROPHIC FAILURE OF 180000M3 LNG STORAGE TANK AT TFA	DATE: 07.12.2020	
	MADE: BNK	
L&T Infra Engineering — L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0705	REV: A

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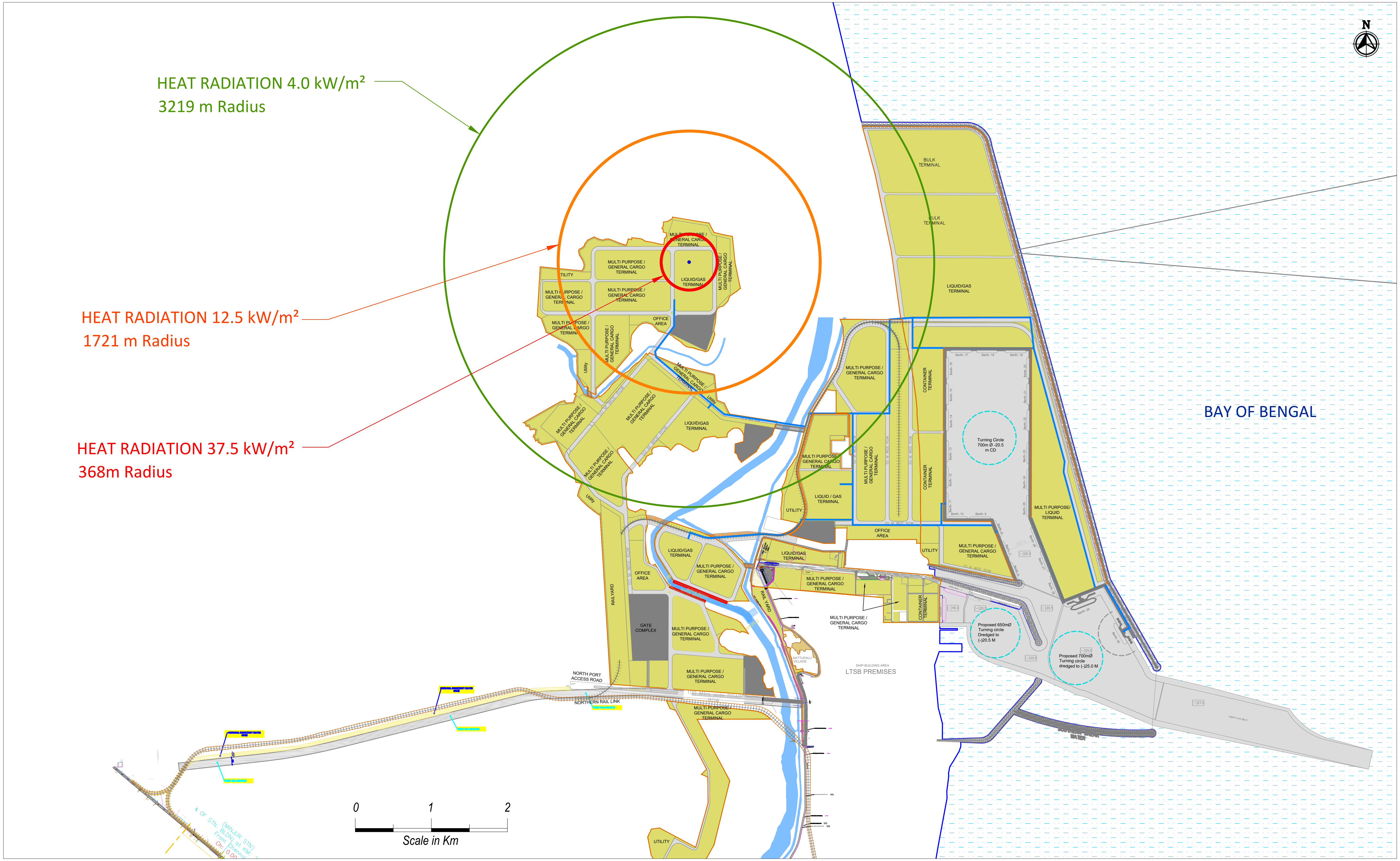

PROJECT: CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS

TITLE: HRDD FOR CATASTROPHIC FAILURE OF 25000MT PROPANE STORAGE TANK AT TFA

PROJECT NO: C1201302

DATE: 07.12.2020

MADE: BNK

FIGURE NO: FD0706

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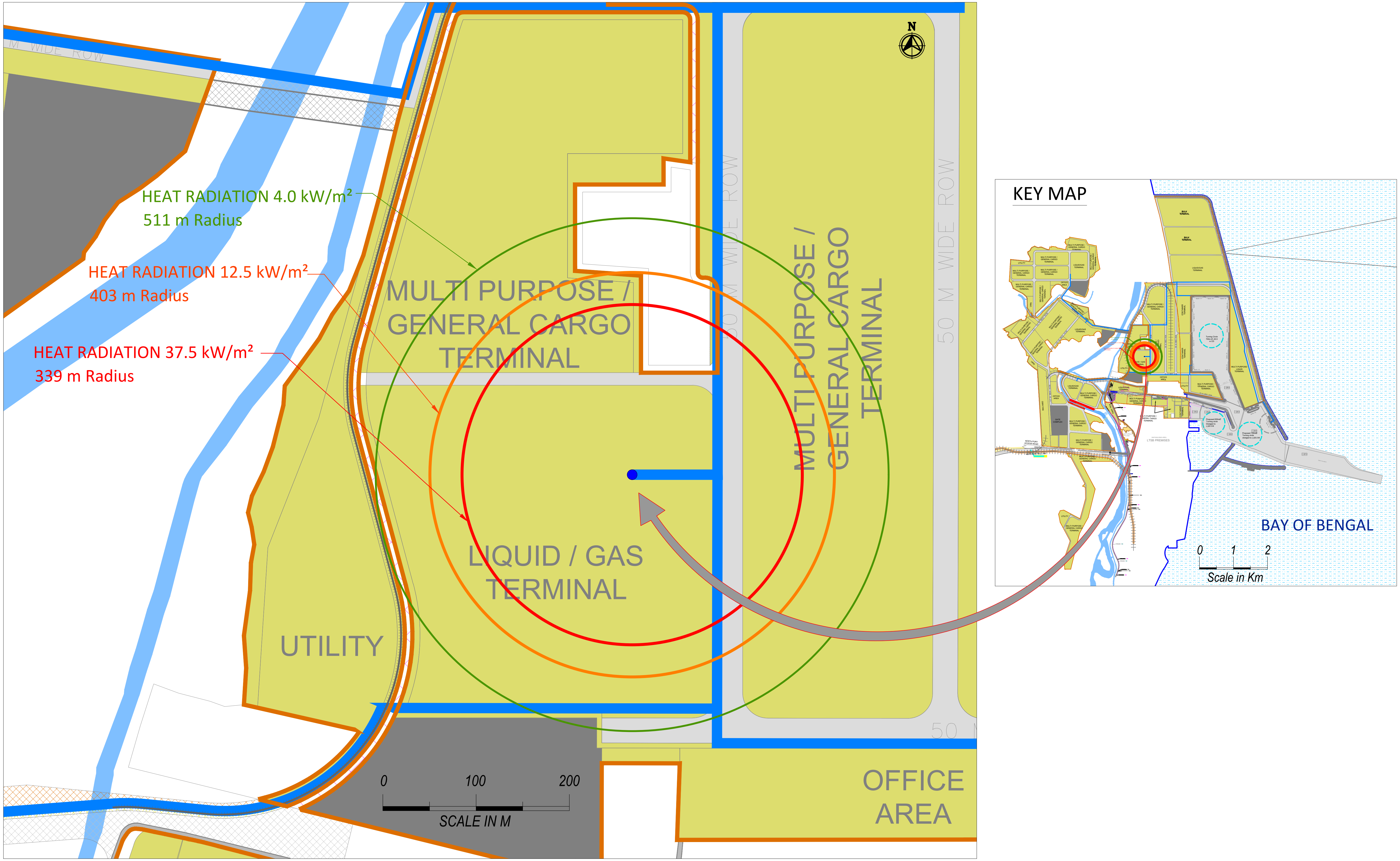

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PROJECT: CEIA KATUPALLI PORT EXPANSION – RISK ASSESSMENT FOR REVISED CARGO PARAMETERS	PROJECT NO: C1201302
TITLE: HRDD FOR CATASTROPHIC FAILURE OF 8" PIPELINE FROM BUTANE BULLET	DATE: 07.12.2020
	MADE: BNK
L&T Infra Engineering / **L&T Infrastructure Engineering Ltd.**	FIGURE NO: FD0707 / REV: A

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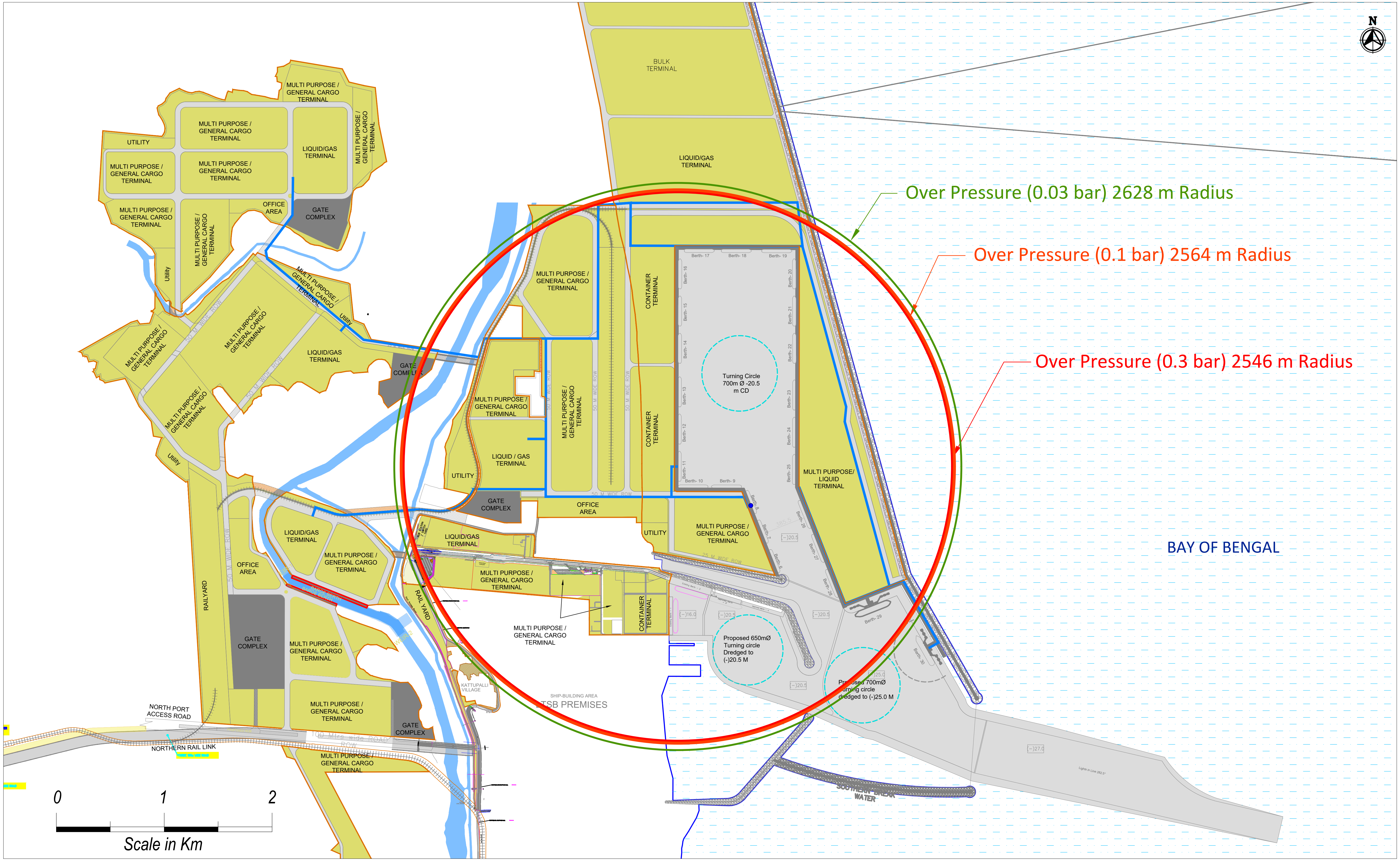

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TITLE:	OPDD FOR CATASTRPOHIC FAILURE OF BUTANE MARINE UNLOADING ARM
PROJECT NO:	C1201302
DATE:	07.12.2020
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FIGURE NO:	FD0708
REV:	A

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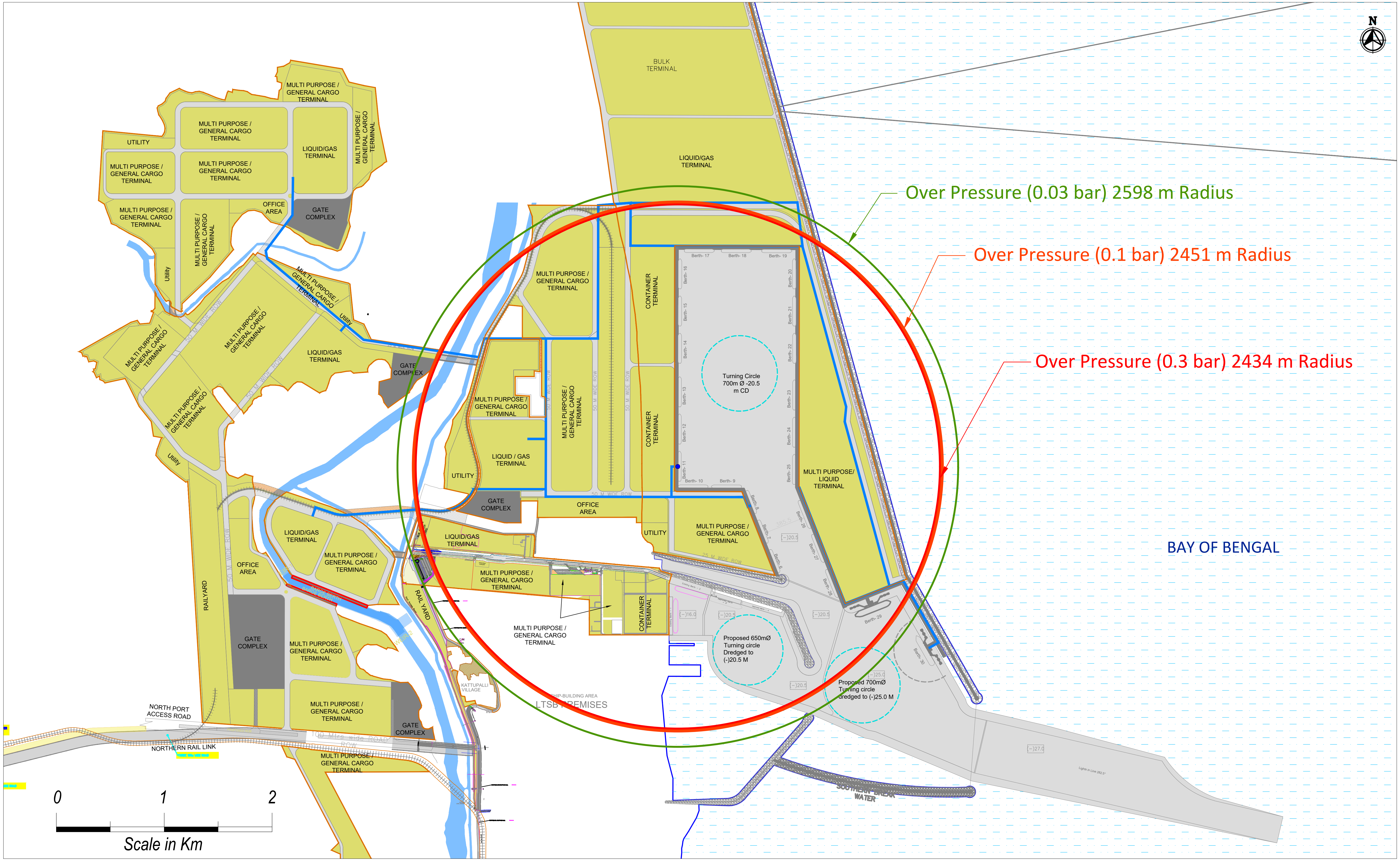

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PROJECT: CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS

TITLE: OPDD FOR CATASTRPOHIC FAILURE OF PROPANE MARINE UNLOADING ARM

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PROJECT NO: C1201302

DATE: 07.12.2020

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FIGURE NO: FD0709

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PROJECT: CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS		PROJECT NO: C1201302	
TITLE: OPDD FOR 25MM LEAK OF 18" ETHYLENE PIPELINE FROM JETTY TO TFA		DATE: 07.12.2020	
		MADE: BNK	
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0710	REV: A

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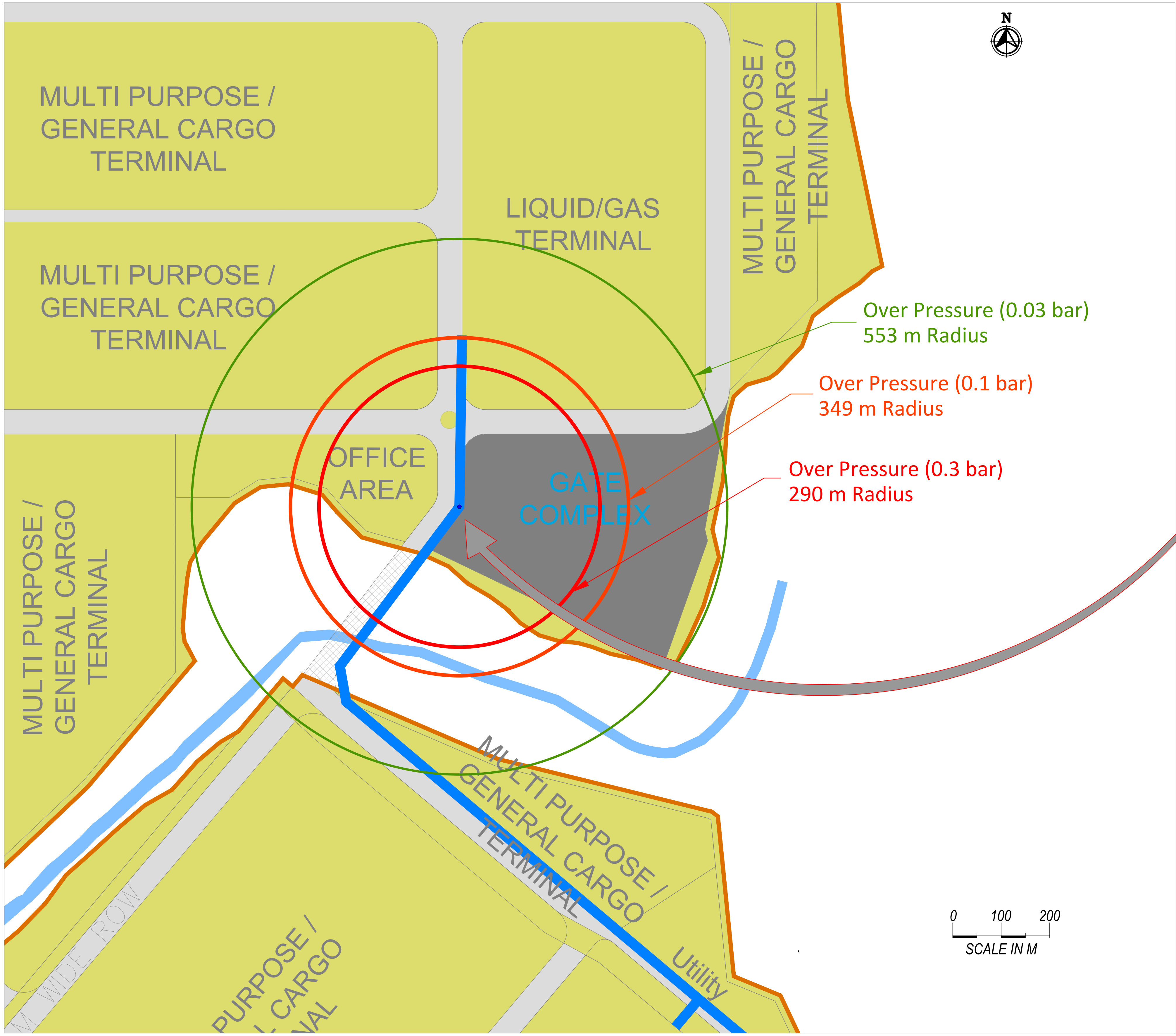

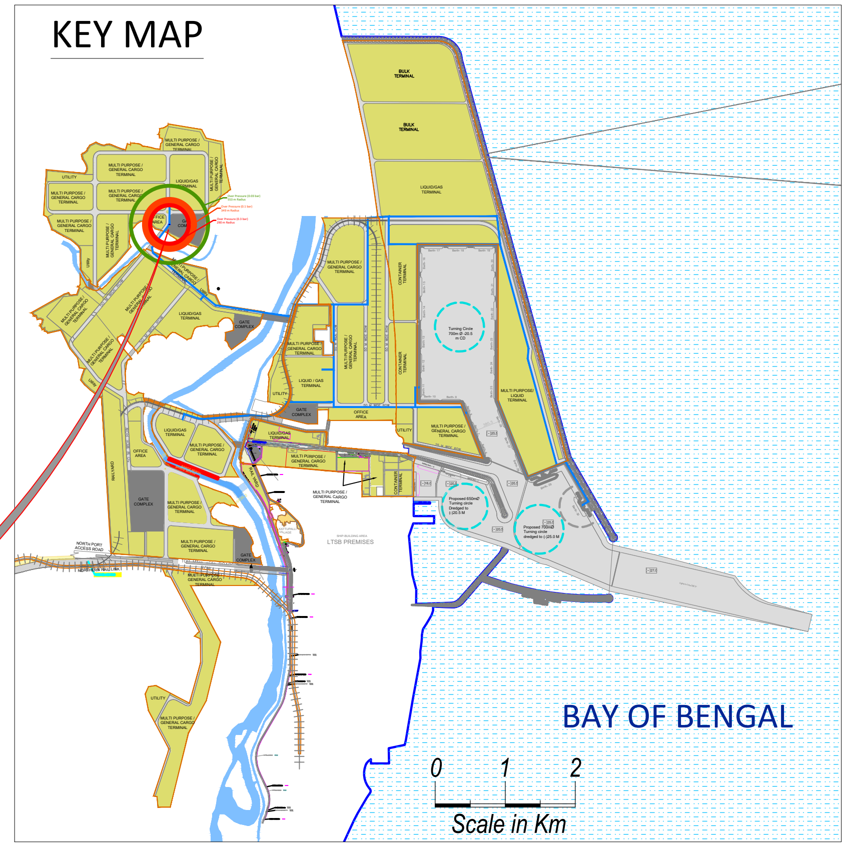

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PROJECT: CEIA KATUPALLI PORT EXPANSION – RISK ASSESSMENT FOR REVISED CARGO PARAMETERS

TITLE: OPDD FOR 25MM LEAK OF 24" LPG PIPELINE FROM JETTY TO TFA

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

PROJECT NO: C1201302

DATE: 07.12.2020

MADE: BNK

FIGURE NO: FD0711

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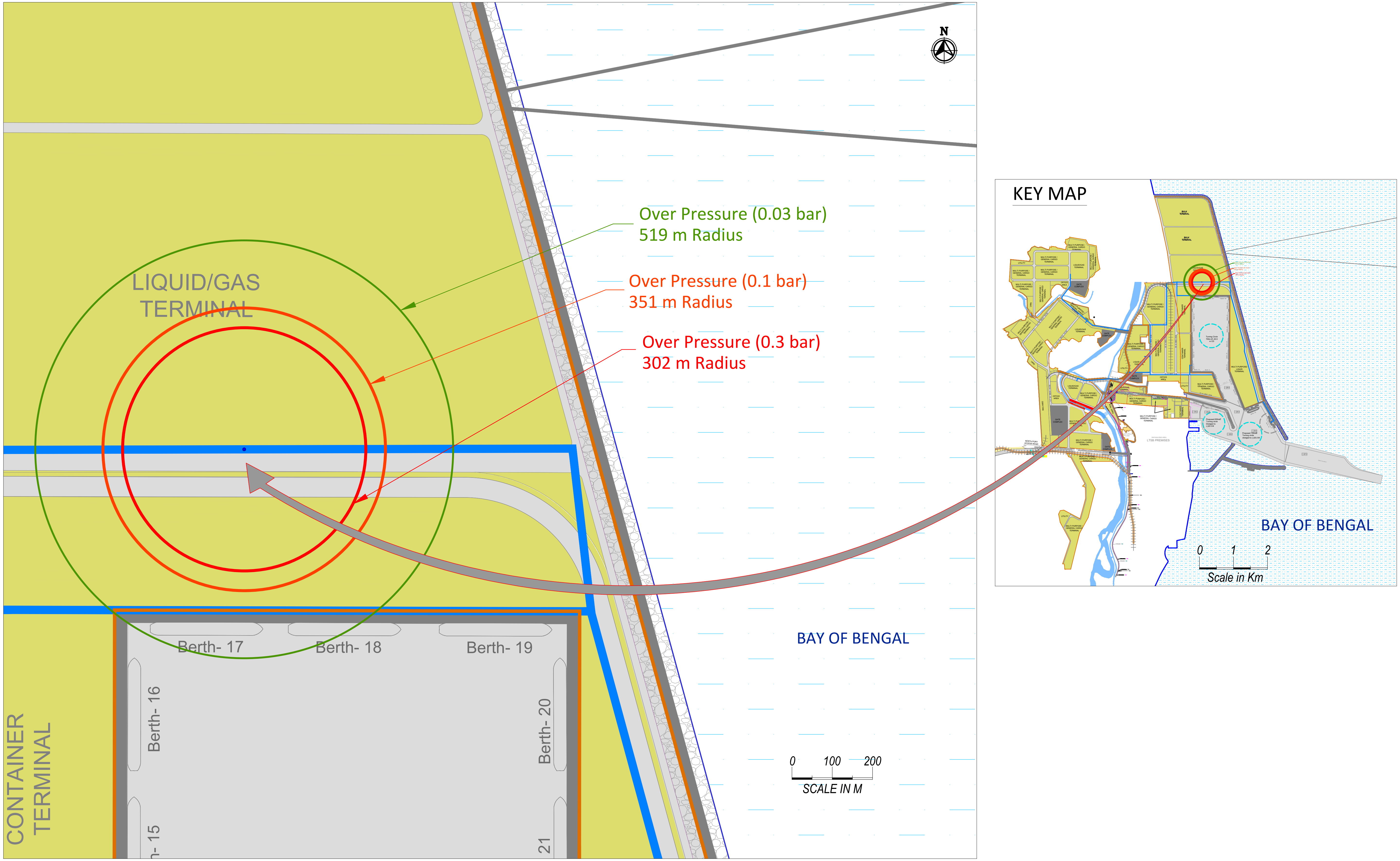

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PROJECT NO:	C1201302
TITLE:	OPDD FOR 25MM LEAK OF 18" NAPHTHA PIPELINE FROM JETTY TO TFA
DATE:	07.12.2020
MADE:	BNK
FIGURE NO:	FD0712
REV:	A

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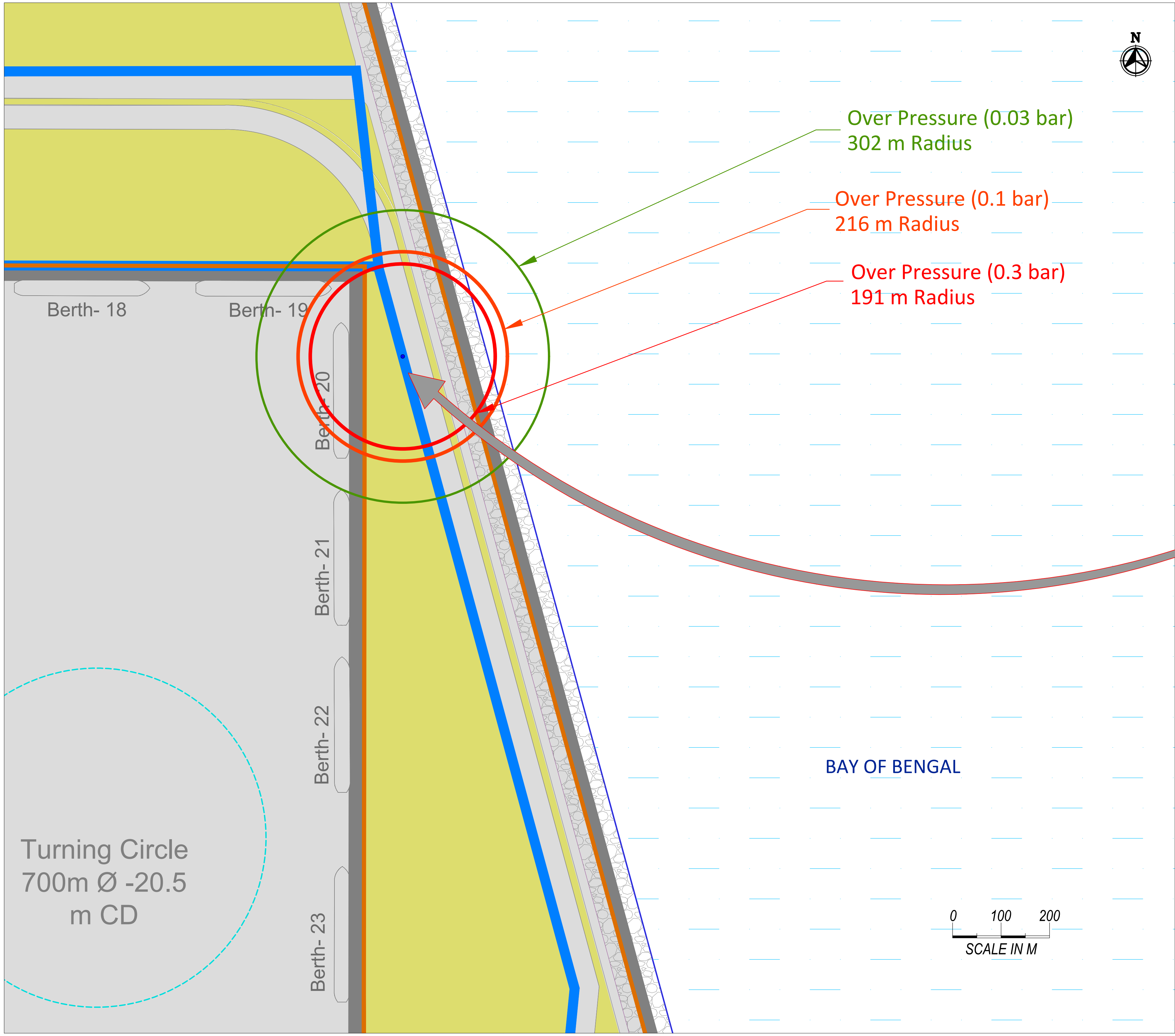

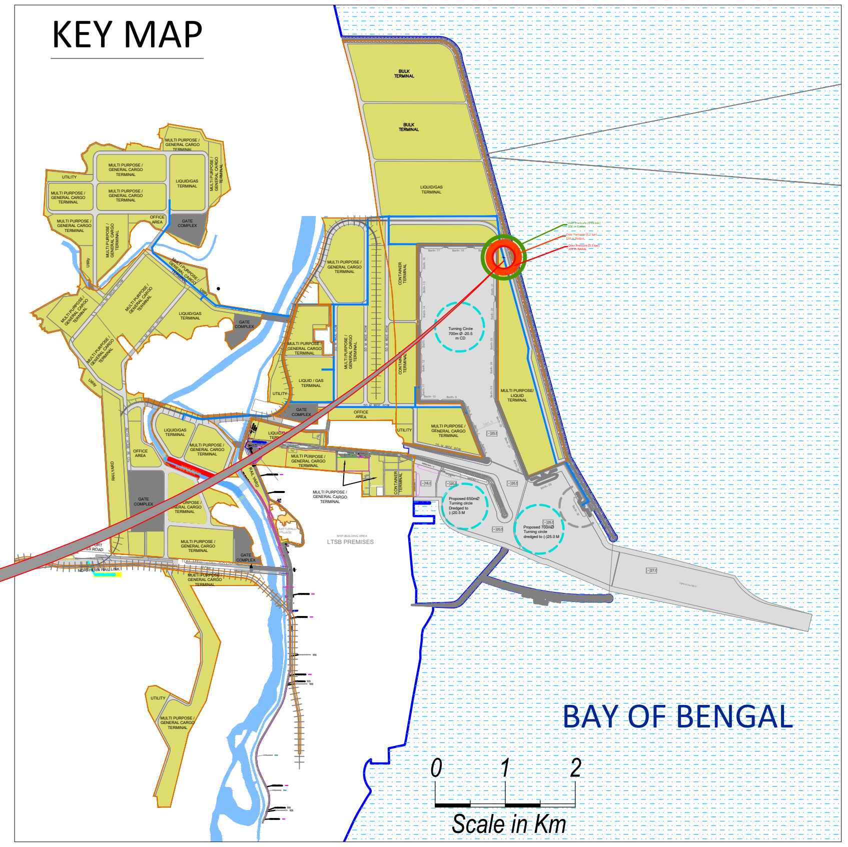

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PROJECT: CEIA KATUPALLI PORT EXPANSION – RISK ASSESSMENT FOR REVISED CARGO PARAMETERS		PROJECT NO: C1201302
TITLE: OPDD FOR 25MM LEAK OF 18" ACRYLONITRILE PIPELINE FROM JETTY TO TFA		DATE: 07.12.2020
		MADE: BNK
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0713 / REV: A

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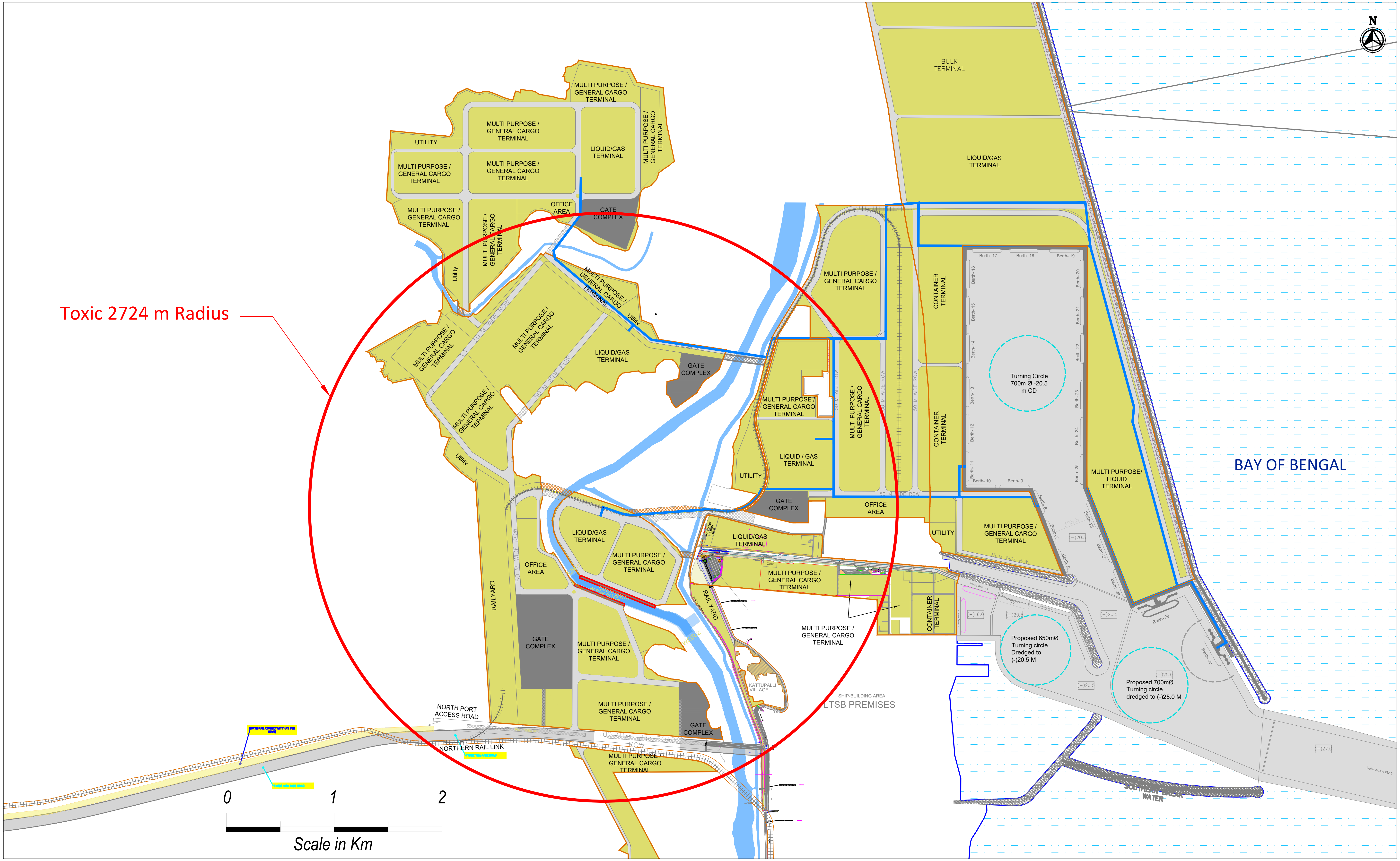

PROJECT:	CEIA KATUPALLI PORT EXPANSION - RISK ASSESSMENT FOR REVISED CARGO PARAMETERS	PROJECT NO: C1201302
TITLE:	TOXIC DAMAGE DIST. DUE TO 25MM LEAK OF 18" ACRYLONITRILE PIPELINE FROM JETTY TO TFA	DATE: 07.12.2020
		MADE: BNK
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0714 REV: A

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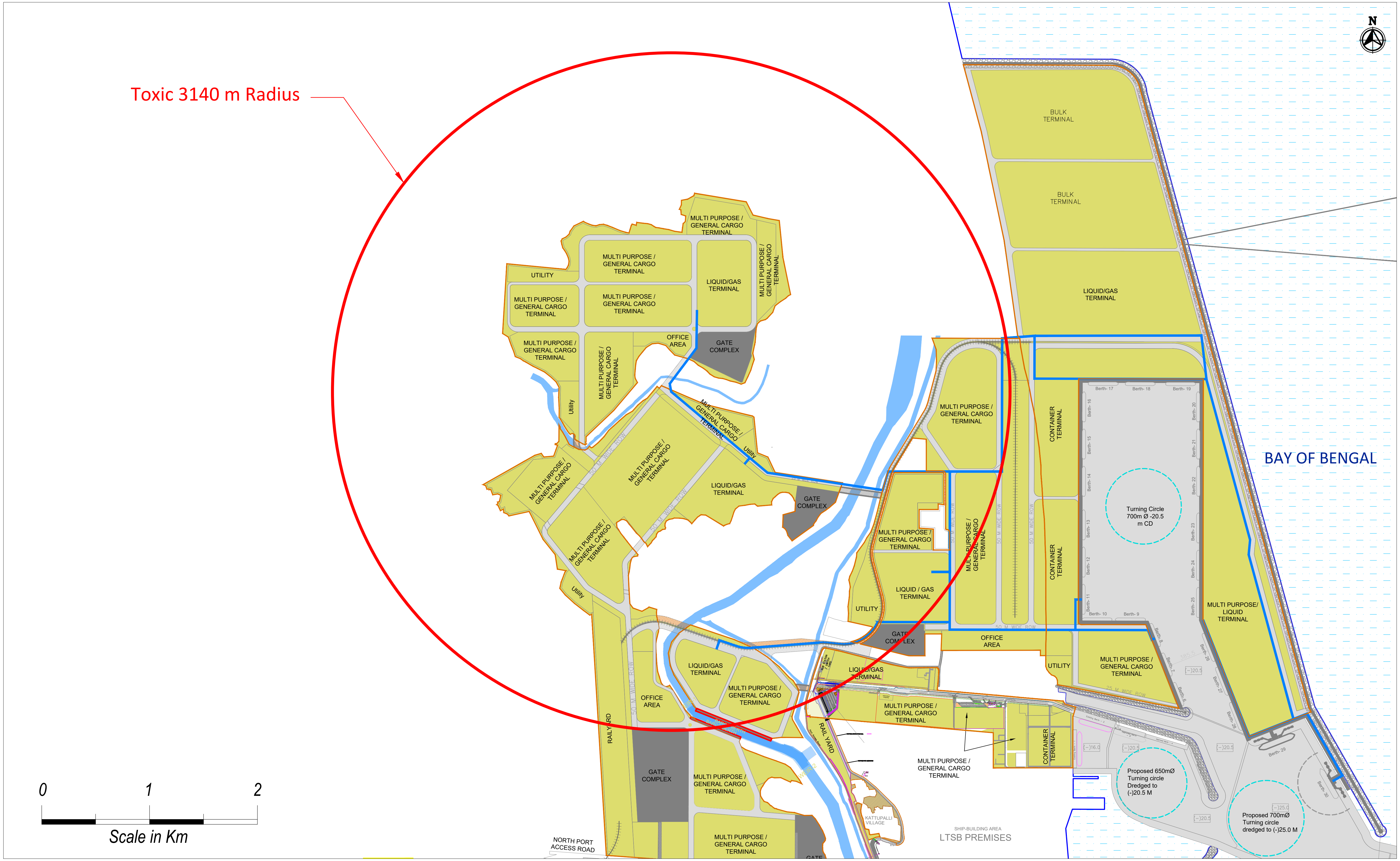

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PROJECT:	CEIA KATUPALLI PORT EXPANSION – RISK ASSESSMENT FOR REVISED CARGO PARAMETERS	PROJECT NO: C1201302
TITLE:	TOXIC DAMAGE DISTANCE DUE TO 25MM LEAK OF 18" AMMONIA PIPELINE FROM JETTY TO TFA	DATE: 07.12.2020
		MADE: BNK
L&T Infra Engineering	L&T Infrastructure Engineering Ltd.	FIGURE NO: FD0715 REV: A

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Chapter 8
Project Benefits

Chapter 8 Project Benefits

8.1 Overview Development-Ports in Tamil Nadu

The maritime State of Tamil Nadu has a glorious history dating back to some 6000 years. Today, the State of Tamil Nadu has emerged as the most industrialized State in India and the eastern gateway of India to the world[6].

