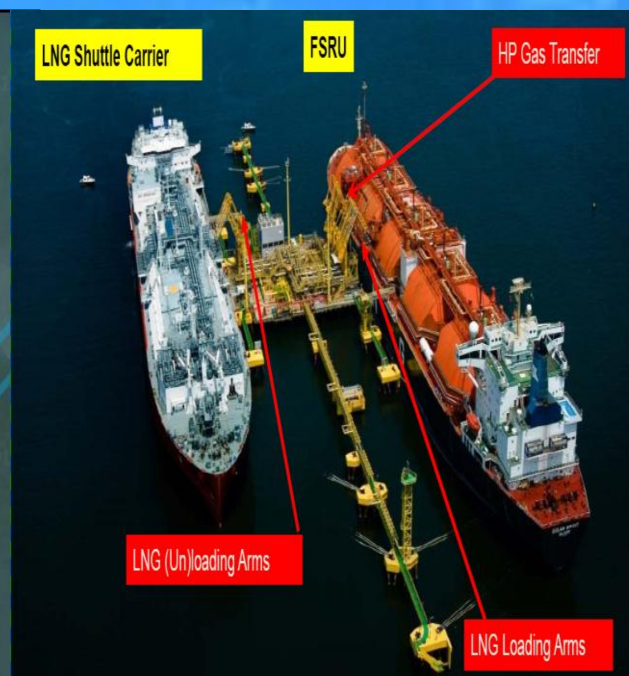
Draft Report

Environmental Impact Assessment of Proposed FSRU based LNG Terminal at Kakinada Deep Water Port, Kakinada, East Godavari District, Andhra Pradesh



Sponsor

Andhra Pradesh Gas Distribution Corporation Limited, Hyderabad

National Environmental Engineering Research Institute

(Council of Scientific and Industrial Research)

Nehru Marg, Nagpur – 440 020

(QCI / NABET Accreditation : Sr.No.102 as per the list published on May 05, 2013)

May, 2013

Draft Report

Environmental Impact Assessment of Proposed FSRU based LNG Terminal at Kakinada Deep Water Port, Kakinada, East Godavari District, Andhra Pradesh

Sponsor

Andhra Pradesh Gas Distribution Corporation Limited, Hyderabad

National Environmental Engineering Research Institute

(Council of Scientific and Industrial Research)

Nehru Marg, Nagpur – 440 020

(QCI / NABET Accreditation : Sr.No. 102 as per the list published on May 05, 2013)

May, 2013

Project Personnel – NEERI

Scientific

Mr. Rama Rao, K.G.
Mrs. Morami Kalita.
Dr. Reddy, M.K.
Mrs. Sumathi, M.
Mr. Ghughe, S.P.
Dr. Bodhe, G.L.
Mr. Lokhande, S.
Mr. Baseshankar,Y. J.
Mr. Bassin, J.K.
Mr. Deshbhratar, P. B.
Dr. Dhopte, S.M.
Mrs. Papiya Mandal
Mr. Shinde, V.M.
Mr. Samudrala, H.R.

Technical / Project Staff

Mr. Balakrishna, G.
Mr. Parameswar, R.
Mr. Shaik Fareed
Mr. Srinivas, K.
Mr. Sudhakar Reddy, G.
Ms. Supreetha, G.
Mrs. Sushma, N.
Mr. Yadagiri, K.
Ms. Agrawal, M.
Ms. Akre, S.
Ms. Bhadange, R.
Ms. Chopra, N.
Mr. Gaidkwad, G.
Ms. Jambhulkar, M.
Ms. Kature, S.
Ms. Khan, A.
Ms. Khanzode, V.
Ms. Lakde, P.
Ms. Roy, R.
Ms. Sharma, A.
Ms. Shinde, P
Ms. Shukla, S.
Ms. Singh, E.
Ms, Singh, M.
Mr. Thakre, S.
Ms. Vaidya, A.
Ms. Warudkar, S.
Ms. Wankhede, A.
Ms. Zha, A.
Mr. Nagarkar, S.
Mr. Kirnake, N.

Consultants

Dr. Ghosh, T.K.
Mr. Sameer Deshpande

Project Leaders

Mr. Pentu Saheb, S.
Dr. Ramteke, D.S.
Dr. Krupadam, R.J.

Project Co-ordinator

Dr. Satish R.Wate

Director

Project Personnel

Andhra Pradesh Gas Distribution Corporation Limited (APGDC)

Mr. S Narayanan, Managing Director

Mr. V Srinivasulu, Director (Finance)

Mr. Kapil Kumar Jain, Director (Commercial)

Mr. K Gopalkrishna, CFO

Mr. Santiram Mandal, Chief Manager

Mr. K S Rao, Advisor

Mr. K Subramanyam, Advisor

GDF SUEZ LNG UK LTD

Mr. Eric Ebelin

Mr. Gordon Milne

Mr. Thomas Pierre

Kakinada Seaports Limited

Mr. M.Murlidhar

Capt. Jacob Satyaraju

CONTENTS

Item	Page No.
Contents	**i to x**
List of Figures	**xi-xiii**
List of Tables	**xiv-xvii**
List of Plates	**xviii**
List of Annexures	**xviii**
Executive Summary	**ES-1 to ES-26**
Chapter 1: Introduction	**1.1 to 1.24**
1.0 Preamble	1.1
1.1 Ports & Harbours	1.1
1.2 Natural Gas Supply Chain	1.2
1.2.1 Liquefied Natural Gas (LNG)	1.3
1.2.2 Benefits of Regasified LNG (RLNG)	1.3
1.3 Project Proponent	1.4
1.4 Proposed Project	1.5
1.4.1 Need of Proposed Project	1.6
1.4.2 Project Location	1.7
1.4.3 Kakinada Bay - Developments	1.8
1.5 Prior Environmental Clearance Process	1.8
1.5.1 Validity of Environmental Clearance	1.10
1.5.2 Transferability of Environmental Clearance	1.10
1.5.3 Post Environmental Clearance Monitoring	1.11
1.6 Terms of Reference (ToR)	1.11
1.7 Environmental Impact Assessment (EIA)	1.11
1.7.1 Objectives & Scope of Work	1.12
1.7.2 Methodology	1.12
1.8 Structure of Balance part of this report	1.13
Chapter 2: Project Description	**2.1 to 2.47**
2.1 Proposed Project	2.1
2.2 Analysis of Alternatives	2.1
2.2.1 LNG Terminal Configurations	2.1
2.2.1.1 Land- Based Terminal	2.1

Item			Page No.
		2.2.1.2 Open Sea Buoy Solution	2.2
		2.2.1.3 FSRU or FSU solution	2.3
		2.21.4 Screening of Design Concepts	2.4
	2.2.2	LNG Regasification Technology	2.6
	2.2.3	Project Site Alternatives	2.7
2.3	Description of Project		2.8
	2.3.1	Floating Storage and Re-gasification Unit (FSRU)	2.10
		2.3.1.1 LNG Contaminant	2.11
		2.3.1.2 LNG Vaporization	2.13
	2.3.2	Marine Receiving Facility	2.15
		2.3.2.1 Island Jetty	2.15
		2.3.2.2 Jetty Platform	2.15
		2.3.2.3 Loading Arms	2.15
		2.3.2.4 Breasting Dolphins	2.17
		2.3.2.5 Mooring Dolphins	2.18
		2.3.2.6 Walkways	2.19
		2.3.2.7 Quick Release Hooks	2.19
		2.3.2.8 Navigational Aids	2.20
		2.3.2.9 Jetty Utilities	2.20
		2.3.2.10 Potable Water	2.21
		2.3.2.11 Fire Water and Protection System	2.21
		2.3.2.12 Jetty Power Generation System	2.21
		2.3.2.13 Access Towers/ Gangway	2.21
		2.3.2.14 Corrosion Protection	2.22
		2.3.2.15 LNG Spill Containment	2.22
	2.3.3	Subsea Pipeline	2.22
	2.3.4	Onshore Receiving Facility (ORF) – Landfall Station	2.23
	2.3.5	Summary of Proposed Project	2.24
	2.3.6	Relevant Codes and Standards	2.24
2.4	Project Site		2.24
	2.4.1	Existing Kakinada Deep Water Port	2.29
		2.4.1.1 Kakinada Deep Water Port Particulars	2.30
		2.4.1.2 Ship to Ship (STS) Transfer of Crude Oil	2.32

Item			Page No.
		2.4.1.3 Oil& Gas Exploration - Supply Support Base	2.32
		2.4.1.4 Environmental Management	2.32
		2.4.1.5 Port Accessibility	2.33
2.5	Geotechnical Details		2.33
	2.5.1	Seismicity	2.34
2.6	Dredging		2.34
	2.6.1	Capital Dredging	2.35
	2.6.2	Maintenance Dredging	2.35
2.7	Surrounding Area		2.36
2.8	Climatology and Sea Conditions in Project Region		2.36
	2.8.1	Depressions / Cyclones in Bay of Bengal	2.36
	2.8.2	Wind	2.37
	2.8.3	Sea Waves	2.38
	2.8.4	Tides	2.38
	2.8.5	Currents	2.39
Chapter 3: Description of Environment			**3.1 to 3.158**
3.1	Study Area		3.2
	3.1.1	Climate	3.2
	3.1.2	Geology / Soils	3.3
	3.1.3	Industrial and Infrastructure Facilities	3.4
	3.1.4	Ecology	3.4
3.2	Marine Environment		3.6
	3.2.1	Hydrography	3.6
	3.2.2	Bathymetry	3.6
		3.2.2.1 Bathymetry at FSRU Area	3.7
		3.25.2 Bathymetry at Dredge Material Dumping Area	3.7
	3.2.3	Waves & Tides	3.7
	3.2.4	Marine Water Quality Assessment	3.8
		3.2.4.1 Seawater – Physico-Chemical Characteristics	3.8
		3.2.4.2 Biological Characteristics	3.10
	3.2.5	Seabed Sediment Quality	3.13
		3.2.5.1 Sediment Characterization – Baseline Status	3.13