The Government of Tamil Nadu have realised that in order to improve the Industrial and Socio-economic activity, it is essential to take measures to ease the heavy congestions in the Ports. The congestions in ports result in demurrages and huge loss in foreign exchange. Therefore, there is a need to expand and develop the existing minor ports and green field sites alongside technological upgradation in terms of cargo handling, container terminals, port layout and allied infrastructure.

With a length spanning 1,076 km, Tamil Nadu has the second-longest coastline among Indian states. The coastline is dotted with 3 Major Ports (at Chennai, Ennore and Tuticorin) and 23 Minor Ports. The Major ports have been developed under the Major Port Trust Act of 1963 and function under the control of Government of India while the Minor Ports are developed based on Indian Ports Act of 1908 by Government of Tamil Nadu.[7]

8.2 Institutional Structure

The major ports at Ennore, Chennai and Thoothukudi are under the administrative control of the Government of India, while the minor ports are under the control of Government of Tamil Nadu. In order to develop these minor ports, the Government of Tamil Nadu have established the Tamil Nadu Maritime Board (hereinafter referred to as “TNMB"), an autonomous body under the Tamil Nadu Maritime Board Act, 1995 (Tamil Nadu Act 4 of 1996). The TNMB’s main function is to co-ordinate the activities of these ports to optimise their efficiency and effectiveness, to reduce congestion and to ensure efficient material handling and provide an integrated solution to the problems of the ports operation and management. The Board is functioning under the Chairmanship of Hon’ble Minister for Highways and Ports, Government of Tamil Nadu.

8.2.1 Minor Ports in Tamil Nadu

8.2.1.1 Overview

There are 23 minor ports in the State of Tamil Nadu which are under the control of the state through Tamil Nadu Maritime Board. 7 of them are Government ports and the remaining 16 ports are captive, four ports, i.e. Ennore Minor Port (Tiruvallur), PY-03 Oil Field (Cuddalore), Thirukkadaiyur (Nagapattinam), Koodankulam (Tirunelveli), MIDPL Kattupalli port are presently operational. The remaining twelve captive ports are under various stages of development.

The minor ports facilitate the establishment of port-based industries such as Thermal Power Plants, Refineries, Fertilizer plants, etc., by providing exclusive port facilities. Given the rapid industrialization and economic development of the State, a port policy was formulated to

[6] http://www.tnmaritime.com/policy_files/6-Port%20Policy.pdf%2016.06.2017.pdf
[7] http://www.tnidb.tn.gov.in/forms/TN%20VISION%202023(PHASE%202).pdf

provide investment opportunities for the development of minor ports in Tamil Nadu through Public-Private Participation.

The minor ports are proposed to be developed with multi-user facilities capable of handling all types of cargo like bulk, breakbulk, containers, liquid bulk petroleum products, chemicals, etc. Private companies making a substantial investment in coastal areas will be allotted sites for construction of captive jetties. The development of all the infrastructure facilities in captive ports is the responsibility of the private developer.

8.3 Corporate Social Responsibility (CSR)

"Corporate Social Responsibility (CSR)" is a process to achieve sustainable and equitable development in societies. CSR referred to as corporate initiative to assess and take responsibility for the company's effects on the environment and impact on social welfare. The term generally applies to companies' efforts that go beyond what may be required by regulators or environmental protection groups. The primary purpose of this plan is to allow the company to meet the requirements of the Companies Act, 2013. It is about how companies manage the business processes to produce an overall positive impact on society.

CSR activities are the mitigation measure to curb the adverse impacts on the community and environment as a whole. CSR activities help in binding the community and sustainability together if planned the right way. The planning of CSR activities involves assessing impacts with the help of primary and secondary data.

As mentioned by United Nations Industrial Development Organization (UNIDO), CSR is generally understood as being the way through which a company achieves a balance of Economic, Environmental and Social imperatives ("Triple Bottom-Line- Approach"), while at the same time addressing the expectations of shareholders and stakeholders. **Figure 8-1** represents the Triple Bottom Line Approach.

Figure 8-1: Triple Bottom Line Approach

8.3.1.1 CSR Regulations

Ministry of Corporate Affairs, Government of India has notified the Section 135 of the Companies Act, 2013 along with Companies (Corporate Social Responsibility Policy) Rules, 2014 "hereinafter CSR Rules" and other notifications related thereto which makes it mandatory (with effect from April 1, 2014) for certain companies who fulfil the criteria as mentioned under Sub Section 1 of Section 135 to comply with the provisions relevant to Corporate Social Responsibility. CSR is a practice that holistically integrates an organization's core business with the social and environmental concerns of the community impacted. It gives impetus to economic development and improves the living standards of neighbourhood community members and society at large.

The CSR provisions within the Act applies to companies with an annual turnover of INR.10,000 Million (INR 1,000 crore) and more, or a net worth of INR.5,000 Million (INR500 crore) and more, or a net profit of INR 50 million (INR.5.0 Crore) and more. These CSR rules, are applicable from the fiscal year 2014-15 onwards, also require companies to set-up a CSR committee consisting of their board members, including at least one independent director. The Act encourages companies to spend at least 2% of their average net profit in the previous three years on CSR activities. The Act lists out a set of activities eligible under CSR. Companies may implement these activities taking into account the local conditions after seeking board approval. The indicative activities which can be undertaken by a company under CSR have been specified under Schedule VII of the Companies Act, 2013.

8.3.1.2 Few Highlights from Schedule VII of the Companies Act, 2013

- Surplus arising out of CSR activities will have to be reinvested into CSR initiatives, and this will be over and above the 2% figure
- The company can implement its CSR activities through the following methods:
  - Directly on its own
  - Through its non-profit foundation set- up to facilitate this initiative
  - Through independently registered non-profit organization's that have a record of at least three years in similar such related activities
  - Collaborating or pooling their resources with other companies
- Only CSR activities undertaken in India will be taken into consideration
- Activities meant exclusively for employees and their families will not qualify
- A format for the board report on CSR has been provided which includes amongst others, activity-wise, reasons for spends under 2% of the average net profits of the previous three years and a responsibility statement that the CSR policy, implementation and monitoring process complies with the CSR objectives, in letter and spirit. This has to be signed by either the CEO or the MD or a director of the company
- The CSR committee will be responsible for preparing a detailed plan on CSR activities, including the expenditure, the type of activities, roles and responsibilities of various stakeholders and a monitoring mechanism for such activities.
- The CSR committee can also ensure that all the kinds of income accrued to the company by way of CSR activities should be credited back to the community or CSR corpus

This Act requires that the board of the company shall, after taking into account the recommendations made by the CSR Committee, approve the CSR policy for the company and disclose its contents in their report and also publish the details on the company's official website, if any, in such manner as may be prescribed. If the company fails to spend the prescribed amount, the board, in its report shall specify the reasons.

Thus, the Act encourages transparency in the CSR activities and bestows greater responsibility on the companies to have a clear framework for their CSR interventions.

The Schedule VII of Section 135, Companies Act, 2013, has listed the interventions that qualify as CSR activities:

- Eradicating hunger, poverty and malnutrition; promoting health care including preventive health care and sanitation; and making available safe drinking water;
- Promoting education, including special education and employment enhancing vocational skills especially among children, women, elderly, and the differently able; and livelihood enhancement projects;

- Promoting gender equality; empowering women; setting up homes and hostels for women and orphans; setting up old age homes, day care centres and such other facilities for senior citizens; and taking measures for reducing inequalities faced by socially and economically backward groups;
- Ensuring environmental sustainability, ecological balance, protection of flora and fauna, animal welfare, agro-forestry and conservation of natural resources and maintaining quality of soil, air and water;
- Protection of national heritage, art and culture including restoration of buildings and sites of historical importance and works of art; setting up public libraries; promotion and development of traditional arts and handicrafts;
- Measures for the benefit of armed forces veterans, war widows and their dependents;
- Provide training to promote rural sports and nationally recognized sports, Paralympics sports and Olympic sports;
- Contribute to the Prime Ministers' National Relief Fund or any other fund set up by the Central Government for socio-economic development and relief and welfare of the Scheduled Castes, the Scheduled Tribes, other backward classes, minorities and women;
- Contribute or provide funds for technology incubators located within academic institutions which are approved by the Central Government;
- Take up rural development projects.

It is also important that the community members are held collectively responsible and encouraged to take ownership of the development, thus promoting the agenda of sustainability for future generation.

8.3.1.3 CSR Activities of Adani Foundation and MIDPL

The Adani Foundation is the Corporate Social Responsibility arm of Adani Group, an integrated infrastructure conglomerate that is committed to inclusive growth and sustainable development in not only the communities it operates in, but also in contributing towards nation building.

MIDPL commits itself to SA-8000, Social Accountability Systems:

- To stimulate infrastructure growth of the state, especially, developing the area into an economically bustling zone.
- To develop the port area with top-class residential, water & power supply facilities.
- To enrich people's life in the area/periphery in every possible way.

The company's CSR planning and its activities is in line with the Schedule VII of Section 135, Companies Act, 2013 such as Health, Education, improving the economic conditions, women empowerment and child development, sustainability etc.

As a part of Corporate Social Responsibility (CSR), MIDPL has taken up its CSR activities/initiatives under following broad areas to achieve its objectives.

- Education
- Community Health
- Sustainable Livelihood Development
- Community Development

8.4 Existing Kattupalli Port CSR Activities

MIDPL CSR activities were planned to cover the total of 31 villages covering the population of 31, 860 numbers with in the periphery of 10km from project boundary.

Specific Focus on Marginalized Section:

- Special focus was given to the villages located within 5 km vicinity of the Port and their community development needs were addressed on priority basis.
- School students' need in core villages were taken on priority basis and the projects were implemented on war foot basis.

8.4.1 Quality of Life

The quality of life in the region is likely to improve due to increase in percapita/per family earning and value appreciation of local resources that would provide economic freedom and facilitate a higher standard of living. MIDPL has taken up activities in the field of Education, Community health, Sustainable livelihood development and Rural infrastructure development to improve the quality of the in the nearby villages.

8.4.2 Education

Education is every child's right and development of any society is often backed by a high literacy rate and quality education. Keeping this in mind, the Adani Foundation, Kattupalli Port has taken up various educational activities.

MIDPL is keen in developing quality of education in schools of the Kattupalli Port periphery. With that view, the following activities are identified, planned and initiated

- Project Uddan
- Distribution of Refreshments to board exam students in Government schools
- Distribution of Bicycles to school children
- Organizing Science festivals
- Merit Scholarship Programme
- Rural Knowledge Centre
- Summer Camp for Rural Students
- Maritime Inter School Quiz
- Turning Point
- Distribution of school Bags and Study Materials to Poor and Orphan Students
- School Awareness Programme

8.4.2.1 Project Udaan

Project UDAAN is learning based initiative for young students, inspired by the life changing story of the Hon'ble Chairman, Mr. Gautam Adani, where children from different high schools along with their faculties come to visit the Port as well as the operation works of the ports.

About 205 students from school as well as professional institutions visited Adani Kattupalli Port Pvt. Ltd. during FY 19-20 accompanied with 16 faculties:

- 130 students from Govt. High school, Nagapattinam district, Tamil Nadu visited the port to learn about port operation and its facilities. The visit was organized for inspiring the children to dream big in their life.

- 30 Final year UG (Under Graduate) students from SCP Jain College visited the port to understand the business process as part of their curriculum pertaining to Business Administration program (BBA)
- 45 Final year Marine Engineering diploma students from Mohamed Sathak Polytechnique visited the port to gain practical knowledge about Marine engineering related activities from Adani Port Engineers.

Figure 8-2: Students Attended Project Udaan

8.4.2.1.1 Reward &Recognition of board exam toppers and Distribution of Refreshments

Scholl board exam toppers from Kattupalli Port intervention schools were felicitated with reward programmes for the academic year 2018-19 followed by distribution of refreshments to board exam students in Government schools, Kattupalli, Kattur & Thiruvellavoyal, attending extended classes in the evening.

	

Figure 8-3: Reward & Recognition of board exam toppers

8.4.2.1.2 Bicycle Project

As per state government's education policy, students studying in Eleventh standard are alone eligible for free bicycle scheme from Government for attending school. The Tamil Nadu Right of Children to Free and Compulsory Education (RTE) Rules, 2011, provide that a primary school can be established within a distance of one km, and upper primary school within three km. whereas high and higher secondary schools are established in 5 km distance to cover maximum number of small hamlets in this radius. In the CSR intervening Panchayaths, one of the basic challenge that the children faced were poor transportation facility to reach their school. In order to overcome this issue, Adani Foundation initiated bicycle distribution program to ensure the continuing of education after middle school in the intervening villages.

- The bicycle distribution has helped the students especially those in 9th standard in our intervention villages to reach school in time, as earlier majority of them has to walk more than 4 km for one way
- The Scheme focused on 9th standard students as they have crossed middle grade and would be moving to SSLC (10th standard) which is most crucial for completing Phase I of their school life
- This has created an outcome for successful completion of middle school and recognition for enrolling in 8th and 9th standard for continuing education. This has further motivated the students to come out of their villages for pursuing higher education
- A total of 214 bicycles were distributed to GHS, Kattupalli, GHSS, Thiruvellavoyal, GHSS, Kattur, MPUMS, KoraiKuppam, Ornambedu and Karungkali

Direct Outcomes:

- Reducing the chance of missing classes
- 99% involvement in coming year's SSLC class
- Joyful schooling rather forceful
- Opportunity to learn extra-curricular activities through staying back in school premises after school hours.
- Replaced the regular steel rim with alloy rims to avoid rusting/corrosion, for prolonged usage of the bicycle, as these bicycles would be used in coastal zone
- Replaced the side stand with centre stand for children's safety purpose.

Figure 8-4: Bicycle Distribution by Adani Foundation

8.4.2.2 Distribution of Television (TV)

Distributed Television to the Minjur Panchayat Union Primary schools in Karungkali and Mouthambedu which lacked Television for screening lessons through electronic media. Based on the request from both the schools, TVs were handed over to the schools which were installed on Republic day of 2020 in presence of the Panchayat president. Received positive feedback from these schools about benefits of TV and joyful learning. Total 53 students benefited in AY 2019-20.

8.4.2.3 Science Festival

For centuries, developed countries have focused on conducting science festivals at vast scale. Many studies have pointed out that these festivals have played a crucial role in improving the scientific quotient of students in these countries. In our country though in past few years, many organizations have come forward to conduct scientific festival but the reach of these festivals is still limited given the vast demography and population of India. In order to extend the reach of science festivals to the underprivileged students in rural areas, Adani Foundation, Chennai, conducted science festival on 28th February 2020, with the following broad objectives:

Objectives:

- To create curiosity among students about day to day science and engineering devices
- Provide a platform for students to get hands-on experience of basic science principles
- To instil the techniques of conducting science experiments at the early stages of students' lives
- Encouraging the teachers to adopt experimental based learning in classroom studies

Keeping the above objectives in mind, we organized science festival in Minjur Panchayat Union Middle school, Velur as part of educational outreach.

Theme of the science festival was ***"Demonstration of Science & Engineering through Low Cost Items"***. The schools were taken on-board and mentor teachers were selected from each school. Low cost items such as, balloons, straws, plastic bottles, magnets etc., were identified and packed together in the form of kits. Kits were prepared in different categories of including Biology, Chemistry, Mathematics, Physics and Engineering subjects.

Each student team consisted of 2 students and were given a kit of their choice. Students were given 15 day's time to prepare models using the items provided in the kit and presented their models on exhibition day 28th February 2020 (National Science Day). Around 35 middle standard students from 5 schools have participated under the mentorship of 10 teachers.

In each subject category, the top three teams were selected. The teams were given some extra science materials as prizes rather than money. This was done to ensure that winning teams will get a further chance to develop more models. The school teachers continue to guide and monitor the students in developing more scientific models.

Figure 8-5: Science Festival

8.4.2.4 Promoting Physical Fitness through Sports

Objectives:

- To promote the sports interest at primary and Middle grade level
- To create a platform to exhibit sports talents
- To foster the ambition to become champions in sports

Events were carried out in two categories including primary and middle grade and following games were conducted: Different types of running races and relay according to grades, long jump, Shot-put, Hula hoop, water filling etc.

In continuation of sports materials distribution to the govt. schools in our intervention villages as part of CSR, we had announced the school level sports meet on the day of national sports day function held at Adani Kattupalli port.

With prior approval from District Education Officer and District Physical Education officer, Ponneri Adani Kattupalli port organized the meet at Govt. Higher Secondary School, Thiruvellavoyal with all the arrangements and referees from physical education college, Chennai, were facilitated for smooth execution of events.

The meet gave the students experiences of necessary life skills like team work and planning towards a common goal, leadership skills and risk assessment which they carry beyond the field. Also, the sports meet broke the monotonous of academic syllabus and promoted co-curricular activities like sports and games which made the education more fun.

Around 340 students from 16 schools took part in the meet, which provided a platform for the students to interact with other school students which helped them to develop communication and interpersonal skills.

Grand finale was organized to felicitate the winners, district physical education officer, local elected representatives and officials from Adani Kattupalli Port participated and presented the trophies to the winners and overall championship to the winning school. Overall championship school received huge applauds from local community and earned reputation and goodwill. Individual winners not only carried their trophies but also loads of joy and happiness with pride.

Figure 8-6: Adani Junior School Sports Meet

8.4.3 Community Health

Kattupalli Port strives to develop a disease-free society by providing quality healthcare services as well as by creating massive awareness among the communities on health and hygiene matters. Keeping in mind the following activities are identified, planned and initiated in remote locations and scattered population of port periphery, attempts were also made to take the healthcare services to the doorsteps of people.

- Community Health Centre
- Mobile Health Unit
- Safe Drinking Water
- Suposhan
- School Health Check-up Programme
- Organizing rural sports meets
- Fishermen Training on First Aid and Rescue
- First Aid Kits to fishing trawlers and schools
- Awareness on Epidemic Prevention
- Blankets to AIDS Patients
- Blood Donation

8.4.3.1 Health camps

Health care is the basic need of each individual to achieve regional and national growth. Nearly 40% of hamlets in Kattupalli region have poor transport connectivity. Poor road connectivity and transportation facility results in poor accessibility of health centers for the villagers. We have organized multispecialty health camps and Eye screening camps in needy villages after preparatory studies in consultation with local key persons.

Following specialties were identified as the highly needed among our intervention villages' apart from General physician:

- Obstetrician and Gynecology

- Dermatology
- Orthopedic
- Ophthalmology

MIDPL made arrangements with Multispecialty hospital and Eye care hospital for expert consultation. Team of professionals from these hospitals visited villages for diagnosing and prescribing treatment. With respect to multispecialty medical camp, basic consultations along with required physical examinations were done. A private room was used to examine the patients depending on the medical need to examine genital part, skin; bone strength, ear/nose/throat, and samples were collected for cervical cancer (pap smear), blood test (Haemoglobin/diabetic/thyroid) etc. Bone marrow test were also done. The collected samples were taken to lab for clinical analysis and reviewed the test reports by medical personal. In camp sites, basic medicines were prescribed and delivered at beneficiaries' doorstep. Proper billing was done at the hospital in order to maintain file records for documentation purpose.

During the financial year (2019-20), 06 health camps were conducted covering 10 villages with 661 registrations.

Figure 8-7: Multispecialty Health camps

8.4.3.2 Eye Care Camps

In Eye screening camps, both surgery based complaints and optical based complaints were diagnosed with proper equipment. Those who were having complaints which require surgery have undergone essential screening at camp site and received referral cards for further treatment in their base camp hospital. Spectacle related measurements were taken at the camp itself for those with vision problems. Spectacles were manufactured at hospital (Sankara Netralaya) and handed over to the beneficiaries at their doorstep with the help of social leaders within one month time.

During the financial year (2019-20), 11 Eye camps were conducted covering 18 villages with 1234 registrations, 715 no. of spectacles distributed and 165 cases referred to respective hospitals.

Figure 8-8: Eye Care

8.4.3.3 Safe Drinking Water

Upon the request from residents of Kattupallikuppam, Adani Foundation (AF) Kattupalli have initiated the process in consultation with AF-Headquarters. To ensure safe drinking water within the village, RO technology was installed in selected site by a leading and experienced RO technology provider with the support from local volunteers. RO with a capacity of 500 litter per hour was selected which caters to the needs of 200 families living in this hamlet. For the installation of RO, an existing public building was selected and electricity supply for the operation of the unit was taken from Panchayath building. Automatic water dispenser which provides water at a nominal cost of Rs.5/lt was installed, which could be operated using individual ATM card. The amount collected in such manner is used for operation and maintenance of the RO plant. Villagers find this project very useful as they get safe drinking water and saves huge amount of money they have earlier spent on drinking water.

8.4.3.4 Natural Terafil Water Filter

Water table in Senghazhanirmedu colony village is available at 12 feet and people collect water from common open wells available within the hamlet. Around 120 families are living near Kosasthalaiyar river. Though water table available is at approachable distance, water is not potable as it is a mix of soil in fine particles. Locals store the water over night and use it for drinking and cooking, in-spite of sediments, and micro particles present in water which is not good for health. AF-Kattupalli have identified Natural Terafil water filter as a cost effective sustainable technology to address the prevailing quality issue in drinking water. 50 beneficiaries have been selected in Phase1 and remaining families will be covered in Phase 2 depending on the success of the project.

Figure 8-9: Natural Terafil Water Filter Distribution

8.4.3.5 SuPoshan

Suposhan have been launched in the first week of January 2020 at Kattupalli in 22 villages. During the launch session, all the Sanginies received orientation about the program and was given training on conducting survey for data collection. Now we have 7 Sanginies and survey work is in progress. Sanginies actively participated in Poshanpakwada and supported the govt. initiatives and also promotes kitchen garden in our intervention villages.

We through project SuPoshan aim to utilize a community-based approach to address the issues of malnutrition and anemia in about 22 villages in Minjur block.

8.4.4 Sustainable Livelihood Development (SLD)

Improving the socio-economic conditions of the people through better livelihood methods, adding sustainability to good livelihood earning practices and through encouragement to self-employability has been a major focus of the CSR by Kattupalli Port. With that view, the following activities are identified, planned and initiated

- Training on Organic farming
- Support to Women SHGs
- Farmers Group Initiatives
- Livestock Healthcare
- Promotion of Palm trees
- Protection of House Sparrow programmes
- Fisher Folk Welfare activities

- Tailoring Training for Women

8.4.4.1 Educating Organic Farming

During financial year 2019-20, MIDPL Organized a training session on organic farming which was handled by an expert recognized by Tamil Nadu Agricultural University (TNAU). Various recipes for growth promoting mixtures and pest repellent solutions were taught for controlling pest in bio method. Awareness on the role of bio-fertilizers in stimulating plant growth and preventing fungal infections was given to the farmers. Bio fertilizers were distributed to the farmers to experiment in half an acre of land and about 40 farmers benefitted from the session.

Figure 8-10: Training Session on Organic Farming

8.4.4.2 Horticulture Development

During financial year 2019-20, MIDPL organized an exposure visit for farmers, to Centre of excellence for vegetables, Reddiarchatiram, Dindigul for learning latest technologies developed for watermelon cultivation. Around 12 progressive farmers were taken to the center and to the model farm.

8.4.4.3 Livestock Development

A veterinary treatment cum awareness camps were organized during 2019-20 in collaboration with Madras Vet. College (MVC) (Tamil Nadu Veterinary and Animal Sciences University). Each camp comprised of UG & PG students under the supervision of one or two professors from MVC (TANUVAS) and 7 members. The camp started at 8.30 am in a place which was easily accessible by the villagers. Deworming of calves and goat/sheep is the common treatment in all the camps and on selected months PPR vaccination are given to goats. Besides these, pregnancy diagnosis for cow, treatment for malnourishment and digestion related issues, distribution of mineral mixture for improving milk yield were also done to improve the livestock productivity. During Jan-Feb 2020 there was an outbreak called Lump Skin Disease (LSD) among the milch animals in Tiruvallur and ethno medicine treatment was prescribed for this disease as it could not be treated through allopathic medicine. Team of doctors had the practice of house visits to attend herds (flock of animals) which could not be brought to common treatment spot.

Visiting veterinarians gave awareness on the importance of learning ethno medicine to give first aids to the affected animals and basic and simple recipes were taught to the participants in order to prevent cattle loss. To increase milk productivity, the livestock owners were advised to replace the low yielding desi cows with crossbreed cows.

For the smooth execution of the camp, group of local youths volunteered in mobilizing animals and regulating the beneficiary crowd.

Calf saving kit, Mineral mixtures, spray for mastitis sponsored by ICAR-TANUVAS and 5.2 tons of concentrated cattle feed, and required medicines needed for treating at camp were organized by Adani foundation.

During the financial year (2019-20), 8 veterinary camps were conducted, 2916 animals were treated and 328 families benefited.

About 5.2 tons of concentrated cattle feed were distributed in following four Panchayats (1. Kattur, 2. Thiruvellavoyal, 3. Voyalur, 4. Kadapakkam) which benefited 245 livestock owners by increasing their milch animals milk yield by 15% which consequently resulted in improvement of their monthly income. Livestock owners' realized the role of concentrated feed in improving milk yield and assured calf for a year for better economy from milch animal.

Figure 8-11: Livestock Development Programmes

8.4.4.4 Green Fodder Promotion

During the financial year (2019-20), MIDPL organized an exposure visit for livestock owners to Regional Fodder Research Station, Alamthi for learning various fodder varieties available for different types of animals. Research station distributed 8 kg fodder seeds (in 20 packets), Azola and bundles of Co4 variety fodder slips to the livestock owners during the visit to research station. Awareness session on fodder cultivation has been organized in village in collaboration with Regional Fodder Research Station as part of knowledge sharing.

Figure 8-12: Green Fodder Promotion Programmes

8.4.4.5 Rural sports – Pongal festival

Kattupallikuppam residents predominantly belong to fishermen community. To promote the sportsmanship Adani Foundation, Kattupalli organized rural sports meet for both men and women. For men, boat race was conducted and for women, musical chair, balloon bursting, sand filling and Rangoli competition were conducted. Large number of participants took part and cheered each other. Local volunteers were all present themselves to organize and moderate the events along with AF staff members. More than 120 individuals took part and enjoyed the day with lots of fun.

Figure 8-13: MIDPL Conducted Rural Sports Fest

8.4.4.6 Promotion of Palm Trees

Kattupalli Port have initiated the palm tree promotion project in association with district administration as a way to achieve the following:

- To improve the rain fall in district
- To control soil erosion around water bodies
- To improve water retention on top soil through palm tree roots
- To improve the green cover in district

30,000 (Thirty thousands) seeds were planted on the bund of Buckingham canal starting from Adani Ennore Container Terminal Private Limited (KPL) to Adani Kattupalli Port and Kaalanji village, Ponneri Taluk, Tiruvallur covering more than 10 km.

Figure 8-14: Promotion of Palm trees plantation

8.4.4.7 Protection of House Sparrow

House Sparrows are friendly with human and prefer to live around the residential zone. Few villagers have fixed carton boxes to provide space for nesting, unfortunately it is not strong enough to withstand the monsoon period. To overcome this, nests which can survive in all seasons of weather were set up to save the chicks from predators.

Along with nest we have also distributed feeder pet bottles filled with fox tail millet to attract the sparrows to nest in the provided space. House Sparrows prefer grains, worms, pests and spill over foods as its feed.

Every creature contributes in establishing healthy eco-system. House sparrows are helpful in controlling pests in agriculture/horticulture field. Conservation of house sparrow will help the farmers to reduce the usage of synthetic pesticides, thereby yielding poison free food for human consumption as well reduce production loss by pests.

Kattupalli Port have distributed 280 earthen ware nests and feeder bottles in 5 villages to increase the House sparrow population.

Figure 8-15: Distribution of Earthen ware Nests and Feeder bottles for House sparrows

8.4.5 Community Development

Improving the rural roads, drinking water facility, rural electrification etc., has been a priority of Kattupalli Port CSR activities/initiatives. With that view, the following activities are identified, planned and initiated

- Shuttle service
- Tube Wells
- Road improvements in nearby villages
- Improvement of Village Roads
- Classroom for School

8.4.5.1 Shuttle service

Kattupalli village is a neighbouring village of Adani Kattupalli Port and has more than 350 families including colony and village with 150 families in Kattupallikuppam and 120 families in Kaalanji. These villages don't have public transport facility, which hinders many development programs. Athipattupudhunagar railway station is the nearest sub-urban railway station which connects Chennai city and Ponneri town where one has to go for higher education after SSLC. As there is no public transport facility available in this route to railway station, students above high school mostly depend on passing vehicles for lift, which is unsafe. After analyzing the ground situation, we have arranged a van to connect these villages to the nearest railway station to meet students' commutation need. Everyday around 60 students are benefitted by this transport arrangement to Athipattu railway station and prime focus is given to students above SSLC, teachers of Govt. High school, Kattupalli and Minjur Panchayat union, Kaalanji. The same vehicle is next used to commute primary and middle grade students of Kaalanji and Kattur. This transportation facility is available both in the mornings and evenings.

- This service facilitates students above SSLC to continue their education
- Girls students find more safety on using this commutation mode
- Students who take this facility have fewer absences and are punctual in schools/colleges
- Saves waiting time which could be effectively used for studies
- Student and teachers could reach the schools in time without much struggle

Good appreciation was received from the village leaders and elders in our initiative which assures continuation of education to promising students. The success of this venture made the elected representatives from these villages to put a proposal of transportation in one more routes- Thangalperumbulam to Pulicat, with the existing route maintain status quo. Thangalperumbulam is a kind of island and has about 30 number of students who could also benefit from this type of transportation facility.

Figure 8-16: Shuttle service Initiated by MIDPL

8.5 Revised Master Plan Development of Kattupalli Port

Considering the future business potential, MIDPL is now proposing a Revised Master Plan of Kattupalli Port. Type of berth and type of cargo is a commercial and business requirement. Hence revised master plan is proposed with flexibilities to accommodate all berths (existing as well as proposed) as Multipurpose.

Along with berths, trans-loading facilities, SPM, backup facilities and independent port craft facilities, waste reception facilities, conveying systems, drainage, water supply, electrical works, internal roads, railway works and other utilities, amenities and bunkering will be developed to accommodate all multipurpose cargo.

Presently there is no railway sliding inside the Kattupalli port. Ennore Port is connected to broad gauge of Southern Railway Main Line, through a siding from Athipattu railway station. Athipattu is at a distance of about 2.7 km from Ennore Port.

For the rail connectivity of Kattupalli port, the nearest IR network is Chennai-Howrah trunk route of double line electrified section with the provision of automatic signalling. This rail line will connect Kattupalli port with nearby southern rail link at Ennore Rail-yard and proposed Northern Rail Link at L&T Spur location.

8.5.1 Infrastructure Facilities

Considering the future business potential MIDPL is now proposing its Revised Master Plan development of Kattupalli port. Development of 5 Berths with total quay length of ~1900 m and 2 Port Craft Berths are approved as a part of existing Clearance. As part of Revised Master Plan development, additional Quay length of ~9567 m berth length, quay length of 1250 m Barge berths and ~12 Port Craft facilities are proposed (including existing approved 2 port craft). Total quay length of berth proposed as a part of revised master plan development will be ~11467 m in addition to 1250 m long barge berths and 2 no SPM's are being proposed.

Along with berths, transloading facilities, SPM's, backup facilities and independent port craft facilities, waste reception facilities, conveyor systems, drainage, water supply, electrical works, internal roads, railway works and other utilities, amenities and bunkering will be developed to accommodate all multipurpose cargo.

MIDPL has already obtained CRZ Clearance for development of Southern rail corridor at Kattupalli Port. As part of the proposed development, Railway Yard (including R&D yard facility) will also be developed within the MIDPL port facility with associated supporting facilities. In addition to these, as per the business requirement, it is proposed to develop Port backup Industries and Industrial development area and its associated infrastructure.

The project stretch increases the connectivity and boosts the travel characteristics of the people residing in nearby villages and thus contributes to the economic development of the region.

Dedicated rail link provides connectivity to Chennai-Gudur main railway line offers an efficient and cost effective supply chain/ value proposition to the local importers and exporters in the state. It will also serve as an alternative gateway to ports on the west coast of India for trade between south east India and Asia.

8.6 Corporate Social Responsibility Plan of Kattupalli Port

8.6.1 Socio-economic Status of Project Area

The total of 108 census villages including hamlets is falling in three Talukas viz. Gummidipoondi, Ponneri and Mathavaram of Thiruvallur District. Project area falls under notified revenue villages (i.e. Kalanji, Kattupalli, Kattur-II, Ebrahampuram, Puzhudivakkam, Voyalur) out of which only four villagers are inhabited and two villages are un-inhabited (viz. Ebrahampuram, Puzhudivakkam). There are 1,74,745 households and population are 6,79,695 out of which males population is 50.21% and females population is 49.79%. The sex ratio of the study area is 992 females over 1000 males. Total Child population which is 74,307 that is around 10.93% of the total population in the study area.

8.6.2 Need Based Assessment Study for CSR activities by MIDPL

MIDPL prepared a five-year CSR plan for meeting the major community needs in the 11 Panchayaths included Kattupalli, Kattur, Voyalur, Neidhavayal, Thiruvella voyal, Thangal Perungbulam, Velur, Nandhiyam bakkamKottai Kuppam, Light House Kuppam and Pulicat coming within an aerial distance of 10 kms from the project boundary of MIDPL covering 22,000 families and 60 hamlets. Almost 40% of population is engaged in fishing (river & marine) whereas the remaining are in agriculture and other coolies works.

This CSR action plan for the next five years has been prepared by Adani Foundation based on the outcomes of Socio Economic Assessment carried as part of EIA (**Section 3.14 of Chapter 3**) and need based assessment study conducted by MIDPL through Madras School of Social Works and also the series of interaction, focussed group discussions with Panchayath samities and community groups conducted by CSR & IR team of Kattupalli Port for the last one year.

The study findings of Need based assessment study conducted to arrive at appropriate CSR intervention for community development are generally classified in to the major heads of Education, Community Health, Livelihood Enhancement & Skill development and Community Development and are summarised as follows

i. Education (SDG-4)

- 50.2% of respondents are uneducated whereas 46.8% are educated only up to middle and high school level.
- The school authorities in the project areas suggested that vocational training can also be imparted to the school children.
- As there are technical graduates in the study areas, up skilling will be highly useful to them to compete in the job market.
- Special scholarships may be provided to the children of fishing community and other deprived section to encourage and enhance their learning out comes.

ii. Community Health (Good Health and wellbeing SDG-3 & 6)

- Improvements need in access to medical facilities, public health and to the quality of life of the Coastal areas, marginalized communities and the general public of the project area at large.
- Majority (86.6%) of the respondents are not having the basic necessity of toilet facility at home.
- No proper waste collection and disposal system is practiced in any of the panchayats or hamlets.
- More than half (68.1%) of the respondents are using the public tap for their drinking water.
- Majority (72.4%) of the respondents are using the wells to take water for household activities.

iii. Livelihood Enhancement & Skill Development (SDG-8)

- 47% of the respondents are working as a fisherman. Looking at the nature of job, they do fish catching, work as a coolie with someone for loading and unloading of the fishing, a few works as boat captain and a few are selling fish.
- 35.9% of the respondents are working in nearby their villages, whereas the same (35. 9 %) number of respondents is not doing anything.
- 53.1% of the respondents are from the Most Backward Communities.
- 36.5% of the respondents of productive age groups are not working
- There is a high need to organise both low end and high end skill courses for the local youth populace to make them employable.

iv. Biodiversity & Environmental Protection (SDG -11)

- De-silting of water bodies for water conservation.
- Dredging of Pulicat lake periodically to enhance fish resources.
- Protect the bio-diversity of Pulicat lake and the Buckingham canal which in turn impact the livelihood of fishing community.
- Protection of water bodies and organising special livelihood programmes through such natural resources.

8.6.2.1 Activities identified for the CSR project Intervention in the Study Areas

The qualitative study and survey findings brought out the genuine needs of the selected villages as mentioned below in the study area by MIDPL. Details of area, sector-wise needs, required short-term and long-term interventions

The Study suggests framework plans (sector wise interventions) for implementing the CSR initiatives. Suitable modifications may be made by the MIDPL authorities based on further consultation if it is required. The activities were proposed by the Madras School of Social Works, Chennai by conducting field level assessment and budget allocation was done accordingly. The budget allocation details are given in **Table 8-1**.