Item				Page No.
		3.2.5.2	Physical and Chemical Characteristics of sediment	3.13
		3.2.5.3	Heavy Metals	3.14
		3.2.5.4	Macrobenthos	3.15
	3.2.6	Fisheries		3.15
3.3	Land Environment			3.44
	3.3.1	Reconnaissance		3.44
		3.3.1.1	Climate and Rainfall	3.44
	3.3.2	Baseline Soil Quality		3.45
		3.3.2.1	Physical Properties of Soil	3.45
		3.3.2.2	Chemical Properties of Soil	3.46
		3.3.2.3	Nutrient Status of Soil	3.47
		3.3.2.4	Heavy Metal Content in the Soil	3.47
		3.3.2.5	Soil Microbiology	3.48
	3.3.3	Satellite Data Analysis for Landuse / Land Cover		3.48
		3.3.3.1	Results	3.50
		3.3.3.2	15 Km Radius Study Area	3.51
		3.3.3.3	10 Km Radius Study Area	3.52
3.4	Water Environment			3.65
	3.4.1	Reconnaissance		3.65
	3.4.2	Baseline Status – Water Quality		3.66
		3.4.2.1	Physico-chemical Characteristics	3.66
		3.4.2.2	Heavy Metals	3.67
		3.4.2.3	Bacteriology	3.67
		3.4.2.4	Biological Characteristics	3.67
3.5	Biological Environment			3.80
	3.5.1	Reconnaissance		3.80
	3.5.2	Survey Methodology		3.81
	3.5.3	Biodiversity in study area		3.81
	3.5.4	Floral Characteristics		3.81
	3.5.5	Mangroves		3.83
	3.5.6	Medicinal Plants		3.84
	3.5.7	Threatened Plant Species		3.84
	3.5.8	Social Forestry		3.84

Item			Page No.
	3.5.9	Agriculture	3.84
	3.5.10	Green Belt	3.85
	3.5.11	Fauna	3.85
		3.5.11.1 Avifauna	3.85
		3.5.11.2 Fisheries	3.86
3.6	Air Environment		3.117
	3.6.1	Reconnaissance	3.117
	3.6.2	Air Quality Surveillance	3.117
	3.6.3	Micrometeorology	3.118
	3.6.4	Air Quality Baseline Status	3.118
		3.6.4.1 Respirable Particulate Matter (PM_{10})	3.119
		3.6.4.2 Gaseous Pollutants	3.119
	3.6.5	Air Quality Secondary Data	3.120
		3.6.5.1 Winter Season Baseline Status	3.120
3.7	Noise Environment		3.129
	3.7.1	Reconnaissance	3.129
	3.7.2	Ambient Noise Levels	3.129
	3.7.3	Ambient Noise Baseline Status	3.130
	3.7.4	Vehicular Traffic Survey	3.130
3.8	Socio-Economic Environment		3.135
	3.8.1	Reconnaissance	3.135
	3.8.2	Baseline Status	3.135
		3.8.2.1 Demographic Structure	3.136
		3.8.2.2 Infrastructure Resource Base	3.137
		3.8.2.3 Economic Attributes	3.138
		3.6.2.4 Health Status	3.139
		3.6.2.5 Cultural and Aesthetic Attributes	3.139
	3.8.3	Socio-Economic Survey	3.139
		3.8.3.1 Sampling & Data Collection	3.139
		3.8.3.2 Field Survey and Observations	3.140
		3.8.3.3 Interview Method	3.140
		3.8.3.4 Awareness and Opinion	3.143

Item			Page No.
	3.8.4	Quality of Life	3.144
Chapter 4: Anticipated Environmental Impacts and Mitigation Measures			**4.1 to 4.44**
4.1	Identification of Impacts		4.1
	4.1.1	Project Specific Impacts	4.2
	4.1.2	Prediction of Significant Impacts - Methodology	4.3
4.2	Impacts Prediction - Construction Phase		4.6
	4.2.1	Capital Dredging	4.7
	4.2.2	Estimated Dredging Rate	4.8
	4.2.3	Disposal of Dredge Material	4.10
	4.2.4	MIKE-21 Model Description	4.10
	4.2.5	Mud Transport - Prediction Results	4.11
	4.2.6	Prediction of Impacts – Marine Environment	4.12
	4.2.7	Land Environment	4.15
	4.2.8	Water Environment	4.16
	4.2.9	Biology/Ecology	4.16
	4.2.10	Air Environment	4.16
	4.2.11	Noise Environment	4.17
	4.2.12	Socio-economic Environment	4.17
	4.2.13	Mitigation Measures	4.17
4.3	Operation Phase Impacts		4.23
	4.3.1	Marine Environment	4.23
	4.3.2	MIKE Model Results and Discussions	4.24
	4.3.3	Land Environment	4.25
	4.3.4	Water Environment	4.26
	4.3.5	Biological Environment	4.27
	4.3.6	Air Environment	4.27
	4.3.7	Noise Environment	4.30
	4.3.8	Socio-economics	4.31
Chapter 5: Environmental Management Plan			**5.1 to 5.28**
5.1	Introduction		5.1
5.2	Environmental Management System		5.2

Item				Page No.
	5.2.1	Health, Safety and Environmental Management System		5.2
	5.2.2	Environment Management Policy		5.4
	5.2.3	Organization		5.5
	5.2.4	Budgetary Provisions for HSE Management Plan		5.5
5.3	Environment Management Plan during Construction Phase			5.6
5.4	Environment Management Plan during Operation Phase			5.8
5.5	Cost of EMP			5.11
5.6	Monitoring			5.12
5.7	Training			5.13
5.8	Framework			5.13
5.9	Emergency Response Plan			5.13
	5.9.1	Emergency Preparedness & Response		5.14
		5.9.1.1	Safety Procedures	5.14
		5.9.1.2	FSRU	5.14
		5.9.1.3	Liquid Cargo Spill Response	5.15
		5.9.1.4	Tiers of Response	5.15
		5.9.1.5	Spill Response Methods	5.16
		5.9.1.6	TIER I Response System Proposed at Kakinada	5.18
		5.9.1.7	Handling Major Spills	5.19
		5.9.1.8	Minor Spills	5.19
		5.9.1.9	Handling Fire and Explosion Emergencies	5.20
		5.9.1.10	Roles and Responsibilities	5.22
Chapter 6: Environmental Monitoring Program				**6.1 to 6.6**
6.1	Pollution Monitoring			6.1
6.2	Marine Environment			6.2
6.3	Land Environment			6.2
6.4	Air Environment			6.3
6.5	Noise Environment Monitoring			6.3
6.6	Inland Water Environment			6.3
6.7	Environmental Management Apex Review Committee			6.3
6.8	Budgetary Provision			6.4

Item				Page No.
6.9	Submission of Monitoring Reports to MoEF / APPCB			6.4
Chapter 7 : Additional studies				**7.1 – 7.91**
7.1	Rapid Risk Assessment & Approach to Disaster Management Plan			7.2
	7.1.1	Past Accidents / Analysis - LNG Marine Transport and Handling		7.2
		7.1.1.1	Safety Record of LNG Ships	7.3
	7.1.2	Hazard Identification (HAZID)		7.4
		7.1.2.1	Objective of HAZID	7.4
		7.1.2.2	Approach & Methodology	7.4
		7.1.2.3	Risk Matrix	7.5
		7.1.2.4	Results of HAZID	7.6
	7.1.3	Fire and Explosion Index (FEI)		7.6
	7.1.4	Maximum Credible Accident (MCA) Analysis		7.7
	7.1.5	Fire and Explosion Scenarios		7.7
		7.1.5.1	Jet Fire	7.8
		7.1.5.2	Flash Fire	7.8
		7.1.5.3	Pool Fire	7.9
		7.1.5.4	Unconfined Vapour Cloud Explosion	7.9
	7.1.6	Models for Calculation of Heat load and Pressure Waves		7.10
	7.1.7	Computation of Damage Distances		7.10
		7.1.7.1	Jet Fire	7.11
		7.1.7.2	Flash fire	7.11
		7.1.7.3	Late Pool Fire	7.11
		7.1.7.4	Vapour Cloud Explosion	7.11
	7.1.8	Quantification of Individual and Societal Risk		7.12
		7.1.8.1	Individual Risk	7.12
		7.1.8.2	Societal Risk	7.12
	7.1.9	Failure Frequencies		7.13
	7.1.10	Risk Acceptance Criteria		7.13
	7.1.11	Risk Evaluation		7.16
	7.1.12	Conclusion		7.17
	7.1.13	Risk Mitigation Measures		7.17
		7.1.13.1	General Recommendations	7.18
		7.1.13.2	Specific Recommendation	7.21

Item			Page No.
	7.1.14	Types of Emergencies at port	7.23
	7.1.15	Approach to Disaster Management Plan	7.24
		7.1.15.1 Objectives of Disaster Management Plan	7.24
		7.1.15.2 Different phases of Disaster	7.25
		7.1.15.3 Key Elements of DMP	7.26
		7.1.15.4 Emergency Planning & Response procedure	7.27
		7.1.15.5 Onsite Disaster Management Plan	7.27
		7.1.15.6 Disaster Management Plan/ Emergency Preparedness Program : Off-site	7.33
	7.1.16	Oil Spill Contingency Plan	7.38
	7.1.17	Management Plan for Natural disasters	7.39
		7.1.17.1 Flood	7.39
		7.1.17.2 Earthquake	7.40
		7.1.17.3 Cyclone	7.40
		7.1.17.4 Tsunami	7.40
		7.1.17.5 Bomb scare / Terrorist Attack	7.41
	7.1.18	Rehearsal / Drills	7.42
	7.1.19	Exercises	7.42
	7.1.20	Records and Updating the Plan	7.42
7.2	Hydrodynamic studies - Coastline Changes		7.44
	7.2.1	Methedology	7.44
	7.2.2	Results and Findings	7.44
	7.2.3	Conclusions	7.45
7.3	CRZ Demarcation Study		7.46
	7.3.1	Methedology	7.46
	7.3.2	Details of proposed facilities	7.47
	7.3.3	Conclusions	7.48
Chapter 8 : Project Benefits			**8.1 to 8.5**
8.1	Energy Security		8.2
8.2	Food Security		8.2
8.3	Environmental Friendly Fuel / Feed Supply		8.2
8.4	Economic Benefits of FSRU based LNG Terminal at Kakinada		8.3
8.5	Social Benefits		8.3

Item			Page No.
8.6	Other Tangible Benefits		8.4
8.7	Corporate Social Responsibility (CSR)		8.4
8.8	No Project Scenario		8.5
Chapter 9 :	**Disclosures of Consultants engaged**		**9.1 to 9.16**
9.1	NEERI Profile		9.1
	9.1.1	NEERI Mission and Vision	9.1
	9.1.2	Mandate of NEERI	9.2
	9.1.3	NEERI Activities	9.2
	9.1.4	NEERI Services & Goods	9.2
	9.1.5	NEERI Human Resources	9.3
	9.1.6	Organizational Chart CSIR and NEERI	9.4
	9.1.7	Financial Resources of NEERI	9.5
	9.1.8	Analytical Instruments, Computer Systems and Software at NEERI	9.6
		9.1.8.1 Analytical Instrumentation Resource	9.6
		9.1.8.2 Computer Hardware & Peripherals	9.7
		9.1.8.3 Supporting Software	9.7
	9.1.9	Clients of NEERI	9.11
		9.1.9.1 Clients : International	9.11
		9.1.9.2 Clients : Central Government	9.11
		9.1.9.3 Clients : State Government	9.12
		9.1.9.4 Clients : Private Industries (National)	9.12
		9.1.9.5 Clients : Private Industries (Multi-National)	9.13
	9.1.10	Studies with International Funding	9.14
	9.1.11	US-AEP AWARD to NEERI	9.15
	9.1.12	Conformity to ISO 9001:2008	9.16
	9.1.13	Contact Persons	9.16
Chapter 10 :	**Summary & Conclusions**		**10.1 to 10.5**
10.1	The project		10.1
10.2	Baseline Environmental Quality		10.1
10.3	Anticipated Impacts and Mitigation		10.2
10.4	Environmental Management Plan		10.2
	10.4.1	Construction Phase	10.3
	10.4.2	Operational Phase	10.4
10.5	Post-Project Environmental Monitoring Program		10.4
10.6	Project Benefits		10.4
10.7	Conclusions		10.5

List of Figures

Fig. No	Particulars	Page No.
1.1	Project Location – Key Map	1.15
1.2	Proposed Project Location	1.16
1.3	EC Process for Category 'A' Projects in Ports & Harbours Sector	1.17
2.1	Proposed Project Location	2.40
2.2	Proposed Twin Jetty Lay-out Configuration-1	2.41
2.3	Proposed Project Conceptual Schematic of Configuration-1	2.41
2.4	Proposed Single Jetty Lay-out Configuration-2	2.42
2.5	Conceptual Schematic of Configuration- 2	2.42
2.6	Overall Layout of Proposed LNG Terminal Project	2.43
2.7	Proposed Project Site – Surrounding Area	2.44
3.2.1	Marine Study Area with Sampling Locations	3.16
3.2.2	Observed Bathymetry in Jetty & FSRU Area	3.17
3.2.3	Observed Bathymetry in Dredge Material Dump Area	3.18
3.2.4	Observed Tidal variations near Vakalpudi	3.19
3.2.5	Currents Vector Rose near Vakalpudi	3.20
3.2.6	Currents Vector Rose Diagram near Uppada	3.21
3.3.1	Soil Sampling Locations	3.57
3.3.2	Predominant Soil Texture in Study Area	3.58
3.4.1	Water Sampling Locations	3.70
3.5.1	Sampling Locations for Biological Environment	3.87
3.5.2	Avenue Plantation by Social Forestry Division	3.88
3.5.3	A View of Paddy Cultivation	3.88
3.5.4	A View of Greenbelt in and around NFCL	3.89
3.5.5	A View of Greenbelt Showing Dense Vegetation	3.89
3.6.1	Ambient Air Quality Monitoring Locations in the Study Area	3.121
3.6.2	Windrose at Project Site during Study Period	3.122
3.6.3	Seasonal Windorses in Project Area	3.123
3.7.1	Ambient Noise Monitoring Locations	3.132
3.8.1	Socioeconomic Survey Locations	3.147
4.1.1	Project Impact Network for Marine Environment	4.4
4.1.2	Comprehensive Impact Network for Proposed FSRU Based LNG Terminal	4.5

Fig. No	Particulars	Page No.
4.3.1	Predicted NOx Impact during Post-Monsoon Season	4.33
4.3.2	Predicted NOx Impact during Winter Season	4.34
4.3.3	Predicted NOx Impact during Summer Season	4.35
4.3.4	Predicted Noise Impact from Stationary Sources	4.36
5.1	Typical Command Structure of Emergency Response	5.24
7.1	HAZID Process	7.49
7.2	United Kingdom Societal Risk Guidelines	7.50
7.3	Commonly Acceptable Individual Risks in Different Designated Land Zones	7.50
7.4	Netherlands Societal Risk Guidelines	7.51
7.5	Hong Kong Societal Risk Guidelines	7.51
7.6	IR contour for LNG Carrier/ Shuttle	7.52
7.7	Risk transect for LNG Carrier/ Shuttle	7.52
7.8	F/N curve for LNG Carrier/ Shuttle	7.53
7.9	IR contour for FSRU (Vessel)	7.53
7.10	Risk transect for FSRU (Vessel)	7.54
7.11	F/N curve for FSRU (Vessel)	7.54
7.12	IR contour for LNG Unloading arms	7.55
7.13	Risk transect for LNG Unloading arms	7.55
7.14	F/N curve for LNG Unloading arms	7.56
7.15	IR Contour for LNG Pump	7.56
7.16	Risk transect for LNG PUMP	7.57
7.17	F/N curve for LNG PUMP	7.57
7.18	IR contour for LNG Vaporizer	7.58
7.19	Risk transect for LNG Vaporizer	7.58
7.20	F/N curve for LNG Vaporizer	7.59
7.21	IR contour for HP gas Send out arm	7.59
7.22	Risk transect for HP gas Send out arm	7.60
7.23	F/N curve for HP gas Send out arm	7.60
7.24	Damage Contours for Jet Fire due to 50mm Leak in RLNG Pipeline at Onshore Receiving Facility (ORF) at Heat Load 4.0 kW/m²	7.61
7.25	Damage Contours for Flash Fire due to 50mm Leak in RLNG Pipeline at Onshore Receiving Facility (ORF)	7.61
7.26	Onsite DMP - Disaster Control / Management System	7.62
7.27	Various Organizations Involved During Emergency	7.62

Fig. No	Particulars	Page No.
7.28	Emergency alert process in case of flood at the LNG Terminal	7.63
7.29	Emergency alert process in case of earthquake at the LNG Terminal	7.63
7.30	Emergency alert process in case of cyclone at the LNG Terminal	7.64
7.31	CRZ Demarcation along with HTL. LTL a project Site	7.65

List of Tables

Table No.	Particulars	Page No.
1.1	Summary of Project Design / Details	1.18
1.2	MoEF Approved Additional Terms of Reference (ToR) for EIA Study and Compliance	1.21
2.1	Evaluation of Alternative Ports in Respect of Key Aspects	2.45
2.2	LNG Specification as per EN 1160:1996	2.46
2.3	Typical FSRU Specifications	2.47
3.2.1	Marine Sampling Locations	3.22
3.2.2	Sea Water – Physical Parameters	3.24
3.2.3	Sea Water – Inorganic Parameters	3.26
3.2.4	Sea Water – Nutrient and Demand Parameters	3.28
3.2.5	Sea Water – Heavy Metals	3.30
3.2.6	Sea Water – Bacteriology	3.32
3.2.7	Sea Water – Phytoplankton	3.33
3.2.8	Phytoplankton Species in Sea Water Samples	3.34
3.2.9	Sea Water – Zooplankton	3.35
3.2.10	Zooplankton Species Identified in Water Samples	3.35
3.2.11	Particle Size Distribution	3.36
3.2.12	Physico-Chemical Characteristics of sediment	3.37
3.2.13	Nutrient and Organic Contents of sediment	3.38
3.2.14	Heavy Metals in Marine Sediment	3.39
3.2.15	Diversities of Macrobenthos in Sediment Samples	3.40
3.2.16	Macro benthos Observed in Sediment Samples	3.41
3.2.17	Marine Fish Production	3.42
3.2.18	Inland Fish Production	3.43
3.3.1	Soil Sampling Locations	3.59
3.3.2	Soil Samples Particle Size Distribution	3.59
3.3.3	Soil Physical Properties	3.60
3.3.4	Chemical Properties Saturated Soil Extract	3.60
3.3.5	Cation Exchangeable Properties of Soil	3.61
3.3.6	Soil Fertility Status	3.61
3.3.7	Heavy Metals in Soil Samples	3.62
3.3.8	Microbiological Characteristics of Soil	3.62