Table 8-1: Comprehensive CSR Intervention Plan for the Kattupalli Port

Area	Sector Wise Community Needs	Intervention Duration Short Term/Medium Term/ Long Term	Implementing Agencies
Neidha-Vayal Core Area	i. **ICDS -** Renovation of Anganwadi centre	Short term	Adani Foundation
	ii. Water and sanitation - Construction of household toilets (50 units)	Short term	Adani Foundation
	iii. Education - Providing books to the existing library	Short term	Adani Foundation
	iv. Livelihood - To educate the farmers about water conservation and adopting latest agrarian technology v. To conduct job fair, to promote employment opportunities and up-skilling	Short term	Adani Foundation
	vi. **Environment-** De-silting of water bodies to replenish ground water vii. Construction of check dams	Short term Long term	Adani Foundation PWD
	viii. Infrastructure- Renovation and providing new roads (10 km)	Long term	SSS PO DRDA
	ix. **Environment-** Greenery initiative	Medium term	Adani Foundation
Korai Kuppam Core Area	**i. Water and sanitation-** Construction of household toilets (25)	Short term	Adani Foundation
	ii. Health - Mobile health camps	Short term	Adani Foundation
	iii. **Livelihood -** Employability skill training and deep sea fishing training (10) **iv. School needs** - bore well, one classroom	Medium term	CIFNET Adani Foundation
	v. Infrastructure - Roads(1 km) Transport facilities	Short term	Adani Foundation
	vi. **Environment-** Greenery initiative vii. Tracker	Medium term	Adani Foundation
Kattupalli Core Area	i. **Water and sanitation-** need for individual household toilet unit (25) **ii. School needs (Primary school) -** Toilet for girls, levelling the low lying areas	Short term	Adani Foundation
	iii. Livelihood - Employability skill training (Apparel making, car driving, welding, plumbing and up-skilling programs to compete in the job market) 50	Medium term	Adani Foundation
	iv. Infrastructure- Road facilities (**Immediate need)** and continue the shuttle services **v.** Revival of day care centre for 25 senior citizens	Short term	Adani Foundation Adani Foundation
	vi. Health - full time medical centre	Short term	Adani Foundation
	vii. **Environment-** Greenery initiative	Medium term	Adani Foundation
Kattupalli Kuppam (R&R Scheme) Core Area	i. **Water and sanitation-** Individual household toilets (25) ii. Drinking water facility	Short term	Adani Foundation
	iii. **Health -** full time health centre with lab facility	Short term	Adani Foundation
	iv. **Livelihood -** Employability training (Apparel making, car driving, welding, plumbing and up-skilling programs to compete in the job market) v. Nurse aid training	Medium term	Adani Foundation

Area	Sector Wise Community Needs	Intervention Duration Short Term/Medium Term/ Long Term	Implementing Agencies
	vi. Access to sea (road connectivity) 2 kms vii. Deploying artificial reef viii. Mangrove cultivation for bio-diversity		
	ix. **Infrastructure -** road and transportation facility x. Street lights (Solar) 20*10	Short term	Adani Foundation
	xi. **Environment -** Greenery initiative	Medium term	Adani Foundation
Kalanji Core Area	i. **Education -** special tuition class	Short term	Adani Foundation
	ii. **Water and sanitation -** Individual household toilets 25 iii. Drinking water facility	Short term	Adani Foundation
	iv. **Health -** mobile health camps	Short term	Adani Foundation
	v. **Livelihood -** skill training for women (Apparel making & nurse aid)	Medium term	Adani Foundation
	vi. **Infrastructure -** road and transportation facility vii. Street lights (Solar)	Short term	Adani Foundation
	viii. **Environment -** Greenery initiative	Medium term	Adani Foundation
Kadal Kanniyur Core Area	i. **Education -** special tuition class	Short term	Adani Foundation
	ii. **ICDS -** need for Anganwadi centre	Short term	Adani Foundation
	iii. **Water and sanitation-** Individual household toilets iv. Drinking water facility	Short term	Adani Foundation
	v. **Health -** mobile health camps	Short term	Adani Foundation
	vi. **Livelihood -** setting up of shrimp culture vii. Hand holding of ST families under ANTHYODHYA scheme (poorest of the poor) viii. Prevention of Social exploitation through legal assistance	Short term	Adani Foundation
	ix. **Infrastructure -** road and transportation facility x. Street lights (Solar)	Short term	Adani Foundation
	xi. **Environment -** Greenery initiative	Medium term	Adani Foundation
Karunkali Core Area	i. **Water and sanitation -** Individual household toilets ii. Drinking water facility	Short term	Adani Foundation
	iii. **Health -** mobile health camps	Short term	Adani Foundation
	iv. **Livelihood -** hand holding of ST families under ANTHYODHYA scheme (poorest of the poor)	Short term	Adani Foundation
	v. **Infrastructure -** road and transportation facility vi. Street lights (Solar)	Short term	Adani Foundation
	vii. **Environment -** Greenery initiative	Medium term	Adani Foundation
Kottai Kuppam Core Area	i. **Education -** communication skills development (learning outcomes)	Short term	Adani Foundation
	ii. **Water and sanitation -** Individual household toilets 25 iii. Drinking water facility	Short term	Adani Foundation
	iv. **Health -** mobile health camps	Medium term	Adani Foundation
	v. **Livelihood –** dredging of the Lake mouth area vi. Protection of Pulicat lake for bio-diversity	Short term	Adani Foundation
	vii. **Infrastructure -** solar street light near Jetty	Short term	Adani Foundation
	viii. **Environment -** Greenery initiative	Medium term	Adani Foundation

Area	Sector Wise Community Needs	Intervention Duration Short Term/Medium Term/ Long Term	Implementing Agencies
	ix. Mangrove cultivation near Pulicat lake mouth		
Anna Nagar (Kattupalli)	i. **Livelihood -** hand holdings of Dalit families (working as casual workers in fishing related activities)	Short term	Adani Foundation
Senjali Amman Nagar- St Families Core Area	i. **Education -** special tuition classes for school going children	Short term	Adani Foundation
	ii. **Water and sanitation-** Individual household toilets 25 units	Medium term	Adani Foundation
	iii. **Health -** mobile health camps	Short term	Adani Foundation
	iv. **Livelihood –** coordination with CIBA for livelihood programs	Short term	Adani Foundation
	v. **Environment -** Greenery initiative	Medium term	Adani Foundation
Light House Kuppam Panchayat Secondary	i. **Education -** communication skills development (learning outcomes) ii. Special tuition classes for school going children	Short term	Adani Foundation
	iii. **Water and sanitation-** Individual household toilets 25 units	Medium term	Adani Foundation
	iv. **Health-** mobile health camps v. Prevention of occupational health hazards	Short term	Adani Foundation
	vi. Community toilet for tourist development vii. (Light House Kuppam) **immediate need**	Short term	Adani Foundation
	viii. **Livelihood -** Employability training (Apparel making, car driving, welding, and plumbing and up-skilling programs to compete in the job market) ix. Nurse aid training x. Deep sea fishing training 10 numbers	Short term	Adani Foundation
	xi. **Infrastructure -** solar street lights	Short term	Adani Foundation
	xii. **Environment -** tractor for garbage clearance	Short term	Adani Foundation
Pazhaver-Kadu Secondary	i. **Education -** compound wall for GHSS Pazhaverkadu (3m) ii. Communication skill development (learning outcomes) iii. Furniture for classrooms (30 sets)	Short term	Adani Foundation
	Social issues – awareness programme on drug addiction among youths	Short term	Adani Foundation
Kattur Core Area	i. **Education -** furniture for GHSS (50 sets) ii. Communication skill development (learning outcomes)	Short term	Adani Foundation
	iii. **ICDS -** construction of building 425 sq.ft	Short term	Adani Foundation
	iv. **Health -** medical equipment for PHC Kattur	Short term	Adani Foundation
	v. **Water and sanitation -** individual house hold toilets 25 vi. Strom water drain	Short term	Adani Foundation
	vii. **Livelihood -** Hand holding of ST families under ANTHYODHYA scheme (poorest of the poor)	Short term	Adani Foundation
	viii. **Infrastructure -**Road facilities in ST colony	Short term	Adani Foundation
	ix. **Environment -** Greenery initiative	Medium term	Adani Foundation
Voyalur Core Area	**i.** **Education -** Communication skill development (learning outcomes)	Short term	Adani Foundation
	ii. **ICDS -** construction of Anganwadi building	Short term	Adani Foundation
	iii. **Health -** mobile health camps	Short term	Adani Foundation

Area	Sector Wise Community Needs	Intervention Duration Short Term/Medium Term/ Long Term	Implementing Agencies
	iv. **Water and sanitation -** individual house hold toilets (25)	Short term	Adani Foundation
	v. **Livelihood -** hand holding of SC families under ANTHYODHYA scheme (poorest of the poor) vi. Job fair for youths **vii.** Formation of FPO's and Agrarian technology for water conservation	Short term	Adani Foundation
	viii. Infrastructure - road facilities (**immediate need)**	Short term	Adani Foundation
	ix. Environment - Greenery initiative	Medium term	Adani Foundation
Thiruvellavoyal Core Area	**i. Education -** Communication skill development (learning outcomes)	Short term	Adani Foundation
	ii. **ICDS -** Construction of 1 Anganwadi building	Short term	Adani Foundation
	iii. **Health -** mobile health camps iv. Mobile veterinary camps	Short term	Adani Foundation
	v. **Livelihood -** Formation of FPO's and Agrarian technology for water conservation	Short term	Adani Foundation
	vi. **Infrastructure -** solar lights and road facility	Short term	Adani Foundation
	vii. **Environment -** Greenery initiative **viii.** De-silting of 2 ponds	Medium term	Adani Foundation
Velur	**i. Education -** Communication skill development (learning outcomes)	Short term	Adani Foundation
	ii. Livelihood - formation of FPO's and Agrarian technology for water conservation	Short term	Adani Foundation
	iii. **Infrastructure -** construction of community hall	Short term	Adani Foundation
	iv. **Environment -** Greenery initiative v. Tracker	Short term	Adani Foundation

Source: Need based Assessment Study by Madras School of Social Works, Chennai.

Corporate Social Responsibility Plan Matrix / Activities were given in **Table 8-2**.

Table 8-2: Corporate Social Responsibility Plan Matrix / Activities

S. No	CSR Activities as per Schedule VII of Companies Act 2013	Project Specific Areas Identified	Project Specific Activities	Key Performance Indicators
1	Eradication of extreme hunger and poverty	• Employment Generation • Water conservation • Clean Drinking Water Facility	• Employment Opportunities • Training of local people • Newer business opportunities • Promotion of health care facilities • Minimum wages are paid • Regular income • Clean Drinking Water Facility • Stakeholder Engagement	• Regular income generation • Health records to be maintained • Minimum wages record to be maintained • Clean drinking water usage and its maintenance • Stakeholders feedbacks
2	Promotion of education	• Promoting Higher Education • Vocational Skill Development Programs to be promoted • The increasing infrastructure of Educational Institute	• Higher education to merit students • ITIs to be promoted • Vocational Skill Development • Educational Building Renovations • Promoting education for special children • Teacher Training Programs • Stakeholder engagement • Grievance to be addressed	• Students enrolment • Drop-out rates of students to reduce • Renovated educational institutions and their maintenance • For enhancing teacher's performance for training programs • Enrolment of special students • Stakeholders Feedbacks to be recorded • Grievance is addressed
3	Gender equity and women empowerment	• Promoting Women Education • Promoting Training for Women	• Promoting girl's higher education • More employment-oriented programs for women • Training to be provided for women-oriented programs	• Women participation in decision making at various levels • Girls enrolment and drop-out rates to be maintained • Feedbacks to be recorded • Grievance to be addressed
4	Combating HIV-AIDS, malaria and other diseases	• Promoting Health Services • Promoting Health camps • Induced Participation Among People	• Promoting health camps • Community check-ups camps • Awareness Camps	• Medical Records to be maintained • Medical Check-ups feedbacks to be recorded • Feedbacks to be recorded
5	Reducing child mortality and improving maternal health			
6	Contribution to Prime Minister's relief fund and other such state and central funds	• District Collectors (DC) Fund for CSR activities • Companies can deposit their CSR fund in DCs' fund • A fund can be allocated to relief fund projects also	• DC CSR Fund for promotion of activities • Promoting government schemes such as Swatch Bharat Abhiyan, Beti Bachao Beti Padavo • PM or state relief fund for disaster management	• Contribution from proponent side

S. No	CSR Activities as per Schedule VII of Companies Act 2013	Project Specific Areas Identified	Project Specific Activities	Key Performance Indicators
7	Employment enhancing vocational skills	• Training to the Locals • Vocational Skill Development Programs to be promoted	• Training to be provided for employment enhancing skills • Promoting ITIs • Vocational Skill Development	• Records of enrolment and drop-outs • Record of trained personnel's employment status • Increase in number of seats in vocational skill development institutes • Feedbacks to be recorded • Grievance to be addressed
8	Social business project	• Promoting self-sustainable business opportunities	• Promote Self Help Groups by women	• Records of data to be maintained • Feedbacks to be recorded • Grievance to be addressed
9	Environmental Sustainability	• Sustainable development	• Optimum use of water resources and other available resources • Water Conservation Programs • Promoting sustainable development • Waste segregation & it's an appropriate disposal • Green belt development • Development of Cultural and Heritage Sites • Improving the biodiversity aspects	• Maintenance of records of increase in available water resources • Water Conservation programs to be promoted among industries as well domestic level locally • Maintenance of waste segregation and its disposal • Places of interest to be developed\ • Enhanced Biodiversity in the area

8.6.3 CSR Budget Allocation for Five Years (2021-26)

Considering the Socio Economic Study, Need based Assessment study, ongoing CSR activities/community consultations the future CSR intervention activities/areas were identified under the broad headings of Education, Community Health, Sustainable Livelihood Development and Community Development and activity wise budgetary allocations are made for Five years (2021-26) which is presented in **Table 8-3**.

Table 8-3: CSR Budget Allocation for Five Years (2021-26)

Sl No	Divisions	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Total 5 years
Total Budget For Five Years		3 Crs	3.5 Cr	4.0 Cr	4.5 Cr	5 Cr	21 Cr
Head Wise Break Up							
1	EDUCATION						
1.1	School Infrastructure Improvement (building, toilet. playground etc..)	0.5	0.5	0.75	0.75	1	3.5
1.2	Quality Enhancement Programme	0.1	0.1	0.1	0.1	0.1	0.5
2	COMMUNITY HEALTH						
2.1	Infra support to PHCs and other healthcare institutions	0.2	0.2	0.2	0.2	0.2	1
2.2	Equipments, Beds, furniture and fixtures to hospitals	0.1	0.1	0.1	0.1	0.1	0.5
2.3	Mobile Health Care Units & Health Camps	0.4	0.4	0.4	0.4	0.4	2
3	SKILL & LIVELIHOOD DEVELOPEMNT						
3.1	Village Skilling Centers	0.2	0.3	0.5	0.5	0.5	2
3.2	Livelihood Enhancement	0.2	0.2	0.3	0.1	0.2	1
3.3	Agri & Animal husbandry	0.1	0.1	0.1	0.1	0.1	0.5
3.4	Mangrove Protection	0.2	0	0.3	0.5	0	1
3.5	Green shield promotion	0.05	0	0.1	0.05	0.3	0.5
3.6	Community Sports	0.05	0	0.05	0.1	0.3	0.5
4.	COMMUNITY DEVELOPMENT						
4.1	Desilting of water bodies	0.1	0	0.2	0	0.2	0.5
4.2	Establish hand water pump	0	0	0	0.2	0.1	0.3
4.3	Check dams -water harvest	0.1	0.1	0.2	0.3	0.3	1
4.4	Renovation of open wells	0	0.1	0	0.1	0	0.2
4.5	Individual / Community Toilet facilities	0.5	0.5	0.5	0.5	0.5	2.5
4.6	Drainage facilities	0	0.2	0	0.3	0	0.5
4.7	Solid Waste Management	0	0.5	0	0	0.5	1
4.8	Village Roads	0.2	0.2	0.2	0.2	0.2	1
	Grand Total	3	3.5	4	4.5	5	21
An amount of Rs.21 Cr is proposed for the next five years of CSR at Kattupalli - MIDPL							

8.6.4 Sector–wise Expected Outcome from CSR Intervention

The community members in the project areas, especially the youth and women, are eager to participate in the development of themselves, their families and community for holistic development through suggested strategies and needs. MIDPL's CSR initiatives in these villages are expected to transform the lives of these communities, especially the women, youth and children. Further these CSR initiatives are expected to give a greater acceptance of MIDPL as a model corporate. The detail shows in below table.

Table 8-4: Sector- wise expected outcome from CSR Intervention

S. No.	Sector	Sector wise	Expected outcome from CSR Interventions
1.	Education	a. Toilet units for girl students	a. To facilitate personal hygiene and ensure clean environment and sanitation
		b. Compound wall	b. Ensure the security of the students, especially girl students.
		c. Soft skill training	c. Enhancing communication skills and self-confidence and increasing career competence
		d. Vocational training	d. To compete in the job market in future by acquiring a new skill
2.	ICDS		The early childhood education centre plays a vital role in the development of children, both psychologically and physically
3.	Livelihood	a. Ornamental fish culture	a. Self-employment venture to increase economic status
		b. Artificial reef installation	B. To enhance quantity and quality of fish species
		c. Dredging work	c. To prevent soil erosion and to facilitate boat movements
4.	Livelihood – Equipment	a. Boat engine and nets	Livelihood support for enhancing economic status and marketing avenues
		b. Providing mini trucks	-
5.	Health	a. Health infrastructure/ ambulance	a. Quality health care free of cost
		b.Health camps/awareness	b. Lifesaving help during the time of emergency
6.	Skill Development and enhancement	Skill Development Training	To equip as well as enhance employability skills among women and youth as an alternative source of livelihood
7.	Environment	Tree planting Water body management (Rivers & Pulicat Lake)	Improve ecology / greenery environment in the study areas
8.	Community hall	Construction of Community Hall	It enables the villagers to arrange functions within their area at nominal cost. Besides, it has multi-purpose social utility.
9.	Road & Transport	Link road and providing transport facilities	It facilitates mobility of the village people living in inaccessible areas to enhance their livelihood opportunities and access better educational and medical facilities.
10.	Women empowerment	Women groups	It enhances the quality of life for women and children
11	Youth development	Awareness of better life skills	Youth with better developmental orientation

Source: Primary study conducted by Madras School of Social Works, Chennai appointed by MIDPL

8.7 Induced Development

Due to the proposed Kattupalli port, apart from the surrounding region adjoining states would also get maximum benefits. The benefits may be realized either as upcoming of industries such as thermal power plants, mineral based plants, small scale industries and their allied ancillary units. Other benefits would be generation of either direct or indirect employment, self-employment and start-up skill development opportunities to the local people. The new connectivity through rail and road there will be a facility to improve the trading and marketing of local products as well as value addition of the local products. The connectivity will also improve the eco-tourism facility which will provide employment to the local people. The development of Kattupalli Port will be a boon for the development of the region

There will be a probable increase in the infrastructure resources due to the project in the region by the way of additional/improved transport, communication, health facilities and other basic facilities being created. Creation of new infrastructure or up-gradation of the existing infrastructure is likely to create a boost to the local economy and enhance the quality of life of the people living in and around the project region.

8.8 Generation of Employment

The project when fully operational also brings direct employment potential of about 1500 nos. hereby opening up employment opportunities for the youth in the catchment region. Additionally, the induced development due to the Port Expansion can bring indirect employment about 4500 people.

8.9 Improved Socio-economic Conditions

The proposed project is likely to have a positive impact on the socio-economic conditions of the region. The social structure in the region is likely to change due to the creation of more job opportunities and avenues for income generation. And there will be an improvement in living standards along with communication & transportation facilities. People are expected to have higher incomes due to direct as well as indirect employment and will have higher earning and buying capacities. And general welfare will also improve in the area as per capita income will go up in the post-project period.

8.10 Economic Impact of Project (Project Cost)

Total capital cost for the proposed Revised Master Plan development is estimated to be **INR.53, 031 Crores**.

8.11 Community Services/ Relief Measures Extended during COVID-19

8.11.1 Distribution if Food Packets

MIDPL under CSR initiatives extended the community services during the COVID-19 pandemic. MIDPL distributed 6338 sets of food packets in two phase (Phase 1 in April and Phase 2 in June 2020).

Adani Foundation, Kattupalli arranged 1168 & 5170 sets of food materials kits including 5kg rice, 1 kg Dhoor Dhall and Cooking Oil of 1 litre at the cost of Rs. 27 Lakhs to the poor fisherman (90%) and agricultural coolies (10%) families living in 25 hamlets spread in 6 of our intervention Panchayats in phases 1 & Phase 2.

Figure 8-17: Distribution of Relief Materials to Beneficiaries

8.11.2 Refrigerator, Computer and Steel Chairs to PHCs

MIDPL provided 6 refrigerators to store COVID medicines to five PHCs, two computers and printers for proper patient documentation and 10 triple sitter steel chairs for patients.

8.11.3 Distribution of PPE & Infrared Thermometer to Govt. Hospital

In order to keep the community hospitals ready with COVID protocols to screen patients, three infrared thermometers, sanitizers, N-95 masks and other patient's masks were provided to Government Hospital-Pulicat, PHC-Kattur and Kattupalli Panchayat Office during June 2020.

Figure 8-18: Distribution of PPE and Infrared thermometer to Govt. Hospital

8.12 Community Services Extended during NIVAR Cyclone Relief Measures

The socially backward Irular community is the worst affected in Nivar cyclone floods. 200 Irular individuals from Kulathumedu village of Pulicat Panchayat, 100 individuals from Senjiamman Nagar of Kottai Kuppam Panchayat and 50 individuals from Koraikuppam fishing village of Thangal Perumgulam panchayat have been displaced from their unsafe homes and moved to the Storm and Flood Relief Centres in the vicinity. The team members of Adani Foundation have actively worked during cyclone period (November 25 & 26, 2020) to ensure that the people who are in the Relief Camps have three meals a day.

Figure 8-19: Distribution of Food items to the Flood Affected Persons

8.12.1 Other Support Extended as Part of Cyclone Relief

- 500 Tarpaulins to protect 500 huts from continuous rain.
- 200 Sweaters to the people above 60 years of age in affected areas.
- 800 fishing nets to those lost the net due to cyclone.

Media Coverage

காட்டுப்பள்ளி அதானி துறைமுக அறக்கட்டளை
ஏற்பாட்டில் 5500 குடும்பங்களுக்கு நிவாரண பொருட்கள்
பொன்னேரி எம்எல்ஏ பலராமன் வழங்கினார்

Dhina Bhoomi dated to 13 June 2020

Makkal Kural dated to 13 June 2020

 மழைவெள்ளம் சூழ்ந்த பகுதிகளில் அதானி பவுண்டேசன் சார்பில் 350 குடும்பங்களுக்கு உணவு **Dhina Bhoomi dated to 29 Nov, 2020**	 திருவள்ளூர் மாவட்டத்தில் கடலோர பகுதி மக்கள் 350 பேருக்கு உணவு! **Media Coverage in local media about relief care offered for Nivar cyclone: Malai Murasu dated on 29 Nov. 2020**

8.12.2 CSR Support Completed / Progressing During the Financial Year 2020-2021

- 300 Bicycles to fishing community and other backward students of 9th class.
- 6 month Nutri Bars on every day to Mal Nourished Children from Panchayats.
- 200 iceboxes to Marine fishing community.
- Promotion of Kitchen garden and fruit bearing trees in communities.
- Village Sports Center in each Panchayat.
- 10 High Mast Light in nearby Panchayats.
- School sanitation facilities and other community infra projects.

Chapter 9
Environmental Management Plan (EMP)

Chapter 9 Environment Management Plan

The main objectives of Environmental Management are to:

- Identify key environmental issues envisaged to be encountered during construction and operation phases of the project
- Provide guidelines for appropriate mitigation measures
- Establish systems and procedures for implementing mitigation measures
- Ensure that the mitigation measures are being implemented
- Monitor the effectiveness of mitigation measures
- Take necessary prompt action when unforeseen impacts occur

9.1 Components of EMP

The environmental impact mitigation and avoidance measures for each likely impact on the prevailing environment have been discussed in detail at the respective sections in **Chapter 5**. The Environmental Monitoring Programme has been discussed in **Chapter 6**. Various project activities, associated impacts and mitigation measures are summarised in **Table 9-1**.

Table 9-1: Project Activities, Associated Impacts and Mitigation Measures

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
Construction Phase					
1.	Capital dredging/ Reclamation/ Disposal/ Construction of Approach Trestle/Berths and other offshore structures such as seawater intake/marine outfall	Marine water quality	– Increase in turbidity – Change in marine water quality due to aqueous discharges (oily waste, sanitary wastes) from dredgers, barges and workboats – Spill of Bentonite Clay during pile driving	– Check turbidity levels with baseline levels as reference during entire monitoring programme (dredging and reclamation periods) – Dredge Management Programme – Discharge of waste into sea will be prohibited – Oil Spill control measures will be adopted – Ensure that slop tanks are provided to barges/ workboats for collection of liquid/ solid waste – Recirculation/Reuse of Bentonite clay and adoption of better construction methods to minimise the spill on marine environment. – Adoption Standard Reclamation methods with containment system to retain the solid inside the reclamation area – Disposal of unused Dredged material at the identified offshore disposal area only. – Planning the environmentally hostile activities of the construction phase during lean fishing season – Proper disposal of dredged sediments into the dumping site (including reclamation site) with silt traps – Turbidity curtains to minimize sediment transport	Construction Contractor/MIDPL
		Marine ecology	Marine Ecology of this environment is already subjected to the changes due to maintenance dredging activities and hence the net impact will be minimal. Some of the likely impacts are: – Decrease in DO levels – Increase in noise levels – Disturbance to benthic communities – Changes in species diversity and density in areas adjoining dredging site – Smothering or blanketing of sub-tidal communities		
		Mangrove area	– Impact on mangrove towards north and west of project site	– MIDPL has excluded mangroves areas from the master plan development and no disturbance will be caused to the backwater located near the site. – Care shall be taken during reclamation and reclamation bund shall be constructed to ensure that no impact on mangroves. – Minimum 50 m buffer will be provided near the mangrove area and all the construction will be	

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				limited as per plan. – Discharge of toxic/hazardous materials during the port construction would not be allowed. – Revised Master Plan ensures the Tidal exchange near the mangrove area which is also ensured by of hydrodynamic modelling studies. – Dredge spoil should not be entered into mangrove area. – Awareness will be imparted to workers in the port about the importance of mangroves and their conservation – Monitoring of turbidity and sedimentation in the mangrove area	
		Fishermen and fishing villages	– Local Fishermen approach to sea – Impact on fishing due to Construction works – Fishing is being carried out at deep sea. Therefore, significant impact on fishing is not envisaged. –	– This is an existing port hence no direct impact is envisaged. – Signboards will be placed at the construction activities in order to make fishermen aware of the on-going construction activities – Necessary marker buoys will be installed – Regular Interactions will be initiated with the fishing community before commencement of construction works – Construction shall be limited to as per development plan.	
2	Material transport and construction activities	Air Quality	– Exhaust emissions from vehicles – Windblown dust during material movement – Fugitive dust during construction material unloading – Dust suspension during site preparation, construction – Emissions from DG Sets	– To reduce impacts from exhausts, emission control norms will be enforced /adhered. – All the vehicles and construction machinery will be periodically checked to ensure compliance to the emission standards. – Construction equipment and transport vehicles will be periodically washed to remove accumulated dirt – Providing adequately sized construction yard for storage of construction materials, equipment tools, earthmoving equipment, etc.	Construction Contractor/ MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				– Provide enclosures on all sides of construction site. – Movement of material will be mostly during non-peak hours. – On-site vehicle speeds will be controlled to reduce excessive dust suspension in air and dispersion by traffic – Water sprinkling will be carried out to suppress fugitive dust – Environmental awareness program will be provided to the personnel involved in developmental works – Use of tarpaulin covers and speed regulations for vehicles engaged in transportation	
		Noise	Noise from following activities – Vehicles transporting construction material – Diesel run engines of construction machinery and dredgers – Pile driving activities during construction of Approach trestle/cargo berths etc.,	– Noise levels will be maintained below threshold levels stipulated by Central Pollution Control Board /Tamilnadu State Pollution Control Board (CPCB/TNPCB) – Procurement of machinery / construction equipment will be done in accordance with specifications conforming to source noise levels less than 75 dB (A) – Well-maintained construction equipment, which meets the regulatory standards for source noise levels, will be used – Any equipment emitting high noise, wherever possible, will be oriented so that the noise is directed away from sensitive receptors – Noise attenuation will be practised for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers – High noise generating activities such as piling and drilling will be scheduled at daytime (6.00 am to 10 pm) to minimise noise impacts	Construction Contractor/ MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				– Personnel exposed to noise levels beyond threshold limits will be provided with personal protective equipment's such as earplugs, ear muffs, etc. – Ambient noise levels will be monitored at regular intervals. – Exercise route selection, traffic regulations, timings etc.,	
		Disturbance to Natural Drainage pattern	– Impact to natural flow of runoff due to reclamation and change of drainage course	– Storm water runoff will be directed as per the storm water drainage network proposed considering the existing drainage pattern and catchment area to carry storm water discharge from nearby area and port area into the sea. – Mathematical Modelling Studies shows Flow regime changes for various tidal conditions in the study domain after the proposed expansion development of the Port are predicted to be not of much significance and is limited to the development location mostly and found to be very much local in nature. No change in the flow regime of the rest of the domain is observed. – Implement the canal strengthening activities	Construction Contractor/ MIDPL
		Vegetation and Strain on existing infrastructure	– Loss of vegetation and strain on existing infrastructure. – Increase in existing road-based traffic	– The area being highly saline and Sea/Submerged inter tidal zone, only scattered vegetation is present in the proposed expansion area. – Construction activities shall be limited within the site and dust shall be contained within the construction area. – For easy evacuation of cargo, a new rail, road and utility corridor is also proposed within the existing port boundary – MIDPL plans to strengthen rail-based infrastructure in order to minimise the impact on the general road-based infrastructure	Construction Contractor/ MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
		Existing Traffic	– Traffic addition	– A 100 m wide ROW for Road Corridor is also proposed by TNRDC as Northern Port Access Road (NPAR) to connect both Ennore and Kattupalli Port to NH-5 which will improve the traffic conditions. – National Water Way (NW-4) will also be used for the transport of part of construction material which will reduce likely congestion on road. – Traffic Wardens shall be deployed for regulating the traffic – Drivers should be sensitized with respect to need to drive carefully while passing village areas. – Speed of the trucks shall be controlled by providing speed breakers, sign boards and other appropriate speed control techniques. – Proper lighting, signboards shall be provided at required locations.	Construction Contractor/ MIDPL
3.	Land Reclamation	Existing Water Resources like Groundwater and surface water	– Proposed expansion is planned in an additional area of 2472.85 ha which includes which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 Ha including basin and all developable area.. – The proposed development of master plan site falls in saline and Sea/Submerged intertidal area without much macro vegetation, habitation and built-up area. The proposed land to be reclaimed will be saline mud and will be separated from the adjoining land mass through the salt dyke. This being an intertidal zone which is sloping towards sea, therefore, there will be no impact on groundwater quality.	– Existing protective bunds (salt dyke) and slope gradient will prevent inundation of salt water to the adjoining land. – Return seawater from reclamation areas will be channelled back to sea.	MIDPL/Construction Contractor.

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
			– Construction phase water requirement will be met through existing and other sources		
4.	Solid Waste Management	Soil quality	– Impacts due to disposal of solid waste on ground	– Proper waste Management practice is being followed and shall be extended. – General refuse generated on-site will be collected in waste skips and separated from construction waste. – Solid Waste Management Rules, 2016 and Construction & Demolition Waste Management Rules, 2016 (as amended) will be followed for environmental sound management of respective waste – Other Construction waste will be used within port site for filling of low lying areas – Burning of refuse at construction sites will be prohibited.	MIDPL/Construction Contractor
5.	Handling of hazardous wastes	Human safety and property/ Environment loss	– Fire accidents due to hazardous material handling – Impact on Terrestrial and Marine Environment	– Hazardous and other waste Management Rules, 2016 (as amended) will be followed for environmental sound management of hazardous waste. – Adequate safety measures as per OSHA standards will be adopted – Construction site will be secured by fencing with controlled/limited entry points. – Hazardous materials such as lubricants, paints, compressed gases, and varnishes etc., will be stored as per the prescribed/approved safety norms. – Construction site will be secured by fencing with controlled/ limited entry points. – Medical facilities including first aid will be made available for attending to injured workers. – Handling and storage as per statutory guidelines. – Positive isolation procedures will be adhered	MIDPL/Construction Contractor

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				– Hazardous wastes will be disposed through approved TNPCB/CPCB vendors.	
7.	Water Resources	Water scarcity/Pollution	– Impacts to the surface water body	– Water required during construction activity will be met through existing and other water supply system. – Optimization of water resource will be done – Based on existing drainage pattern and catchment area, main outfall drains are proposed to carry storm water discharge from village area and port area and discharging into seas. – Care will be taken to prevent the runoff from the construction site to the nearby natural streams connecting to rivers. – Construction camp wastewater will be collected and treated. Treated wastewater will be used for Plantation/Greenbelt development.	MIDPL
Operation Phase					
1.	Cargo handling and Inland Cargo movement and storage areas , Regasification process and equipment operation such as pumps, compressors, etc.,	Air Quality	– Emissions from loading/unloading equipment, DG sets, vehicular dust emissions, fugitive emissions from storage areas, Emissions from vessels visiting Port, Vehicular emissions due to cargo transport, emissions from LNG/LPG regasification process, spillage of cargo etc., – Air Quality Modelling study is carried out to Predict the GLCs at the receptors due to Fugitive emissions from Dry bulk cargo stockyard and Vehicular movements, etc., and it is found that resultant concentrations are well within the NAAQs standards at all receptors.	– Most of the cargo transportation through rail and Pipelines (~ 70%). – Use of specialised ship loaders/unloaders, wagon tippler, track Hopper, covered conveyors and rapid loading system through silos – Use of -low sulphur diesel fuel is proposed. – Dust Suppression measures at loading/unloading points, wagon tippler complex, Track Hoppers, transfer points, stock yards, rapid loading system and at internal roads. – Scientific and regulated stacking of cargo piles. – Wind screens will be provided along stack yard. – Periodic cleaning of cargo spills. – Use of tarpaulin covers and speed regulations for vehicles/wagons engaged in transportation. – Greenbelt Development	MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				– Proper house keeping – Regularisation of truck movement – Vessels visiting the facility shall meet emission standards as per MARPOL. – Use of Eco friendly regasification technology such as Seawater based/ Ambient Air Based for LNG Regasification.	
		Noise	– Due to equipment handling and vehicular movement – Ship (un)loading operations – Due to Regasification Process and equipment operation	– Acoustic Barriers and Enclosures – Personal Protective Equipment (PPE) – Greenbelt Development – Counselling and traffic regulation	
		Traffic Addition	– Cargo movement from/to port	– Most of the cargo transportation through rail and Pipelines (~ 70%). – Proposed National Water Way (NW-4) will also be used for the transport of cargos which will reduce likely congestion on road. – In addition, for easy evacuation of cargo, a new rail, road and utilities corridor is also proposed.	
		Fishermen and fishing villages	– Local Fishermen approach to sea – Fishing is being carried out at deep sea. Therefore, significant impact on fishing is not envisaged.	– Kattupalli Port is an existing port, fishermen in the area are well aware of the existing port activities. Therefore, no direct impact is envisaged – Creation of awareness among the fishermen about proposed master plan activities is being done and will be continued – Providing adequate Marker buoys along the channel – Educate the fishermen about the orientation of approach channel and ships visits etc., – Regular interactions will be initiated with the fishing community – Conflicts, if any, with fishing community will be amicably resolved in all cases.	
2.	Aqueous	Marine water quality and	– Change in marine water quality/ecology due	– Vessels/Ships will be required to exchange	MIDPL have Waste Reception

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
	discharges in harbour basin	ecology	to discharge ship wastes (sullage), sewage, bilge water, Desalination Plant reject water, LNG/LPG regasification return water etc.	ballast water in a deep sea location prior to arrival in the harbour. – Ships are prohibited from discharging wastewater, bilge, oil wastes, etc. into the near-shore as well as harbour waters. – Ships would also comply with the MARPOL regulation. – As a mitigation measure for spillages, an Oil spill contingency plan is prepared and will be implemented. – Provision of waste reception facility for bilge water and waste oil will be provided. – Desalination Plant water requirement selected prudently and will be sourced from sea water and ensure that the reject TDS will be always less than the seawater TDS and hence no significant impact due to reject discharge into marine environment. – LNG/LPG regasification return water with low temperature (<7^{0}C than ambient) will be sent back through marine outfall system with diffusers at identified location through mathematical model studies which will ensures attainment of ambient conditions (within 600 m) in the harbour area – Marine Water Quality monitoring is proposed as a Part of Environmental Monitoring	Facility/ Suitable arrangements and will provide regulations to vessel operators
3.	Cargo and Oil spills (Accidental)	Marine water quality and ecology	– Change in marine water quality	– In case of any cargo spillage during transfer from/to ships, it will be attempted to recover the spills. – Oil spill control equipment such as booms / barriers will be provided for containment and skimmers will be provided for recovery. – Response time for shutting down the fuelling, containment and recovery will be quicker.	MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
4.	Maintenance dredging	Marine water quality/Marine Ecology	– Increase in turbidity – Decrease in DO levels	– It will be ensured that dumping of the maintenance dredge material would be uniform at the identified offshore disposal ground. – Dredge spoil disposal studies reveals that the changes in bed level at disposal site due to deposition of dredge spoil is less than 0.28 m. The spread of plume is also ensured that it will never reach the channel, shoreline and other eco sensitive areas. – Pre and post dredge material disposal bathymetry survey at disposal location shall be carried out – Based on the TSS/Turbidity monitoring results during dredging, nearby receptors if any impacted would be provided with suitable mitigations measures such as silt screen to contain the turbidity.	Dredging Contractor/MIDPL
5.	Water Supply	Water resources	– Impact on existing water resources	– Raw water shall be taken from Sea water. The maximum water withdrawal shall be 75 MLD (for 30 MLD desalination plant). – LNG/LPG water withdrawal shall be 2880 MLD – Necessary permission (if required) will be obtained from the concerned authorities for revised Master plan requirements.	MIDPL
6.	Wastewater Discharge	Water Quality	– Impact due to discharge of runoff from stock piles and disposal of untreated sewage. – Impact due to discharge of brine (reject from Desalination plant) runoff from stock piles and disposal of untreated sewage	– Collection of runoff from stock piles and directing into settling ponds for recycling and supernatant water will be used for dust suppression. – Neutralisation using lime/caustic alkali to ensure settlement of heavy metals, if any. – STP to treat the sewage generated in the premises. – ETP to treat the effluents – Storm Water Drainage System for collection / harvest and reuse	MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				– Treated Sewage and effluents shall be reused for dust suppression, irrigating greenbelt and other requirements	
7.	Seawater withdrawal for Regasification and water withdrawal from Sea water for desalination plant	Marine ecology/ River Ecology	– Impingement/Entrainment/Entrapment of aquatic life	– Intake with proper screens will be Provided – Maintaining Low Intake Velocity to minimise the Entrainment & impingement – Intake is proposed near breakwater – Entrapment will be insignificant	MIDPL
8.	Solid Waste Management	Groundwater and Soil quality	– Impact due to disposal of solid waste on ground	– 5 R (Reduce /Reuse/Recover/Recycle and Re Process) principle shall be explored – STP sludge will be used as manure in green belt. – Organic Waste Convertor will be provided. Composted bio-degradable waste will be used as manure in greenbelt/ gardens – Other recyclable wastes will be sold to TNPCB authorised vendors. – Commercial use will be explored for the materials settled in dump pond	MIDPL
9.	Handling of hazardous materials/wastes	Fire accidents due to products handling and other health hazards/ Groundwater and soil contamination.	– Human life and loss of property – Impact on Terrestrial and Marine Environment	– Hazardous and other waste Management Rules, 2016 (as amended) will be followed for environmental sound management of hazardous waste. – Adequate safety measures as per OSHA standards will be adopted – Hazardous materials such as lubricants, paints, compressed gases, and varnishes etc., will be stored as per the prescribed/approved safety norms. – Medical facilities including first aid will be made available for attending to injured workers. – Handling and storage as per statutory	MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
				guidelines. – Positive isolation procedures will be adhered – Hazardous wastes will be disposed through approved TNPCB/CPCB vendors or shall be given to nearby approved cement industry for co-processing. – Risk analysis has been carried out and suggested risk mitigation measures shall be adopted. – Emergency alarms, provision of fire hydrant system and fire station. – Effective Disaster Management Plan (DMP) which covers onsite and offsite emergency plans. – Recovery of spills to the maximum extent possible.	
10.	Presence of Breakwaters	– Shoreline Changes – Change in Hydrodynamics	– The shoreline modelling studies shows that existing breakwaters impact the maximum shoreline changes are around 303m for the 1km stretch of shoreline immediate north of port. The maximum shoreline erosion is around 198m at 2km from north of the port and around 31m at 3km from north of the port breakwater. Thereafter, the shoreline is stable and subjected to no erosion and deposition – Proposed breakwater development of master plan after 15 years the shoreline erosion of the order of 200m is predicted immediate north of the proposed northern breakwater – Flow modelling shows that Variation in the flow regime (in the current speeds) after the expansion is limited to the development location mostly and found to be very much local in nature. No change in the flow regime	– Monitoring of shoreline with the help of high resolution satellite imageries during operation phase shall be carried out periodically. – Based on the monitoring results and if required, appropriate remedial measures such as beach nourishment/ creation of sand trap/ any other suitable methods shall be carried out to maintain the stability of coast	MIDPL

S. No.	Activity	Relevant Environmental components likely to be impacted	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsible Agency for Implementation
			of the rest of the domain is observed.		
11.	Operation of port	Socio-economic conditions of the region	During operational phase the expected direct and indirect employment will be 1500 persons and 4500 persons during development. Local people will be given preference based on their qualification and skill set. Together with this employment potential, project will help to enhance the socio economic conditions of the area with better schooling, communication and transport facilities that will be developed/ triggered as a part of overall economic development of the region.		
		Natural Hazards	Disaster Management Plan (DMP) is already in place and will be continued after expansion also with required revisions. Port Conservator will act as the overall in-charge of the control of educative, protective and rehabilitation activities to ensure least damage to life and property.		
		Induced Development	Offers an efficient and cost effective supply chain/value proposition to the local importers and exporters in the state. Also serves as an alternative gateway to ports on the east coast of India		

9.1.1 Administrative and Technical Setup for Environmental Management

MIDPL has appointed a specific Management Representative, Environmental Head and a Site Environmental Officer who have defined roles, responsibilities and authority for:

- Ensuring that an Environmental Management System is established implemented and maintained in accordance with the requirements of ISO 14001.
- Reporting to top management on the performance of the Environmental Management System for review, including recommendations for improvement.