Table No.	Particulars	Page No.
3.3.9	Landuse/Land Cover Classification System (NRSC)	3.63
3.3.10	Inventory of Landuse/Land cover in study area	3.64
3.4.1	Water Quality Sampling Locations	3.71
3.4.2	Surface Water Quality – Physical Parameters	3.72
3.4.3	Surface Water Quality – Inorganic Parameters	3.72
3.4.4	Surface Water Quality – Nutrient & Demand Parameters	3.73
3.4.5	Ground Water Quality – Physical Parameters	3.73
3.4.6	Ground Water Quality – Inorganic Parameters	3.74
3.4.7	Ground Water Quality – Nutrient & Demand Parameters	3.75
3.4.8	Water Quality – Heavy Metals	3.76
3.4.9	Water Quality – Bacteriology	3.77
3.4.10	Water Quality – Phytoplankton	3.78
3.4.11	Water Quality – Zooplankton	3.79
3.5.1	List of Sampling Locations in the Study Area	3.90
3.5.2	Flora in Project Region	3.91
3.5.3	Flora Dominant Families in Project Region	3.104
3.5.4	Medical Plants in Project Region	3.105
3.5.5	Agriculture Production in East Godavari District	3.112
3.5.6	List of Animals Project Region	3.113
3.5.7	List of Fauna (Avifauna) Observed in Study Area	3.114
3.5.8	Species Wise Craft wise Marine Fish Landings in Kakinada Division: April 2008 – March 2009	3.115
3.6.1	Details of Locations for Ambient Air Quality Monitoring	3.124
3.6.2	Techniques Used for Ambient Air Quality Monitoring	3.125
3.6.3	Ambient Air Quality Status within the Study Area	3.126
3.6.4	Total Hydrocarbons within the Study Area	3.127
3.6.5	Ambient Air Quality Status within the Study Area	3.128
3.7.1	Locations for Monitoring Ambient Noise Levels	3.133
3.7.2	Ambient Noise Levels in Study Area – LNG Terminal Project	3.134
3.8.1	Socio-economic Surveyed Locations	3.153
3.8.2	Demographic Structure	3.154
3.8.3	Demographic Summary	3.155
3.8.4	Infrastructure Resource Base in Study Area	3.156
3.8.5	Main Workers Employment Pattern	3.157

Table No.	Particulars	Page No.
3.8.6	Exports & Imports Handled at Kakinada Port	3.158
3.8.7	Quality of Life	3.159
4.2.1	Identification / Evaluation of Impact Characteristics – Construction Phase	4.20
4.3.1	Identification / Evaluation of Impact Characteristics – Operation Phase	4.37
4.3.2	Details of Stack Emissions	4.39
4.3.3	Micrometeorological Data for Prediction of Impacts-Post-Monsoon Season	4.40
4.3.4	Micrometeorological Data for Prediction of Impacts-Winter Season	4.41
4.3.5	Micrometeorological Data for Prediction of Impacts-Summer Season	4.42
4.3.6	Details of Individual Noise Sources at FSRU	4.43
4.3.7	Major Noise Sources for Prediction of Impact	4.43
4.3.8	Expected Change in Subjective Quality of Life	4.44
4.3.9	Expected Change Cumulative Quality of Life	4.44
5.1	Transportation of raw material	5.25
5.2	Construction activities / fabrication and welding	5.25
5.3	Labour Force	5.26
5.4	Capital / Maintenance Dredging	5.26
5.5	Ship Operations based on Frequency	5.27
5.6	Cost for Environment Management Plan	5.28
6.1	Environmental Monitoring Details	6.5
7.1	Chronological summary of incidents involving LNG ships	7.66
7.2	Risk Matrix and Definition	7.72
7.3	HAZID analysis actions details	7.73
7.4	Degree of Hazards Based on FEI	7.76
7.5	Fire and Explosion Index for Process Units	7.76
7.6	Pasquill – Giffard Atmospheric Stability	7.77
7.7	List of Damages Envisaged at Various Heat Loads	7.77
7.8	Damage Criteria for Pressure Waves	7.78
7.9	Consequence Analysis for Jet Fire Scenario	7.79
7.10	Consequence Analysis for flash fire	7.81

Table No.	Particulars	Page No.
7.11	Consequence Analysis for Late Pool Fire Scenario	7.83
7.12	Consequence Analysis for UVCE Scenario	7.84
7.13	Failure Frequencies for various Equipments[4]	7.86
7.14	Land use and Industrial Risk According to MIACC	7.86
7.14A	Summary of Recommended Personal Protective Equipment According to Hazard	7.87
7.15	Responsibilities during Flood	7.88
7.16	Responsibilities during Eathquake	7.89
7.17	Responsibilities during cyclone	7.90
7.18	Frequency of drills	7.91

List of Plates

Plates No.	Particulars	Page No.
3.3.1	False Colour Composite of 15 km Radius around Project Site	3.53
3.3.2	Landuse/Landcover Classified Image - 15 km Radius	3.54
3.3.3	False Colour Composite of 10 km Radius around Project Site	3.55
3.3.4	Landuse/Landcover Classified Image - 10 km Radius	3.56
3.8.1	Socioeconomic Survey at Komaragiri Grampanchayat	3.148
3.8.2	Socioeconomic Survey at Kovvada village	3.148
3.8.3	Survey with local people in Suryaraopeta (CT)	3.149
3.8.4	Survey with Grampanchayat member in Sarpavaram village	3.149
3.8.5	Grampanchayat building in Komaragiri village	3.150
3.8.6	Grampanchayat building in Vakalpudi village	3.150
3.8.7	Education facility in Suryaraopeta (CT) village in the study area	3.151
3.8.8	Free education facility for slum children in the study area	3.151
3.8.9	Women drying fish at Suryaraopeta village in the study area	3.152
3.8.10	Primary health centre in Panduru village in the study area	3.152

List of Annexures

Annexure	Particulars
I	National Ambient Air Quality Standards - 2009
II	The Noise Pollution (Regulation and Control) Rules, 2000
III	International IMO Marine Engine Standards

Executive Summary

1.0 Introduction

Andhra Pradesh Gas Distribution Corporation Limited (APGDC) is a Joint Venture Company of Andhra Pradesh Gas Infrastructure Corporation Pvt. Ltd (APGIC),[a wholly owned company of APGENCO & APIIC] and GAIL Gas Limited, [a wholly owned subsidiary of GAIL (India) Limited, a Public Sector Undertaking under the Ministry of Petroleum & Natural Gas, Govt. of India]. The Government of AP has mandated APGDC for setting up an FSRU based LNG terminal at an existing port in Andhra Pradesh.

APGDC together with GDF SUEZ UK LNG Ltd as technical partner propose to develop a Floating Storage and Re-gasification Unit (FSRU) based LNG import terminal at Kakinada Deep Water Port. Based on a Feasibility study, a near shore island jetty & FSRU based LNG terminal has been found to be suitable to meet the immediate requirement of natural gas demand in the state at the earliest possible time, with an optimum Capital Expenditure (CAPEX) and with appropriate safety aspects. Capacity of the project has been planned as 3.5 MTPA (Million Tons per Annum) with necessary operational flexibility up to maximum of 5.25 MTPA. Nominal gas supply from the project shall be 14 MMSCMD, with maximum capacity up to 21 MMSCMD.

1.1 Classification of the Project as per EIA Notification

As per the Environmental Impact Assessment (EIA) Notification of September 2006, the proposed FSRU based LNG Terminal falls under 'Category-A' and project activity scheduled as '7(e)'. The Ministry of Environment & Forests (MoEF) has issued Terms of References (TORs) for undertaking a detailed EIA study vide letter no.11-70/2012-IA.III dated 6th November, 2012. The present EIA report has been prepared in compliance with the EIA guidelines as well as approved ToRs.

1. 2 CRZ status of the project

The CRZ demarcation study has been carried out by National Institute of Oceanography (NIO), Goa through their- Regional center at Vishakhapatnam for the proposed project site and the vicinity. As per the study results, the proposed project falls in the permissible activities in different CRZ classifications and the proposed onshore receiving facility (ORF) will be located outside CRZ demarcation in CRZ- III category.

1.3 Importance of Project

There is substantial gap in demand and supply of Natural Gas in India in general and within Andhra Pradesh in particular. Existing Gas based power plants having capacities of around 2700 MW are running on very low Plant load factor (around 26%) due to non-availability of gas. In addition, new capacity to the tune of 1000 MW has been added and waiting for commissioning. Further additional capacity of approx. 2800 MW is under installation. The government of India in his policy document "Hydrocarbon vision 2025" outlined India's goal to significantly increase gas usage by 2025. This ambition is mainly an effort to wean the overall Indian economy off its dependence on coal for environmental reasons. Gas-fired power generation currently comprises around 9% of total power production in India, well below world average of 22%.

Apart from above, Natural Gas demand exists from fertilizer, city gas distribution and other industries. As per the industry data available, it is observed that domestic availability and production are inadequate to meet the demand of natural gas in the country in general and Andhra Pradesh in particular. Import is going to be unavoidable to meet the growing demand. An LNG import terminal at Kakinada is planned by a Public sector enterprise with the partnership of Govt. of Andhra Pradesh and shall be having priority to supply natural gas within the State of Andhra Pradesh particularly in the coastal belt. Accordingly, the proposed project would address the need of natural gas in the region and the state in substantial way.

1.4 Advantages of FSRU project over land based LNG terminal

- Reduced project schedule: FSRU based terminal is generally commissioned in 2 years, whereas a land based LNG Terminal typically takes 4-5 years.
- Requirement of land is minimal, limited to a small metering terminal (the ORF)
- FSRU is flexible in terms of capacity expansion
- FSRU is flexible to re-location

Capital Expenditure is considerably less when compared to land based LNG terminal.

2.0 Brief Description of the Project

The proposed LNG terminal consists of marin**e** LNG import facilities (Jetty Platform), an FSRU for storage and regasification within harbor area, a high pressure subsea pipeline to transport re-gasified LNG (RLNG) to coast, and an onshore receiving facility / landfall station for metering and supply to consumers.