MIDPL's Environmental Department has a team of dedicated staff to:

- Identify environmental aspects, normal, abnormal and emergency conditions
- Ensure implementation of standard operating procedures as updated from time to time
- Evaluate any non-conformity to the environmental standards, as stipulated by different regulatory agencies.
- Ensure and implement necessary corrective actions
- Establish procedures for reporting, document and record control
- Establish and implement procedures for incident and near miss reporting, investigation and root cause analysis and prescribe corrective action.

9.1.2 Institutional Mechanism for Implementation of Mitigation Measures

The effective implementation and close supervision of the environmental management to mitigate the environmental impacts, which are likely to arise due to the construction and operational phases of the project could be achieved through a suitable institutional mechanism. The proposed institutional mechanism recommended for the implementation of the mitigation measures is presented in **Figure 9-1**.

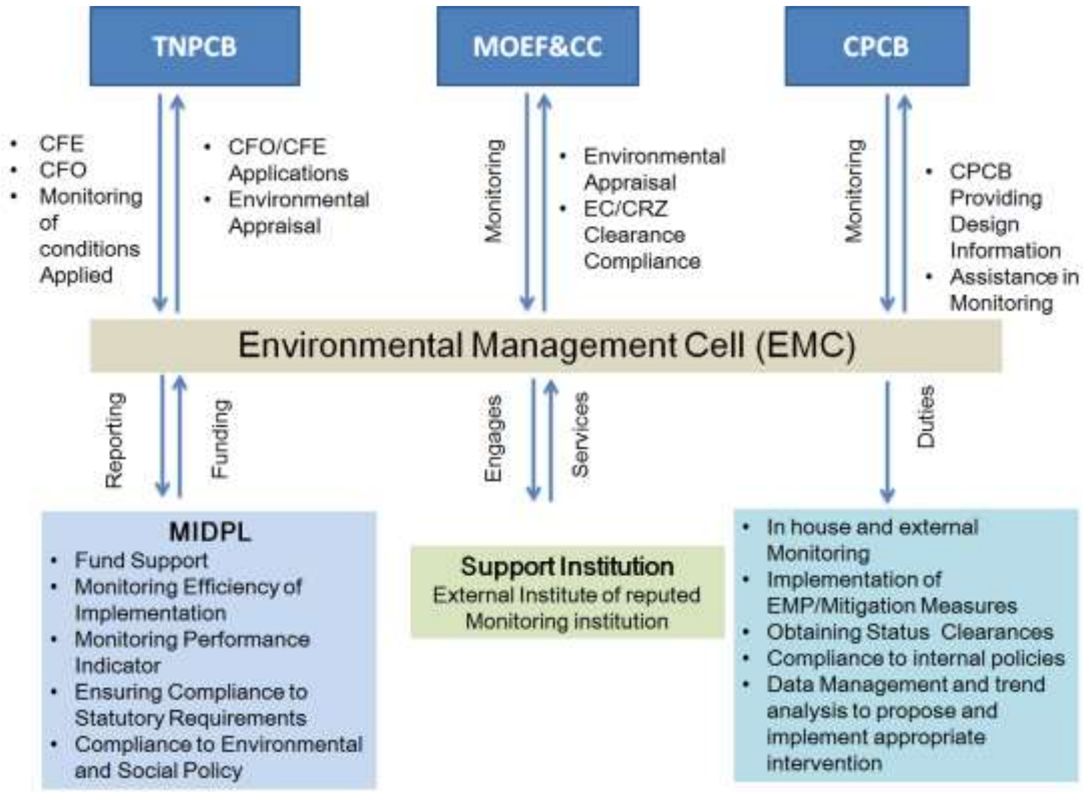

Figure 9-1: Institutional Mechanism for Implementing Mitigation Measures

A proper institutional mechanism to understand and implement appropriate environmental management measures during various stages of the project is a prerequisite and has a strong bearing for the overall success of the project management. Implementation of the Environmental Management measures will become easy once a good project management team is in place.

9.2 Environmental Management Cell (EMC)

The Organizational Setup for Environmental Management Cell (EMC) for MIDPL is given as **Figure 9-2**.

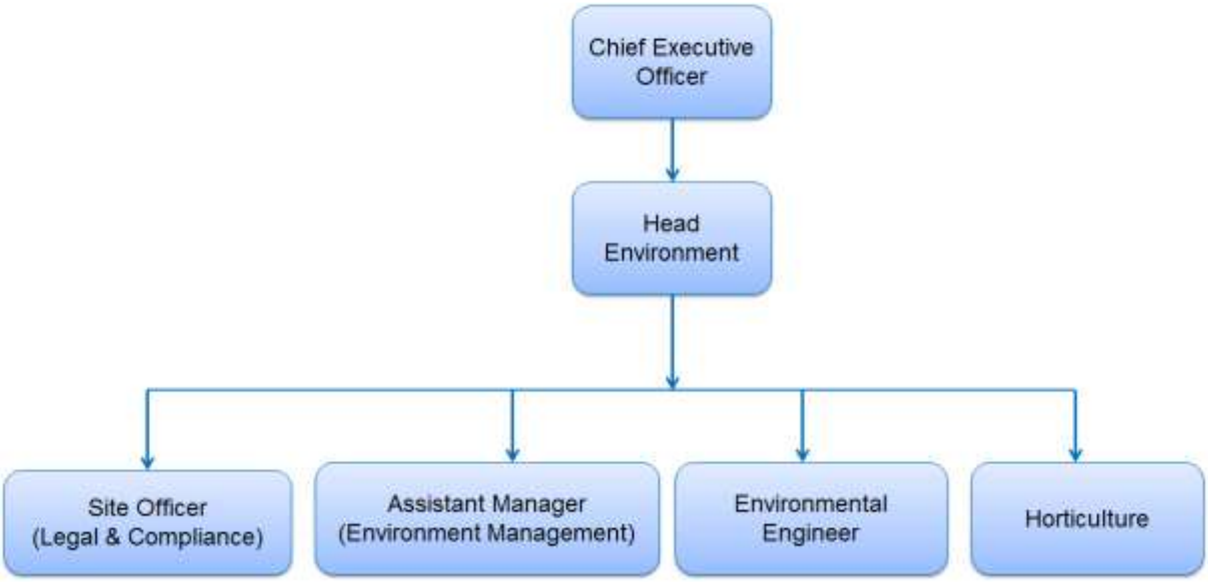

Figure 9-2: Organizational Setup for Environmental Management Cell

9.3 Greenbelt Development Plan

Kattupalli Port has made plantation around 16.73 ha. inside Port Complex. A proper greenbelt plan for Kattupalli Port is envisaged for the proposed project. The greenbelt programme is proposed in phased manner. Further plantation will adopt the following additional guidelines along with the executing plans.

Existing green belt area are shown in the below

Existing green belt plantation with *Peltophorum pterocarpum*

	
Existing avenue plantation with *Peltophorum pterocarpum*	Existing green belt plantation with *Cassia fistula*
	
Woodlot plantation in the port	Samplings of *Ficus religiosa*
	
Existing Greenhouse Nursery in the port premises	

Exhibit 9-1: Existing green belt blocks maintained in the port premises

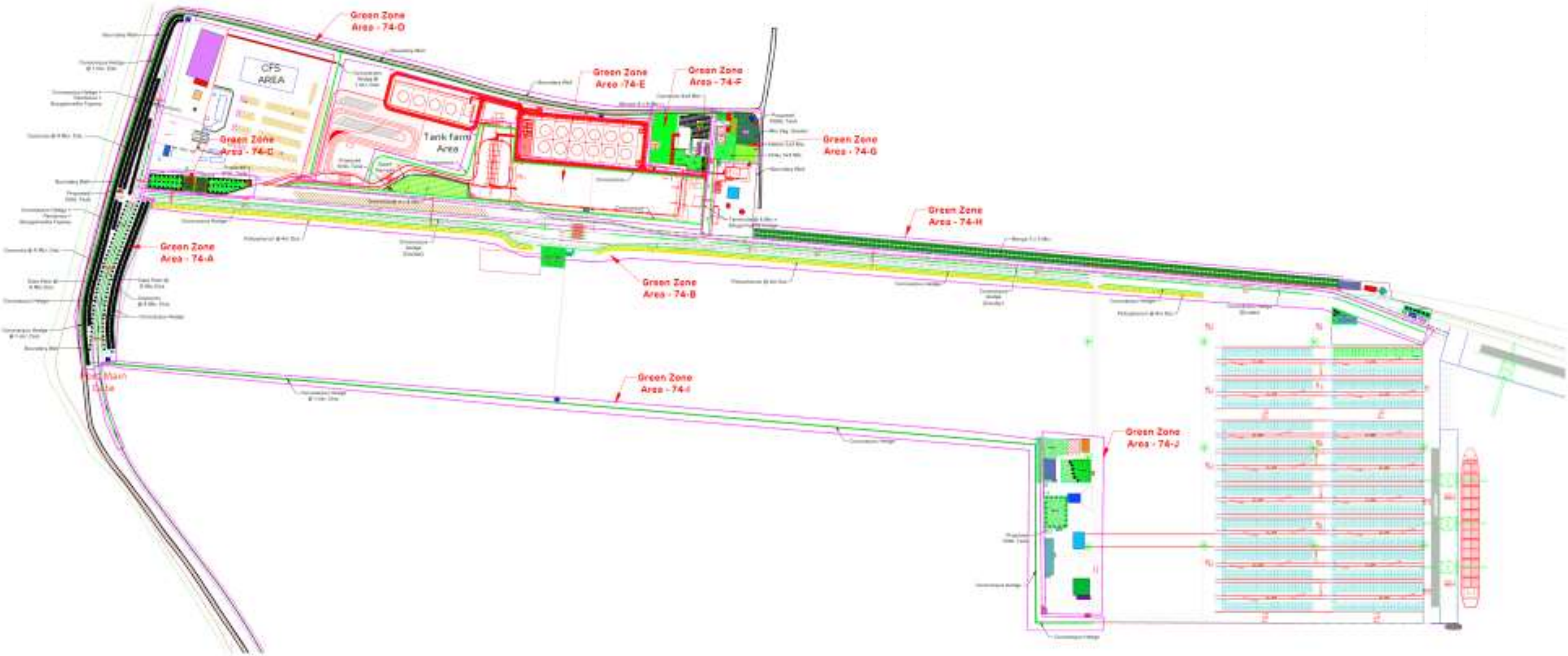

Figure 9-3: Green Areas of Existing Kattupalli Port

9.3.1 Greenbelt Development - Master Plan

Adequate green peripheral buffers are provided all along the port load ward boundary. About, **241 acres (97.5 Ha)** of land is delineated for green space of the total project area. Greenbelt of suitable width along boundary (as feasible) & dusty cargo storage area will be developed.

9.3.2 Guidelines for Plantation

The plant species identified for greenbelt development will be planted using pitting technique. The pit size will be either 45 cm x 45 cm x 45 cm or 60 cm x 60 cm x 60 cm. Bigger pit size is preferred on marginal and poor quality soils. Soil proposed to be used for filling the pit will be mixed with well decomposed farm yard manure or sewage sludge at the rate of 2.5 kg (on dry weight basis) and 3.6 kg (on dry weight basis) for 45 cm x 45 cm x 45 cm and 60 cm x 60 cm x 60 cm size pits respectively. The filling of soils will be completed at least 5 - 10 days before the actual plantation. Healthy seedlings of identified species will be planted in each pit.

9.3.3 Species Selection

Based on the regional background and soil quality, greenbelt will be developed. In greenbelt development, monocultures are not advisable due to its climatic factor and other environmental constrains. Greenbelt with varieties of species is preferred to maintain species diversity, rational utilization of nutrients and for maintaining health of the trees. Prepared in this way, the greenbelt will develop a favorable microclimate to support different micro-organisms in the soil and as a result of which soil quality will improve further. Manure and vermin-compost may be mixed with the soil used for filling the pit for getting better result for survival of plant species. Adequate watering is to be done to maintain the growth of young seedlings. Based on the regional background, extent of pollution load, soil quality, rainfall, temperature and human interactions, a number of species have been suggested to develop greenbelt in and around the port. These species can be planted in staggering arrangements within the port premises. Some draught resistant plant species have been identified which can be planted for greenbelt development if sufficient water is not available. The suitable species for greenbelt development programme are given in **Table 9-2**: and **Table 9-3**.

The species suitable for planting in the area as recommended by Central Pollution Control Board in their publication “Guidelines for Developing Greenbelts” (PROBES/75/1999-2000) are followed.

9.3.4 Design of Green Belt

Green belt will be developed as per CPCB guidelines with concept of three tier greenbelt development with tall, medium and short height in general.

A survey was conducted with respect to existing forest types and vegetation diversity in the study area for development of greenbelt around project components. The following guidelines will be considered in green belt development.

- The spacing between the trees will be maintained at 3 x 3m
- Planting of trees in each row will be in staggered orientation
- It is to be ensured that in the front row shrubs will be grown.

- The short trees (<10 m height) will be planted in the first two rows of the green belt. The tall trees (> 10 m height) will be planted in the outer three rows
- One line of tall trees and another line of short trees will be planted to reduce the noise.
- Preparation of manure pits
- Expose the manure pits to direct sunlight for about 15 days and
    - If the soil at the site is reasonably good, pits will be filled with 80% site-soil + 20% composted cow-dung. About 200gm Neem-cake and leaf-litter, grass or agricultural residue will be added
    - If the soil at the site is poor, pits will be filled with 35% site-soil + 35% fertile soil (from an external source) + 30% composted cow-dung. Neem-cake and other organic matter will be added as in the previous instance
- Saplings will ideally be planted after the annual rains begin. The saplings would need to be watered once the rains cease.
- Saplings will be suitably nurtured and maintained. Soil conditioning and fertilizer application shall be undertaken. If required, suitable soil treatment shall be provided to ensure good growth of tree cover.
- Construction of temporary shelters of locally available materials such as bamboo and grass around the growing saplings is recommended in the summer, to help the plants withstand the hot sun.
- During construction period
    - Ground-vegetation should be allowed to shed seeds before cutting or moving it for mulching. This would leave behind a seed-bank to flourish in the next growing season, providing a natural source of mulch for the following year.
    - Open burning of bushes and other waste on land must be avoided, as it reduces soil-quality, and harms the ground-vegetation, amphibians, reptiles and ground nesting birds.
- Development of greenbelt will start with construction phase and will be continued full-fledged with operation phase.
- As a part of improving biodiversity, areas need to be ear marked for the growth of creepers that are always neglected in green belt development category. Creepers are becoming increasingly threatened due to lack of concern and selective dereliction of this species.

The indicative sketch of three tier greenbelt development is given in **Figure 9-4**.

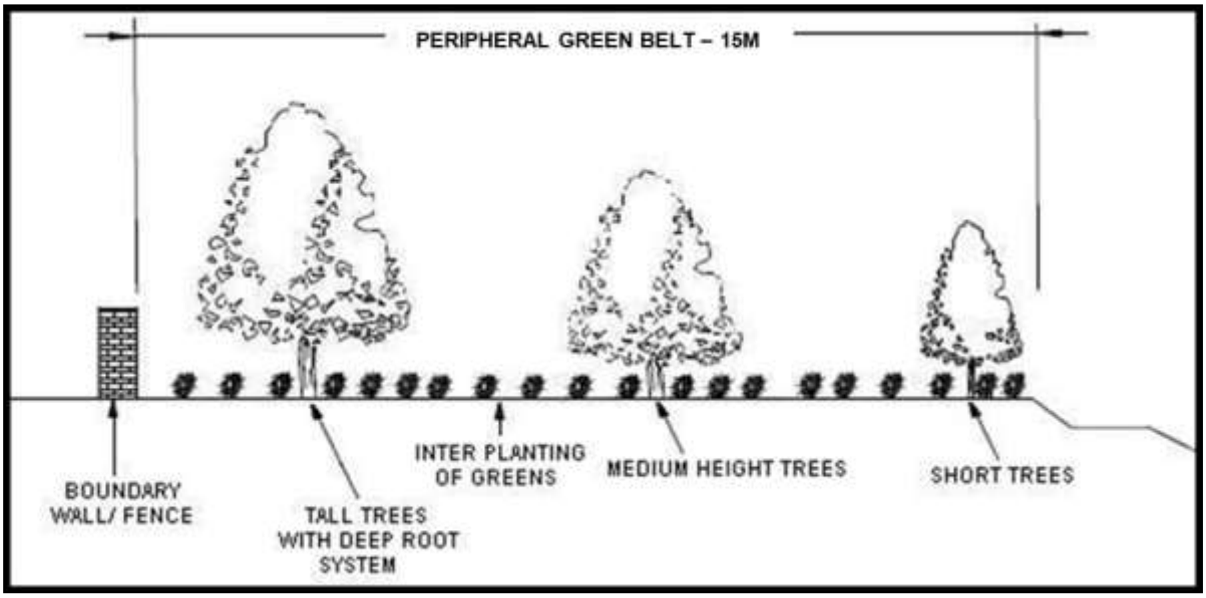

Figure 9-4: Indicative Sketch of Three Tier Greenbelt Development

9.3.5 Cost estimations for Greenbelt Development

Approximately **241 ac.** of green area proposed to be planted in port premises. The survival of the plantation shall be monitored frequently and survival rate of the plantation during operational phase shall not be less than 90%.

A capital cost of **INR 9.55 Crores** shall be earmarked for this purpose and **INR of 1.77 Crores** shall be allocated for recurring expenses per annum towards green belt development and maintenance. The capital and recurring cost will be spent over a period of time based on the port development plan at project site. The lay out plan of the green plant and green areas in project site is depicted in **Figure FD0203**. Greenbelt shall develop be at other suitable areas.

9.3.6 Recommended Species for Plantation

Based on climate and soil characteristics of the study area, some species are recommended for plantation. The climate of the region is extreme where there is rainfall as well as extreme heat and soil temperature in summer. The pollutants from stack, dust/fugitive emissions namely sulphur dioxide, smoke and carbon dioxide along with the noise pollution can be effectively curbed by planting specific floral species. The recommended species for greenbelt and plantation are given in **Table 9-2**.

Table 9-2: List of tree species suggested for green belt development

S. No.	Botanical name	Common/Local name	Importance
Trees preferable towards the coastal side			
1.	*Casuarina junghuhniana*	Savukku	Adaptable to saline soils
2.	*Acacia auriculiformis*	Kaththi Karuve	Fast growing, Adaptable to saline soils
3.	*Pongamia pinnata*	Pungai	Shady, Fast growing, Adaptable to saline soils
4.	*Mimusops elengi*	Magadam	Native and Adaptable to saline soils
5.	*Alstonia scholaris*	Ezilai piLLai	Broad leaved, Ever green & Fast growing
6.	*Polyalthia longifolia*	Nadunar	Fast & Tall growing
7.	*Ailanthus excelsa*	Pi-Nari Maram	Shady & Fast growing, Adaptable to saline soils
8.	*Calophyllum inophyllum*	Punnai	Shady, aesthetic & Fast growing
9.	*Borassus flabellifer*	Talam	Tall growing, resistant to winds

S. No.	Botanical name	Common/Local name	Importance
10.	*Syzygium cumini*	Nagai	Shady & Fast growing, Adaptable to saline soils
11.	*Thespesia populnea*	Puravasu	Shady & Fast growing, Adaptable to saline soils
Trees preferable rest of the port area			
12.	*Azadirachta indica*	Neem	Shady, Pollutant absorbing, Adaptable to saline soils & Fast growing
13.	*Samanea sama*	Amaivagai	Shady, Fast growing, Adaptable to saline soils
14.	*Melia dubia*	Malai vembu	Shady, Pollutant absorbing , Adaptable to saline soils & Fast growing
15.	*Neolamarckia cadamba*	Arattam	Shady, aesthetic & Fast growing
16.	*Gmelina arborea*	Kumul	Broad leaved, Drought tolerant & Fast growing
17.	*Manilkara zapota*	Chappotta	Fruiting bearing
18.	*Holoptelea integrifolia*	Tambachi	Shady, Pollutant absorbing, Tall & Evergreen
19.	*Mangifera indica*	Mamaram	Fruiting bearing
20.	*Spathodea campanulata*	Patadi	Ornamental avenue, bird attracting tree
21.	*Tamarindus indica*	Puli	Fruiting bearing
22.	*Tectona grandis*	Teak	Timber yielding
23.	*Terminalia arjuna*	Marutu	Timber and shade tree, Adaptable to saline soils
24.	*Mitragyna parvifolia*	Neerkkadambai	Shady, Native & Fast growing
25.	*Psidium guava*	Segappu koyyaa	Fruiting bearing
26.	*Artocarpus heterophyllus*	Palaa	Broad leaved & Fast growing
27.	*Dendrocalamus strictus*	Kattu-munkil	Tall growing
28.	*Bombax ceiba*	Mullilavu	Attractive & Tall growing
29.	*Plumeria alba*	Perungali	Broad leaved, Fast growing and Adaptable to saline soils
30.	*Plumeria rubra*	Perungali	Broad leaved, Fast growing and Adaptable to saline soils
31.	*Millingtonia hortensis*	Mara Malli	Attractive & Tall growing

Table 9-3 List of Shrubs & Herbs proposed for plantation between the trees

S. No.	Scientific name	Common Name
1.	*Agave cylindrica*	Kitha nara
2.	*Tecoma stans*	Sonnapatti
3.	*Nerium oleander*	Chevarali
4.	*Euphorbia nill*	Euphrobia
5.	*Durantha repens*	Durantha
6.	*Murraya paniculata*	Karu-veppilai
7.	*Bambusa vulgaris*	Nama-tari
8.	*Vitex negundo*	Nocchi
9.	*Aloe vera*	Kathalai
10.	*Tagetes patula*	Tulukka Samandi
11.	*Bougainvillea glabra*	Kantankattiri
12.	*Nyctanthes arbor-tristis*	Parjatamu
13.	*Ixora coccinea*	Vedchi
14.	*Hibiscus rosa-sinensis*	Shamberattai
15.	*Duranta repens*	Saamandi
16.	*Clerodendrum inerme*	Pincal
17.	*Caesalpinia pulcherrima*	Mayurkonrai

9.3.7 Post Plantation Care

Immediately after planting the seedlings, watering will be done. The wastewater discharges from different sewage treatment plant / out falls will be used for watering the plants during non-monsoon period. Further watering will depend on the rainfall. In the dry seasons watering will be regularly done especially during February to June. Watering of younger saplings will be more frequent. Organic manure will be used (animal dung, agricultural waste, kitchen waste etc.). Younger saplings will be surrounded with tree guards. Diseased and dead plants will be uprooted and destroyed and replaced by fresh saplings. Growth / health and survival rate of saplings will be regularly monitored and remedial actions will be undertaken as required.

For irrigation the inline to conventional methods drip and sprinkler systems shall be applied according the feasibility.

Drip Irrigation

Drip irrigation is a low-pressure, low-volume lawn and garden watering system that delivers water to home landscapes using a drip, spray or stream. A drip irrigation system keeps roots moist, but not soaked, all while using less water than other irrigation techniques.

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favorable high moisture level in the soil in which plants can flourish.

Drip irrigation is suitable for most soils. On clay soils water must be applied slowly to avoid surface water ponding and runoff. On sandy soils higher emitter discharge rates will be needed to ensure adequate lateral wetting of the soil.

Drip irrigation is particularly suitable for water of poor quality (saline water) like soil of proposed development where saline content is due to saline back water influence. Dripping water to individual plants also means that the method can be very efficient in water use. For this reason it is most suitable when water is scarce. he water savings that can be made using drip irrigation are the reductions in deep percolation, in surface runoff and in evaporation from the soil.

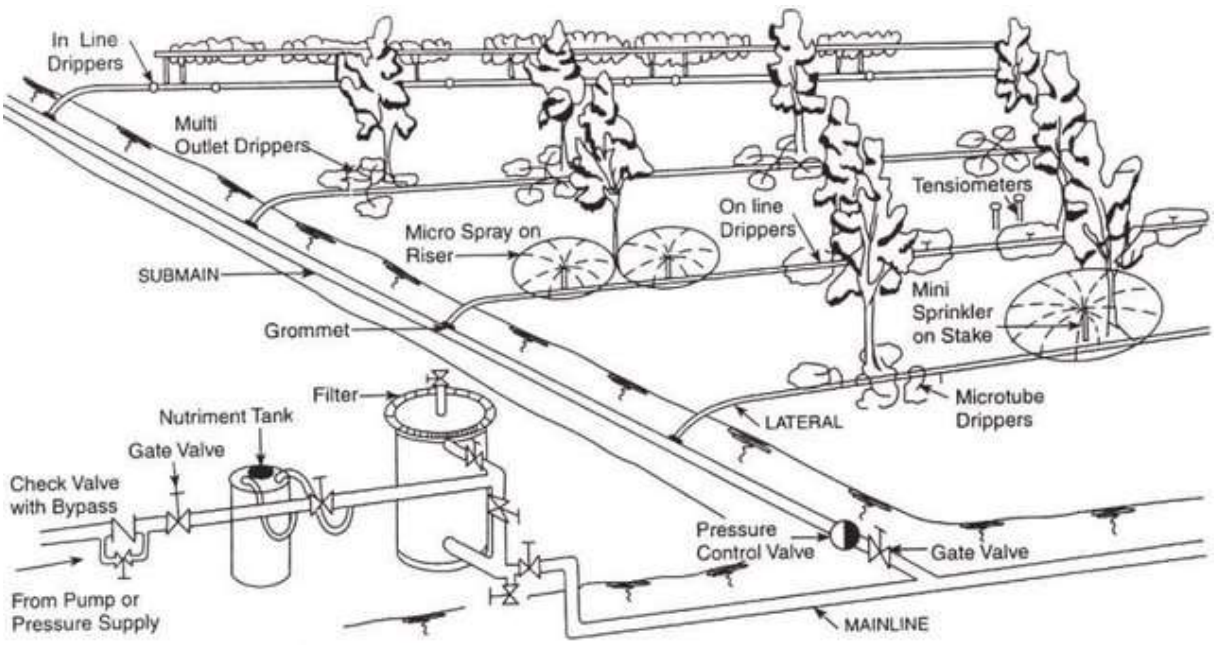

Figure 9-5: A typical Sketch of micro irrigation technique

Sprinkler Irrigation

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy. Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils.

As water sprays from a sprinkler it breaks up into small drops between 0.5 and 4.0 mm in size. The small drops fall close to the sprinkler whereas the larger ones fall close to the edge of the wetted circle. Large drops can damage delicate crops and soils and so in such conditions it is best to use the smaller sprinklers.

Drop size is also controlled by pressure and nozzle size. When the pressure is low, drops tend to be much larger as the water jet does not break up easily. So to avoid crop and soil damage use small diameter nozzles operating at or above the normal recommended operating pressure.

Figure 9-6: A typical example of Sprinkler irrigation

9.4 Conservation Strategies for Terrestrial Biodiversity

9.4.1.1 Conservation Plan for IWPA Scheduled I Fauna recorded in the 10 km buffer area

Wildlife management is the application of scientific knowledge and technical skills to protect, conserve, limit, enhance, or conserve the existing wildlife habitat. Wildlife management also includes implementing laws regulating wildlife management tools to the area of interest.

9.4.1.2 Conservation Plan for Indian peafowl (*Pavo cristatus*)

General Description: Indian Peafowl (*Pavo cristatus*) is the largest of all pheasants and has been declared as the national bird of India since 1963 due to its flagship value founded on its glorious position in Indian mythology. It is believed to be widely distributed (IUCN Red List) and is fully protected under the Indian Wildlife Protection Act, 1972. Despite the immense protection and wide distribution, the species is becoming locally extinct from several parts of its former range due to habitat conversion and changes in the cropping pattern, human interference, poaching, and pesticide-related issues.

Distribution: The Indian peafowl is a resident breeder across the Indian subcontinent and is found in the drier lowland areas of Sri Lanka. Besides its native habitat, the bird has been introduced by humans to the United States, Mexico, Brazil, Uruguay, Argentina, South Africa, Madagascar, Mauritius, Indonesia, Papua New Guinea and Australia. Global distribution of Indian peafowl is shown in the **Figure 9-7**.

Habit and Habitat: Peacocks are commonly found in dry areas, Forest areas and near the settlements. The male peacock has enormous tail feathers that fan out behind the peacock and can be nearly two meters in length. The peacock is an omnivorous bird and feeds on insects, plants, seeds, small mammals, reptiles and flowers.

Population Status: In the absence of reliable information and data, it is hard to place the current distribution status and population size of the species; although a conservative 'guesstimate' suggests that the population may exceed 100,000. While the species is becoming locally extinct from several parts of its former range due to habitat conversion and changes in the cropping pattern, poaching and pesticide related issues.

Conservation Status: The Indian peafowl is listed as least concern species in the red list of international union for conservation of nature (Bird Life International, 2008), probably owing to its widespread distribution, occurrence of locally abundant semi-feral populations, and protection from people on religious grounds. In India, it is given the utmost protection by inclusion in the Schedule-I of Wild Life Protection Act in 1972.

Figure 9-7: Global distribution of Indian peafowl (*Pavo cristatus*)

Major Threats: The demand for feathers and wild meat, conflict with farmers during cropping season. Increased use of chemical fertilizers and pesticides in the agricultural practices Causalities caused by eating chemically treated agricultural crop seeds, Habitat degradation and Fragmentation by conversation of forest habitat into agriculture and habitation activities.

9.4.1.3 Conservation Measures for Indian Peafowl:

Habitat Improvement:

Habitat improvement programme will be undertaken through plantation of suitable tree, shrubs and grass species in the surrounding villages adjacent to the open areas. While selecting the tree/ shrub species care shall be taken for fruit bearing trees which attracts these birds for roosting.

Water Filling:

Adjacent to the scrub lands artificial water holes should be created along the natural drained canals which can provide sufficient drinking water up to summer of the region. Awareness:

Awareness programmes:

Awareness programmes (community and school level) will be conducted for conservation of peacocks in the area and also through organizing competitions during “Wildlife Week” and “Van Mahotsav” other important Environment day’s celebrations. In school of nearby villages for peacock conservation Drawing Competition. (Peacock Picture) & Essay Writing on Peacock etc. shall be organised.

9.5 Marine Biodiversity Management Plan

Marine biodiversity is very important in terms of ecology and economy. Blue economy has been given priority in recent years. The biodiversity of a marine ecosystem is fragile and suffers when physical, chemical or biological parameters are changed. In view of the ecological and economic benefits of biodiversity, the developmental activities along the coastal belt have to be carried out with utmost care by following all measures of conservation, management and protection.

Effective conservation and management plans should be in place to mitigate the impacts of project activities. Monitoring of biological parameters in and around the project site is warranted for any developmental activity. Such monitoring carried before, during and after the developmental activity would help to better manage and minimize the impacts as well as to take appropriate remedial measures through effective mitigation actions.

MIDPL approached the Suganthi Devadason Marine Research Institute (SDMRI) for study the biodiversity of the project region and preparation of Marine Biodiversity Management Plan in line to ToR conditions specified by MoEF&CC.

SDMRI assessed the Biodiversity of Marine, Brackish Water and Fresh Water Ecosystems by conducting comprehensive surveys and baseline data was generated same was presented in **Chapter 3**. Based on the baseline observations Impact Assessment and Management Plan was prepared. SDMRI report on Comprehensive Biodiversity Assessment and Management Plan ais attached as part of Volume 2 of this report.

9.5.1 Impacts on the environment and biodiversity due to the proposed activities during construction phase

The major activities undertaken during the construction and operation phases that could potentially impact the marine environment include

9.5.1.1 Anticipated Construction Phase Impacts

1. Dredging and Reclamation Activity

9.5.1.1.1 Impact on Benthic Organisms

- Benthic organisms will suffer the maximum damage as they are directly affected.
- Sedimentation in the dredged channel would likely be heavy and would also affect all the benthic organisms.
- Sedimentation caused by dredging could potentially bury the benthic organisms in the nearby region.
- Dumping of dredged soil is also likely to affect all the benthic organisms in the dumping site apart from causing excessive sedimentation.

9.5.1.1.2 Impact on Plankton and Productivity

- Increasing the suspended sediment concentrations, sediment deposition and turbidity
- Reduced light penetration, decrease in photosynthetic efficiency and primary productivity in the water column
- Changes in circulation pattern and littoral sediment transport
- Project activities would affect the nutrient movement and plankton density

9.5.1.1.3 Impact on Fishery Resources

- The impact on plankton community and benthic organisms would directly affect the fishery resources
- Increased turbidity may cause significant changes in fish behaviour, which include avoidance, disorientation, decreased reaction time, increased or decreased predation, increased or decreased feeding activity, and physical injury and even mortality.
- Noise generated during dredging would force the fishes in the area to move away.
- Suspended sediment concentration in the dredging and reclamation sites influences the fish availability in the area.
- At the dredging zone, smothering of eggs in spawning grounds is likely to reduce the fish population.
- Benthic fishery resources such as shrimps and crabs will be disturbed and dislocated and hence their population is likely to be affected during dredging operations.

2. Construction of Breakwater, SBM and Berths

9.5.1.1.4 Impact on Benthic Organisms

- Intertidal and subtidal benthic organisms will be the primary victims
- Changes in bathymetry potentially affect all the benthic macrofauna such as molluscs, and other organisms.
- Sediment movement and could affect the inter-tidal and sub-tidal benthic organisms
- Sand dunes and coastal vegetation that occur in the immediate vicinity of the port will likely be affected

9.5.1.1.5 Impact on Plankton and Productivity

- Likely to affect the current pattern and nutrient circulation
- Current circulation will affect the flushing of sea water inside the proposed port
- Wave energy transformation near the construction sites will also have its impact on plankton and productivity

9.5.1.1.6 Impact on Mangroves and Associated Biodiversity

- The possible alteration in the flushing is likely to affect the dependent mangroves and associated biodiversity
- Shoreline changes caused by the proposed construction would destabilize this area causing damages to the nearby mangroves

9.5.1.1.7 Impact on Fishery Resources

- The likely changes would affect the plankton communities and thus the dependent fishery resources
- Impacts on benthic and pelagic organisms would also eventually affect the fishery resources of the area
- Any impact on fishery resources would possibly affect livelihood of fishermen of nearby villages

9.5.1.1.8 Impact on Pulicat Lake

- Though Pulicat Lake is situated considerably far from the proposed project site, it is likely to be affected due to the presumed hydrological changes
- The presumed increase of the sediment load and turbidity may affect pelagic and benthic organisms in the Lake

3. Other allied infrastructure development activities close to intertidal and coastal belts, such as land reclamation, backup storage structures, rail and road network

9.5.1.1.9 Impact on Mangroves and Associates

- Mangroves are seen along the Ennore Creek, Kosasthalaiyar River, Buckingham Canal and Pulicat Lake
- Land reclamation works may lead to loss of shores, seabed, flora and fauna within the reclaimed areas
- The floodplain and may reduce the infiltration of water into the ground
- Increase the run off into the sea causing sedimentation
- Reclamation in the area would cause sedimentation in the water bodies such as Buckingham Canal and Kosasthalaiyar River and it may affect all the benthic and pelagic organisms in the mangrove area.
- Mangrove associated fishing activities such as hand picking of prawns, shell collection, polychaete collection and other fishing activities is likely to have minimal impact due to the land reclamation activities

9.5.1.1.10 Impact on Avifauna and Other Animals

- The increase in the volume of traffics is likely to have an adverse effect on the environment and lead to air pollution, noise pollution and water pollution
- The extension and construction of new lanes will affect the land use pattern of the proposed area

4. Laying of Sub-Sea Pipelines

- Require minor dredging and hence would affect the benthic organisms that live in the area
- A localized sedimentation is very likely and it would affect both benthic and pelagic organisms

5. Intake and Outfall Pipelines for Desalination Plan

- Benthic and pelagic organisms living in the vicinity are likely to be affected

9.5.1.2 Anticipated Operation Phase

1. Maintenance Dredging and Disposal
- Potential turbidity and suspended solids would affect the dredged and disposal areas.
- Associated fishery resources are also likely to be affected
2. Cargo Handling in the Waterfront & Offshore Berth/Jetty
- Dry and bulks cargoes generally produce a lot of dust which can impact both benthic and pelagic organisms and would consequently affect the fishery resources
3. Ship Traffic
- The pollution related to ship traffic includes fuel leakage from ships, leaching of antifouling paints, transfer of harmful aquatic organisms, dumping of wastes and oil spills.
- Increased shipping traffic would affect the paths of fishing boats near the proposed project area and would make the area prone to collisions with larger marine animals such as dolphins
- The impacts of oil spills last long and will have detrimental effects on the benthic and pelagic organisms
4. Discharge from ETP, Desalination Plant and Bilge Water
- On the intake side of the desalination plants, small organisms such as fish larvae and fingerlings can get sucked into the desalination plant
- Brine will be substantially higher in salinity and warmer than normal oceanic water and this condition would make it more difficult for marine life to survive in the immediate vicinity of the discharge
- The brine will also have chemicals, and chronic exposure to these chemicals would make the marine organisms accumulate them in the food chain
- the ETP may contain biodegradable organic substances and micro-organisms, non-biodegradable and toxic substances that can contaminate coastal waters
- If the sludge is not treated properly it would cause serious environmental problems

During the baseline biodiversity assessment it is observed that there is no threatened or endangered species of benthic fauna recorded in the project site.

9.5.2 Mitigation and Management Plan

Managing the environment in its original state is most important and imperative for the sustainability and long term benefits. Effective measures of mitigation and management could help to reduce these negative impacts for sustainable and inclusive development which ensures the health of the marine environment.

This section of the report is aimed to suggest measures for maintaining a healthy biological environment and this would also help to form proper management strategies to conserve the existing biodiversity in and around the proposed project site and to recommend mitigation measures if there is any loss to biodiversity due to project activities.

Based on the comprehensive baseline data gathered and the possible impacts on biodiversity predicted, a holistic mitigation and management framework for conserving the marine biodiversity and ecology in the vicinity of the proposed project area are suggested below.

9.5.2.1 Baseline Data Creation and Monitoring of Biological Parameters

It is mandatory to collect baseline data on the marine environment in the vicinity of the proposed project area in line with developmental activities. Baseline data have already been collected on water quality parameters, planktonic and benthic (intertidal and subtidal) composition, density, diversity and productivity in the relevant water bodies namely Bay of Bengal, Kosasthalaiyar River, Buckingham Canal, Ennore Creek and Pulicat Lake.

Baseline data was generated and presented in **Chapter 3**.

On the basis of baseline data, it is essential to have continuous and periodic monitoring of the marine environment in terms of vital parameters which are indicative of the health of the marine environment. Regular monitoring of vital parameters will provide indication of any deviation from the baseline status.