The KDWP location (16°58.37' N, 82°17.06' E) for the LNG import facilities has been chosen to benefit from the protection of the existing breakwater. Floating Storage and Regasification Unit (FSRU) will be berthed at a jetty on the lee side of breakwater, LNG will be unloaded to, stored on, regasified on and in RLNG form offloaded from the FSRU.

2.1 Project Location

Different alternative locations of existing ports, namely Vishakhapatnam, Gangavaram and Kakinada have been evaluated for the proposed project and Kakinada has been chosen, in view of tranquility conditions on the lee side of the existing break water for positioning the FSRU for year round operation, low traffic at present, availability of Government land and proximity to existing natural gas distribution networks and consumers. The proposed project will be developed within the limits of Kakinada Deepwater Port, which is presently being operated by M/s Kakinada Seaports Limited as concessionaire. The approximate coordinates of the proposed project facilities are:

Marine Facility	:	$16^0$58'35"N, $82^0$18'00"E $16^0$58'53"N, $82^0$17'42"E $16^0$59'12"N, $82^0$18'12"E $16^0$58'53"N, $82^0$18'23"E
ORF	:	$17^0$0'34.605"N, $82^0$17'3.720"E $17^0$0'32.121"N, $82^0$17'2.913"E $17^0$0'31.094"N, $82^0$17'6.867"E $17^0$0'33.415"N, $82^0$17'7.674"E

Brief details of the project location are as follow:

- Village : Kakinada
- Mandal : Kakinada
- District : East Godavari
- State : Andhra Pradesh
- Nearest railway station : Kakinada Port / Kakinada Town
- Nearest airport : Rajahmundry (Approx. 65 Km)
- Nearest city : Kakinada (Population – 0.312 million)
- The land requirement for the proposed LNG terminal is estimated about 2.64 Ha. for the ORF only. The location is within Kakinada port limit. Identified land is owned by Revenue Dept., Government of Andhra Pradesh and at present vacant with sparse casuarina plantation. The ground elevation at the site is 1-2 m above mean sea level.

The topographical features of the onshore study area within 10 km and 15 Km radial stretch around the proposed LNG Terminal are shown in Figure-1. It consists of coastal flat terrain, Kakinada town, industrial area, sea port activities etc. The land cover is mainly agriculture fields. Coastal activities are mainly fisheries including aquaculture ponds; salt ponds etc. Coringa sanctuary & Hope island as well as Uppada (identified as high erosion coastline) are also falling within this area.

2.2 Summary of Project Designs / Details:

LNG Terminal Details	
• Location	Kakinada Deep water port, Kakinada (AP)
• Design capacity (Max)	5.25 mtpa (million tonne per annum)
• Peak send out	21 mmscmd (750 MMSCFD)
• Operating Pressure	80-120 bar (g)
• Operating Temperature	0 - 50^{o} C
FSRU	
• LNG Storage Capacity	215,000 m^3 (Max)
• Regas technology	Open Loop / close Loop (as per availability of FSRU)
• HP Gas sendout Temperature	0-50^{o}C
• Spare philosophy	O + S for critical equipment
• Flaring	Zero Flaring
• Staff/crew composition	Operation phase – 32 persons on board FSRU
ISLAND JETTY AND LNG FACILITY	
• Location	16058'35"N, 82018'00"E 16058'53"N, 82017'42"E 16059'12"N, 82018'12"E 16058'53"N, 82018'23"E
• Marine area	35.4 Ha (approx.)
• Jetty Dimension	110 m x 70 m
• Jetty height	11.4 m from CD (initial studies)
• LNG unloading arm	2+1 (on each side- FSRU & LNGC sides)
• Vapour arm	1 (on each side- FSRU & LNGC sides)
• HP arm	1 (on each side- FSRU & LNGC sides)
• Power Requirement	290 KW
• Navigation Exclusion Zone	375 m
• Maritime Exclusion Zone (MEZ)	500 m

• Staff	Operation phase: 3 (2 operation+1 maintenance) in 24hrs shift
SUBSEA PIPELINE	
• Diameter	24”
• Operating pressure	120 bar (Max)
• Pipeline Length (Jetty to ORF)	4.2 Km(approx.)
CONNECTIVITY TO EXISTING GAS GRID	
• Pipe Diameter	24”
• Operating Pressure	50-90 bar
• Pipeline length	1.1 Km (approx.)
ONSHORE RECEIPT FACILITY (ORF)	
• ORF location	17°0'34.605"N,82°17'3.720"E 17°0'32.121"N,82°17'2.913"E 17°0'31.094"N,82°17'6.867"E 17°0'33.415"N,82°17'7.674"E
• Plot Dimensions	185 m x 142.5 m (2.64 Hectare)
• Present Land Status	Presently with Revenue Department. Already applied for allocation of identified land.
• Gas Handling Capacity	21 mmscmd
• Power Requirement	290 KW (grid power)
• Fire water tank	2000 m^3 storage capacity
• Staff	Operation phase – 8 (5 day shift and 3 night shift
DREDGING	
• Navigation channel width	250m (existing channel width 160 mts)
• Turning basin diameter	700m
• Depth (Navigation channel , Turning basin and berthing area)	14.5 m below CD
• Capital Dredging	Very soft clay : 9.6 million m^3 (approx.) Stiff clay : 4.2 million m^3 (approx.)
• Maintenance Dredging	FSRU basin : 0.9 m^3 (approx.)

Resource requirement	
• Cooling Water	At maximum operation: 370000 KLD sea water as heating medium for LNG vaporization and for machinery cooling (open loop mode)
• Potable water	20 KLD (to be generated on-board FSRU)
• Power	600 KW (for ORF and Jetty) to be taken from Grid Power. Backup power by DF Generator. FSRU will be self-sustained for power.
• Construction Material : concrete	ORF – approx. 1000 m^3 Jetty - approx. 7000 M^3
steel	ORF – approx. 250 MT Jetty - approx. 17000 MT
OTHER	
• Visiting LNG carrier Ships	138,000m^3 to 215,000m^3 (Q-Flex)
PROJECT COST AND SCHEDULE	
• Estimated Capital expenditure	Rs. 1571 crore
• Project Schedule	15 months from the date of financial closure (which will be after receipt of Environment Clearance)

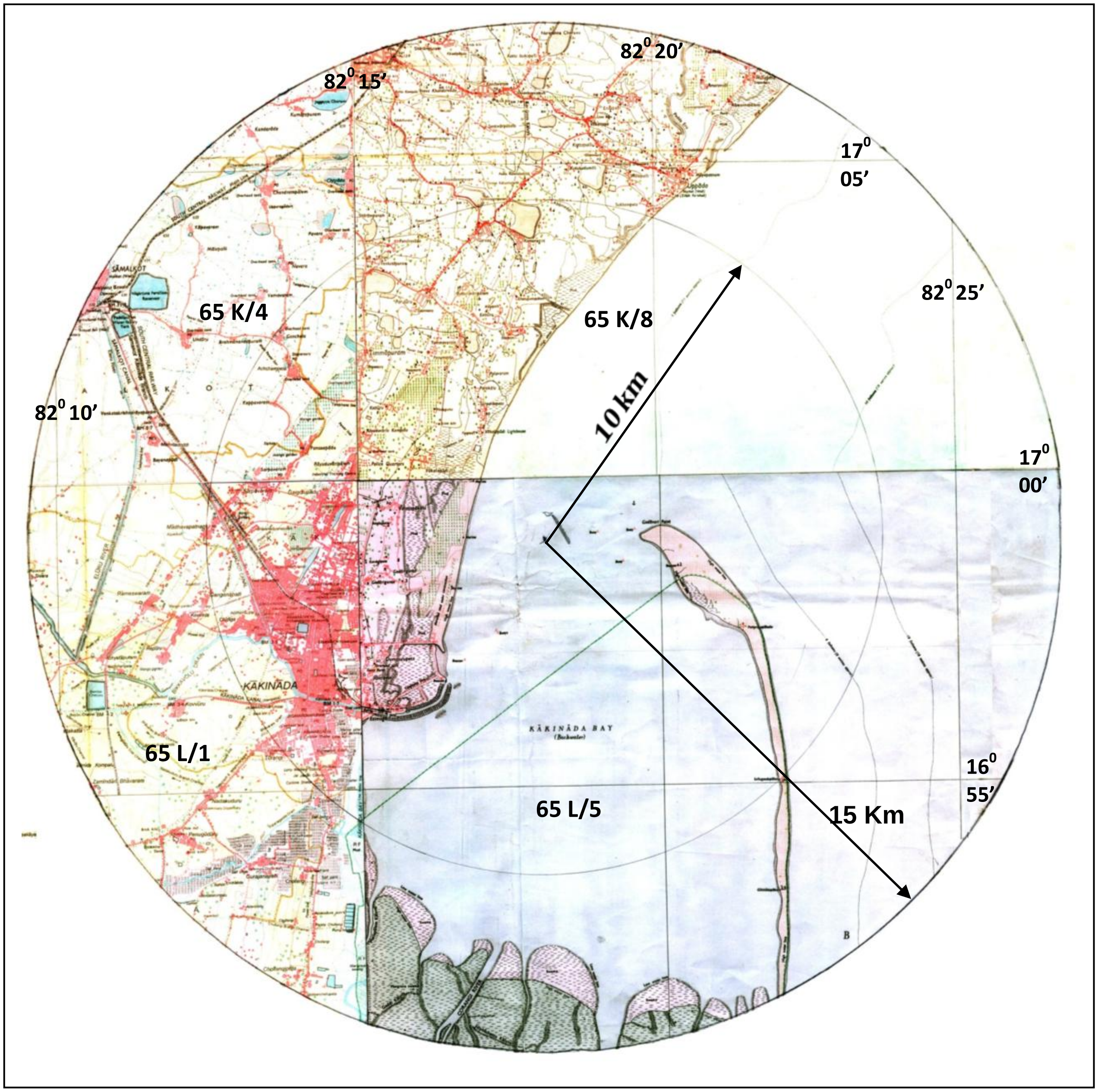


Figure-1: Study Area around Proposed LNG terminal, Kakinada

3.0 Description of Environment

As per EIA notification 10-km radius study area around the project site has been considered for primary data collection through field studies and 15 km radial distance for secondary data compilation.