9.5.2.2 Mitigation and Management Measures during Construction Phase

- Planning of environmentally hostile activities during lean fishing season
- Proper disposal of dredged sediments into the dumping site (including reclamation site) with silt traps should be done to reduce the dispersal of silt and turbidity.
- A safety exclusion zone around the dredging vessel in accordance with the international standards and best practices should be adopted
- Turbidity curtains can be used to minimize sediment transport.
- Dredging practice should be modified in tune with the tidal condition until no more signs of sedimentation are reported in the subsequent monitoring studies
- Provision of adequate sanitary facilities and disposal of wastes during construction
- Provision of adequate drainage to solve stagnation and subsequent contamination of coastal waters
- All the constructions should be planned in such a way that it does not restrict the prevailing tidal entrance in the mangrove habitats through Pulicat mouth and Ennore mouth
- Appropriate stringent monitoring plan (Monitoring Protocol Section 9.4.3) should be in place for water bodies such as Bay of Bengal, Kosasthalaiyar River, Buckingham Canal, Ennore Creek and Pulicat Lake, to take all necessary precautionary and remedial measures

9.5.2.3 Mitigation and Management Measures during Operational Phase

- The solid waste generated from the port during operational phase should be properly segregated, stored and disposed
- The minor and major oil/chemical spillages should be effectively controlled with appropriate tools and equipments.
- Critical parameters such as suspended solids, DO, BOD and nutrients should be regularly monitored and compared with baseline study.
- Use of biocides should be kept at the minimum and their concentration at the outlet should be regularly tested.
- Comprehensive and easy to implement Standard Operating Procedure (SOP) should be made for each category of cargo in order to avoid oil or chemical spillages.
- Transfer of bulks to the coal stack yards should only be through closed conveyors.
- Water sprinkling should be done at stack yards prone to generate wind-blown dust.

9.5.2.4 Mitigations and Management Measures on Maintenance dredging

- Suitable dredging equipment for fine sediments should be used to minimize the level of turbidity during maintenance dredging operations
- Measures to be taken in order to limit the lateral movement of turbid water during dredging activity
- Appropriate silt curtains should be used to reduce sediment transportation.
- Dredging activity should not be undertaken during periods of rapid water current and strong trade winds.
- Establishment of a dredging monitoring (Monitoring Protocol Section 9.4.3) and emergency response plan will be useful to monitor the direction of the plume and to monitor for equipment malfunction and accidental dredge spills.
- Detailed assessment on water quality and biological resources should be carried out to identify the problems at the earliest

9.5.2.5 Management of Benthic Organisms and Plankton in the Water Bodies

- Rapid underwater assessment of these fragile organisms should be done at least once in a year during the construction phase and once in two years during operational phase to compare their abundance with baseline information
- Permanent monitoring locations should be fixed in all the water bodies including Bay of Bengal, Kosasthalaiyar River, Buckingham Canal, Ennore Creek and Pulicat Lake for regular monitoring.
- Monthly sample collection and monitoring should be done to understand the changes in benthic biota.
- If the amount of benthic organisms goes drastically down from the baseline data, necessary remedial measures should be adopted
- Measures should be taken to reduce the run-off slurry and sediment plume through silt traps and turbidity curtains
- Regular and continuous monitoring (Monitoring Protocol Section 9.4.3) of plankton density and diversity in permanently fixed locations should be done during the different phases of the proposed project

9.5.2.6 Management of Mangroves and Associated Biodiversity

- Three mangrove species namely *Avicennia marina, Avicennia* sp. and *Rhizophora mucronata* are available in the area along with five halophytic plants
- A dedicated action plan should be in place for continuous mangrove monitoring and maintenance (**Section 9.5.4**)
- It should be ensured that wastes generated during the construction and operation phases do not in any case enter the mangrove waters.
- Special attention should be given to chemical and hydrocarbon spillages in the port waters.
- Immediate measures should be taken to contain spillage and to reduce impact.
- Oil emergency contingency plan is to be put in place. Waste oil, garbage and building material rubble should be managed in such a way that they do not reach mangroves.
- Vegetation structure of mangroves should be studied once in a year and could be used to check short-term and long-term mangrove health
- Mangrove formations in the vicinity of the port should be mapped using GIS and RS once in a year to monitor changes in their physical extent.

- Regular monitoring (once in six months) of mangrove macrofaunal abundance, diversity and composition will throw light on the diversity and dynamics of this ecosystem.
- Comparison of data over the years will reveal the status of mangrove faunal component, which could be linked with overall ecosystem changes.
- Environmental training and awareness imparting should be given to all port related personnel and contractors on the ecological and environmental importance of coastal habitat and the measures necessary to protect and preserve this habitat

9.5.2.7 Management of Birds and other fauna

- Periodical monitoring (once in six months) of birds would identify the positive or negative changes in bird composition of the area.
- Endangered marine mammals (dolphins) have also been observed near the project area during the baseline study period and hence proper action plans should be executed to reduce the noise during dredging operations with existing acoustic controls on noise-generating equipment.
- Arrangements should be made to monitor marine mammals during construction and operational phases particularly during dredging and reclamation period
- Any incident of injury or mortality during the project activities should be immediately reported

9.5.2.8 Management of Fishery Resources

- Deployment of artificial reef structures (**Section 9.5.5**) are comparatively cheaper and easily implementable and would provide substrate that will support marine organisms.
- Artificial reef modules should be so designed as to enhance biodiversity and fish production, and once built they will last many decades supporting rich faunal components since they provide ideal habitat for them.
- They have great potential to enhance biodiversity by attracting diverse marine fauna within a short period of time.
- The impact of artificial fish habitats should also be studied regularly (covering the four seasons in a year) to assess the enhancement of biodiversity, fish production and socio-economic conditions of the dependent fisher folk

9.5.2.9 Management of Pulicat Lake and Associated Biodiversity

- Sea ranching (**Section 9.5.6**) of cultured fingerlings of these shrimps and crabs would provide sustainable fishery yield to the fishermen

9.5.2.10 Management of Desalination and ETP Discharges

- Wastes produced during the construction of desalination plant should be carefully removed from the marine environment to the landfill site
- Assessment of seawater quality during and after the installation is imperative.
- Proper monitoring of the quality of marine water and sediment should be in place during construction phase which involves dredging for laying intake and outfall pipes.
- The desalination plant effluent should be pre-diluted and dispersal of the discharge plume should be enhanced by installing a diffuser system.
- Negative impacts from chemicals should be minimized by treatment before discharge by substitution of hazardous substances, and by implementing alternative treatment options.

- To minimize the impingement and entrainment of marine organisms a combination of differently meshed screens and a low intake velocity should be considered.
- Regular monitoring of seawater quality and assessment on marine organisms in the vicinity of the intake and outfall sites should be done monthly to understand the changes and adopt management actions
- The treated effluent should be regularly checked for water quality according to the norms of CPCB.
- Water quality in the outfall area should be regularly monitored to identify the changes
- The sludge should be properly treated, which involves a combination of thickening, digestion, and dewatering processes according to the norms
- Proper disposal of sludge
- It may also be used on agricultural land to take advantage of its value as a soil conditioner and fertilizer after due analysis

9.5.2.11 Management of Ship Traffic Impacts

- Discharges of all kinds of wastes should be regulated and a proper disposal system should be in place.
- Proper training should be given to the staff on salvage, marine firefighting, and spill prevention and preparedness for reducing the risk of occurrence of an incident and, if an incident occurs, for appropriately responding to prevent further damage or to remove oil spilled in the marine environment.
- Speed restrictions can greatly reduce impacts and risks related to animal injuries and accidents with fishing boats

9.5.3 Monitoring Protocol

Considering the importance of project area from the ecological, biological and social perspectives, comprehensive monitoring protocol should be in place to take appropriate and timely management and remedial actions during the construction and operation phases of the project.

9.5.3.1 Construction and Operational Phase – Monitoring Protocol

The systematic monitoring would help to understand the status of environmental health during the construction period and accordingly the management and remedial action could be taken up.

The activities of the project during the construction and operational phases have to be regularly monitored in a holistic manner in order to manage and protect the health of environment and biodiversity. It is important to closely monitor the sites of reclamation, sites of sediment disposal, and sediment deposition to record any changes in and depletion of environmental quality.

The number of monitoring locations in the marine zone and land side covering coastal wetlands, inland region, Ennore Creek, Pulicat Lake, Kosasthalaiyar River, and Buckingham Canal, the number of sampling locations are same for construction and operational phases, which would help to take effective management and remedial actions, in case of any adverse impacts.

Details of monitoring components, parameters to be monitored, locations and monitoring frequency during construction and operational phases are given in **Table 9-1**.

Proposed Monitoring Locations during construction and operational phases are shown in **Figure 9-8**. Proposed monitoring locations in the land side covering coastal wetlands, inland region, Ennore Creek, Pulicat Lake, Kosasthalaiyar River, Buckingham Canal during construction and operational phases are shown in **Figure 9-9**.

Table 9-4: Details of Monitoring Components, Parameters to be Monitored, Locations and Monitoring Frequency during Construction and Operational Phase

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
I - Marine Zone				
1.	Marine Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices	23 (Surface and bottom) covering all project activities such as Dredging, Reclamation, desalination plant activities, and SPM.	***Monthly*** *(*However, the parameters like Chlorophyll content, TSS, TDS, salinity, turbidity, oil and grease, DO, BOD and COD should be monitored **fortnightly** in 15 locations (M-1 to M-3), (M-8, 11, 13, 17 & 18) and (M-4, 5, 7, 9, 12, 14 &16) during dredging and reclamation period.
2.	Marine Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	23 locations covering all project activities such as Dredging, Reclamation, desalination plant activities, and oil spill.	**Monthly** (However, the parameters like organic matter, organic carbon, alkalinity, sediment texture, oil and grease should be monitored **fortnightly** in 15 locations (M-1 to M-3), (M-8, 11, 13, 17 & 18) and (M-4, 5, 7, 9, 12, 14 &16) during dredging and reclamation period.
3.	Fish Population Monitoring	Diversity and Abundance	Randomly selected 6 sites around the project area	**Monthly**

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
			(dredging and reclamation sites)	
4.	Rapid underwater biodiversity Assessment	Diversity and Abundance	Marine Zone (in line with baseline data)	**Yearly**
II – Pulicat Lake				
1.	Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices	4 Locations (Surface and bottom)	**Monthly**
2.	Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	4 Locations.	**Monthly**

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
3.	Fish Population Monitoring	Diversity and Abundance	2 sites around the sampling locations	**Quarterly**
III - Kosasthalaiyar River				
1.	Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices	7 Locations (Surface and bottom)	**Quarterly**
2.	Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	7 Locations.	**Quarterly**
IV - Buckingham Canal				
1.	Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility	4 Locations (Surface and bottom)	**Quarterly**

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
		Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices		
2.	Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	4 Locations.	**Quarterly**
V. Ennore Creek				
1.	Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt	3 Locations (Surface and bottom)	**Monthly**

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
		Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices		
2.	Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	3 Locations.	**Monthly**
VI - Mangroves				
1.	Water Quality	Physical properties: Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility Chemical Properties Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Pigment Parameters:** Chlorophyll –a, Phaeo-pigments, Total biomass	5 Locations	**Monthly**

Sl No.	Components	Parameters to be Monitored	Locations	Monitoring frequency
		Phytoplankton: Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices		
2.	Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Biological parameters **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	5 Locations.	**Monthly**
3.	Mangrove Area Monitoring	• Species composition and vegetation structure • Density, height, growth and canopy • Associated fauna and flora. • Numbers, species composition, size and structure of fish populations. • Juvenile fishes, especially target species. • Threats (sedimentation) etc. • Avifauna (Diversity and abundance)	5 sites	**Half Yearly**
VII – Others (Turtles, Mammals etc.)				
1.	Others – Turtles, Mammals etc	Presence of Turtles, Mammals etc. in the study area. Diversity and abundance; Action to rescue them if seen in activity area	(Around the project/operation site)	Marine Biologists onboard should monitor during dredging and reclamation period

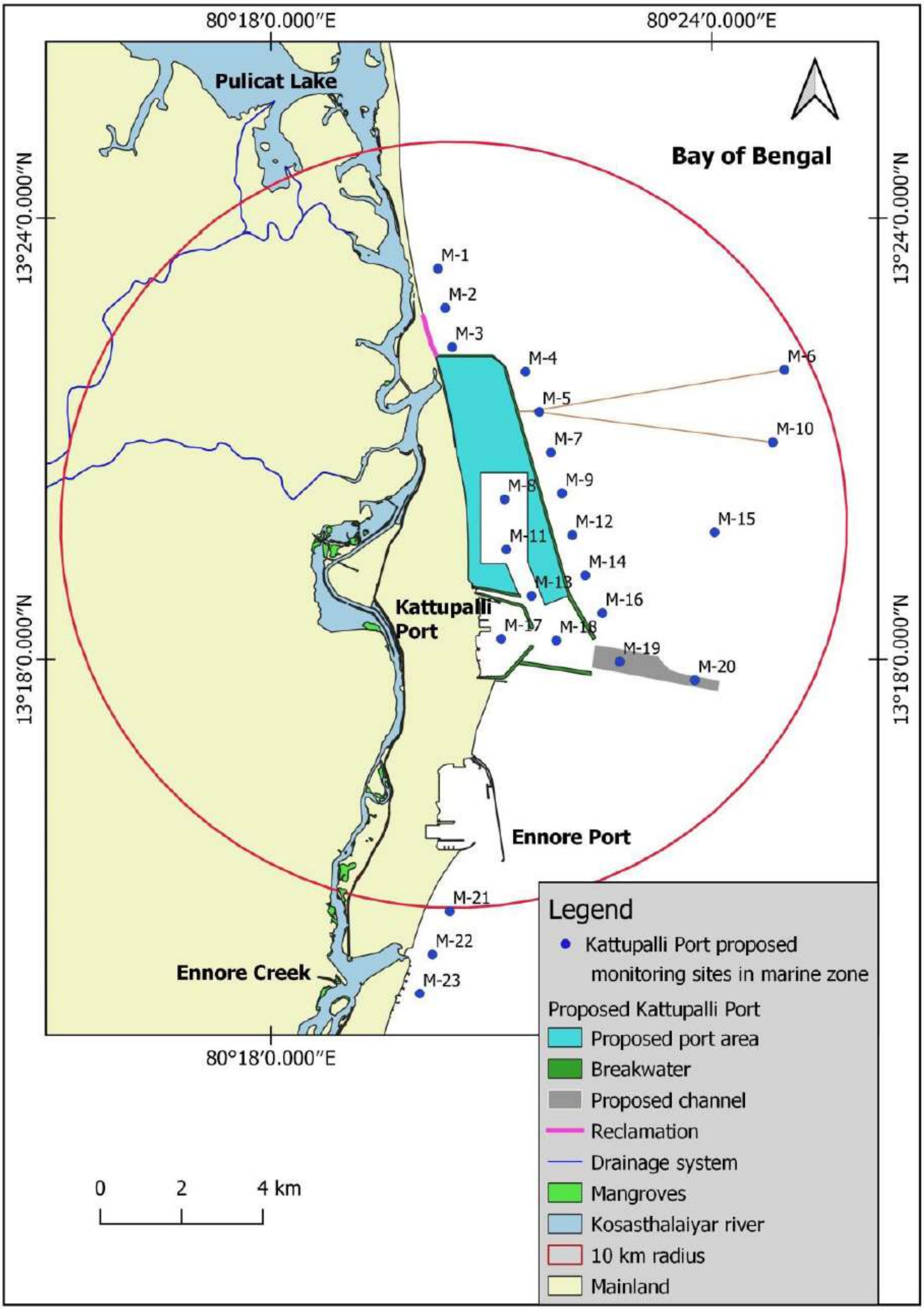

Figure 9-8: Proposed Monitoring Locations during Construction and Operational Phases

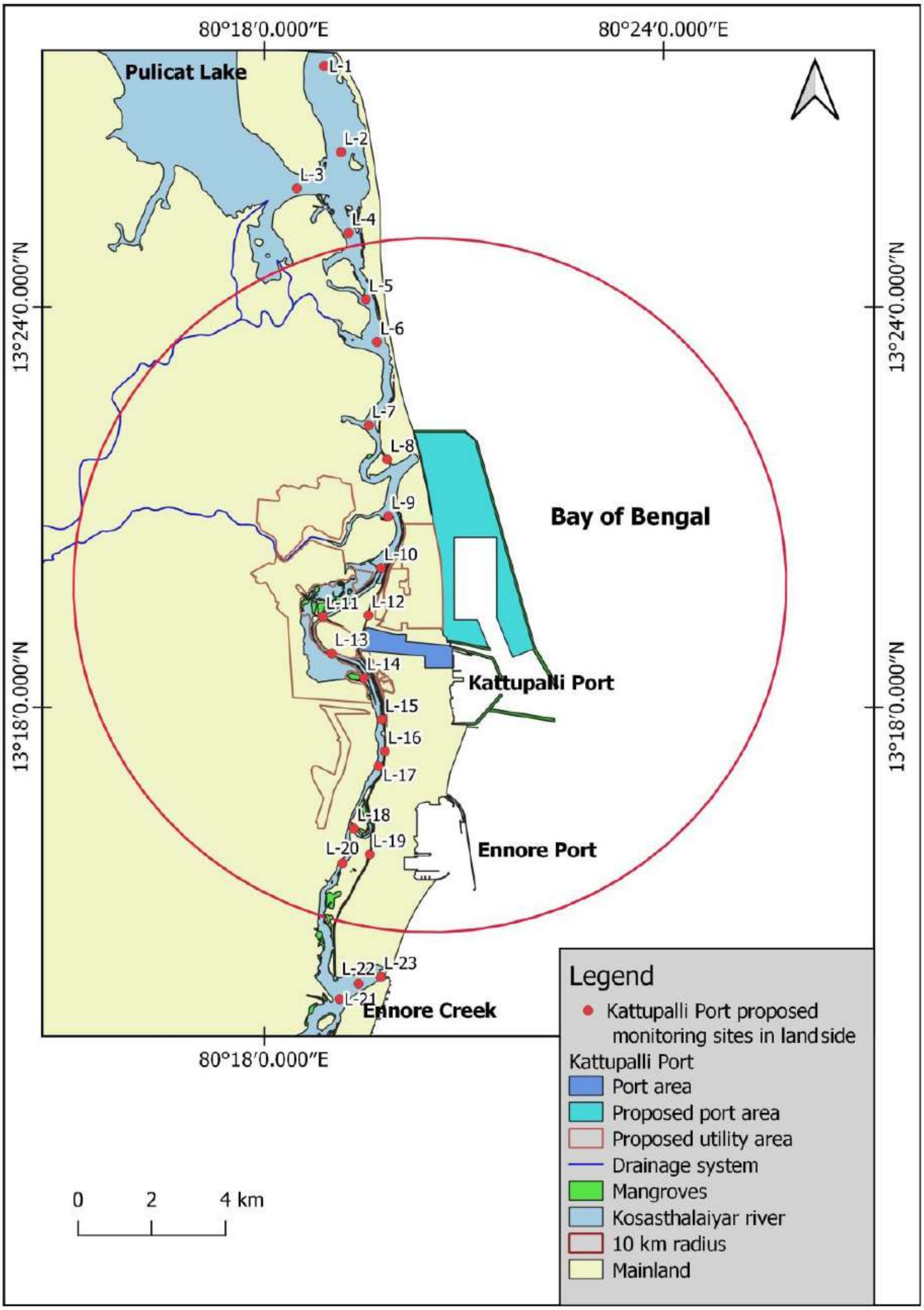

Figure 9-9: Proposed monitoring locations in the land side covering coastal wetlands, inland region, Ennore Creek, Pulicat Lake, Kosasthalaiyar River, Buckingham Canal during construction and Operational Phases

9.5.4 Mangrove Management Plan (during construction & Operational Phases)

9.5.4.1 Existing mangrove resources in the vicinity of the proposed project area

The proposed project area is endowed with water bodies of different salinities, suitable for mangrove growth. Mangroves are frequently seen in Ennore Creek, Kosasthalaiyar River (connecting Ennore Creek and Pulicat Lake), mouth of the Buckingham Canal and Pulicat Lake.

Mangroves are seen as patches and lines. Small to larger patches of mangroves are seen on the mudflats present inside and on the banks of the river. Similarly, sparse distributions of mangroves also occur along the banks of the river at many locations. Mangroves are also seen at a few locations along the mouth of Buckingham Canal, where it meets the Kosasthalaiyar River. Halophytic plants are also seen in association with mangroves. detailed observations on Mangroves were presented in **Chapter 3**.

The three species of mangroves observed in the study area are *Avicennia marina, Avicennia* sp. and *Rhizophora mucronata* dominated by *Avicennia marina*. The density of mangrove vegetation near the proposed project site ranges between 1.3 and 11.3 plants per 5 square meters. Stem circumference of mangrove trees ranges between 4 and 69 cm near the project area. Mangrove seeds and saplings are extensively available in the area. Five types of halophytic plants are also observed near the project area dominated by *Suaeda monoica* and *Sesuvium portulacastrum*. In the mangrove ecosystem near the proposed project area, twelve species of fishes, eight species of crabs, five species of shrimp, four species of bivalves and 22 species of gastropods are recorded. Significant level of fishing happens in the mangrove area near the proposed project site and provides livelihood to hundreds of fishermen who live in the vicinity.

9.5.4.2 Impact on mangroves due to the project activities

Construction of buildings, roads, bridges, parking areas includes reclamation of low-lying areas which are natural flood plains. Land reclamation activities during the constructional phase are likely to impact the mangroves.

These activities may hinder the flow of water into sea during floods and it may reduce the floodplain area cover and may reduce the infiltration of water into the ground.

Potential reduction in low-lying areas may hinder the water flow to the sea and may flood the adjacent water bodies during heavy floods and the flood water may take its course via the channels and is likely to impact the banks of water bodies during a flood and the mangroves. Likely increase in the water may consequently increase the run-off into the sea causing sedimentation. Moreover, reclamation in the area would cause sedimentation in the water bodies such as Buckingham Canal and Kosasthalaiyar River and it may affect all the benthic and pelagic organisms.

9.5.4.3 Management of mangroves

9.5.4.3.1 Coastal communities and mangroves

The communities have been using the mangroves sustainably for hundreds of years and hence they have a deep understanding of mangrove ecology and utilization. Coastal communities have also knowledge about mangrove degradation due to different factors. Hence, coastal communities will remain a key stakeholder in management initiatives, which will include schemes to appreciate and reward community conservation management. The local communities should be educated on conservation of mangrove habitats. Their capacity in mangrove conservation and management should be strengthened.

9.5.4.4 Management of indirect impacts

9.5.4.4.1 Altered Tidal Flushing

Some small intertidal channels may have disrupted flows while other channels may have comparatively faster flow. The causeway should be designed to maintain adequate tidal flow for the support of healthy mangrove habitat. Engineering design of the infrastructure facility should ensure the tidal flushing from the water bodies through appropriate provision.

9.5.4.4.2 Slippage of Fill

Construction workers should be trained to work carefully not to allow the slippage of fill into mangrove areas. Engineering measures to manage and/or prevent slippage of fill, as much as practicable, include the use of rock armouring to contain fill to the base of the channel crossing and stabilize earth fill as it is placed.

9.5.4.4.3 Dust Deposition

The following measures will be useful in reducing dust deposition:

- Watering of unsealed roads, exposed surfaces, active construction areas and stockpiles
- Use of environmentally safe dust suppressants
- Restriction of vehicle movements and vehicle speeds to reduce dust emissions
- General housekeeping practices to manage waste materials within the construction site that may generate dust
- Awareness programs to ensure that all persons onsite are aware of the need to minimize dust emissions
- Reporting of any community complaints regarding dust levels.

9.5.4.4.4 Mangrove associated biodiversity

- Impacts on mangrove associated organisms will primarily be managed by reducing the impacts to mangroves.
- Management of indirect impacts on mangrove avifauna will be by restricting direct habitat loss to the defined project footprint.

9.5.4.4.5 Mangrove monitoring

Monitoring to assist in the management of potential impacts on mangrove vegetation associations will include,

- Mangrove mapping
- Mangrove health surveys
- Monitoring of any sediment accumulation and turbidity within mangrove vegetation associations
- Assessment of water and sediment quality in the vicinity of the infrastructure development area

9.5.4.4.6 Mangrove mapping

- Satellite images and field surveys should be used to map the distribution and coverage of mangrove vegetation situated near the proposed project area.
- Mangrove mapping should be done prior to the commencement of the project to provide current information on mangrove distribution and at project milestones including the completion of clearing activities and through the operational phase.
- Mangrove distribution and cover should be compared to the baseline data to confirm that the negative impact does not exceed the approved limits.

9.5.4.4.7 Mangrove health surveys

- Mangrove health surveys should be undertaken once in a year to detect the negative impacts as soon as possible.
- Mangrove health monitoring will consist of regular visual assessments to determine mangrove condition.
- Mangrove monitoring sites should be established before the construction activities begin. The number and location of these sites should be fixed based on the baseline survey.
- Parameters such as number of species, number of trees, number of dead limbs, number of stems per tree, stem diameters, health status of trees, height of trees and foliage density should be collected during health surveys.
- A change in mangrove health leading to increased yellowing, wilting and dead leaves at any monitoring site should be shared and discussed with the stakeholders for proper action.
- The health survey should use the available results of the mangrove mapping and sedimentation monitoring to determine if the decline in mangrove health is directly related to the infrastructure development of the proposed project activities.

9.5.4.4.8 Turbidity and Sedimentation

Monitoring of sedimentation and turbidity should be done at the same monitoring sites used in the mangrove health surveys.

4.3.2.9. Assessment of water and sediment quality

Regular sample collection and monitoring of water and sediment quality parameters from permanent monitoring sites will be of utmost importance to understand the deviations from the baseline.

It will enable the managers to take corrective action if a parameter goes higher or lower than the permissible limits.

Details of mangrove survey and monitoring protocol were provided in Table 9-4. Mangrove survey and monitoring protocol is given in **Table 9-5**.

Table 9-5: Mangrove survey and monitoring protocol

Assessment	Periodicity
Mangrove health surveys (Natural & Rehabilitated Mangroves) Mangrove diversity Number of trees present Number of dead limbs Number of stems per tree Stem diameters Health status of trees Height of trees	Annual

Assessment	Periodicity
Foliage density	
Mangrove mapping	Annual

9.5.5 Artificial Fish Habitats (during construction and operational phases)

Multipurpose Artificial Fish Habitats for the enhancement of biodiversity, fish production, and sustained livelihood

AFHs act as fish habitats to enhance fishery production, and help to stop migration of fishes due to climate change, and thereby sustain the livelihood of the dependent fisher folk.

The proposed AFH deployment activity has the following purposes:

- to increase fish production through the development of Artificial Fish Habitats,
- to help fisher folk have a sustained fish catch throughout the year,
- to enhance the daily income of poor fishermen and improve socio-economic conditions,
- to enrich the marine biodiversity,
- to assess the impact of AFHs on the socio-economic aspects,
- to study the adaptive benefits of climate change impacts on both the fishermen community and the environment

9.5.5.1 AFH deployment sites

Adequate AFH modules need to be deployed, covering considerable extent of fishing grounds at every 1 km outside the proposed project area in Bay of Bengal. It is suggested to deploy such AFHs in 15 sites in the first phase before the start of operational phase. The deployment of artificial fish habitats (artificial reefs) should start parallel to Ennore and should be done upto to Pulicat at every 1 km parallel to the shore. Artificial fish habitats would attract not only fishes but also all the benthic organisms, and would create a diverse ecosystem which would provide long-lasting results.

9.5.5.2 Impact Assessment

The impact of artificial fish habitats should also be studied regularly (covering the four seasons in a year) to assess the enhancement of biodiversity, fish production and socio-economic conditions of the dependent fisher folk

9.5.6 Sea Ranching (during operational phase)

Sea ranching of commercially important organisms in Pulicat Lake

Commercial fishing by small scale fishermen is practiced to a significant degree in Pulicat Lake as it is the second largest brackish water lake in India. Important catch includes shrimps and crabs. On account of the likely impact on these commercially important fishery resources due to the proposed project activities, eco-friendly and sustainable measures leading to livelihood enhancement may be considered. To compensate the loss, fingerlings of cultured shell fishes can be ranched in this brackish water Lake. Release of fingerlings would certainly help the fishermen to get good catch sustainably for a long time. Ranching of *Penaeus* spp., *Portunus* spp. and *Scylla serrata* would provide much economic benefits to the fishermen.

9.6 Rainwater Harvesting

Rainwater harvesting (RWH)[8] refers to collection of rain falling on earth surface for beneficial uses before it drains away as run-off. The region receives an annual rainfall of 1382.9 mm. As developmental activity, rainwater harvesting in terms of collection, storage and reuse is proposed within the Port. Rainwater harvesting and conservation practices reduce the soil erosion, increases soil moisture and enhance recharge to groundwater body. Concept of rainwater harvesting lies in

- Tapping the rainwater from where it falls
- Techniques of rainwater harvesting involves channelling and catching rainwater from localized catchment surfaces such as roof top, plain and sloping ground surfaces etc. It is easy process to collect Rainwater and diverted into ponds, vessels or underground tanks to store for longer periods and to recharge by construction of RWH Structures in a suitable sites.

Rainwater harvesting is in two ways:

Direct Use: The process of collecting and storing the rainwater by construction of sump through filters for future productive use and

Artificial recharge to groundwater: Recharge the rainwater in a scientifically planned way by construction of rain / roof top water harvesting structures to augment the groundwater.

The objectives of rain water harvesting are as follows:

- Rainfall – runoff management
- Control soil erosion
- Increase the soil moisture
- Prevent rush of surface flow of water
- Recharge to ground water in favourable areas
- Direct use of harvested rainwater
- Saving in pumping cost

Surface characteristics of Kattupalli Port area:

The area is covered by top soil which is sandy loam in texture, followed by dry sand and clay to a depth of around 10m underlain by sand[9]. As the area is located on the coast, the water table is shallow. The depth to water level is at 2m below ground level. Geologically the area is classified under marine sediments of quarternary period. The Buckingham Canal Back waters are located to the west of the site carry sea water during high tides and this in turn makes the groundwater brackish in the area. Hence fresh water occurs as lenses and as floating aquifers because of the difference in the Total Dissolved Solids between the fresh and saline water.

Geophysical survey in the form of Vertical Electrical Soundings (VES) were carried out and shown in Figure 9-10. It is inferred that the sub surface formation is sandy in top and becomes sandy clay and clay with depth. The continuous falling trend of the data shows the level of brackish nature of the groundwater as we go deeper. The steep fall in curve is also an indication of the clayey sub stratum and the brackishness of the groundwater.

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[8] *Ref: Concepts & Practices for Rainwater Harvesting- CPCB 2001*

[9] *Feasibility study report on rainwater harvesting in Kattupalli port of M/s. MIDPL, Adani Ports and Special Economic Zone, Kattupalli village, Ponneri taluk, Tiruvallur district - 600 120, Tamil Nadu, India*

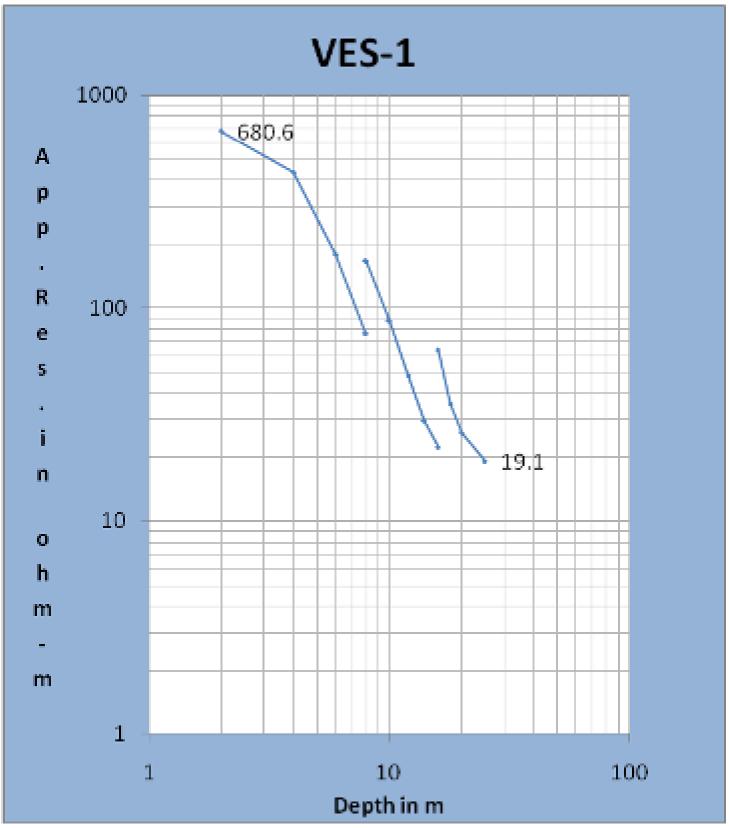


Figure 9-10: The plot of depth Vs Apparent resistivity

9.6.1 Existing Rainwater Harvesting System in Kattupali Port

Rain Water harvesting system has been provided in all port buildings. Rain Water collection system is provided at the following 5 locations in port area.

The Rain Water Harvesting locations are as follows:

- Port Operation Building (POB)
- Engineering Workshop
- Customs Building
- CFS Admin Building
- CFS Warehouse

Typical section of percolation pit is presented below

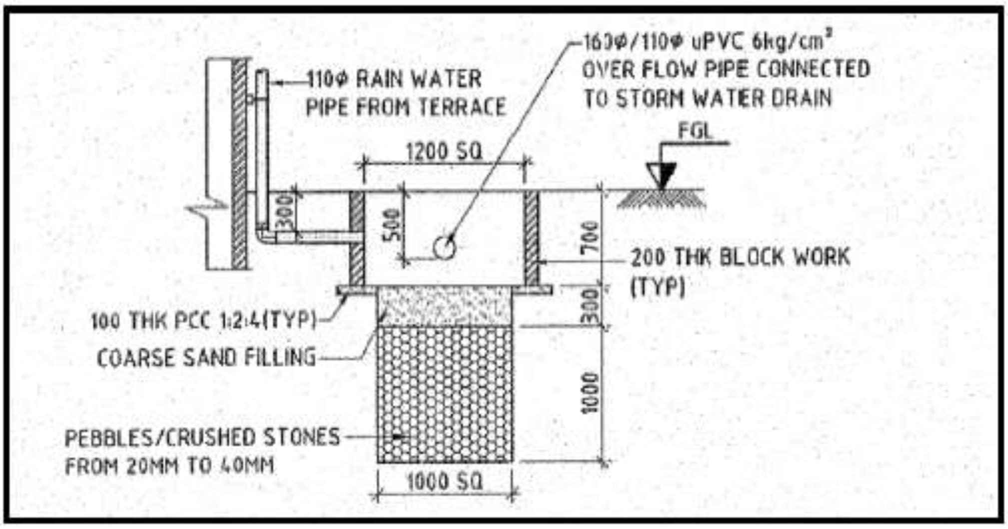


Figure 9-11: Typical Section of Percolation Pit (PP)


Exhibit 9-2: Rain Water Harvesting Structures in Port buildings

Surface Runoff Water collection

Surface rain water is collected through rain water drainage system and is stored in the rain water collection pond (50m X 48m X 1.5m) of storage capacity 3600 m^3 is located in our Port premises and the collected rain water is used for gardening purpose.


Figure 9-12: Surface Runoff Water Collection Pond at Port Area

9.6.2 Estimation of Rainwater Harvesting Potential

Rainwater Harvesting shall be implemented at proposed RMP to conserve rainwater. Roof top area, greenbelt/green area, road/paved area and open areas proposed in RMP are considered for arriving the rainwater which can be harvested.

The approximate quantities of rainwater that can be harvested at RMP are given in **Table 9-6.** The equation used for run off estimation is based on CPCB guidelines on 'Concepts and Practices for Rain water Harvesting'- Oct 2001.The calculations are based on following:

- Average annual rainfall is 1382.9 mm based on 1981-2010 IMD data.
- Average No of rainy days are 58.8

Run of co-efficient are considered as given by CPCB guidelines.

Table 9-6: Estimated Volume of run-off can be Harvested

S. No	Land Use	Area in Acres	Area (m^2)	Volume (m^3)	Coefficient	Volume/year
1	Roof top area	197.95	801069.0088	1107798	0.6	664679
2	Road Area	569.5	2304666.838	3187124	0.7	2230987
3	Green area	241	975284.825	882535	0.1	88254
4	CFC area	90	364214.25	329577	0.2	65915
	Total	1098.45	4445235	5507035		3049835
Note: - Roof top area is considered as 50% of the plotted area.						

9.6.3 Harvesting Plan

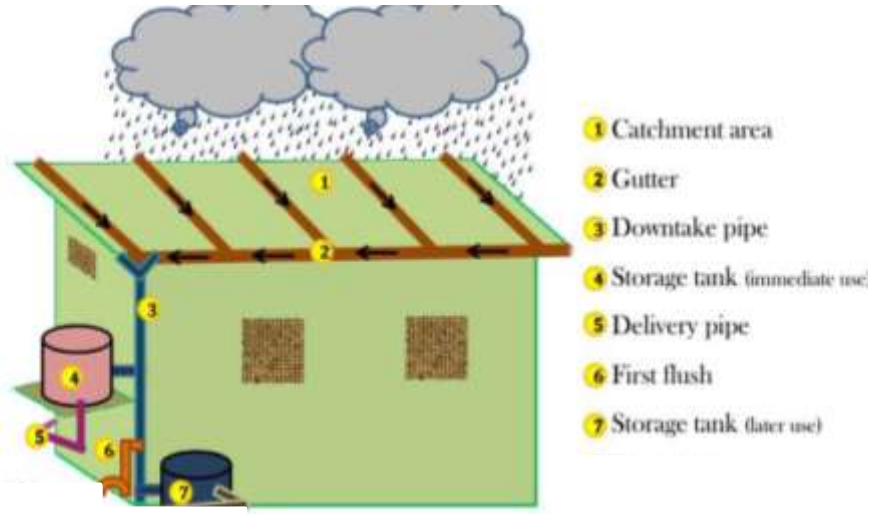
9.6.3.1 Roof-top Rainwater Harvesting

Roof-top rain-water harvesting is one of the appropriate options for augmenting groundwater recharge/storage where natural recharge is considerably reduced and not much land is available for implementing any other artificial recharge measure.

In a typical roof top rain-water harvesting system, rain-water from the roof is collected in a storage vessel or tank for use during periods of scarcity. Such systems comprise a roof, a storage tank and guttering to transport the water from the roof to the storage tank. In addition, a first flush system to divert the dirty water, which contains debris, collected on the roof during non-rainy periods and a filter unit to remove debris and contaminants before water enters the storage tank are also provided. Therefore, a typical Roof top Rain-water Harvesting System comprises following components:

- Roof catchment
- Filter unit
- Drain pipes
- Storage tank.
- Gutters
- Collection sump.
- Down pipe
- Pump unit
- First flush pipe

A typical Roof-top rainwater harvesting system is given in **Figure 9-13.** However, during detailed engineering of the suitable structure will be arrived for rainwater harvesting.



(Source: Rainwater Harvesting in India – An Appraisal, CPCB)

Figure 9-13: A Typical Rainwater Harvesting System

Filtration forms the most important process in the purification of water. It usually involves allowing water to pass through a filter media e.g. sand. Filtration essentially involves removal of suspended and colloidal impurities present in water. Depending on the type of filtration, the chemical characteristics of water may be altered and the bacterial content may be considerably reduced. These effects take place due to various processes such as mechanical straining, sedimentation, biological metabolism and electrolytic changes.

The sand being used for filter in roof top rain-water harvesting systems should be free from clay, loam, vegetable matter, organic impurities etc. and should also be uniform in nature and grain size. There are three types of filters i.e.

i) Slow Sand Filters,
ii) Rapid Sand Filters (gravity type) and
iii) Pressure Filters.

9.6.3.2 Storage Ponds/Tanks

In addition to roof top rainwater harvesting, RMP will also adopt storage tank /pond system for storm water/rain water storage. Storage ponds/tanks are civil structures to store harvested rainwater. From these storage facilities, water can be pumped directly to points of demand or supplied through over-head tanks. Silt trap pits and filter beds have to be maintained before letting the water to the storage pond / tank. The storage tanks may be properly cemented to avoid leakage or seepage into ground. Dimensions of these structures may be maintained at 20 m x 10 m x 2 m.

9.6.4 Monitoring wells for Impact Assessment

Monitoring of the groundwater regime is done by establishing a network of observation wells tapping the shallow and deeper aquifer systems separately.

The phreatic aquifer can be monitored by measuring groundwater levels in the open dug wells or dedicated shallow water table wells. The existing dug wells may also be selected for monitoring. Piezometric surface in the deeper aquifer may have to be monitored by installing dedicated piezometers. Piezometer is a small diameter (38 mm) tube with a 2 to 3 m perforated pipe at the bottom lowered in a borehole (100 to 150 mm) drilled down into the confined aquifer. The perforated portion of the tube has to be positioned against the bottom of the confined aquifer with clean sorted gravel shrouded between the tube and the borehole surface. Rest of the borehole may be filled with unsorted gravel or clay.

The observation wells/piezometers are to be monitored at least four times in a year, i.e. in the months of January, May, August and November. Data collected from these wells, provide more meaningful record / database and clarity in the changes in the ground water regime in the Project area.

Digital water level recorders, which collect water level information automatically ranging in time from 1 hour to 1 month, provide accurate and valuable data for groundwater management. The recorder is an electronic device which is installed within the water column of the observation well. The device collects the groundwater level data at the desired interval of time and stores the digital data on board which can be retrieved through data retrieval systems or hand held computers and can be downloaded directly into office computers for further analysis. Groundwater chemical quality monitoring also can be done through these devices with appropriate add-on probes.

9.7 Energy Conservation Activities in Kattupalli Port Area

Kattupali Port is implementing the energy conservation measures and thereby marching towards the sustainable development.

9.7.1 Projects Implemented for Energy Conservation during last 2 years

9.7.1.1 Conversion of Diesel RTG's into E-RTG's

Fifteen (15) Nos. of Diesel operated Rubber Tyred Gantry cranes (RTG's) are completely converted into Electrically operated RTG's

- Diesel Fuel requirement: 1.5Ltrs /Container, (Rs. 111.6/Container)
- Electricity: 3kwh /Container, Rs. 25.5/Container
- Savings per container is around Rs. 86/-
- Consider 9,20,000 RTG moves per annum.
- Project Cost for implementation is Rs. 44 Crs.
- Cost saving of Rs. 7.92 Crs. per annum.
- Emission reduction – 375.936 Kg CO_2 /Annum

RTGC's with DG Set

RTGC's converted to ERTGC

9.7.1.2 Installation of Solar Power Panels and Biomass Plant

Kattupalli port Installed 450 kWp capacity Solar Power facility in CFS Roof Top and Biomass Plant with a capacity of 6m^3/Day with Gas output of 3 Kg/Day to treat Canteen Food Wastes & Vegetable peels in canteen area

- Solar Unit Generation FY 2018-19 is 5,67,030 KWh
- Solar Unit Generation FY 2019-20 is 5,72,080 KWh.
- Energy Saving - Around 6,00,000 Units per Annum
- Cost Saving – Around Rs. 35,00,000 Per Annum
- Project Cost: Rs. 2.2 Crs

9.7.1.3 LED and Eco plug

Kattupalli port converted Indoor conventional lamps in to LED which require very less maintenance

- Project Cost – Rs.10 Lakhs
- Energy Savings – Around 59,000 Units/Annum
- Cost Savings – Around Rs. 5 Lakhs / Annum

Kattupalli port fitted the building air conditioners with Eco plug energy saving device

- Project Cost – Rs. 1.76 Lakhs
- Energy Savings – Around 22,100 Units / Annum

Installed LED in office area

Eco plug energy saving device

9.7.1.4 Other Energy Saving Activities Implemented In Kattupalli Port

- Solar power enabled Pinning station introduced for container pinning activity which is having warning Beacon, Horn and focus lights.
- RTG Stack monitoring system implemented - Height detection sensor to improve accuracy of stack profile (Energy saving: 18,000 Units per year amounting to Rs. 1.35 L /Year)
- Paperless office concept implemented by the way of using mobile tab with maintenance software for all Engineering maintenance activity.
- All street light and High mast's, Existing High Pressure sodium Vapor lamp (HPSV) converted in to suitable LED fittings. Resulted in savings of 4,40,000 KWH/ Annum i.e. approximately Rs. 25.72 lakhs / Annum.
- Street light and High mast lighting controlled by light intensity sensor (Energy Savings around 29,000 Units amounting to Rs.2.15 Lakhs/Annum)
- Motion sensors fixed inside Office areas

9.8 Exploring Renewable Source of Energy

9.8.1 Solar Power Harnessing Potential

Solar Power Harnessing potential within the Port built up areas are particularly at available roof tops. The available technologies for generating solar power are mainly Solar Photo Voltaic (PV) Cells and Solar Thermal. Technology of Solar PV Cells is suitable for solar power generation with proper utilization of the roof top areas available on the roofs of buildings/structures within the industry premises. The off grid solar PV system shall be used for the solar power harnessing.

Kattupalli Port has 450 kWp capacity solar power facility on CFS area Roof Top to reduce the dependency on regular power sources. MIDPL will augment the utilization of solar power harnessing by strengthening the existing infrastructure and adopting new technologies for proposed expansion.

Basic components that are used to build a solar PV system are as follows:

- Flat Roof Solar PV Panel mounting systems
- Solar PV Panels and solar modules
- Solar PV Charge Controllers
- Solar Batteries
- PV Junction Boxes/PV Combiner Boxes
- Off-Grid Solar PV Power Inverters
- Solar PV Cables & Connectors
- Solar PV Generation Meters
- AC & DC Isolators
- Solar PV System monitoring

For the purpose of installation of off grid solar PV cells, the suitable buildings and structures are identified and the roof top areas are considered for calculation of total possible capacity of installed solar PV.

The calculation for installed capacity and cost is based on following assumption:

- 100 sq m area is required for the installation of 10 kWp capacity
- Capital cost including batteries and other accessories is INR 1 lakh/kWp.

The capacity and approximate cost details for solar power harnessing potential in the proposed RMP are as given in **Table 9-7**.

Table 9-7: Estimated Installation Capacity and Cost for Solar Power Harness

Total roof top area (m^2)	Actual area (considering 15% of total area) (m^2)	Installation capacity (Considering 100 sqm for 10kWP) kWp	Installation capacity in MW	Cost for installation (considering Rs.8 cr/ MW) Rs. Crores
918	288	43	0.004	0.03

Only minimum of 15% of roof top area is considered for the estimation of solar power installation capacity.

The above mentioned roof top areas are approximate and can be firmed up after the concrete design and engineering. Based on various technology options considered, it is recommended that the solar PV cells shall be installed in the available area of roof tops within the industry premises for the purpose of harnessing solar power by means of utilizing the available roof top area.

Based on our initial assessment, it is predicted that up to 0.01MW of Solar energy can be harnessed in this area. Precise capacity will be worked out during detailed engineering of various structures and will be implemented accordingly. Depending on availability of suitable area, solar power harnessing potential will also be considered during overall implementation of Revised Master Plan.

9.8.2 Wind Energy Harnessing Potential

India is blessed with a coastline of about 7600 km surrounded by water on three sides and has good prospects of harnessing offshore wind energy. Considering this, the Government had notified the “National offshore wind energy policy” as per the Gazette Notification dated October 06, 2015[10].

Offshore wind power offers a plausible alternative in such a scenario. Absence of any obstruction in the sea offers much better quality of wind and its conversion to electrical energy. Offshore wind turbines are much larger in size (in range of 5 to 10 MW per turbine) as against 2-3 MW of an onshore wind turbine. While, the cost per MW for offshore turbines are higher because of stronger structures and foundations needed in marine environment, the desirable tariffs can be achieved on account of higher efficiencies of these turbines after development of the eco system.

Ports have been adopting various measures to reduce their environmental impact, such as utilising alternative fuels for their equipment, providing onshore power supply to vessels (also known as cold ironing) and utilising renewable sources for energy production.

Figure 9-14: Typical Wind Energy Harnessing Structures in Port Areas

Onshore wind is one of the cheapest forms of renewable energy available and Kattupalli port intended to focus on redeploying and redeveloping facilities to take advantage of the opportunities provided by offshore wind farms.

Kattupalli port shall conduct wind energy analysis for suitability and economical implacability of the wind energy options in the port area.

9.9 Occupational Health and Safety

Occupational health and safety are important aspects for any development/industrial/port activity. Occupational health and safety (OHS) needs attention both during construction, operation and maintenance phases. A broad framework for Occupational health and safety measures is presented in this section.

9.9.1 Existing OHS Facilities

Kattupalli port is an operational port having the upgraded facilities in compliance to national and international safety regulations

[10] *https://mnre.gov.in/wind/offshore-wind/*

9.9.1.1 Adani Green Book

Safety Manual of Adani group (Adani Green Book) is made available in employee portal and it can be accessed by all employees at any time. Adani green book consists of 20 elements. These elements can be considered as the keynotes that are covered under Adani Safety management System.

Elements in Adani green book are;

1. Felt Leadership & Commitment

An effective Occupational Health and Safety (OHS) program demonstrates Felt Leadership, a firm Commitment to the program and a willingness to improve the workplace safety culture. The purpose of this procedure is to establish, maintain and continuously improve the organizational Occupational Health and Safety Management System through setting Goals & Objectives (G&O) in the Environment, Health and Safety (EHS) Policy of Adani Group.

2. Employee Involvement Program

The purpose of this policy is to outline the Adani Group Employee Involvement programs. It outlines implementation techniques and responsibilities for all Adani group Sites in order to promote the input and involvement of all employees in the development, enforcement and improvement of the Occupational Health and Safety programs.

3. Safe Working Procedures

This element of Adani green book consists of safe working procedure for all the operations being carried out inside company premises.

4. Incident Reporting & Investigation

The purpose of this procedure is to provide guidance policies for Incident Reporting, Investigation and Follow-up and to ensure that all work-related Near Miss incidents or accidents, injuries, illnesses, spills, releases, property damage and other such events that occur while working at Adani business sites or at customer sites are identified, reported, investigated and communicated to stop recurrence.

5. Induction & Training

This procedure outlines Adani Occupational Health and Safety (OHS) Induction and Training program. It includes guidance for determining, providing and tracking training completion.

6. Planned Safety Inspections

This element includes guidance for general workplace inspections, along with other legal inspection requirements. The purpose of this procedure is to provide Adani Group guideline for OHS related inspections to help ensure confirmation with safety program.

7. Personnel protective Equipment

This procedure outlines the Personal Protective Equipment (PPE) program. It provides guidance for management of PPE and specific types of PPE and situations where the proper use of PPE is required.

8. Contractor Safety

The purpose of this procedure is to provide Contractor Safety program, the minimum requirements for working under contract with Adani sites and includes all contractors and subcontractors.

9. Emergency Preparedness

This procedure provides guideline for Site Emergency Preparedness & Response Plan (EP&RP) preparation, Response Team training, Employee Training and organize actions for prevention and response for workplace emergencies.

10. Fire Prevention & Protection

Purpose of this procedure is to provide guidance for prevention of fire and installation and management of fire protection system to comply local regulation related with fire and life safety.

11. JSA & Risk Assessments

Purpose of this procedure is to provide guidance for Adani Job Safety Analysis and Risk Assessment program. It outlines the system used to identify and analyze job tasks performed at business site and customer facilities, and to communicate and train employees to safely perform those tasks.

12. PTW System, High Risk Management

The purpose of this procedure is to provide structure and process of permit to work process and defines role specific authorizations and responsibilities to establish a standard and consistent process for all activities.

13. Management of Change

This procedure outlines a process for management of process or operational changes which have the potential to adversely impact the health and safety of employees or the environment, defined as a ‘potentially hazardous change’.

14. Chemical Safety management

Purpose of this procedure is to outline the chemical Safety management program and method for informing employee of chemical hazards and protective precautions that need to be taken when working with hazardous chemicals.

15. Industrial Hygiene

This element describes the industrial hygiene and anticipation, recognition, evaluation, prevention, and control of health hazards at workplace and food and water safety.

16. Ergonomics

The purpose of this procedure is to establish an ergonomics program for Adani sites to aid in the prevention of occurrences of work-related musculoskeletal disorders, reduce the severity of work-related musculoskeletal disorders through early medical management or control measures, and to ensure employee involvement in identifying exposures to ergonomic risk factors in the workplace.

17. Motor Vehicle Safety

Purpose of this Procedure is to Outline Adani Group guidelines for all Motor Vehicle used by employee for company business.

18. Medical Services

This procedure is to provide guideline for setup of occupational health services to protect, maintain and improve the employee health and wellbeing at the workplace against occupational risk.

19. Legal Compliance

Purpose of this element establish, implement and maintain procedure for identification, periodic updation and compliance evaluation with applicable Occupational Health and Safety aspects, OHS Legal & Other requirements as applicable to the activities, products or services.

20. Program Evaluation

This procedure outlines the Adani group OHS Program Evaluation process, which is applicable across all group business uniformly to identify level of OHS management system implementation and its effectiveness.

9.9.1.2 Safety Awareness Program

To cultivate safety culture among the workforce and reducing incidents and enhancing productivity by arranging various occupational health and safety related promotional and motivational activities. The society today expects the industries to eliminate accidents and sufferings. The awareness/ celebration works towards the renewal of "commitment of the employees" and the "organization as a whole" to integrate safety in their day to day activities both on and off the job. This is done by motivating and inspiring the workforce by adopting safe working methods and OHS department is dedicated to help promote workplace safety and improve upon it by organizing safety training in offices as well as in workplace. Various awareness campaigns were organized during the financial year to promote workplace safety which includes:

- Road Safety Week Celebration
- Lifting Tools and Tackles Inspection Drive
- “OHS Shikhar” – A Health, Safety, Environment Engagement for Associates
- Worlds Aid Day
- Hand and Power Tools - Equipment’s Inspection
- Fire Day Celebration
- World Health Day
- Blood Donation Day

9.9.1.3 OHSE Expectation & Performance Appraisal

Specific OHSE responsibilities considered as OHS expectation has been developed for all employees (job description) at Adani sites. All employees are held accountable for complying with these responsibilities. OHSE expectations are included in the performance appraisal process for all employees on an annual basis, including proactive indicator and accountability for compliance with all OHSE rules.

9.9.1.4 OHSE Goals and Objectives

Every year we set the high level of OHSE Goals and Objectives based on the OHS improvement needs. Respective Head of Department will frame out action plan by picking up applicable actionable item associated to achieve high level Goals set as per OHSE / IMS policy and allocate the same down the line to all respective employees which is considered as OHS expectation for respective employees (the respective HOD will finalize the measurement method for each G&O assigned to employee, track the progress and assist the employee to achieve expected Goals & Objective)

9.9.1.5 BBS Suraksha Samwaad

Suraksha Samwaad is the way of interaction of top management with workmen rather than inspection. It will exhibit that the management empathy the work carried out by its entire staff. On regular basis (at least fortnightly) suraksha samwaad is carried out for all the departments/ sections in order to identify the HSE risks arising out of the activities and to reduce them to the lowest practical level.

9.9.1.6 Reward & Recognition

At our company we encourage creative ideas & innovative approach for improving safety of any activity. We also recognize such employees / contractual staffs who had adopted innovative methods in their routine / special jobs during the Reward & Recognition Program which is being conducted monthly. In addition to this to promote a sense of belongingness and motivation among employees by recognizing and rewarding exemplary behavior/ contribution of employees instantaneously schemes such as Spot Reward Scheme has been introduced.

9.9.1.7 Training & Education

A dedicated hub for safety knowledge, it imparts knowledge in all port users about the safety of the port. The center is equipped with thought provoking banners and posters which can visually treat the users and improve their safety awareness.

9.9.1.8 Integration of Mobile in Fire Alarm System

Mobile number of Safety department head, Operation department head, Engineering department head, Operation Supdt, duty safety officer and fire supervisor are integrated with fire alarm system. In case of fire alarm activation, warning message will go to the above mobiles immediately, which will make emergency preparedness faster and easier.

9.9.1.9 Workmen Safety

To cultivate safety culture among the workforce and to improve safety of workmen safety awareness programs, promotional activities, training programs, safety interventions, management walk through, reward and recognition programs have been conducted.

Operation Safety

All the operators has to undergo assessment training prior to deployment. Job specific training refresh training has been conducted to operators and other workmen on regular basis. Engineering initiatives by coordinating with engineering team have been done to improve safety.

Workplace Safety- 5S Implementation

- MIDPL implementing 5S is the first step towards workplace safety and efficiency.
- 5S at all operational areas and offices.
- Safety shall be the honorary sixth “S” for MIDPL.

Driving Safety

At Kattuappli Port all employees and stakeholders are supposed to follow the driving safety policy inside and outside the company premises.

9.9.1.10 Concern Reporting

MIDPL implemented Gensuite mobile application for reporting any safety related concern like unsafe acts and conditions, safety suggestions, near misses and incidents etc. the corresponding department HOD has to close the concern before the due date.

9.9.1.11 Occupational Health Center Facility

Occupational Health Center at Marine Infrastructure Developer Private Limited is operated and maintained by M/s Kilpauk Mediline Services, Chennai. OHC team comprises of Qualified male nurses and ambulance with qualified drivers available on 24 X 7 basis.

First aid cases, treatment for minor injuries and illness rising to employees & contractors during their working hours is being taken care at the OHC.

Existing Facilities of OHC

The following equipments/facilities are available at our OHC.

CONTENT	Quantity (Nos)	CONTENT	Quantity (Nos)
Glucometer	1	Weighing scale	1
Iv stand	1	BP Apparatus	1
Privacy curtain(screen)	1	Splints-3	1
Needle destroyer	1	S.S.Tray-2	1
Sterilizer	1	Artery Forceps-2	1
Pillow with cover	1	Curved Forceps	1
Linen	1	Needle Holder Forceps	1
Stethoscope	1	Non Toothed -2	1
Infrared lamp	1	Toothed	1
Fire extinguisher	1	Scissor	1
Mobile stretcher	1	Kidney Tray-4	1

CONTENT	Quantity (Nos)	CONTENT	Quantity (Nos)
Patient chair	1	Basin With Stand	1
O_2 Cylinder	1		

First aid shall be provided by nurse at the OHC for the personnel suffering from minor injury/illness. For cases beyond the first aid are referred to M/s Kilpauk Mediline Services and the victim will be shifted using the ambulance.

Storage and handling of OHC equiqments / medicines

The medicines and equipments are stored and handled as per the standard instructions of the equipment manufacture and physician. 5s technique is adopted in the OHC to store the medicine

Collection and storage of Bio Medical Wastes

Bio Medical Wastes generated out of treatment are appropriately collected in the closed containers with different colour codes for the wastes as per the Bio Medical Waste Rules

Disposal of wastes

The stored Bio Medical wastes are disposed regularly to M/s Kilpauk Mediline Services. The hospital already having the agreement with M/s Tamil Nadu Waste Management Limited wherein the generated wastes are safely disposed finally in accordance with the Bio Medical Waste Rules 2016.

9.9.1.12 Safety Training Facilities at Kattupalli Port

MIDPL conduct training for industrial safety based on training need identification for employees as well as contract workmen TNI file was prepared by Training element owner along with OHS head. Safety training center, a dedicated hub for safety knowledge, it imparts knowledge in all port users about the safety of the port is established at MIDPL. The center is equipped with thought provoking banners and posters which can visually treat the users and improve their safety awareness.

Industrial safety training includes

- Firefighting training
- First aid training
- Emergency evacuation training
- Job specific training
- Training on permit to work
- HIRAC training
- Defensive driving training
- Material handling training
- Training on integrated management system etc.

Exhibit 9-3: Safety Training Sessions at Kattuaplli Port

Training programs conducted during Financial year (2019-20)

S.No	Types of training	No. of participants
1	Driving safety awareness	106
2	Wharf & Deck Checker training	48
3	Golf cart Training	54
4	Gensuite	62
5	Road safety awareness	58
6	IMDG training	16
7	Evacuation training from elevator	15
8	Fire extinguisher training and demo	81
9	HIRAC training program	17
10	Permit to work	18
11	Electrical safety -external	24
12	PPE awareness	22
13	Fall Protection Awareness	30
14	First aid - external	20
15	ITV- Assessment	49
16	Pre-assessment conducted for RMQC& RTG operators	61
17	FLT –assessment	24
18	RMQC – training & final assessments	11

9.9.1.13 Safety Promotion Activities at Kattupalli Port

Safety promotion activities like National Safety Day, Road Safety Week, Fire Service Day etc. are being celebrated at MIDPL.

Activities during National Safety Day

- NSW Celebration and Reward & Recognition
- Refresher training on Hazard Identification and Risk Assessment and Controls(HIRAC)
- Safety skits with life saving rule (LSR) theme
- Online Quizzes, poster and slogan competition and Spot the Hazard competition on Risk Assessment.
- Training program on conducting activity specific tool box talks effectively.
- Evaluation of effectiveness of TBT.


Activities during Fire Service Day

- Basic fire fighting training to cover all employees.
- Mock drill programs on evacuation in case of fire emergency situations.
- Fire fighting competition among departments.
- Carry out fire risk assessment at high hazard and fire prone areas.

- Quiz, Poster and Slogan competition on fire safety theme.
- Training on operation of fire pump house in case of emergency.

Activities during Road Safety Day

- Training on Road on defensive driving.
- Inspection of vehicles (LMV/HMV)
- Online quiz, Poster and Slogan competition on road safety theme.
- Road safety awareness campaign for external drivers.

9.9.1.14 On Site & off Site mock Drills conducted at Kattupalli Port

In order to handle various types of emergencies, different scenarios have been created and mock drills are conducted. For every month 2 different type of mock drills are conducted. The scenarios tested can range from Fire in Kitchen, Trailer, Waste/ scrap materials, offices etc, Fire evacuation, Diesel Spillage, Gas Leakage, Tsunami alerts, falling in sea, Heat stroke, Snake bite, Electric Shock etc.

At the end of the drills, drill reports are circulated; discrepancies and time duration are analyzed by the team of experts. Measures to improve the time response are identified and implemented.

9.9.2 Occupational Hazards

Occupational health hazards, areas associated with hazards and proposed mitigation measures are given in **Table 9-8.**

Table 9-8: Occupational Health Hazards and Proposed Mitigation Measures

S. No.	Occupational Health Hazard Component	Areas Associated with Hazards	Mitigation
1.	Noise	Construction, operational activities such as cargo handling, storage and transportation, maintenance, and repair activities like metal working such as welding, cutting; the use of heavy equipment and vehicles, DG sets	• Provision of sound-insulated control rooms with noise levels below 60 dB(A) • Procurement of generators to meet applicable occupational noise levels • Identify and mark high noise areas and provision of PPE where people have to enter high noise areas • To reduce the risk of noise exposure isolate noisy equipment and rotate tasks to minimise time spent in a noisy area over an eight hour period.
2.	Confined Spaces	Specific areas for confined space entry.	• Adequate engineering measures shall be implemented to eliminate the degree of confined spaces • Entry into confined spaces should be strictly controlled • Unavoidable confined spaces shall be provided with permanent safety measures • System shall follow “Recommendations for entering enclosed spaces aboard ships” of IMO Resolution A.1050(27) • Local exhaust ventilation shall be installed
3.	Electrical Hazards	Energized equipment, earthing and welding equipments and power lines can pose electrical hazards for workers	• Installation of hazard warning lights shall be taken up • Use of voltage sensors prior to and during workers' entrance • Deactivation and proper grounding of live power equipment and distribution lines according to applicable legislation and guidelines • Provision of specialized electrical safety training to workers • Welding machines and consumables should be kept dry at all times • Adequate earthling for transformers
4.	Fire and Explosion	Handling and storage of fuel, combustible material & products, etc.	• Use of automated fire and safety controls • Implementation of startup and shutdown procedures • Automated sensors and regular cleaning mechanism • Mock Drills

5.	Dust	Dust may arise due to handling of dry bulk cargo	• Use of dust controls such as:
			  ○ Covered Conveyor
			  ○ Dust Suppression System at stockyard, Transfer towers, at berth/Unloaders, at wagon (Un) loading, at Truck loading Silos, Discharge and feeding points of Conveyors etc.
			  ○ Use of Specialised Unloaders
			  ○ Proper house keeping
			  ○ Trucks before leaving the loading area shall be covered with tarpaulin and also the railway wagons
			  ○ Trucks Tyres and areas susceptible for coal dust before leaving premises shall be cleansed washed to remove coal particles.
			  ○ Use of PPEs

S. No.	Occupational Health Hazard Component	Areas Associated with Hazards	Mitigation
6.	Slip, Trip and Falls	Decks, gratings, ladders and walkways are likely to become slippery or hazardous due to cargo residues, welding rod ends, Spill liquids, scrap metal, etc., Mal operation of lifting equipments	• Good housekeeping practices shall be in place • Adequate lighting shall be provided • Regular maintenance of lifting equipments shall be undertaken • Appropriate fall arrest equipment shall be provided • A safe means of access between vessel and shore to prevent falls shall be ensured
7.	Falling objects	• Hoisting of material on and off the ship and movement of equipment or material within tanks, engine rooms and pump rooms	• Use of safety helmets • Incomplete works should be stabilized by temporary support and/or bracing systems
8.	Heat	• Occupational exposure to heat occurs during operation and maintenance of combustion units, pipes, and related hot equipment like Boilers etc.	• Regular inspection and maintenance of pressure vessels and piping • Provision of adequate ventilation in work areas • Time reduction for work in elevated temperature and ensuring access to drinking water • Shielding surfaces where workers come in close contact with hot equipment • Use of warning signs near high temperature surfaces and personal protective equipment (PPE)

9.9.3 Personal Protective Equipment

The Personal Protective Equipment (PPE) offers protection to worker, co-workers and visitors. Staff should be trained in the correct selection, use and maintenance of PPE. Typically when working at port facilities, minimum PPE should include a long sleeved suit/coveralls, safety footwear, safety helmet, reflective jakets, safety spectacles/goggles, torch, gloves and hearing protection. When working aloft, an appropriate safety harness should be utilised. If the work being undertaken could create a potential inhalation hazard then respiratory protection should be worn. It is of paramount importance that prior to use, respirators are checked to ensure that they have been maintained in accordance with manufacturer's recommendations. **Table 9-9** provides list of PPE that shall be used at the port facilities:

Table 9-9: List of Personnel Protective Equipment

Protection For	Equipment	Protection Against
Hand	• Leather gloves • Asbestos gloves • Electrical resistance gloves • Canvas gloves • Hand sleeves	• Cuts due to handling • Heat radiation • Electrical shock • Contact with oil & grease, etc. • Falling of hot slag
Leg	• Leg-guards • Leather safety boots • Asbestos safety boots	• Welding sparks • Striking by objects, fall of objects and stepping on sharp or hot objects • Heat radiation stepping on sharp or hot objects
Eye	Spectacle type goggles with plain shatter proof lens	Foreign bodies entering eyes and reflected arc rays
Head	Fibre Helmet	Fall of objects/hitting against objects during construction, maintenance, etc.
Ear	Ear plugs or muffs	High noise level

Protection For	Equipment	Protection Against
Nose	Dust protection mask	Fine dust particles

9.9.4 Occupational Health and Safety Improvement Measures

Following are some of the occupational health and safety improvement measures to be implemented at the port:

- Provision of Personal Protective Equipment (PPE) that is fit for the task to prevent injury and maintain hygiene standards
- PPE should be inspected regularly and maintained or replaced as necessary
- Training of workers in correct use of machinery and safety devices
- Installation of mechanical lifting aids where possible and rotate work tasks to reduce repetitive activities
- Separation of people from moving equipment
- Installation of walkways to separate people from vehicles or moving parts to reduce risk of collision

9.9.5 Health Monitoring

MIDPL has already established an Occupational Health Service Centre within the port premises to promote and maintain physical, mental and social well-being of the employees same shall be strengthen according to proposed development. The unit will be equipped to detect and prevent occupational/work related diseases and shall offer effective emergency and injury care. The centre will develop health education training packages including use of PPE for all employees and impart training accordingly. Occupational Health Service shall arrange to provide adequate number of First Aid Boxes with approved contents on the shop floor. Ambulance will also be provided to meet any emergency situations.

The records of health check-up of all employees will be maintained. The occurrence of occupational health hazards and diseases will also be maintained. The records may be reviewed at regular intervals to check the effectiveness of various measures implemented. Based on the review, action plan to improve the effectiveness of occupational health and safety measures shall be prepared.

9.9.6 Safety

Overall safety of men and material is an important aspect of port performance. MIDPL shall implement separate safety measures for construction and operation phases and the Safety Engineer shall be engaged to coordinate the safety aspects. All applicable National Safety standards shall be implemented by MIDPL to provide safe working environment.

9.9.6.1 Safety Circle

In order to fully develop the capabilities of the employees in identification of hazardous processes and improving safety and health, safety circles would be constituted in each area of work. The circle shall consist of 5-6 employees from that area. The circle shall normally meet for about an hour every week.

9.9.6.2 Safety Training

Safety training shall be provided by the Safety Engineer on a regular basis. In addition to regular employees, contract employees/labours shall also be provided safety training.

9.9.7 Legislations

Legislations relating to Occupational Health & Safety in India (Ref: Report of the Working Group on Occupational Safety and Health – Planning Commission of India, GoI, September 2001) and applicable/relevant to port operations are listed below:

- The Factories Act, 1948 and the State Rules notified there under
- The Dock Workers (Safety, Health & Welfare) Act, 1986
- The Explosives Act, 1884 and the Rules framed there under
- The Petroleum Act, 1934 and the Rules framed there under the Indian Electricity Act, 1910 and the Indian Electricity Rules, 1956

9.10 Budgetary Estimates

The budgetary estimate for Capital Environmental Management Cost for Revised Master Plan is ~INR **2324.11 crores** and the annual budgetary estimate during operational phase is ~INR **120.19 crore**. The breakup of cost is given in **Table 9-10** and **Table 9-6**.

Table 9-10: Environmental Management - Capital Cost

S. No.	Purpose	Cost in Lakhs (INR)	Million (INR)	Cost in Crores (INR)
1	Green Belt	955	95.5	9.55
2	Solid Waste Management	200	20	2
3	Desalination Plant	27,450	2745	274.5
4	Marine Life Protection (Add.Tug boat, Oli spill, Equipment, Training etc.)	1800	180	18
5	Dust Sweeper	196800	19680	1968
6	Air Pollution Control (Sprinkler System, Conveyor Belt with hood, Wagon loading, truck loading with Silos)*			
7	Environment Monitoring and Terrestrial and Marine biodiversity Conservation	200.942	20.09	2.01
8	Effluent Treatment Plant	4005	400.50	40.05
9	Sewage Treatment Plant	200	20.00	2.00
10	Settling Pond for Bulk Cargo	800	80	8
11	Settling Pond for Iron Ore			
	Total	**232410.94**	**23241.09**	**2324.11**

** Wind screens will be provided along stack yard.*

Table 9-11: Environmental Management - Annual Recurring Cost

S. No.	Purpose	Cost in Lakhs (INR)	Million (INR)	Cost in Crores (INR)
1.	EMC Running expenditure	66.60	6.66	0.67
2.	Greenbelt Maintenance	176.66	17.67	1.77
3.	Waste Management	35.00	3.50	0.35
4.	Awareness campaigns-Training	42.00	4.20	0.42
5.	Maintenance of tugboat, booms and skimmer etc.	25.00	2.50	0.25
6.	Maintenance of Air Pollution Control System	9840.00	984.00	98.40
7.	Desalination Plant	1372.50	137.25	13.73
8.	ETP Maintenance	200.00	20.00	2.00
9.	STP Maintenance	10.00	1.00	0.10
10.	Maintenance of Settling Ponds for Coal	40.00	4.00	0.40

S. No.	Purpose	Cost in Lakhs (INR)	Million (INR)	Cost in Crores (INR)
11.	Environment Monitoring (incl. Terrestrial and Marine biodiversity Conservation	143.32	14.33	1.43
12.	Statutory compliance for environmental protection	68.00	6.80	0.68
	Total	**12019.08**	**1201.908**	**120.1908**
			Round off	**120.19**

Chapter 10
Summary and Conclusion

Chapter 10 Summary and Conclusion

10.1 Introduction

Tamil Nadu Industrial Development Corporation Limited (TIDCO), a Government of Tamil Nadu Enterprise, identified the leading technology, engineering and construction conglomerate, Larsen & Turbo (L&T), as partner for developing Shipyard cum Port Complex on a Joint Venture (JV). GoTN allotted about 1200 acres of land at Kattupalli for development of Shipyard cum Port Complex. L&T Shipbuilding Limited, a JV of L&T and TIDICO, was formed and JV agreement was signed between the parties on April 15, 2008 to develop the Shipyard cum Port Complex at Kattupalli.

L&T Ship Building Limited (LTSB) has obtained required EC & CRZ clearance for Shipyard cum Port Complex at Kattupalli, Thiruvallur District, Tamil Nadu vide Letter No. 10-130/2007-IA.III, dated July 03, 2009. Tamil Nadu Pollution Control Board (TNPCB) has accorded Consent to Establish (CTE) vide letter dated August 18, 2009. LTSB obtained amendment for dredging and dumping from MoEF&CC vide Letter No. 10- 130/2007-IA.III, dated May 12, 2010. LTSB has commissioned its operations on January 30, 2013. LTSB obtained amendment to handle revised cargo traffic at the Kattupalli Port in EC & CRZ clearance along with extension of validity from MoEF&CC vide Letter No. 10- 130/2007-IA.III, dated December 17, 2014.

Considering the divergent nature of business of LTSB and to harness the potential for growth with clear focus on port business, LTSB had approached the Hon'ble National Company Law Tribunal (NCLT), Chennai with a Scheme of arrangement for demerger of port business of LTSB into a separate company Viz., M/s Marine Infrastructure Developer private Limited (MIDPL). The Hon'ble NCLT after careful examination of the scheme had accorded its approval on March 20, 2017. Pursuant to the said NCLT Order, the Port business in Kattupalli Shipyard cum Port Complex on a going concern basis together with the identified port assets, powers, sanctions, approvals, registrations etc., stands transferred and vested with MIDPL. Accordingly LTSB had approached MoEF&CC to bifurcate the existing Environmental and CRZ Clearance in the name of L&T Shipbuilding for Shipyard and MFF related activities and in the name of MIDPL for Port and common infrastructure related activities. MoEF&CC granted the bifurcated EC vide letter no. F. No.10-130/2007-IA.III dated February 9, 2018 in the name of MIDPL.

Considering the future business potential, MIDPL proposed development of Revised Master Plan of Kattupalli Port.

10.1.1 Project Location

The Kattupalli Port is located towards North of Kamarajar (Ennore) Major Port near Kattupalli village of Ponneri Taluk, Thiruvallur District, Tamil Nadu. The geographic location of the Kattupalli port is at Latitude 13^0 18' 50.35" N and Longitude 80^0 20' 45.68" E. Location map of the project site is given as **FD0101**.

10.1.2 Need and Justification of Project development

To address the basic infrastructure needed to match the growing GDP of the country, Sea Port infrastructure are grossly inadequate for the nation to meet the growing challenges which in turn successfully integrate Indian Trade with the Global economy in terms of productivity, efficiency, state-of-art technology and surpass global developments in the Shipping sector.

The port is located on the east coast of the Indian peninsula known as the Coromandel Coast in the Bay of Bengal and is known at the "gateway" to India and is well connected to other major cities by rail and road network. The port lies in northern suburbs of Chennai is poised to act as an ideal alternative gateway for Chennai and Ennore port.

Buckingham Canal is a tidal influenced canal and is passing through the proposed Revised Master Plan development, which has also been declared as prestigious National Waterway-4 project by GoI shows that there is enormous potential of movement of cargo.

Based on the available hinterland the revised traffic forecast for the Kattupalli port has been worked out as given below:

- Multi-Purpose (including Liquid) – 320 MMTPA (including Existing - 24.65 MTPA)

10.2 Project Description

Revised Master Plan of Kattupalli Port is proposed with flexibilities to accommodate all berths (existing as well as proposed) as multipurpose Cargo Port with transloading facilities, backup facilities and independent port craft facilities, waste reception facilities, conveyor systems, drainage, water supply, electrical works, internal roads, railway works and other utilities, amenities and bunkering considering the future business potential.

- Revised master plan development – additional Quay length of ~9567 m berth length, quay length of 1250 m Barge berths & ~12 Port Craft facilities are proposed (including existing approved 2 port craft). Total quay length of berth proposed as a part of revised master plan will be ~11467 m in addition to 1250 m long barge berths & 2 no SPM's are also proposed to handle Multi-Purpose and Liquid/Gas/Cryogenic cargoes. Total cargo handling capacity will be approximately 320 MMTPA along with increased backup facilities.
- For easy evacuation of cargo, a new rail, road and utility corridor is also proposed within the existing port boundary.
- The Project Cost in line to Revised Master Plan development is INR **53,031 Crores**[11].

10.2.1 Cargo Mix and Cargo Handling Capacity

The indicative list (but not limited to this list) of cargo mix proposed to be handled in RMP is presented in **Table 10-1**.

Table 10-1: Cargo Mix for Revised Master Plan

S. No.	Cargo Type	Cargo Mix
1.	Multipurpose (Including Liquid)	Coal / Iron ore / limestone / Mines & Minerals & other dry bulk/Fertilizers and raw materials for manufacture of fertilizer / food grains / sugar / clinker / cement / Project cargo / timber & wood / machines/ Iron steel products / Break Bulk etc./Container, Ro – Ro & Automobiles and any other non-hazardous cargo All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos Tentative list of hazardous liquid cargo but not limited to are as follows: Ethylene, Propylene (Propene), Butadiene, Pentane, Ethyl Mercaptan Motor Spirit, Propylene Oxide, Hexane, Naphtha, Acetone, Methyl Chloride / Chloro Methane, Cyclohexane, Benzene, Ethyl Acetate, Acrylonitrile Acetonitrile, Methyl Methacrylate, Methacrylonitrile, Methanol (Methyl Alcohol),Isopropyl Alcohol, Ethyl Alcohol (Ethanol), Ethylene di chloride, Methyl Isobutyl Ketone, Ethyl Benzene, N-Butyl Acetate, Isobutyl Alcohol (Iso Butanol), N-Butyl Alcohol (N-Butanol), Epichlorohydrine, Styrene, O-Xylene, High Speed Diesel, Cumene, Crude Oil, Aviation Fuel, Kerosene, Acetic Acid, Acetic

[11] *Above cost also does not cover land acquisition cost*

S. No.	Cargo Type	Cargo Mix
		Anhydride, Non-edible/Mentha Oil Low Sulphur Heavy Stock/ Furnace oil, Carbon Black Feedstock (CBFS), Aniline, Methyl Ethyl Ketone Peroxide, Ethyl Hexanol-2, Vinyl Chloride, Phenol, Naphthalene, Ethylene Glycol, Mono Ethylene Glycol, Toluene 2.4 -di isocyanate, Diphenyl Methane Di-Isocynate, Edible oil/Palm Oil, Paraffin, Bitumen, Sulphur, Lube oil, Asphalt, Coal, CNG, NG, Ammonia (NH_3), Diammonium Phosphate, Muriate of Potash (MOP), Soda Ash (Sodium Carbonate), Urea, Limestone, Caustic Soda, Sulphuric acid, Phosphoric acid, Piperine/ Piperdine, Chloroform, Hydrochloric Acid (HCL), Ethylene diamine (EDA), CMDI etc.
2.	Gas / Cryogenics/Liquid	LNG, Propane, Butane, LPG, CNG, NG and All Class A, B, C petroleum products, excluded petroleum products Including Petrochemical products, Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos.

10.2.2 Salient Features of the Revised Master Plan Development

The salient features of Proposed Kattupalli port have been tabulated in **Table 10-2** and Revised Master Plan is presented as **FD0202**.