The proposed project corresponds to development in the coastal area consisting seafront activities (LNG jetty, Floating storage Regasification Unit, Subsea pipeline) as well as land based Onshore Receiving Facilities (ORF). The 10 km radial study area consists of Kakinada town (populated built up area) , existing sea port, various industries viz. NFCL, Corromondal fertilizer etc. and Hope Island (natural sand spit) offshore in the east of the project site. 15 km radial distance consists of Coringa Sanctuary (dense mangrove forest) notified by A.P. state Govt.

Existing environment quality status with respect to land, water, marine, biology, air quality, noise levels and socio-economic components are nominated within 10 km radial distance. The baseline data has been collected during October-December 2012. Two season data has been compiled from the recent past EIA study reports in the project area, for KSPL and NFCL.

3.1 Land Environment

3.1.1 Land Use

A land use and land cover study has been carried out for a 15 km radius (706.5 sq. km.)around the proposed FSRU site using satellite imagery (IRS P6 LISS III) of 4 April 2012 procured from the National Remote Sensing Data Centre, Hyderabad and Survey of India toposheets

From the satellite imagery it could be found that almost half (47.33%) of the study area is covered by sea, vegetation / mangroves: 6.53%, Agricultural land: 35.99 %, built – up: 5.81%, sand cover: 1.25 % and balance 3.09 % correspond to water bodies/ river/ waste land.

In the study area land-use is marked by intensive agricultural use with a majority of double cropping. There are coconut groves as well as double cropped paddy fields in coastal villages. Coast line areas have a mix of existing mangroves, aquaculture ponds and saltpans.

3.1.2 Soil Quality

Soil samples were collected at 9 locations within the study area. Predominant soil texture observed is loamy sand followed by sandy loam and sandy clay. At all locations, the soil falls in fertile category as per observed organic carbon content in the soil. The heavy metals are monitored in the soil samples. The results indicate Hexavalent chromium, Mercury, cadmium, arsenic and nickel were below respective detectable limits. The other metals like Zinc, Iron, Copper etc. were found as in conventional soil samples. The available Nitrogen levels were observed in range of 62 – 289 Kg/Ha; Potassium: 29.92 - 293.9 Kg/Ha; Phosphorous: 11.65 – 85.49 Kg/Ha.

3.2 Onshore Water Environment

The sampling locations are selected keeping in view the existing activities in the study area. The water environment in the surrounding villages has been studied through surface water quality assessment (2 locations) and groundwater quality assessment (13 locations) to represent the existing (pre-project) status of water quality within the study area. The ground water samples are collected from dug / open wells as well as tube wells / hand pumps.

3.2.1 Surface water

Surface water quality (2 locations) observed during the study period is presented in following table:

Parameter	Units	Observed levels
pH	-	6.6 - 7.4
Conductivity	µS/cm	340 - 370
TDS	mg/l	240 – 280
Fluoride	mg/l	1.01 – 1.14
Sodium	Mg/l	3.9 – 4.0
Nitrate	mg/l	1.0 – 2.0

All water samples were analyzed for 12 heavy metals including Cr, Hg, Cd, Co, As etc.

The results indicate that all metals were below detection limits except Fe and Mn which were observed as Fe: BDL – 1.03mg /l and Mn: BDL - 0.49 mg/l.

3.2.2 Ground Water

Ground water samples were collected from 13 locations (10 borewells + 3 dug wells). The ground water quality status observed during the study period (December 2012) is presented in the following table:

Parameter	Units	Observed levels
pH	-	6.8 - 8.1
Conductivity	µS/cm	790 – 3000
TDS	mg/l	652 – 2010
Chloride	mg/l	78 – 476
Sodium	mg/l	54 - 508
Nitrate	mg/l	0.53 – 7.18
Fluoride	mg/l	BDL – 1.2

Pre-project water quality status in the project region indicate no pollution stresses on water resources except the natural phenomenon of high TDS in ground water samples (coastal phenomena).

3.3 Marine Environment

The coastal marine studies have been carried out with respect to hydrography (bathymetry, tides and currents), marine water quality and seabed sediment characteristics at and around the proposed marine facilities as well as dredge material dumping area. Tidal variation during the study period (February 2013): the maximum tidal range has been recorded at neap tide: 0.39 m CD and spring tide of 1.5 m CD near Vakalpudi (project area). The currents within the harbor area were recorded between 0.2 knots to 0.5 knots. While currents near dredge material dumping area were recorded in the range: 0.3 knots to 0.7 knots. The marine water as well as sediment samples were collected at 24 locations.

3.3.1 Marine Water Quality

The observed marine water quality during study period is given in the following tables:

Parameter	Units	Observed levels
pH	-	7.3 - 8.2
Temperature	^{o} C	25.0 - 28.0
D.O.	mg/l	6.2 – 7.7
Turbidity	NTU	0.5 – 8.0 (except along coastline surface zone)
Chloride	mg /l	17562 – 20555
Salinity	‰	32 – 37
B.O.D.	mg/l	< 3
Oil & Grease	mg/l	0.4 – 1.2
Heavy metals :		
Cd	mg/l	BDL – 0.005
Cr	mg/l	BDL – 0.009
Ni	mg/l	BDL – 0.009
Pb	mg/l	BDL – 0.081

3.3.2 Sediment Characteristics

The seabed sediment characteristics observed during study period are as follow:

- The silt (0.002 – 0.02 mm) and clay (<0.002 mm) content is predominant (about 60% in harbor / bay area, while the sand (>0.02 – 2.0 mm) content is predominant (>60%) in dredge material dumping area
- Total organic carbon (TOC) in sediment samples vary from 0.01% in deeper area (>15m depth) to 1.92% towards coastline
- Heavy metals Cd : 0.07 – 0.18 mg/100 g; Ni: 1.3 – 5.04 mg/100 g; Cr : 1.2 – 5.8 mg/100 g ; Co: 1.78 – 3.68 mg/100 g

3.4 Biological Environment

- Marine Fisheries is one of the major professions in coastal villages of the project region. The commercial fishing is permitted outside the port limits. Kakinada has full-fledged fishing harbor. Fishermen in this region use country boats as well as mechanized boats. As per the district statistics, during 2008 -2010, the marine fish and shrimp catch has been recorded at about 52000 tons per annum. The

Elasmobraches, Mackerels, Catfish and Clupinoids are predominant in fish catches while the peniled prawns are major components.

3.4.1 Coastal Ecology

- The Coringa Sanctuary (dense mangrove forest) is beyond the 10 kilometer radial distance and is within 15 km radial distance in south direction.
- The Hope Island (natural sand spit) on the eastern side of the bay consists of extended mangrove reserve forest at about 4 km distance from the proposed jetty location.
- As per MOEF Office Memorandum dated 03.11.2009, Uppada is one of the high erosion coastal locations, which is about 11 km distance on north side from the project location.

3.4.2 Inland Ecology

The terrestrial (Inland) / Onshore study area does not consist of human habitat except the Coringa and Hope Island as mentioned above.

The major Khariff crops in this region are paddy, red gram, Jowar, sugarcane whereas paddy, maize, tobacco, black gram, green gram, mango are the Rabi crops. The horticulture / crop: Coconut

The most dominant trees in this region are *Bomax ceiba, Artocarpus chaplasa, Albizzia process, Azadirachta indica, Magnifera indica, Tamarindus indica, Caesealpinia spries, Achrus sapote* etc.

3.5 Air Environment

3.5.1 Micrometeorology

The micrometeorological data at project site were recorded during study period using battery operated weather station. Data was recorded every hour continuously from October 2012 to December 2012. The windrose corresponding to study period shows that predominant winds are from NE, E and NNW directions with 2.04%ncalm conditions. Accordingly the impact zone will be spread in W-SW-SSE sector in the season. The hourly meteorological data corresponding to project area (Kakinada) obtained, remote sensing weather satellite was procured for the period of January-December 2012 and analyzed for seasonal variations.

As per climatological and oceanic data records by IMD, there were 33 storms and 50 depressions in Bay of Bengal which have hit the coast near Kakinada port during 1971 - 2011.

3.5.2 Air Quality Baseline Status

The pre-project ambient air quality was monitored at 9 locations within 10 Km radial study area during October-December 2012. The summary of observed air quality levels during the study period is presented in following table:

Ambient Air Quality Status

Parameter	Observed Range ($\mu g/m^3$) Post monsoon season	Observed Range ($\mu g/m^3$) Winter season
RPM/PM_{10} (24 Hrs.)	10-58	30 - 94
$PM_{2.5}$ (24 Hrs.)	7-37	15 - 31
SO_2 (24 Hrs.)	2-14	5 - 13
NO_x (24 Hrs.)	5-20	7 - 16
O_3 (3 Hrs.)	10-31	12 - 35
MHC (spot / grab samples)	0.62 – 1.08 ppm	–
NMHC (spot / grab samples)	0.01 – 0.06 ppm	–

Ambient air quality status in the project area during study period complies with prescribed NAAQS-2009.