Table 10-2: Salient Features of Proposed Development

Features/Description	Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
Handling Capacity	MTPA[12]	**24.65**	**320** (including existing approved capacity)
Cargo Mix	-	Container MTEUs), Break Bulk / General (MTPA), Project Cargo, Ro-Ro (No's), Non-Hazardous Liquid Cargo (MTPA)	Revised Master Plan Development of Kattupalli Port involves handling and storage of Multipurpose Cargoes including liquid, Coal, Iron Ore, Bulk, Break Bulk, Project Cargo, General Cargo, Dry Cargo Container, Fertilizer and FRM, Ro – Ro & Automobiles and any other non-hazardous cargo and Liquid/ Gas / Cryogenics (Upto -162 degree Celsius) cargoes including All Class A, B, C petroleum products, excluded petroleum products, Non - Classified Chemicals & Petroleum products Hazardous, Toxic and Non Hazardous chemicals/Liquids and other Liquid cargos Including LNG/CNG/LPG etc., etc. Apart from port backup area, external road, rail (double line), utility corridors and 30 MLD capacity of desalination plant etc. Port backup Industries & Industrial development area and its infrastructure
Length of North Western Breakwater	m	1775	Apart from existing breakwaters, two new breakwater of about total 12.1 km length is proposed, out of which new Northern Breakwaters will be about 9.02 & 1.22 km and new Southern Breakwater will be about 1.86 km
Length of South Breakwater	m	1665	
Total Area	Ha	~136.28	Revised Master Plan Development of Kattupalli Port will be carried out in total area of 2472.85 ha which

[12] *MTPA: Million tons per annum*

Features/Description			Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
					includes which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 Ha including basin and all developable area.
Dredging Quantity			MCM	8.0 out of 24 approved	Dredging will be carried out at proposed berthing areas and for widening and deepening of existing approach channel, as per the revised master plan development requirements. It is estimated that ~ 85 Mm^3 (MCM) of dredged material will be generated. Entire dredged material will be used for reclamation. Additional material for reclamation will be borrowed from identified borrows area (onshore/offshore). Total proposed quantity for Reclamation including landfilling is estimated about 138 Mm^3 (MCM) which will be used for reclaiming 1145 Ha area.
Reclamation			MCM	6.0	
Offshore Disposal			MCM	2.0	1.2 (Avg.) - 3.2 (Max) of maintenance dredging quantity
Maintenance Dredging			MCM/Annum	~0.4	1.2 (Avg.) - 3.2 (Max)
Diameter of Turning Circle			m	580	One 650 m & two new 700 m
Depth at Turning Circle (Manoeuvring Areas)			below CD m	(-) 14.0	(-) 20.5 & (-) 25.0
Quay Length			m	1900 and 2 Port Craft Berths. Only 3 out of 5 berths are existing	11467 (Cumulative) in addition to 1250 m long barge berths and 12 Port Craft Berths + Trans loading Facility & 2 SPMs
Approach Channel	Outer Channel	Width	-	180 m	500 m
		Depth		(-) 14.0 m	(-) 27.0 m
		Length		2325 m	5000 m
	Inner Channel	Width		215 m	500
		Depth		(-) 14.0 m	(-) 25.0 m
Water (Potable) Source			m^3/day	60/CWSSB Desalination Plant	30000 (Proposed Captive Desalination Plant Cumulative))
Seawater Intake for Desalination Plant			MLD	-	~75
Reject from Desalination Plant			MLD	-	~45
Seawater intake for Regasification/Process if any			MLD	-	~2910 (including Desalination and LNG/LPG water requirement)
Power			MVA	6.5	100
Greenbelt and other areas			Acres	~7.0	241

Features/Description	Unit	Existing Facilities at Kattupalli Port	Proposed Revised Mater Plan Development
New Road/Rail	-	Road access developed	In future the existing facility of southern connectivity of the Kattupalli Port, will not be sufficient to cater the projected increase in traffic of the port as well as operationally there will be need of another railway link to the Kattupalli port which is proposed from Minjur station, situated on the north side of existing railway link and is termed as northern link. However, feasibility of alignment of proposed corridor will be checked during detailed study. Apart from port backup area, external road, rail and utility corridor is proposed in an area of around 30 ha to provide connectivity
Employment	Nos.	250	1500 Direct & 4500 Indirect
Project Cost	Crores	4675 As per EIA	53031
Navigational Aids	-	Channel marker buoys, Fairway buoy and Turning circle buoys, Front and rear leading light, Berth corner lights, Maritime Buoyage Systems (Lateral marks, Cardinal marks, Isolated danger marks, Safe water marks, Special marks) and Other Marks (Lighthouse, Beacons, Sector lights, Leading lines, Port or Harbour marks), VTMS, Tugs, etc.,	
Environmental Aspects	-	Stacks for DG, Oil Water Separator (5KLD), STP (45 KLD), Organic Waster Convertor, Hazardous waste to Authorized Vendor/TSDF, PPEs, Approved Oil Spill Contingency Plan and Green Belt	Covered Coal Storages; Wind Barrier; Covered Conveyor; Dust Suppression System; Use of Specialised Unloaders; Proper housekeeping; Trucks & railway wagons covered with tarpaulin; Washing of Trucks Tyres and areas susceptible for coal; Green Belt, Stacks for DG, ETP (1500 KLD), STP (240 KLD), Settling Pond at Coal Stockyard; Storm Water Drainage System, Organic Waster Convertor, Hazardous waste to Authorized Vendor/TSDF, PPEs, Updated Oil Spill Contingency Plan and Green Belt

With a view to optimize the waterfront area, utilize the maximum marine development potential, increasing the backup area usage to accommodate future cargo projections and business requirement, MIDPL proposes to revise the Master Plan.

10.2.3 CRZ Compatibility

The National Centre for Sustainable Coastal Management (NCSCM), has carried out demarcation of High Tide Line (HTL), Low Tide Line (LTL) and Coastal Regulation Zone (CRZ) classification of the project site. Based on the survey, CRZ set back lines were demarcated and the project layout was superimposed on CRZ map.

- Revised masterplan activities are falling CRZ IB, CRZIII, CRZ IVA and CRZ IVB. Cargo handling operations at berths and transportation, SPM operations, Intake outfall facilities of Desalination and LNG/LPG etc. are envisaged in CRZ area.
- The activities proposed within CRZ area are permissible as per CRZ notification, 2011
- Proposed port location does not contain environmentally sensitive areas such as National parks / marine parks, sanctuaries, wildlife habitats, corals / coral reefs. It also does not include breeding and spawning grounds of fish and other marine life, area of outstanding natural beauty / historically / heritage area, area rich in genetic diversity.

10.2.4 Project completion Schedule

The proposed RMP is prepared considering development in next 15-20 years.

10.3 Description of Environment

Project Influence Area (PIA)/Study Area: As per the Ports and Harbour EIA guidance manual issued by MoEF&CC, an area within 5 km radius from project boundary for primary data generation and 15 km radius as the general study area for secondary data generation is considered. A map showing the study area is given as **Figure FD0102**.

Study Period: The baseline terrestrial and marine environmental surveys were carried out covering the following three seasons:

- Winter season (January 2018 – February 2018)
- Summer season (March 2018 – May 2018)
- Post monsoon season (June 2018 – September 2018)

In line to assure the accomplishment of ToR conditions MIDPL has also assessed Biodiversity of estuary and coastal region, studies on impacts of the proposed project on the Pulicat Lake, Shoreline change studies, Ennore Shoals and Socio-economic assessment in the project influence area.

10.3.1 Terrestrial Environment

- The site is comprised of Sea, Wetlands-Manmade (Waterlogged/Saltpans), Agriculture Lands, Scrub Land, Plantation, Built-up-Industrial, River/Stream/Canals, Aquaculture etc.
- The study area mostly comprises of Bay of Bengal, Wetlands-Manmade (Waterlogged/Saltpans), Agriculture-Crop Land, Wasteland-Scrub Land, Reservoir/Lakes/Ponds, Built-up-Industrial, Built-up-Rural, Agriculture-Aquaculture, Built-up-Urban, River/Stream/Canals, Agriculture-Plantation, Forest-Swamp and Inland Wetland. Buckingham Canal is passing through the proposed RMP, which has also been declared as prestigious National Waterway-4 project by GoI.
- The existing Kattupalli port back-up area is plain with few undulations and back-up area was reclaimed to a height of (+) 4.5 - (+) 5.0 m CD which serves as the cargo storage yards.
- Proposed development area falls under Seismic Zone-III (medium risk zone) and Cyclone prone area as per IS 1893 (Part I) and Climatic Disasters Risk map of Tamil Nadu.
- As per the Project site specific meteorological data, the predominant wind directions observed were from South East followed by South West.

Air Quality:

Maximum concentrations of Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}), Carbon Monoxide (CO), Ozone (O_3), Ammonia (NH_3), Lead (Pb), Benzene (C_6H_6), Benzo (a) Pyrene (BaP) – Particulate phase only, Arsenic

(NH_3), Lead (Pb), Benzene (C_6H_6), Benzo (a) Pyrene (BaP) – Particulate phase only, Arsenic (As), Nickel (Ni), are well within the National Ambient Air Quality Standards for Residential areas at all monitoring locations during the study period.

- PM_{10} concentration ranged between 37 µg/m^3 (at Kattur during summer and winter seasons respectively) and 86 µg/m^3 (at Uranambedu during summer season). NAAQ stipulated standard for PM_{10} for 24 hr average is 100 µg/m^3.
- $PM_{2.5}$ concentration ranged between 12 µg/m^3 (at Kattupalli during Winter season) and 40 µg/m^3 (at Uranambedu during Summer season). NAAQ stipulated standard for $PM_{2.5}$ for 24 hr average is 60 µg/m^3.
- SO_2 concentration ranged between 3.5 µg/m^3 (at Karungalikuppam during winter season) and 9 µg/m^3 at Attipattu during Summer season. NAAQ stipulated standard for SO_2 for 24 hr average is 80 µg/m^3.
- NO_2 concentration ranged between 9.4 µg/m^3 (at Karungalikuppam during winter season) and 17.9 µg/m^3 (at Attipattu during Winter and summer seasons). NAAQ stipulated standard for NO_2 for 24 hr average is 80 µg/m^3.
- O_3, CO, NH_3, Pb, C_6H_6, BaP, As, and Ni were observed below detectable limits in all the locations.

Noise Quality:

It is observed that the day and night equivalent noise levels at most of the monitoring locations except Karungalikuppam, Neidhavoyal and Kattur where both the day and night noise levels are exceeding. Intense vehicular movements were observed in these areas and rest of the of the locations noise limits are well within the prescribed CPCB standards.

- Day equivalent noise levels (Ld) for Residential areas L_d ranged between 55.98 dB(A) at Karungalikuppam during Winter to 65.38 dB(A) at Kattur during winter season and for Industrial areas, L_d ranged from 58.13 dB(A) at Kalanji during Summer season to 67.8 dB(A) at Attipattu during Winter season.
- Night equivalent noise levels (Ln) for Residential areas, L_n ranged between 50.05 dB(A) at Karungalikuppam during Summer season to 56.05 dB(A) at Karungalikuppam during winter season and for Industrial areas, L_n ranged from 53.21 dB(A) at Kalanji to 63.21 dB(A) at Kattupalli both during Winter season.

Water Quality:

- All the Ground water parameters were observed to be well below the desirable limit except colour at Ramanathapuram and Urnambedu, Turbidity, Iron (Fe), Sulphates at Urnambedu, Flouride at all locations but well within the permissible limits of standard IS: 10500(2012).
- It is inferred that almost of the parameters for surface water sample are within the permissible limits as per ISI-IS2296-1982 Class C (Drinking water source with conventional treatment followed by disinfection) Standards for use based Classification of Surface Water except Iron, TDS, Chloride, Sulphates, BOD, Cadmium and Lead at all locations during all seasons.

Soil Quality:

- At Kattupalli, Kalanji, Karungalikuppam villages, silt was dominant, at Attipattu village, Silty loam is dominant, at Kattur, Neidavayal villages Sandy loam is dominant and at Uranambedu village Clay is found to be dominant and the soil samples are slightly acidic as well as alkaline in nature

Flora:

- Among the 235 plant species reported from the study area no species is listed in IUCN (International Union for Conservation of Nature) threatened category from the project site.

Fauna:

- Among the 111-fauna species reported in 15 km buffer area.

The four species were listed in the IUCN/IWPA (Wildlife Protection Act, 1972) are discussed in **Table 10-3**.

Table 10-3: IUCN/IWPA listed Fauna species reported in 10 km buffer area

S. No	Scientific Name	Common Name	IUCN	IWPA Schedule
1	*Pavo cristatus*	Indian peafowl	Least concern	I (Part III)
2	*Mycteria leucocephala*	Painted stork	Near Threatened	IV
3	*Pelecanus philippensis*	Spot-billed pelican	Near Threatened	IV
4	*Anhinga melanogaster*	Oriental Darter	Near Threatened	IV

Pulicat bird Sanctuary[13] is located ~2.1 km, NW to the project site.

10.3.2 Marine Environment

Water and sediment samples for physico-chemical, petroleum hydrocarbons, heavy metals and biological analysis were collected from twelve (12) locations including two (2) intertidal locations for three seasons.

Sediment Quality

- Sand ranged between 6.04% and 57.48%; Silt ranged between 23.20% and 50.39%; Clay ranged between 4.87% and 58.20% for offshore areas. Sand ranged between 53.70% and 61.80%; Silt ranged between 24.30% and 34.00%; Clay ranged between 11.95% and 13.84%for intertidal areas
- pH is alkaline in nature and varied from 8.32 to 8.69 for offshore locations and 8.32 to 8.74 for intertidal locations.
- TOC values ranged from 2.01 mg C/g to 5.78 mg C/g for offshore locations and 2.20 mg C/g to 3.96 mg C/g for intertidal Locations.
- Cadmium values ranged from 7.28 µg/g to 12.48 µg/g for offshore locations and the values for intertidal locations are ranged between 7.03 µg/g to 12.38 µg/g.
- Copper concentration ranged from 22.42 µg/g to 28.33 µg/g for offshore locations and the values for intertidal locations are ranged between 22.10 µg/g to 27.85 µg/g.
- Iron concentration ranged from 1128.90µg/g to 1953.53 µg/g for offshore locations and the values for intertidal locations are ranged between 1504.73µg/g to 1938.50 µg/g.
- Lead concentration ranged from 5.20 µg/g to 10.99 µg/g for offshore locations and the values for intertidal locations are ranged between 5.56 µg/g to 11.47 µg/g.
- Zinc concentration ranged from 11.90 µg/g to 33.40 µg/g for offshore locations and the values for intertidal locations are ranged between 19.60 µg/g to 31.90 µg/g.

[13] Pulicat Wildlife Sanctuary, Tamil Nadu and mentioned village boundaries as the sanctuary boundaries vide G.O .Ms .No.1247, Forests and Fisheries dated 22nd September 1980. The areas (village boundaries) covered by these village and also the areas included by the boundaries described above shall be the "Pulicat Lake Birds" Sanctuary. As per the Minutes of 34th ESZ Expert Committee Meeting for the declaration of Eco Sensitive Zone (ESZ) around Wildlife Sanctuaries/National Park held on 06th March 2019, in the MoEF&CC Tamil Nadu government has decided not to propose any eco sensitive zone for Pulicat Birds Sanctuary. PCCF & CWLW, Government of Tamil Nadu presented that "no ecological requirement of any other buffer area for the conservation management of the sanctuary which is only seasonal in nature at the time of arrival of birds".

- Mercury concentration ranged from 0.60 µg/g to 1.05 µg/g for offshore locations and the values for intertidal locations are ranged between 0.64 µg/g to 1.03 µg/g.
- Nickel concentration ranged from 9.68 µg/g to 17.9 µg/g for offshore locations and the values for intertidal locations are ranged between 11.28 µg/g to 17.78 µg/g.
- Manganese concentration ranged from 51.50µg/g to 90.47 µg/g for offshore locations and the values for intertidal locations are ranged between 65.80 µg/g to 81.30 µg/g.
- Chromium concentration ranged from 5.37µg/g to 10.37 µg/g for offshore locations and the values for intertidal locations are ranged between 5.22 µg/g to 10.86 µg/g.
- The E. coli population ranged between 19 $x10^3$ CFU/g to 28 $x10^5$ CFU/g for offshore locations and 16 $x10^3$ CFU/g to 22 $x10^5$ CFU/g for intertidal locations.
- The Total Viable Count ranged between 22 $x10^3$ CFU/g to 27 $x10^5$ CFU/g for offshore locations and 15 $x10^3$ CFU/g to 28 $x10^4$ CFU/g for intertidal locations
- Macro benthos density was ranged between 575/m^2 to 1125/m^2 for offshore locations and 525/m^2 to 650/m^2 for intertidal locations
- Meiofauna density was ranged between 198 nos/10 cm^2 and 382 nos/10 cm^2 for offshore locations and 158 nos/10 cm^2 and 312 nos/10 cm^2

Water Quality

- Water temperature ranged from 28.0°C to 33.0°C
- Minimum and Maximum Salinity recorded varied between 30 ppt and 35 ppt
- pH ranged between 7.9 and 8.3
- Total suspended Solids varied from 48.1 mg/l to 142.4 mg/l
- Turbidity varied from 4.6 NTU to 8.7NTU
- Dissolved Oxygen (DO) varied from 3.6 mg/l to 5.9 mg/l
- BOD ranged between 1.0 mg/l and 3.1 mg/l
- Nitrite concentration ranged between 0.23 µmol/l and 2.26 µmol/l
- Nitrate concentration ranged between 2.51 µmol/l and 5.67 µmol/l
- Ammonical Nitrogen concentration ranged between 0.031 µmol/l and 0.091 µmol/l
- Total Phosphate concentration ranged between 1.01 µmol/l and 3.28 µmol/l
- Inorganic Phosphate concentration ranged between 0.23 µmol/l and 1.74 µmol/l
- Silicate concentration ranged between 25.49 µmol/l and 51.24 µmol/l
- Total Nitrogen ranged between 14.32 µmol/l and 22.01 µmol/l
- Particulate organic carbon concentration ranged between 104.06 µgC/l and 143.64 µgC/l
- Petroleum hydrocarbons concentration ranged between 0.301 µg/l and 0.963 µg/l
- Cadmium varies between 1.52 µg/l and 3.21 µg/l
- Copper concentration ranged between 13.41 µg/l and 21.05 µg/l
- Iron concentration ranged between 13.01 µg/l and 24.07 µg/l
- Zinc concentration range is 18.02 µg/l and 26.98 µg/l
- Mercury concentration ranged from 0.19 to 0.85µg/L.
- Lead concentration range is 2.62 µg/l and 5.39 µg/l
- Manganese concentration varied from 35.01 µg/l and 51.83µg/l
- Nickel concentration ranged between 1.31 µg/l and 3.27µg/l
- Chromium concentration ranged between 1.2 µg/l and 3.28 µg/l
- Phytoplankton density was recorded as 7775 and 17322 Cells/l
- Zooplankton density was between 4080/m^3 and 8616/m^3
- Primary Productivity ranged from 4.683 to 5.849 mgC/m^3hr
- Chlorophyll-a in water sample varied from 0.035 to 1.526 mg/m^3
- Total Biomass varied between 3.984 ml/100 m^3 at ML-7 during Winter Season and 31.09 ml/100 m^3
- The E. coli population ranged between 10 $x10^3$ CFU/ml and $17x10^4$ CFU/ml

- The Total Viable Count in the samples varied from 13 $x10^2$ to $20x10^4$ CFU/ml

10.3.2.1 Three Season Estuarine Study

As per the MoEF&CC ToR recommendations, three Season Estuarine Study was conducted by Centre for Advanced Studies in Marine Biology, Annamalai University (a pioneering institute in the estuarine, marine and oceanographic studies) during September and November, 2019 and January, 2020 covering the Pre-monsoon, Monsoon and Winter seasons.

Water and sediment samples for physicochemical, petroleum hydrocarbons, heavy metals and biological analysis were collected from Eight (8) locations for three seasons.

Sediment Quality

- Sand ranged between 8%% and 47%
- Silt ranged between 10% and 52%
- Clay between 19% and 60%
- pH is alkaline in nature and varied from 7.8 to 8.38
- Cadmium values ranged from 6.17 µg/g to 10.42 µg/g
- TOC ranged between 5.72 mg C/g to 10.58 mg C/g.
- Copper ranged between 21.17 µg/g and 24.98 µg/g
- Iron ranged between 1456.5 µg/g to 3873.1 µg/g
- Lead ranged between 6.04 µg/g and 8.45 µg/g
- Zinc ranged between 15.9 µg/g and 23.7 µg/g
- Mercury concentration ranged between 0.52 µg/g and 0.87 µg/g
- Nickel concentration ranged between 7.67 µg/g and 13.76 µg/g
- Chromium concentration ranged between 6.49 µg/g to 8.75 µg/g
- Manganese concentration ranged between 58.5 µg/g and 72.5 µg/g
- E.coli population ranged between 21 $x10^3$ CFU/g and 32 x 10^5 CFU/g
- The Total Viable Count ranged between 34 $x10^3$ CFU/g and 22 $x10^6$ CFU/g
- Macro benthos Maximum density is 950 Nos/m^2 and Minimum Density is 350 Nos/m^2
- Meiofauna density was ranged between 186 nos/10 cm^2 and 254 nos/10 cm^2

Water Quality

- Water temperature ranged from 27.6 to 29.1°C
- Minimum and Maximum Salinity recorded varied between 14.5 ppt and 40.5 ppt
- pH ranged between 7.5 and 8.3
- Total suspended Solids varied from 73.65 mg/l to 156.69 mg/l
- Turbidity varied from 7.3 NTU to 8.6NTU
- Dissolved Oxygen (DO) varied from 4.2 mg/l to 5.5 mg/l
- BOD ranged between 0.6 mg/l and 1.5 mg/l
- Nitrite concentration ranged between 0.17 and 2.15 µmol/l
- Nitrate concentration ranged between 3.51 µmol/l and 5.42 µmol/l
- Ammonical Nitrogen concentration ranged between 0.051 µmol/l and 0.095 µmol/l
- Total Phosphate concentration ranged between 1.41 µmol/l and 2.76 µmol/l
- Inorganic Phosphate concentration ranged between 0.87 µmol/and 1.64 µmol/l
- Silicate concentration ranged between 28.93 µmol/l and 51.18 µmol/l
- Total Nitrogen ranged between 14.84 µmol/l and 21.75 µmol/l
- Particulate organic carbon concentration ranged between 115.32 µgC/l and 141.48 µgC/l
- Petroleum hydrocarbons concentration ranged between 0.456 µg/l and 0.914 µg/l
- Cadmium varies between 1.63 µg/l and 2.39 µg/l

- Copper concentration ranged between 16.61 µg/l and 20.14 µg/l
- Iron concentration ranged between 13.18 µg/l and 20.32 µg/l
- Zinc concentration range is 18.84 µg/l to 22.56 µg/l
- Lead concentration range is 2.08 µg/l to 3.14 µg/l
- Mercury concentration varied from 0.39 µg/l to 0.81 µg/l
- Manganese concentration varied from 36.67 µg/l to 42.19 µg/l
- Nickel concentration ranged between 1.81 µg/l to 2.67 µg/l
- chromium concentration ranged between 1.69 µg/l to 2.56 µg/l
- Phytoplankton density was recorded as 4460 Cells/l to 11862 Cells/l
- Zooplankton density was between 4105/m^3 and 7794 /m^3
- The E. coli population ranged between 12 $x10^2$ CFU/ml and 29 $x10^4$ CFU/ml
- The Total Viable Count in the samples varied from 28 $x10^3$ CFU/ml to 48$x10^4$ CFU/ml

10.3.2.2 Marine Biodiversity Assessment

- Molluscan diversity is fair in the study area comprising a total of 38 species. Species richness varied from 21 to 38 among the different assessment zones. *Babylonia zeylanica*, *Babylonia spirata*, *Cerithium columna* and *Ficus gracilis* were the most sighted species during the survey.
- Very low population of Marine sponges has been observed. Only 10 species were observed, of theses, *Clathria microciona*, *Echinodyctium* sp. and *Chalinula* sp. were the common species. The density of sponges ranges between 0.4±0.34 (no/5 m^2) and 4.4±1.24 (no/5 m^2).
- Sparse occurrence of soft coral communities was observed in deep waters. Only 5 species of soft corals were observed, of which, *Carijoa* sp., *Virgularia* sp. and *Cavernulina* sp. were the common species. The density of soft corals ranges between 0.2±0.2 (no/5 m^2) and 1.8±0.58 (no/5 m^2).
- Relatively poor occurrence of other fauna was observed in the marine zone. Totally 9 species were recorded, among them echinoderms comprising *Astropecten indicus, Clypeaster* sp. and *Echinodiscus auritus* are the dominant ones.
- Fish communities in terms of diversity and abundance were relatively low. A total of 50 fish species were recorded in the study area. Species richness varies from 12 to 50, while total fish individuals counted ranges between 69 and 542. Fish density and diversity vary between zones as the density ranges between 13.18 no/250 m^2 and 38.71 no/250 m^2. *Rastrelliger kanagurta, Rhabdosargus sarba, Sphyraena jello, Alepes melanoptera* and *Selaroides leptolepis* are the common fish species observed in the study area.
- Underwater assessment carried in the study area revealed that the seascape is dominated by sandy and clayey bottom. Because of the bottom topography and prevailing strong currents, benthic communities were very less in number and variety
- Three species of mangroves are observed in the study area. *Avicennia marina*, *Avicennia* sp. and *Rhizophora mucronata* belonging to family Avicenniaceae and Rhizophoraceae. The study area is dominated by *Avicennia marina*, whereas *Avicennia* sp. and *Rhizophora mucronata* are scanty and limited to the northern side of the study area.
- Five types of halophytic plants were observed in the study area. They are *Sesuvium portulacastrum, Suaeda monoica, Suaeda sp., Suadea nudifolra Moq*. and *Salicornia brachiate* Roxb. They are seen in the periphery of mangrove patches and also with Mangrove along the banks of the river.
- In the Mangrove waters, the Macrobenthic organisms were represented by six groups viz., Polychaetes, Gastropods, Bivalves, Amphipods, Isopods and others. Among them, Polychaetes were the dominant group followed by Gastropods. A total of 40

Macrobenthic species from 29 genera of 24 families were identified in the Mangrove waters.

- Density and diversity of meiofauna were comparatively less with six major groups such as nematodes, Foraminifera, cumaceans, Harpacticoids, Ostrocods, and others of which nematodes constitute the dominant group. A total of 75 species of meiofauna from 58 genera belonging to 45 families were observed in the mangrove waters.
- In Kosisthalaiyar River, a total of 34 Macrofaunal species from 28 genera belonging to 22 families were observed. Polychaetes represent the dominant group in Kosasthalaiyar River.
- In the samples collected from Buckingham canal, a total of 27 macrofaunal species from 19 genera belonging to 17 families were observed. Polychaetes form the dominant Macrofaunal category in the canal samples
- Samples from Pulicat Lake and Ennore Creek revealed 42 macrofaunal species from 35 genera belonging to 27 families. As in other cases, polychaetes form the dominant macrofaunal group.
- Density and diversity of Phyto and Zooplankton in the study areas were fair.
- In the Marine zone, a total of 57 Phytoplankton species of Diatoms, Dinoflagellates and Cyanophyceae were recorded where phytoplankton density ranged from 200-46900 cells/l. Zooplankton density ranges between 120 and 6,480 no/m^3. Chlorophyll 'a' ranges between 0.22 and 12.73 mg/m^3 and chlorophyll 'b' ranges between 0.10 and 10.45 mg/m3 while the range of primary productivity is between 100.13 and 500.88 $mgCm^{-3}d^{-1}$ in the study area.
- Microbial parameters such as total viable count, total coliform count, faecal coliform count and *E. coli* count are not very high in the samples collected from Ennore Creek. In the water samples collected from the study area, total viable count ranges from 2.51 $x10^4$ to $7.98x10^4$ CFU/ml and total coliform ranges from 0.72 $x10^4$ to $2.10x10^4$ CFU/ml. In the case of sediment samples total viable count ranges from 1.62 $x10^5$ to $8.95x10^5$ CFU/g and total coliform count ranges between 0.64 $x10^5$ and $2.27x10^5$ CFU/g.

10.3.3 Socio Economic Conditions

The socio-economic profile of the 15.0 km (Study area) secondary data for Kattupalli Port expansion is studied and analysed based on the Census of India 2011.

- The project area falls in six notified revenue villages i.e. Kalanji, Kattupalli, Kattur-II, Ebrahampuram, Puzhudivakkam, Voyalur out of which only four villagers are inhabited and two villages are un-inhabited (viz. Ebrahampuram and Puzhudivakkam).
- In the study area, 108 revenue villages are falling which includes hamlets and settlement villages of three talukas i.e Gummidipoondi, Ponneri and Mathavaram talukas of Thiruvallur Districts of Tamil Nadu.
- In the study area, the population is 6,79,695 of which males are 50.21% and females are 49.79%. The sex ratio of the study area is 992 females over 1000 males.
- The literate population in the study area is 5,11,558 which constitute to be 75.26% of the total population of the study area.
- The working population in the project area are 2,67,917which are around 39.42% out of which males are constituted to 76.08% and females account to 23.92%
- The study area covers 7 fishing villages and 12 fish landing centres
- Traditional fishermen families are 1065 with Fisher folk population of 3585 from seven villages of ponneri taluk from Thiruvallur District.

10.4 Anticipated Environmental Impacts and Mitigation Measures

Anticipated impacts on the environmental and social attributes, which are likely to arise due to construction and operation of proposed project have been identified, predicted and mitigation measures are evaluated.

10.4.1 Construction Phase

The development activities such as capital dredging, reclamation, dredge spoil disposal, expansion/modification of navigational facilities, offshore structures will impact marine environment. Site development, civil construction, mechanical erection of infrastructure and backup area development is likely to cause impacts on the terrestrial environment.

Capital / maintenance dredging, reclamation, dredge spoil disposal and development of offshore structures will result in disturbance to marine environment.

Deepening the approach channel will most likely increase the amount of deposition in the channel there by increasing the needed maintenance dredging. The predicted quantities of maintenance dredging with the proposed Master Plan is around 1.2-3.2 Million m^3/year of predominantly fine material from the approach channel, turning circle and berth area.

Dredge material will be disposed at two spoil grounds, both the spoil grounds having an area of 1716264m^2 and approx.4.5km away from the proposed port location. The maximum bed level change incurred due to dumping is around 0.53m at both the dumping grounds after 45 days simulation period.

Most of impacts during construction are short-term in nature and will cease on completion of construction activities.

Summary of possible construction phase impacts and appropriate mitigation measures are discussed below.

10.4.1.1 Impacts due to port activities and Infrastructures

Possible Impacts:

- Change in marine water quality/Ecology
- Increase in noise levels
- Disturbance to benthic communities
- Changes in species diversity and density
- Impact on nearby mangroves

Mitigation Measures:

- Dredge Management Programme
- Discharge of waste into sea will be prohibited
- Adoption of standard reclamation and construction methods with containment system
- Slop tanks are provided to barges/ workboats for collection of liquid/ solid waste
- Disposal of unused Dredged material at the identified offshore disposal area only
- Discharge of toxic/hazardous materials during the port construction would not be allowed.
- Awareness will be imparted to workers in the port about the importance of mangroves and their conservation
- Mangrove Monitoring & Management Plan
- Biodiversity Management Plan

10.4.1.2 Material Transport and Construction Activities

Possible Impacts:

- Exhaust emission and noise from vehicles
- Windblown and fugitive emission during material movement and unloading
- Emission and noise from DG sets
- Emission and noise from construction activities
- Disturbance to natural drainage pattern
- Strain on existing infrastructure and traffic addition

Mitigation Measures:

- Impacts during construction phase of the project are temporary in nature and will cease upon completion of construction phase. Necessary measures such as Emission control norms; Periodic checking and washing of vehicles & construction machinery; Adequately sized construction yard; Enclosures on all sides of construction site; Non-peak hour movement and onsite speed control; Water sprinkling; Environmental awareness program; Noise levels to be maintained below threshold levels stipulated by CPCB/TNPCB; Maintenance of construction equipment; Scheduling of High noise generating activities at daytime (6.00 am to 10 pm); Personal protective equipment's etc will be followed/adhered.
- Few natural third/fourth order drains passing through the project site, therefore, storm water drainage network is proposed to facilitate proper drainage of the area by diverting the drains flowing across the project site. Based on existing drainage pattern and catchment area, main outfall drains are proposed to carry storm water discharge.
- The outlets drain the storm water from the proposed backup area either into the river (for port area on the west of the river) or directly into the sea (for port areas east of the river).
- Construction activities shall be limited within the site and dust shall be contained within the construction area.
- A 100 m wide ROW for Road Corridor is also proposed by TNRDC as Northern Port Access Road (NPAR) to connect both Ennore and Kattupalli Port to NH-5 which will improve the traffic conditions.
- National Water Way (NW-4) will also be used for the transport of part of construction material which will reduce likely congestion on road.
- Proper lighting, signboards shall be provided at required locations.

10.4.1.3 Land Reclamation

Possible Impacts:

Impact on the existing water resources such as groundwater and surface water

Mitigation Measures:

- Existing protective bunds (salt dyke) and slope gradient will prevent inundation of salt water to the adjoining land.
- Return seawater from reclamation areas will be channelled back to sea.

10.4.1.4 Marine Side Construction Activities and Fishing

Possible Impacts:

Ship traffic may disturb fishing activities like fishing nets getting entangled with the moving vessels in outer harbour areas which may cause financial losses to fishing communities.

Mitigation Measure:

- Proper access to the sea for the local fishermen is considered during planning stage itself.
- Signboards will be placed at the construction activities in order to make fishermen aware of the on-going construction activities
- Necessary marker buoys will be installed
- Regular Interactions will be initiated with the fishing community before commencement of construction works

10.4.1.5 Solid Waste Management including Handling of Hazardous Waste

Possible Impacts:

- Impact on soil quality due to disposal on ground
- Fire accidents
- Impact on terrestrial and marine environment

Mitigation Measures:

- Solid Waste Management Rules, 2016 (as amended) and Construction & Demolition Waste Management Rules, 2016 (as amended) will be followed for environmental sound management of respective waste
- Construction waste will be utilized for filling low lying areas
- Hazardous and other waste Management Rules, 2016 (as amended) will be followed for environmental sound management of hazardous waste.
- OSHA standards will be adopted
- Hazardous wastes will be disposed through approved TNPCB/CPCB vendors.

10.4.1.6 Water Resource

Possible Impacts:

- Water scarcity and pollution on existing surface water body resource.

Mitigation Measures:

- Groundwater table at Kattupalli is high. However, optimization of water resource will be done
- Based on existing drainage pattern and catchment area, main outfall drains are proposed to carry storm water discharge from village area and port area and discharging into seas.
- Construction camp wastewater will be collected and treated. Treated wastewater will be used for Plantation/Greenbelt development.
- The return sea water quality from the reclaimed area shall be monitored during reclamation phase
- Groundwater quality shall be monitored
- An adequate drainage system will be provided at the site with separate collection streams to segregate the storm run-off from roads, open areas, material storage areas, vehicle wash water and other wastewater streams. Suitable measures will also be taken to prevent the washing away of construction materials into the drainage system.
- Contaminated storm water will be collected and conveyed to sedimentation tank for removing grit.
- Mobile STP units shall be provided at site /construction workers camp or existing STP will be used for treatment of wastewater
- No wastewater shall be disposed directly on land or on existing surface water resources without appropriate treatment.

- Construction workers camp shall be located outside CRZ area

10.4.2 Operation Phase

The operational phase impacts due to all components of the projects have been identified, predicted and evaluated. Some of the models used for prediction of impacts are given below.

10.4.2.1 Hydrodynamic Study

2-dimensional hydrodynamic model (MIKE 21 HD FM) was set-up and calibrated for the baseline conditions in order to simulate the water levels and current pattern from Ennore to Pulicat creek. The model account for bottom friction, wind effect, wave radiation stresses. The open boundaries were provided with water levels. The simulation was carried out with tide and pre monsoon wind conditions for a period of 15 days, which covers spring and neap tidal cycles. The simulated water levels and currents are having a good agreement with the measured water level and current data. The two major forcing functions, i.e., tide and wind, influence the circulation pattern, latter being a dominant forcing function, which controls the direction of current. The flow field south of Kattupalli Port was complex and circulation north of port was influenced by the presence of shoals. Hydrodynamic model study with proposed masterplan shows that there is no change in the circulation pattern at Pulicat lake and ennore shoal area due to proposed development of the Kattupalli port.

10.4.2.2 Spectral Wave Study

Spectral Wave model (MIKE 21 SW) was to predict the annual wave climate for Ennore-Pulicat coast. The basic requirement for the model i) wave boundary data, which was obtained from NIOT Wave model ad ii) the bathymetry, which was obtained from echosounder survey and C-map source.

The annual distribution of wave data indicates that during November-December the waves are mostly from 600-700 in other months from 1200-1400. Thus, the annual wave climate along Kattupalli Port leads to a net northward littoral sediment transport pattern over a year. Wave periods between 3 to 9 sec and heights from 0.5 to 2.0m. Most percentage of waves occurs in the height range 1.0 to 1.5 m and in the periods of 4-10 sec.

Simulations were conducted for predominant wave directions prevailing at Kattupalli. The coast north of Kattupalli experiences concentrations of wave energy at some places due to convergence of wave rays resulting from complex bathymetry (shoals).

The spatial variation of significant wave height (Maximum was 1.3m) and peak wave period (Maximum was 16 Sec) for baseline and layout conditions were observed. Significant wave height at five locations are extracted from layout and the values are varies from 1.36m to 0.03m

There was an insignificant change observed during the assessment of model results of baseline and layout conditions. The only change observed after introducing the layout in the spectral wave model is a shadow zone with less energy waves are noticed immediate north of the breakwater when waves are coming from southwest direction. Otherwise the wave transformation study indicates the similar results for baseline and layout models. Pulicat Lake is located at a distance of 10 km from the proposed master plan boundary, and the model results shows that there was no change in the Pulicat lake wave pattern after the layout was introduced.

10.4.2.3 Historical Shoreline Changes

GIS techniques used to estimate the changes historical shoreline changes and Littoral Process FM model used for 20 years shoreline prediction. Satellite images were downloaded for years from 2000-2020 to estimate the historical shoreline changes. The shorelines from each image are digitised using GIS techniques to estimate the changes. Coastline from the entire study area are divided in to Six zones (Zone-A to Zone-F). The north side area of Kattupalli Port (Zone-C), where erosion was more predominant, and it is active after the construction of Kattupalli Port, and it was increasing. These changes started during the construction stages of the port affecting the area within the port as well as on south and north sides of the port.

10.4.2.4 Shoreline Change Prediction

To simulate shoreline evolution along Ennore-Pulicat coast, the one dimensional model I LITPACK system was used. The model has the capacity to simulate the influence of structures like groin, breakwater, jetties etc on shoreline evolution and has the facility to include sediment source and sinks. The model predicts variations in shoreline position within a stipulated period of time under the combined action of waves and currents.

Three different profiles are considered for the present studies. Wave at 30 m water depth also used. The littoral drift along the Ennore coast was calculated as 3000 m3/year/m for a shoreline orientation of 170-degree N.

The following results have noticed from the shoreline change prediction:

- Northward movement of sand in the order of 213484.3m^3 and southward movement of sand in the order of 31668.9 m^3 was noticed with the baseline conditions for 1 year.
- Northward movement of sand in the order of 213178.7 m^3 and southward movement of sand in the order of 31422.0 m^3 was noticed with proposed port facilities for 1 year.
- Northward movement of sand in the order of 1358018.5 m^3 and southward movement of sand in the order of 60221.8 m^3 was noticed with proposed port facilities for 5 years.
- Northward movement of sand in the order of 3063603.2 m^3 and southward movement of sand in the order of 131301.0 m^3 was noticed with proposed port facilities for 10 years.
- Northward movement of sand in the order of 5102208.0 m^3 and southward movement of sand in the order of 170769.3 m^3 was noticed with proposed port facilities for 15 years.

10.4.2.5 Shoreline Management Plan

In order to prevent the erosion along north coast two types of interventions and the consequent impacts on shoreline management along the coast was studied. Both soft (sand bypassing) and hard measures (groynes) were tested with appropriate model simulations.

Option -1: One km of the coastline immediate north of the proposed port was nourished with dredged material and predicted its movement during the prevailing longshore currents. The shoreline was stable up to 12 years and started eroding thereafter.

Option-2: One km of the coastline immediate north of the port was nourished with dredged material and protected by groin field after 3 km from proposed breakwater. The results indicate that the shoreline was protected in the nourished area and behind the groin field. The erosion was further shifting to north of the groin field.

Hybrid solution i.e beach nourishment along with the groyne field has been proposed. The artificial beach nourishment of 2 million cum of sand from capital dredging will regulate the erosion on the northern side by supplying sediment to the north and 0.5 million cum of sand need to be nourished in every alternate year to protect the region against further erosion immediately after the proposed development in future. Along with beach nourishment, we propose the implementation of three groynes having a length 100 m and 150 m with a distance of one km each to avoid the quick flow of the nourished sand towards the north due to littoral transport movement. The groyne field will also help to keep the nourished material on the beach during extreme weather conditions such as tsunami and cyclones.

The model analysis clearly shows that the Pulicat lake mouth is further 7km from the erosion stretch and the mouth will not have any impact due to the proposed development and protection measures considered.

10.4.2.6 Tsunami Modelling

MIKE 21 HD model was used for tsunami generation and propagation of fault parameters for 1881, 1941 and 2004 Earthquakes in the Bay of Bengal. The maximum water level predicted at Kattupalli Port entrance was about 2.18m due to 2004 Sumatra tsunami. The corresponding current speed at Kattupalli Port entrance was estimated about 2.8m/s.

10.4.2.7 Cyclone Modelling

The cyclones are the extreme conditions and most of the time all the port operations need to be shut down after receiving cyclone warning. The damages to coastal structures, beach erosion and flooding inundation are often associated with the cyclonic storms that form through cyclogenesis in the Bay of Bengal.

Nine (09) cyclonic events were selected for cyclone study and the cyclone data are collected from IMD. From the 9 cyclones, December 2016 Vardah cyclone made severe impact at the study area. At Kattupalli Port location, the Vardah cyclone has caused a maximum surge height of 0.78m and a maximum current speed of 2.74 m/s. Similarly, the maximum significant wave height estimated at Kattupalli port due to 2016 Vardah cyclone was 5.15m.

10.4.2.8 Ship Tranquillity Study

The simulated results of the model has provided keen insight into the performance of the harbour layout in the wave agitation point of view. From the study results it could be seen that the tranquillity inside the harbour is very good.

Across all modelled scenarios the breakwater provides a large reduction of wave height for the modelled combination of wave periods and direction.

Maximum wave disturbance coefficient for five extraction locations at the study area from case-1 are 1, 0.7, 0.44, 0.18 and 0.25 respectively

Maximum wave disturbance coefficient for five extraction locations at the study area from case-2 are 1, 0.67, 0.40, 0.15 and 0.05 respectively

10.4.2.9 Flood Model Study

The inundation depth and current speed in the vicinity of the port area induced by the 2015 flood event with baseline configuration was studied. It is observed from the model that the maximum water depth is 3.5 m near the meandering area of the Kosasthalaiyar river where multipurpose area for the port is expected. The west side of the port (right bank of the river) is heavily flooded, where depth is varying between 1.8 m and 3.5 m. Because of the existing high ground elevation, flooding has minimal impact on the eastern part of the port (left bank of the river) compared to other area. The current speeds are low in this area, less than 0.2 m/s, presumably due to the flat terrain.

Recommendations & Management Aspects:

- Flood model studies indicate that the raising of proposed Master Plan backup area of the port to +5m CD is effective in protecting the port infrastructure from the overtopping of the river during a 100-year rainfall event of 24-hour duration.
- Locations where the embankments of the Kosasthalaiyar backwater river and B-canal are damaged must be identified and strengthened to reduce overtopping from the banks.
- Storm Water Drainage network plan has to be laid out to drain the storm water from the port area into the river/canal or the sea. The port backup area will be raised, and the flow directions will be ensured into the drains
- The existing open channel towards the western side and periphery of the port backup is recommended to be retained for mitigation of flooding in this area.
- The de-silting of this canal is important to have a quick recession of flood water.
- The open channel must also be extended as suggested in the previous section and integrated with the Storm Water Drainage network of the port area.

10.4.2.10 Sedimentation Study

The calibrated hydrodynamic model was further extended by sediment transport process calculations using DHI’s MIKE 21 FM Mud Transport (MT) model to assess the sedimentation (maintenance dredging quantity) in the proposed dredging area.

From the study the following broad conclusions can be drawn:

- To maintain a water depth of 27m w.r,t CD in the approach channel of the proposed Master Plan, the predicted average and maximum dredging quantities are 8,54,045 m^3/year and 1,56,5750 m^3/year respectively.
- To maintain a water depth of 25m w.r,t CD in the basin area of the proposed Master Plan, the predicted average and maximum dredging quantities are 2,23,363 m^3/year and 1,21,2543 m^3/year respectively.
- To maintain a water depth of 20.5m w.r,t CD in the basin area of the proposed Master Plan, the predicted average and maximum dredging quantities are 1,80,342 m^3/year and 4,50,856 m^3/year respectively.
- To maintain a water depth of 16m w.r,t CD in the basin area of the proposed Master Plan, the predicted average and maximum dredging quantities are 3119 m^3/year and 3119 m^3/year respectively.

For the given Master Plan consisting of approach channel, turning circle and berthing area, the total predicted average and maximum dredging quantities are 12,60,869 m^3/year and 32,32,267 m^3/year respectively.

During the dredging period, it has been observed that the impact on the quality of marine water is mostly in the immediate vicinity of the port area was high and subsequently the turbidity level will reach the ambient level within a very short period of time. Thus, it can be inferred from the above that dredging would have a short-term and localized impact on the quality of marine water in the study area.

10.4.2.11 Dredge Soil Disposal and Dispersion

Deepening the approach channel will most likely increase the amount of deposition in the channel there by increasing the needed maintenance dredging. The predicted quantities of maintenance dredging with the proposed Master Plan was around 1.2-3.2 Million cu.m/yr of predominantly fine material from the approach channel, turning circle and berth area.

In the present study, two spoil grounds are considered, both the spoil ground having an area of 1716264m2 and approx.4.5km away from the proposed port location.

The maximum bed level change incurred due to dumping was around 0.28m at both the dumping grounds in 60 days simulation period. The spread of the disposed sediment on the seabed is presented in the form of bed level change and total suspended solid concentration. The model results show that the dumped materials not spreading beyond the port limit and also 1.2 -3.2 MCM of annual maintenance dredging will not make any impact to the Pulicat lake.

10.4.2.12 Recirculation study

Three intake and outfall locations have been considered for 30 MLD desalination Plant. The recirculation study shows that in all the simulations the excess salinity does not influence at the intake locations. It was concluded that the 30 MLD outlet result in excess salinity below 1.5 PSU at the point of discharge and 0.1 PSU at the farthest point from the outlet. For 30MLD outlet the excess temperature was comparatively less, and the values are 0.18^{o}C and 0.07^{o}C respectively.

Two intake and outfall options were considered for 20 MMTPA LNG/LPG processing facility. The results indicates that, there will not be any recirculation and there will be no impact on water quality at the intake as well as at the shore due to the disposal taking place at the proposed outfall discharge location.

10.4.2.13 Oil Spill Risk Assessment

Eight oil spill scenarios have been modelled, each spill event involve simulation of 6000 (200 particles per 10 minutes for 5 hours) discrete oil spill particles whose advection, dispersion and weathering will be computed over a maximum two-week (14 days) period.

- Scenario 1 to 4: Collision at the turning circle with Gas oil and Heavy oil for NE and SW monsoon.
- Scenario 5 to 8: Collison at SPM location with possible rupture from hale.

Some key observations include:

Spillage occurrence at turning circle was not having any shoreline impact. This was due to the shelter effect of the proposed breakwater and predominant wind direction was from southeast direction. The oil slick was concentrated within the berth area and does not travel far away. For some combination of tide and wind conditions, the oil slick tends to get trapped within the port.

Spillage occurrence at SPM location was having shoreline impact on the northern side of the proposed development. During the southwest monsoon (June to August), winds from south-easterly was making oil slick moving very far to the east.

10.4.2.14 Air modelling

AERMOD, steady-state‟ Gaussian model was used to predict the incremental concentration of air pollutants at the receptors in the study area. Results show that predicted incremental/resultant concentrations are within the NAAQS.

All wastewater discharges from the projects will ensure discharge standards stipulated by TNPCB/CPCB.

Some of the operation phase impacts and appropriate mitigation measures during the operation phase of the Revised Master Plan is discussed below.

10.4.2.15 Cargo handling/Inland Cargo Movement/Storage/Regasification/ Equipment Operation

Possible Impacts:

- Emission and Noise due to loading/unloading, DG sets, vehicles, regasification process
- Traffic addition due to cargo from/to port

Mitigation Measures:

- Most of the cargo transportation through rail and road.
- Dry bulk cargo shall be transported through covered conveyors from berth to the stockyard.
- Use of specialised ship loaders/unloaders, wagon tippler, track hopper, covered conveyors and rapid loading system through silos; Dust Suppression measures; Scientific and regulated stacking of cargo piles; Periodic cleaning of cargo spills; Greenbelt Development; Proper housekeeping; Regularisation of truck movement etc.
- Wind screens will be provided along stack yard
- Use of tarpaulin covers and speed regulations for vehicles/wagons engaged in transportation.
- Acoustic Barriers, Enclosures and Personal Protective Equipment (PPE)
- National Water Way (NW-4) will also be used for the transport of cargos which will reduce likely congestion on road.
- Proposed rail and road will be sufficient to cater the MIDPL revised master Plan transportation requirements.

10.4.2.16 Aqueous Discharges including Accidental Spills

Possible Impacts:

- Impact on marine water quality and ecology due to discharge ship wastes (sullage), sewage, bilge water, Desalination Plant reject water, LNG/LPG regasification return water etc.

Mitigation Measures:

- Ships will exchange Ballast water in deep sea prior to arrival in the harbour; prohibited from discharging wastewater, bilge, oil wastes, etc. into the near-shore as well as harbour waters, Comply with the MARPOL regulation.
- Waste Reception facility will be provided
- Oil spill contingency plan prepared and will be implemented.
- The reject TDS from the desalination plant discharged into the sea will be much lesser than the TDS value observed for the seawater in the region. Hence there is no significant impact in Salinity and on marine environment.

- LNG/LPG regasification return water with low temperature (<7°C than ambient) will be sent back through marine outfall system with diffusers at identified location through mathematical model studies which will ensures attainment of ambient conditions (within 600 m) in the harbour area
- Maximum recovery of oil with oil spill control equipment with quick response time

10.4.2.17 Maintenance Dredging

Possible Impacts:

- Impact on marine water quality and ecology

Mitigation Measures:

- Dumping of dredged material will be uniform and at identified location
- Bathymetry monitoring pre and post dumping
- Marine Environment monitoring will be carried out

10.4.2.18 Water Resource

Possible Impacts:

- Impact on existing water resources
- Water quality due to discharge of runoff and brine reject from 100 MLD plant and proposed 30 MLD plants.

Mitigation Measures:

- 3 intake & outfall location for proposed 30 MLD Desalination plant have been studies and most appropriate intake & outfall location has been proposed based on modelling outcome. Necessary permission for the same shall be obtained.
- Raw water from intake location at Kattupalli port for the proposed 30 MLD Desalination Plant and necessary permission shall be obtained from the concerned authorities.
- On the basis of the studies, it is concluded that the 30 MLD outlet result in excess salinity below 1.5 PSU at the point of discharge and 0.1 PSU at the farthest point from the outlet. For 30MLD outlet the excess temperature is comparatively less, and the values are 0.18^0C and 0.07^0C respectively.
- Collection of runoff from stock piles and directing into settling ponds and supernatant water will be used for dust suppression.
- Neutralisation using lime to ensure settlement of heavy metals, if any.
- STP of 240 KLD capacity will be developed to treat the sewage generated in the premises.
- ETP 1500 KLD capacity will be developed to treat the effluents.
- The oil contaminated water will be sent to ETP and the separated oil will be given to the authorised waste oil recycler.
- Storm Water Drainage System
- Treated Sewage and effluents shall be reused for dust suppression, irrigating greenbelt and other requirements.

10.4.2.19 Seawater (Regasification) and Water (Desalination Plant) Withdrawal

Possible Impacts:

- Impact on marine/river ecology due to Impingement/Entrainment/Entrapment of aquatic life

Mitigation Measures:

- Intake with proper screens and maintaining Low Intake Velocity to minimise the Entrainment & impingement
- Seawater Intake is proposed in protected harbour basin and near to the LNG terminal will reduce major marine organism entry

10.4.2.20 Solid Waste Management including Handling of Hazardous Waste

Possible Impacts:

- Impact on groundwater and soil quality due to disposal on ground
- Fire accidents
- Impact on terrestrial and marine environment

Mitigation Measures:

- 5 R (Reduce /Reuse/Recover/Recycle and Re Process) principle shall be explored
- Solid Waste Management Rules, 2016 (as amended) will be followed for environmental sound management of respective waste
- Hazardous waste Management Rules, 2016 (as amended) will be followed for environmental sound management of hazardous waste.
- OSHA standards will be adopted
- Hazardous wastes will be disposed through approved TNPCB/CPCB vendors.

10.4.2.21 Fishing Livelihood

Kattupalli port is an existing port which is operational since 2012. Fisher men around the vicinity are well aware of operations of Kattupalli port. Safe navigation routes shall be earmarked for movement of fishing vessels.

Possible Impacts:

- Local Fishermen approach to sea
- The port approach channel orientation and vessel movements
- Interference to fishermen and fishing activities during seaside construction activities.
- The construction of cargo berths, approach trestle and activity of capital dredging, etc. are likely to impact the fishing activity near port.
- Impacts on benthic and pelagic organisms would also eventually affect the fishery resources of the area
- Pelagic and benthic fishery resources will be disturbed and dislocated and hence their population is likely to be affected during dredging operations
- Associated fishery resources are also likely to be affected during maintenance dredging and disposal during the operational phase
- Any impact on fishery resources would possibly affect livelihood of fishermen of nearby villages

Mitigation Measures:

- Safe navigation routes will be earmarked for movement of fishing vessels and the route will be finalised in consultation with fish landing authorities and fishing communities
- Necessary sign boards and marker buoys shall be installed and interactions shall be initiated with the fishing community about the marker buoys indicating the areas of operation
- Fishing is being carried out at deep sea. Therefore, significant impact on fishing is not envisaged

- Fishermen in the study area operate motorised and non- motorised fishing boats. Fishermen with motorised boats generally go up to 10 km in the sea for fishing
- Deployment of Artificial Fish Habitats/Reef Structures to enhance biodiversity and fish production
- Sea ranching of cultured fingerlings of these shrimps and crabs would provide sustainable fishery yield to the fishermen
- AFH and Sea ranching will enhance the biodiversity, fish production and socio-economic conditions of the dependent fisher folk

However, the port activities involved in the operation phase will be confined to the project area. All appropriate measures will be taken to minimize the hindrance to fishing activity during construction & operation phase.

10.4.2.22 Reclaimed Backup Area or Bund

Possible Impacts:

- Impact on Shoreline
- Change in hydrodynamics

Mitigation Measure:

- Variation of flow regime will be limited to development location and localised in nature
- Monitoring of shoreline with the help of high resolution satellite imageries during operation phase shall be carried out periodically.
- Based on the monitoring results and if required, appropriate remedial measures such as beach nourishment/ creation of sand trap/ any other suitable methods shall be carried out to maintain the stability of coast
- Adequate buffer shall be maintained near the mangrove areas

10.4.2.23 Operation of Port

Possible Impacts:

- Socio-economic conditions of the region
- Natural Hazards
- Induced development

Mitigation Measures:

- Employment generation and local people will be given preference based on qualification and skill. Project will help to enhance the socio economic conditions of the area
- Disaster Management Plan (DMP) is already in place and will be suitably modified/upgraded and continued after expansion with appropriate resources as necessary.
- Proposed port operation will offer an efficient and cost effective supply chain/value proposition to the local importers and exporters

10.4.2.24 Proposed use of LNG FSRU and LPG FSO as an Interim Option

LNG jetty shall be designed to accommodate LNG carriers in the size range of 20,000 m^3 to 265000 m^3. However, during further review of the LNG Terminal Technical aspects and development Plan, it has been understood that, Kattupalli LNG onshore terminal shall take few years and there is a need for an interim solution to serve the country by easing the immediate energy needs. For this purpose FSRU is planned with a maximum capacity of 2.5 MTPA (interim arrangement) as a part of Revised Master Plan.

It is pertinent to mention that the impacts and Risks scenarios related to FSRU is much lesser than the impact and Risk predicted for Onshore LNG terminal (as the maximum inventory considered in Risk Assessment will not exceed 1,80,000 m^3) and hence the measures considered for Onshore Terminal will holds good for FSRU.

Similar to LNG, the details of LPG Onshore Terminal including Handling, storage and heating. Kattupalli LPG onshore terminal shall take few years and there is a need for a interim solution to serve the country by alleviating the immediate energy needs. For this purpose FSO is planned with a maximum storage capacity of the compartments of vessel not more than 25000 MT at a time (interim arrangement) as a part of Revised Master Plan.

It is pertinent to mention that most of the impacts and Risks scenarios predicted for Onshore LPG terminal will remain same or less compared to FSO and the measures suggested for Onshore LPG terminal will holds good for FSO.

10.5 Analysis of Alternatives

Kattupalli port is already been established and operational. For expansion/revision of Master Plan of the port no other site selection criterion has been considered and study of site alternatives has least significance.

The proposed expansion area is also selected on the basis of pre dominant wind direction and away from existing habitation areas/notified ESZ of Pulicat Bird Sanctuary. Majority of areas under proposed expansion will be developed through reclamation of Sea in order to avert Resettlement and Rehabilitation (R&R).

10.6 Environmental Monitoring Programme

Comprehensive Environmental Monitoring Programme for construction and operation phases of project has been formulated. The Environmental Monitoring Programme for Both Terrestrial and Marine environment covers the technical and network design of monitoring including measurement methodologies, frequency, location, etc., and budgetary estimates.

Environmental Monitoring Programme for Construction and Operation Phase by Employing Standards Methods for Sampling & Analysis

• Air Quality @ Six (06) locations • Noise Levels @ Six (06) locations • Water Quality - Groundwater @ Three (03) & Surface water @ Twenty three (23) locations • Soil @ Four (04) locations • Meteorology – continuous monitoring @ Existing Meteorological station at Kattupalli port • Groundwater level @ Three (03) locations	• Marine Water Quality/ Plankton and Benthic Communities/ Sediment Quality @ Twenty three (23) locations Fish Population Monitoring - Six (06) locations • Rapid underwater biodiversity Assessment - Marine Zone (in line with baseline data) • Stack Monitoring @ DG sets • ETP/STP @ ETP outlets & STP outlets

10.7 Additional Studies

10.7.1 Risk Analysis

Risk analysis covering the Hazard Identification including potential release events and Failure Frequency and Consequence modelling of release rate and damage distances was carried out. In this revised master plan development, the proposed cargos are divided into different class i.e. (i) Class - A Petroleum (ii) Class - B Petroleum (iii) Class- C Petroleum (iv) Excluded Petroleum (v) Other Gases and (vi) Other liquid Cargos. In case of accident, all the above cargo likely to cause Fire & Explosion and Toxic effects except other liquid cargos. **Among these cargos, representative items from each class which cause maximum damage distances based on NFPA hazard classification have been selected and risks associated were quantified**. It is implied that any other cargo having lesser risk against the representative cargos considered for RA can be handled.

Storage of cargo in the CRZ area will be as per the CRZ Notification 2011/2019 (as amended).

Also, scenarios from other cargos have health hazard as the most probable hazard. The necessary measures will be taken during handling, transfer and storage of such cargos.

10.7.2 Disaster Management Plan

The Disaster Management Plan (DMP) is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in the same order of priorities. For effective implementation of DMP, it should be widely circulated and a personnel training is to be provided through rehearsals/drills.

The Disaster Management Plan (DMP) for Kattupalli port is already in place and will be used and improved suitably to match the requirements of revised master plan. The disaster management plan mainly deals with continuous and integrated process of planning, organising, coordinating and implementing measures. An On-Site Emergency Preparedness Plan and Off-Site Emergency Preparedness Plan including Oil spill contingency plan were prepared to deal with emergencies and prevent disasters.

The clear assignment of roles and responsibilities was prepared with which location of Emergency Control Centre and Assembly Points is identified. Communication system and alarm systems for effective communication in the event of a disaster are identified. DMP for natural hazards such as floods, cyclones, tsunami and earthquake was prepared.

10.7.3 Traffic and Transportation Study

The detailed traffic survey was conducted for the road connectivity in the Road Corridor around Kattupalli port. The intent of the study conducted inline to address the specific ToR requirement on the cumulative impact of all development and a detailed traffic management and a traffic decongestion plan was drawn.

10.7.3.1 Proposed Road Connectivity

Based on the traffic assessment due to the normal traffic and generated traffic due to proposed expansion of kattupalli port and the IRC guidelines the Port Access Road (SH-56), SH- 107 Near Thiruvellavoyal as well as Athipattu Main Road are has to be upgraded to four lane road and SH-56(Near Vinay Nagar Temple) will require capacity augmentation before 2040.CICT Road and SH-104 (Near Pulicat Check Post) will be sufficient to cater the projected increase in traffic of the port.

10.7.3.2 Proposed Railway Connectivity

In future the existing facility of southern connectivity of the Kattupalli port, will not be sufficient to cater the projected increase in traffic of the port as well as operationally there will be need of another railway link to the Kattupalli port which is proposed from Minjur station, situated on the north side of existing railway link and is termed as northern link. Rail corridor lengths within and outside the port has been mentioned in the **Table 10-4Error! Reference source not found.**. Separate CRZ clearance for Southern link has been obtained However, feasibility of alignment of proposed corridor will be checked during detailed study.

Table 10-4: Details of Rail Corridor

Details off Rail Corridor		
	Northern Link (Double Line)	Southern Link (Double Line)
Inside Port	12.32 Km (Running Length)	2.29 Km (Running Length)
Outside Port	1.5 Km (Running Length)	3.74 Km (Running Length)

10.7.3.3 Proposed Inland Waterway Connectivity

To augment the efficacy of NW-4 and treating it as great opportunity, evacuation by waterways is also proposed just like railways and roadways in our RMP. Waterway Evacuation is considered approximately 5% of total projected traffic. In NW-4 barges of capacity 300 Tons (40m X 9m) will be navigating, which requires 1.5 m draft. Two 'weirs' at both end of berthing area are proposed which will maintain same water level as that of Buckingham Canal all around the year and will also not obstruct water flow during heavy monsoon season.

10.7.4 Social Impact Assessment

This assessment is specifically addressing the potential impacts which will be generated as a result of proposed development of Port. It states the following:

- Revision of master plan development will be carried in total area of 2472.85 hectares which includes 136.28 ha of existing area, 927.11 Ha of government land, 613.31 ha of private and proposed sea reclamation of 796.15 hectares including basin all developable area. The site selected is without Habitations hence no R&R issue is envisaged.
- The anticipated impact on nearby settlements during construction phase such as air pollution and the noise generating will be of temporary nature and cease upon completion of the construction.
- Dust suppression measures and enclosures around high noise generating areas will be provided.
- During the construction phase approximately 500-1000 workers will be employed in the form of skilled, semiskilled, unskilled and technical manpower is envisaged. During operation phase, direct and indirect employment generation of the proposed revised master plan is expected to be 1,500 and 4,500.
- The port management will conduct regular consultation with fishermen associations reading safe navigation. Conflicts, if any, with fishing community will be amicably resolved in all cases
- All Appropriate measures will be taken to minimize the hindrance to fishing activity during construction & operation phase. The port management will conduct regular consultation with fishermen associations reading safe navigation. Conflicts, if any, with fishing community will be amicably resolved in all cases

10.8 Project Benefits

- Probable infrastructure development due to project expansion in the region would facilitate creation of additional/improved communication, health, education, sanitation, hygiene and other basic need of the locality
- Due to proposed project expansion the surrounding population would get maximum benefits from upcoming of industries and its allied ancillary units in form of direct and indirect employment, self-employment and start up, skill development opportunities etc.,
- Improved socio-economic conditions
- Quality of life in the region is likely to improve due to increase in per capita/per family earning and value appreciation of local resources that would provide economic freedom and facilitate a higher standard of living
- As part of the Corporate Social Responsibility (CSR), MIDPL is strongly committed towards fulfilling its social obligations and has taken up and proposed many activities for improving the way of living of people the locality in field of Education, Health care, Community development and Sustainable livelihood development[14]
- The proposed project shall further act as a catalyst to industrialization and urbanization of the region
- During the construction phase there will be large-scale employment generation (around 500-1000 workers) in the form of skilled, semiskilled labourers and technical staff. During operation phase, direct and indirect employment generation expected is approximately 1500 and 4500 respectively.

10.9 Environment Management Plan

The effective implementation and close supervision of the environmental management to mitigate the environmental impacts, which are likely to arise due to the construction and operation phases of the project will be best achieved through a suitable institutional mechanism.

Environment Management Plan for the revised master plan has been prepared keeping in mind the sensitivity of area in the vicinity of Kattupalli port and MIDPL commitment towards sound environment management practices. The environment management plan consists of Greenbelt Development Plan; Marine Biodiversity Management Plan; Wildlife Conservation Awareness Programme; Exploring Renewable Source of Energy in terms of Solar and Wind; MIDPL Measures towards India's Commitment for Climate Change; Occupational health and Safety etc., Apart from these the designed inbuilt components such as Air pollution abatement measures, water and wastewater treatment measures, Storm water management Plan, Stockyard runoff management plan, Noise abatement measures, Solid and hazardous waste management measures, selection of suitable outfall locations etc., which will ensure effective environment management.

10.10 Budgetary Estimate for Environment Management

The budgetary estimate for Capital Environmental Management Cost for Revised Master Plan (including immediate development plan) is ~ **INR 2324.11 crores** and the annual budgetary estimate during operational phase is ~**INR 120.19 crore**.

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[14] *CSR budget of INR 21 crore were prosed as five year plan for identified activities based on need based assessment carried out and same may be revised based on the consultations during the public hearing according to its merits and priority. The CSR activities will be taken up in a phased manner as per project development activities*

Chapter 11
Disclosure of Consultants

Chapter 11 Disclosure of Consultants Engaged

Marine Infrastructure Developer private Limited (MIDPL) considering the future business potential is now proposing Revised Master Plan of Kattupalli Port. Type of berth and type of cargo is commercial and business requirement. Hence revised master plan is proposed with flexibilities to accommodate all berths (existing as well as proposed) as multipurpose.

MIDPL have appointed L&T Infrastructure Engineering Limited (LNTIEL) in August 2016, to carry out the CEIA Study for the Revised Master Plan of Kattupalli Port. The nature of consultancy service rendered covers both terrestrial and marine environmental assessment.

11.1 Brief Profile of L&T Infrastructure Engineering Limited

L&T Infrastructure Engineering Ltd., a subsidiary of Larsen & Toubro Limited is a leading multi-disciplinary Indian Consultancy firm. LNTIEL has made a distinctive mark by creating new standards in providing sustainable solutions. Today, LNTIEL is distinguished from others not limited to its lineage but its relentless quest for quality - a unique tradition of placing client's needs above all.

LNTIEL offers a diverse array of talents together with practical experience. We assure our clients a professional approach by innovation and evolving optimal solutions. At LNTIEL, we recognise that human resources are the key to organisational success. LNTIEL's expertise ranges across a broad spectrum of sectors with special forte in Infrastructure Projects and Industrial Parks/SEZs. LNTIEL has expertise in carrying out Techno-Economic Feasibility Studies, Preparation of Master Plans & Detailed Project Reports and Bid Process Management. LNTIEL is rendering the following services for Port and Harbours/ Break Waters and Dredging/Shipyards/Industrial Clusters/SEZs/Industrial Parks/Investment Regions:

- Environmental and Social Impact Assessment including assistance to Client in obtaining necessary clearances/approvals from various statutory authorities: State PCB's, State CZMA, MoEF&CC (GoI)
- Field surveys (Terrestrial & Marine Environments) and investigations
- Numerical modelling especially for the marine projects
- Project formulation/conceptualisation & configuration
- Market study and demand assessment
- Master planning, Urban planning, Environmental planning and Tourism planning
- Infrastructure design and engineering
- Block cost estimation
- Economic and financial analysis
- Bid Process Management
- Assistance in domestic and international marketing including road shows/investors conference (or meet) for marketing the project.
- Assistance to Client in achieving technical and financial closures

Strengths of LNTIEL

LNTIEL has a well-equipped Corporate Office at Chennai. LNTIEL's staffs is replete with a wide range of professionals – Urban Planners, Engineers, Designers, Environmental and Social Specialists, Financial Analysts, Project Structuring, Marketing and Privatisation Experts, Construction Supervision Managers – covering a wide spectrum of services. The skills of the Experts are continuously aligned to suit the changing Client requirements.

LNTIEL has strategic tie-ups with Associates for specialized services. Services of an eminent group of Expert Consultants are also available to LNTIEL. Our clients value the highly motivated and dedicated team of professionals who assure them international quality service through focused and optimal solutions.

LNTIEL provides a stimulating working environment. We have assembled a team of skilled, creative and dynamic professionals who strive to translate the organisational ethos into reality. To enhance the efficiency of the personnel and enable them to be updated with the latest developments in technology, we organise comprehensive technical training programmes and organisational development programmes at regular intervals. A creative work environment, motivated staff, structured training, latest methodologies and tools, continuous adherence to quality, adoption of best ethical standards and a keen client orientation are the factors that spur on LNTIEL's journey into the future. Our driving philosophy is 'Client First'. We work towards complete satisfaction of our clients by adopting good work practices and meeting their requirements through timely delivery of appropriate solutions. Further for achieving this objective, we have acquired state-of-the-art IT facilities and software to ensure quality in all spheres of our activity.

LNTIEL has modern fully computerized offices with latest computational and communication facilities. A large number of high-end computers are available and are connected by a network. Further, Internet connectivity enables fast exchange of information with the clients, as well as within the offices and the parent companies. These facilities help us to provide our clients high quality services within the shortest possible time. LNTIEL has more than Four hundred regular employees at four offices forming a leading consulting group with extensive operations at Chennai, Hyderabad, Delhi and Mumbai.

Quality Policy of LNTIEL

LNTIEL is committed to achieve and sustain excellence in consultancy services to customers world-wide through an in-house Quality Management System that conforms to ISO 9001:2015. The commitment stated above will be fulfilled by:

- Working towards complete satisfaction of LNTIEL's customers by adopting good work practices and meeting their requirements through timely delivery of appropriate solutions.
- Striving to achieve continual improvement of quality management system through periodic review of quality policy, processes and quality objectives.
- Striving to maintain well-qualified and motivated staff by empowering them and providing a stimulating work environment.
- Adhering to the best ethical standards for business behaviour by respecting the rules of law governing LNTIEL's business and presenting a well-audited financial statement every year.
- Impelling employees at all levels in achieving the objectives of the organisation and ensuring that all employees are aware of and act within the policy framework of LNTIEL.
- Propagating our quality policy and procedures to our sub-consultants and associates and ensuring adherence to the relevant components of the quality system.

QCI-NABET - EIA Accreditation

National Accreditation Board for Education & Training (NABET) is a constituent board of the Quality Council of India (QCI). QCI, NABET has accredited LNTIEL for carrying out EIA studies in the following Ten (10) sectors:

S. No.	Sector
1	*Industrial Estates/Parks/Complexes/Areas, Export Processing Zone (EPZs), Special Economic*

S. No.	Sector
	Zones (SEZs), Biotech Parks and Leather Complexes
2	**Ports, Harbours, Break Waters and Dredging**
3	Highways
4	Airports
5	Thermal Power Plants
6	River Valley Projects
7	Common Effluent Treatment Plants (CETPs)
8	Common Municipal Solid Waste Management Facility (CMSWMF)
9	Building and Construction Project
10	Townships and Area Development Projects

NABET Certificate was given as **Attachment 1**. Further details may be seen on the following URL: www.lntiel.com

11.2 Other Consultants Engaged by LNTIEL

11.2.1 Green Chem Solutions Pvt Ltd

Nature of Consultancy Services Rendered: Terrestrial Baseline Environmental Surveys

M/s. Green Chem Solutions was set up in the year 2007. The agency is offering consultancy services in generation of baseline terrestrial environmental data for the detailed EIA studies. Green Chem Solutions is also an NABL Certified agency (ISO/IEC 17025:2017) in the field of chemical testing. It is also certified by ISO 9001:2008. Further details on the agency may be seen on the following URL: www.greenchemsolutions.in

11.2.2 Centre for Advanced Studies in Marine Biology, Annamalai University, Parangipettai

Nature of consultancy service rendered: Marine & Estuarine Environmental Surveys

The Centre of Advanced Study in Marine Biology (CASMB) is a reputed Marine Institute in India which is actively engaged in teaching, research and extension activities with an ideal location and easy access to different biotopes such as estuary, mangrove, backwaters and coastal waters. It has made rapid strides in various facets of Marine Science.

Research contribution through the years to Marine Science pertaining to the tropical environment by this Centre resulted in the establishment of exchange programmes with research institutions of the United Kingdom and the United States of America. The major thrust areas identified for the Centre by the experts of the UGC visiting committee are Biological Oceanography, Physical & Chemical Oceanography, Physiology, Biochemistry & Microbiology, Fishery Science and Ecology & Aquaculture.

The ENVIS Centre (Environmental Information System), which is one among the 78 Centres in the country sponsored by the Ministry of Environment Forest and Climate Change (MoEF&CC), Government of India, New Delhi, started functioning from March 2, 1992 at the Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu, a pioneering Marine Biological Research Institute.

This Centre is meant to collect information on Estuaries, Mangroves, Coral reefs and Lagoons. The Centre has been serving with a motto to "Collect, Collate and Disseminate" and is engaged in several information services viz., query/answer, and abstract service, press clipping service, publication and development of database for the benefit of user community.

In addition to ENVIS Centre, ENVIS Node on the Environmental Management Capacity Building - Technical Assistance Project (EMCB-TAP) on Estuaries, Mangroves, Coral reefs and Lagoons has been established by the Ministry of Environment Forest and Climate Change (MoEF&CC), Government of India, under the World Bank (WB) Assistance.

ENVIS centre has also been selected as one among the 20 Sustainable Development Network Partners (SDNP) of ENVIS under Indo-Canada Environmental Facility (ICEF) Project, India. Further details on the agency may be seen on the following URL: www.casmbenvis.nic.in.

11.2.3 RS Geoinformatics Solutions Private Limited

Nature of Consultancy Services Rendered: Risk Assessment

Since 2007 RS Geoiformatics Solutions Pvt. Ltd. Has been involved involved in providing geospatial solutions to its clients across the world, It is involved in the acquisition, and analysis of geospatial mapping data and how it is applied to meet the needs and challenges of its clients. The services RS Geoinformatics offers are Risk Assessment, Quantitative Risk Assessement (QRA), Digital Aerial Triangulation, Planimetric Mapping, Digital Topographic Mapping, Digital Orthophoto process, LiDAR classification, 2D Mapping & GIS conversion, Training & Development as well as Assistance in dissertation to university students. More information of this agency may be seen in the following URL: www.rsgeoinformatics.com.

11.2.4 National Centre for Sustainable Coastal Management (NCSCM)

Nature of Consultancy Services Rendered: Demarcation of HTL\LTL and CRZ Area

The National Centre for Sustainable Coastal Management (NCSCM), under Ministry of Environment, Forest and Climate Change, Government of India promotes integrated and sustainable management of coastal and marine areas in India and advice the Union and States/ Union Territory Governments and other associated stakeholders on policy, and scientific matters relating to Integrated Coastal Management (ICZM).They offer services like Shoreline change assessment & coastal vulnerability assessment, Coastal and marine environmental monitoring, Mapping of coastal land use land cover, Numerical modeling of near-coastal processes, Preparation of Coastal Zone Management Plan (CZMP), Post-project monitoring for specific project sites, Tourism Carrying capacity of islands and coastal areas, Beach carrying capacity, Coastal Regulation Zone maps at state and local levels, Capacity building in Integrated Coastal Zone Management (ICZM), Preparation of Conservation Management Plan, Sale of data Products, Decision Support System for Coastal Management. Further details on this center may be seen on the following URL: http://ncscm.res.in/.

11.2.5 Suganthi Devadasan Marine Research Institute (SDMRI)

Nature of Consultancy Services Rendered: Marine Biodiversity Study

Suganthi Devadason Marine Research Institute (SDMRI) is a Marine Research and Higher Education organization. SDMRI was established in 1998 under the Suganthi Devadason Trust (Reg. No. 290/1997) at Tuticorin, Tamil Nadu, India. This Institute is recognized by the Department of Scientific and Industrial Research (DSIR) of Ministry of Science and Technology, Government of India as Scientific and Industrial Research Organization (SIRO). The coastal baseline studies and monitoring carried by the institute are Water quality, Sediment quality, Heavy metals in organisms, Fish catch, Underwater survey and monitoring of fish population in coral reef, seagrass bed areas and associated fauna and flora. Further details of this institute may be seen on the following URL: www.sdmri.in.

11.2.6 FP India Project Management Consultancy Services Private Limited

Nature of Consultancy Services Rendered: Traffic Assessment Study

FP India Project Management Consultancy Services Private Limited operates as a consultancy company. The Company provides consultancy services in design, engineering, and project management across variety of sectors. FP India Project Management Consultancy Services serves government, real estate developers, contractors, and other private sectors in India. More information of this agency may be seen in the following URL: www.fpindia.com / www.pellfrischmann.com.

11.2.7 National Institute of Ocean Technology (NIOT)

Nature of Consultancy Services Rendered: Oceanographic, Bathymetry and Topography Data Collection

The National Institute of Ocean Technology (NIOT) was established in November 1993 as an autonomous society under the Ministry of Earth Sciences, Government of India. NIOT is managed by a Governing Council and the Director is the head of the Institute. Major aim of starting NIOT under the Ministry of Earth Sciences, is to develop reliable indigenous technologies to solve the various engineering problems associated with harvesting of non-living and living resources in the Indian Exclusive Economic Zone (EEZ), which is about two-thirds of the land area of India. The goals of the Coastal & Environmental group in NIOT are to promote programs consistent with the overall development perspective of the country in the infrastructure sector thereby contributing to the nation building exercise. Further details of this Institute may be seen on the following URL: www.niot.res.in.

11.2.8 DHI India Water Environment Private Limited

Nature of Consultancy Services Rendered: Modelling Studies, Oil spill risk assessment

- DHI India Water & Environment Pvt. Ltd is a wholly owned subsidiary of the DHI Group. Established in India as an independent company in 2001, it focuses on water resources, marine and environment consultancy services and sales. In the Water Resource Department, DHI’s competencies include: integrated water resources management, flood forecasting, flood management, flood risk management and flood inundation modelling, decision support systems including real time decision support systems for flood forecasting and reservoir operation and integrated water resources management, dams & reservoirs, river morphology modelling systems, reservoir sedimentation studies, water quality modelling, restoration of lakes , rivers and reservoirs, feasibility studies for inland waterways, river basin management, ground water modelling, catchment area treatment plans, managing non-revenue water and water supply systems.

In the marine department It has extensive experience in integrated coastal zone management, feasibility studies for ports and harbours, shoreline management, sedimentation studies, dredging and spill management and so on

More information of this agency may be seen in the following URL: www.dhigroup.com

11.2.9 BMT Consultants India Pvt. Ltd.

Nature of Consultancy Services Rendered: Ship Navigational Studies

From concept through to commissioning, BMT has played an integral role in delivering ‘through life’ solutions for major infrastructure projects in India. Their navigation assessment services have been developed in concert with several navigation specialists including pilots and are recognised by the Nautical Institute. It executes assessments on coastal voyages, capturing the planning of the passage, preparation for sailing, pilotage, coastal passage and berthing. All our assessments are conducted with minimal impact on operations or hours of rest whilst allowing the assessor to see the vessel being navigated naturally. More information of this agency may be seen in the following URL: www.bmt.org.

11.2.10 Madras School of Social Work (MSSW)

Nature of Consultancy Services Rendered: Primary Socio-economic surveys, Need based assessment

Madras School of Social Work, established in 1952, located in Chennai, South India, is an Autonomous Institution, NAAC accredited and affiliated to University of Madras. The school is a member of the Association of Schools of Social Work in India and the Asia – Pacific Association of Social Work Education. Also, it enjoys the affiliation of the International Association of Schools of Social Work. Madras School of Social Work is considered as the best college for social work in South India and the third-best in the country. MSSW playing an active role in advocacy and policy formulation and access to contemporary knowledge resources and implementing community outreach in our core competency areas, need and evidence based community practice interventions and delivering training and consultancy services to Corporate, Government and Civil Society Organizations. More information of this agency may be seen in the following URL: https://mssw.in/.

L&T Infra Engineering

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