3.6 Noise Environment

Ambient noise levels were monitored during the day time as well as night time at 19 locations covering residential, commercial and industrial activities and villages in study area. The equivalent noise levels (Leq) recorded at all locations during study period are summarized as follows:

	Day Time Leq (dB(A))	Night Time Leq (dB(A))
Residential	42.1 - 53.4	40.1 - 43.8
Commercial	56.4 - 62.1 (Vehicular Traffic)	43.2 - 51.7
Industrial	50.8 - 71.9	56.7 - 67.5

The noise levels at all locations found to be within the standards prescribed by CPCB (11th April 1994). The commercial areas in Kakinada town and industrial area have been found relatively noisy due to vehicular movement and urban/commercial activities.

3.7 Socio-Economic Environment

- The east Godavari district has population density of 477 persons/ sq. km (as per the Provisional Census details of India information for 2011).
- The study area (10 Km radius) consists of 18 villages / wards of Kakinada Town.
- Schedule caste population – 12.1% while Schedule Tribe Population – 0.6%.
- Kakinada urban agglomeration total population is 4,42,936 (provisional data Census 2011) with the sex ratio 1044 female / 1000 male. The decadal population growth rate in this area fall in 10-20% growth category.
- The literacy in the study area is about 74% (2011)
- Fisheries and agriculture are major occupations in coastal / rural areas
- The State Government revenue land (at present vacant) about 2.64 hectare within port limits will be used for proposed ORF/ Landfall station.

4.0 Anticipated Environment Impacts and Mitigation Measures

Any major developmental project is expected to have interference with the surrounding environment and cause some environmental impacts which may be inevitable. Keeping in view environmental sustainable practice, such impacts arising out of the project are identified in advance and predict the consequences for incorporating necessary preventive / mitigatory (precautionary) measures during design, implementation and operation phases. Accordingly, the impacts due to construction and operation of proposed project at the identified location are predicted and necessary mitigation measures are delineated to minimize adverse impacts on individual environmental components.

Different mathematical models relevant to coastal marine environment, air and noise components are used in this study to predict the impacts from proposed project activities based on the available design data.

As per the details given in the project description, the major component correspond to development of marine facilities (jetty platform for FSRU and LNGC, turning circle and berth pockets) within harbour area covering 35.4 Ha and on land activities would be limited to 2.64 ha for ORF. There will be no private land acquisition for the proposed project.

The proposed project will deal with cleaner fuel, i.e. LNG/RLNG with no sulfur and ash contents.

4.1 Impacts during construction phase

The construction of marine facilities includes, Capital Dredging, (estimated as 13.8 million m^3), dredge material disposal at designated dumping area (offshore), construction of island jetty with berthing / mooring, navigation related facilities and laying of subsea gas pipeline (buried in sea bed) from jetty to landfall point.

- The proposed widening of entry channel would be on the north side of existing channel, away from Hope Island, hence the impact on the Hope Island will be negligible. The existing sand trap would also prevent any adverse impact on the Hope Island.
- The dredge material disposal at designated dumping area at the estimated rate of 50,000 m^3/day, shall not have any significant impact due to existing high wave/tidal currents and sufficient dilution factor at designated offshore dumping area.
- The dredging to be carried out using suction type dredgers to minimize the turbidity impact at dredging location. There will be no drilling or blasting required as per geotechnical details at proposed dredging area.
- All relevant / necessary conditions will be included in the EPC contract to comply prescribed environmental regulatory standards during construction phase. All construction equipment / machinery operated at site shall comply with prescribed environmental standards such as emissions, noise, waste management etc.

- Construction phase impacts envisaged from dust generation during construction works of ORF / landfall station, transportation of construction material by road (through vehicular emissions). No external / borrowed material is envisaged for leveling ORF site.
- The fugitive emissions generated due to vehicular movement are not expected to travel beyond 200 -300 m distance. Since there is no habitation or ecologically sensitive areas in the immediately vicinity of project site, the impact of air environment during the construction phase is not expected to be significant.

Mitigation Measures

- All dredged material will be disposed in offshore designated dumping area causing no impact on land.
- Dust suppression during site grading construction of ORF / landfall station
- Monitor the marine construction barges / vessels movement and maintain no interference with the movement of fishing boats / trawlers
- Greenbelt plantation along approach roads and on the boundary of project site
- Use of cleaner (Euro-II/IV quality) fuels and meeting relevant emission standards (Bharat II/IV)

Occupational Health Aspects

- Maintenance of occupational health & safety standards at workplace along with marine safety and PPEs
- Adequate quantity of potable water shall be provided to the workers through contractors
- Adequate number of community toilets with arrangements of sewage disposal in septic tanks shall be provided for the use of entire migratory labor force
- Medical facilities need to be provided in association with local hospitals and health centers including immunization for children
- To ensure that all the workers are paid at least minimum wages as per government norms so that their sustenance requirements can be taken care of

4.2 Impacts during Operation Phase

The floating Storage and Regasification Unit (FSRU), will be the main processing unit operating on a continuous basis at the project. The FSRU shall be berthed / located offshore, but well within port harbor area on lee side of existing breakwater. The LNG regasification process at the FSRU will be through open loop system, i.e. using sea water, estimated around 15700 m^3/h (377,000 KLD), which after regasification, to be discharged back to sea at lower temperature (cooler than ambient sea water) / close Loop (as per availability of FSRU in the market). The temperature difference of maximum 7^0C will be maintained. As per the modeling study, estimated discharge shall have negligible impact on marine ecology due to fast dissipation (heat transfer) with the existing currents and dynamics within harbor area. The heat from the seawater raises the temperature of the LNG until it converts from a liquid to a gaseous state.

4.2.1 Land Environment

- The solid waste generation in operation phase is expected to be in the categories of domestic waste, recyclable and hazardous waste categories.
- The hazardous waste comprising empty barrels, spent oils / lubricants, pipeline, pigging wastes etc. shall be managed as per Hazardous Waste Rules 2008 including latest amendments
- The Recyclable wastes like metallic scraps, used batteries etc. shall be disposed through APPCB / CPCB authorized agencies

Mitigation Measures

- Project proponent should introduce appropriate clauses in the contract so that the entire contractor related activities – onsite and offsite, are done in environment friendly manner

4.2.2 Water Environment

- The potable water requirement for the LNG terminal is estimated to be $20m^3/day$ (approx.).
- Keeping in view the availability of water from existing port allocation and the ability to manufacture potable water onboard the FSRU, there will not be any additional burden on

available water resources in the region.

- The wastewater generated at the FSRU will be treated and managed in accordance with International (IMO-MARPOL) regulations and also to meet Indian Standards.
- The insignificant domestic effluent at ORF is planned to be managed through soak pit / septic tank
- No ground water abstraction or use envisaged at proposed project, hence negligible impact on ground water.

Mitigation Measures

- Water required during construction will be supplied by the existing port operator, M/s KSPL, without affecting the domestic water supply to surrounding dwellings.
- Special care shall be taken during construction works to avoid any spillage of construction debris so as not to pollute the marine environment.

4.2.3 Marine Fisheries

- The proposed marine facilities will be located within port harbor (Non Fishing Zone). However, marginal impact envisaged on movement of fishing boats / trawlers during the movement (temporary) of LNG carrier ships.

4.2.4 Coastal Biology / Ecology

- As per coastal hydrodynamic study carried out by CWPRS, the proposed project does not cause any adverse impact on coastline dynamics up to and beyond Uppada, i.e. MoEF notified area.
- As per the prediction results through modeling studies (marine, atmospheric, noise) the proposed project does not cause any adverse impacts on Coringa Sanctuary ecological sensitive area the mangroves at about 12.5 km distance and extended Coringa forest on Hope Island at 4.0 km distance from project site.
- The land on which the project will be established is at present vacant land with sparse casuarinas plantation. Thus it can be concluded that the proposed project is unlikely to cause any adverse impact on terrestrial ecology

4.2.5 Air Environment

- The impact due to exhaust emissions from FSRU will be insignificant on land as the estimated emissions are very low due to proposed cleaner fuel usage (RLNG). During normal operation the predicted maximum NOx concentrations from proposed project are 8.6 µg/m^3 in post-monsoon, 10.5 µg/m^3 in winter and 14.9 µg/m^3 (24 hrly) in summer season. The post project status, i.e. cumulative / net NOx levels will be well within the prescribed NAAQS.
- The proposed project (operation phase) will not cause any additional road traffic as the total RLNG (gas) will be transported through pipeline from terminal up to consumers.

4.2.6 Noise Environment

- All the LNG unloading regasification equipment including DFDE, GCU, on FSRU as well as Emergency DG sets, cranes etc. on jetty platform, backup generator (Dual Fuel) at ORF shall comply to prescribed Indian Standards of Noise Generation
- The design of the terminal will be such that the noise levels in the operators (major) working area will not exceed 85 dB (A).
- The Noise levels will be well within 75 dB(A) at the perimeter of the LNG terminal facilities.
- As per the prediction results the noise impact from proposed project at nearest habitat will be negligible and well within the prescribed ambient noise standards.

4.2.7 Socio- Economic Environment

- There will be no private land acquirement for the project
- The proposed marine facilities jetties & FSRU will be at more than 1.2 km distance from existing fishing harbor and will not have any interference on ongoing marine fisheries activities
- Although there is possibility of some temporary impact on marine fish population due to increased turbidity during dredging and disposal, (construction period), it will be purely temporary, and will get normalized within few weeks time after commissioning of the

project due to existing relatively high currents in offshore dumping area

- In operation phase, direct employment would be very limited hence there is no scope for additional stress on local communities
- The proposed project will supply cleaner fuel & total supply will be through pipeline, hence no significant additional road traffic is envisaged due to proposed project
- The overall socioeconomic adverse impact would be insignificant

5.0 Environment Management Plan

As described in the previous, section, based on the available design data/details of the proposed project evaluation of significant impact prediction indicate insignificant adverse impacts on marine as well as coastal / onshore/ terrestrial environmental components from proposed project including preliminary mitigation measures. In view of this the project proponent should maintain the environmental loads as estimated/considered in prediction of impacts and may attempt to improve further where ever possible during implementation and operation of proposed project.

To ensure the initial mitigation measures as well as suggested Environmental Management Plan are effective, the required ports-project environmental monitoring is also delineated in this section.

The Environment Management Plan exclusively for the proposed project will be implemented and maintained by project proponent. However, the overall KDWP environmental management will remain with KSPL as operator of the port. Hence the project proponent shall coordinate with the port operator in all EMP aspects and it shall be ensured that the total port operations / activities including proposed project (cumulative impacts) shall comply to prescribed environmental / regulator standards.

5.1 Construction Phase

Following control measure are proposed for the project :

- Water sprinkling in construction area to mitigate fugitive dust impacts;
- Asphalting the main approach road;

- Proper maintenance of vehicles and construction equipment; and
- Tree plantation in the area earmarked for greenbelt development.
- Provision of earplugs and earmuffs to workers.
- Tree plantation (large size species) should be undertaken at the time of preparation of site in the area identified for greenbelt, so that they would grow to considerable size by time of commissioning of the proposed project.
- Avoid additional road traffic (construction material) during local peak hours of vehicular traffic
- The dredge material disposal shall be ensured at only designated offshore dumping area through dispersive diffuser manifold, if possible at specific time intervals of not less than 3 hrs to minimize impacts on local marine ecology

5.2 Operation Phase

Following control measure are proposed for the project:

i. Land Environment

- The solid waste generated during operation phase of the project will be disposed as per the applicable regulations in an identified area.
- General solid waste (packaging, glass, paper, cardboard etc) will be collected and delivered onshore for disposal on a regular basis;
- Adequate number of collection bins will be provided;
- Plastic bottles, glass bottles and plastic bags will be stored in the separate bins and will be sold to recyclers;
- Cardboard sheets will be stored in separate yard and sold as a scrap; and
- All the hazardous waste generated will be handled and managed as per the Hazardous Wastes (Management, Handling & Trans- boundary Movement) Rules, 2008

ii. Water Quality Environment

- Rainwater harvesting structures can't be built in the project area as the ground water table is very shallow.

- No open discharge of sewage or oily wastes in marine waters;
- The FSRU shall be equipped with a centrifugal-type bilge oil/water separator that reduces oil in the discharge to 10 ppm;
- The FSRU to be moored on long term basis within Kakinada Port and intake and discharge of ballast water will be from the same source and thus not transferring alien and potentially invasive marine species;
- Sewage generated on FSRU will be treated at on-board STP and will meet MARPOL/MoEF/ CPCB/ APPCB's effluent standards;
- Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging; and
- Controlled dredging operations during high tidal disturbances.

iii. Biological Environment

The measures required to be undertaken to minimize the impact on the ecology are:

- The felling of trees will be kept at minimum; and
- Greenbelt will be developed around the metering and distribution station boundary. The total greenbelt will amount to about 33% of total project area.
- The plantation schedule will be completed within the construction period of the project. This green belt will be planned as per guidelines issued by CPCB.

iv. Air Environment

The air pollution control measures proposed for the project are described below:

- Providing adequate stack height to all emission sources in conformance to the set norms of CPCB/MoEF;
- The combustion processes (DFDE, GCU on FSRU and water bath heaters / backup generator set at ORF) shall be maintained with optimum air fuel ratio and control NOx emissions to less than 50 ppm.
- Installation of Online Flue Gas Monitors & Emergency Stop Systems;

- Compliance to the emission norms prescribed by MoEF vide No GSR 520 (E) dated 01-July 01, 2003 and GSR 448 (E) dated July 12, 2004 for the DG set capacity up to 800 KW

v. Noise Environment

- Equipment's should be designed to conform to noise levels prescribed by regulatory authorities;
- The major noise generating units will be acoustically enclosed to the extent possible;
- Use of rubber padding underneath high noise and vibration generating machines;
- Regular ambient noise quality monitoring at the project site and around site
- Provision of greenbelt at ORF/metering and distribution station to attenuate the noise impact
- Provision of Personal Protective Equipments (PPE) such as earplugs, earmuffs to the workers working in high noise working area; and

vi. Socio-economic Environment

Fishing activity is prohibited in the navigation channel and as precautionary measure Port's Patrol boats are constantly on the vigil and guides fishing boats from straying into the channel

CSR Activities

As a part of socio-economic development following CSR activities are proposed:

S.No	List of Activities
1	Adoption of one of the neighbor village depending upon the condition for socio-economic development
2	Drinking water provision
3	Educational facilities
4	Health and Awareness Camps
5	Environmental Initiatives (Tree plantation and tree guards in nearby villages
6	Support sports and cultural activities
7	Development of new main/approach road, and proper drainage system in nearby villages

5.3 Environmental Monitoring Programme

Post project environmental monitoring is important in terms of evaluating the performance of pollution control measures implemented at proposed project. The sampling and analysis of the environmental attributes will be as per the guidelines of CPCB / Andhra Pradesh Pollution Control Board. The following attributes will be covered during the operational phase environmental monitoring in and around the project site:

- The environmental quality-monitoring program will be carried out in the impact zone (marine as well as onshore) with suitable sampling stations and frequency for different environmental components as per requirements.
- All stack emissions (PM_{10}/$PM_{2.5}$, SO_2, NOx, CO and HC as applicable) shall be monitored on continuous basis The Project will undertake monitoring of SO_2, NOx, PM_{10}/$PM_{2.5}$, CO and HC for ambient air twice a week at locations identified in consultation with APPCB / KSPL (port operator)
- Temperature monitoring of the cold water discharge shall be done on continuous basis. Marine water quality monitoring shall be as per APPCB / MoEF stipulations. The seabed sediments will be monitored on quarterly basis. In addition, marine ecology will be monitored on quarterly basis;
- Noise levels in the work zone environment and ambient noise levels will be monitored as per statutory requirement;
- All the results will be compiled and thoroughly analyzed to assess the environmental performance of the project
- An Environmental Management Apex Review Committee (EMARC) shall be constituted to review, assess and monitor the progress of Environment Management Plan implementation

Budget provision of INR Rs.6.0 crore has been proposed for Environmental Management Plan and Marine Contingency Response Plan and CSR activities.

6.0 Risk Assessment and Disaster Management Plan

6.1 HAZID

The objectives of the HAZID was to Identify hazards at a system level, including external factors that pose a hazard to the facilities and to examine and identify mitigation measure, taking into consideration the consequences and likelihood of such hazards and existing safeguards considered for the project and to evaluate the marine exclusion/safety zones.

The HAZID was performed based on a structured brain storming session using an appropriate list of guidewords. The facilities were split into small systems ("Nodes") to facilitate brainstorming. The hazards associated with each element were reviewed by the HAZID participants and following nodes were identified for HAZID:

- LNGC
- FSRU
- Jetty
- ORF
- Subsea Pipelines

6.2 Risk Assessment

The potential risk due to accidental release of LNG has been evaluated according to PESO and NFPA 59 A codes. Fire and Explosion indices have been computed to identify the hazards and categorize the units. Maximum Credible Accident (MCA) Analysis has been carried out at 7D atmospheric conditions at various heat radiation levels. The damage distances for fire and explosion scenarios fall within the terminal site. The risk has been quantified in terms of iso-contours and F/N curves for the worst case scenarios. The individual risks and F/N curves are in acceptable zone. Risk mitigation measures have been recommended to tackle any emergency. Disaster Management Plan (DMP) has been delineated incorporating roles and responsibilities of key personnel.

The Risk modeling scenarios considered for the proposed LNG terminal are

- Leakage of pipeline
- Unloading arm failure

6.3 Disaster Management Plan

An effective Disaster Management Plan (DMP) to mitigate the risks involved has been prepared. This plan defines the responsibilities and resources available to respond to the different types of emergencies envisaged. Training exercises will be held to ensure that all personnel are familiar with their responsibilities and that communication links are functioning effectively.

6.4 Emergency Response Plan

The project proponent will develop an Emergency Response Plan with addresses of potential terminal major incidents including LNG / oil spillages, Fire accident, Ship Collision etc. It will also deal with possible environmental incidents on land and possible social impacts. The plan will therefore be developed in construction and co-operation with existing port operator as well as local coast guard authorities and emergency services

7.0 Project Benefits

The proposed LNG Terminal will result in improvement in the social infrastructure in following manner:

- Help in meeting the growing energy requirements of major consumers of natural gas, particularly power plants and other industries such as fertilizer and petrochemicals units and CGD business.
- Generation of employment for unskilled people during construction phase and skilled people during operation phase of the LNG terminal.
- Generation of revenue for the state Government
- Development of the basic amenities viz. roads, transportation, electricity, drinking water, proper sanitation, educational institutions, medical facilities, entertainment
- Overall the project would change living standards of the people and improve the socio-economic conditions of the area.

****

Chapter 1

Introduction

Chapter 1

Introduction

1.0 Preamble

In the recent years natural gas evolved as an essential commodity (natural resource) with its usages in various sectors, such as feed for fertilizer manufacturing, fuel in energy sector (auto fuel, domestic fuel, power generation etc.),feed for petrochemicals etc. In energy sector natural gas has gained popularity as 'Green fuel'/ 'Environment friendly fuel' since it is cleaner (no ash and negligible sulfur contents), compared to other fossil fuels.

The transport of natural gas in bulk quantity to other counties and for long distances is done by converting it into liquid form at-161^{0}C, i.e. liquefied natural gas (LNG), especially for maritime transport by LNG carrier ships (as it occupies 1/600th of the natural gas volume). Special infrastructure facilities termed as "LNG terminals" are required at the coasts (landfall), for handling of import/ export of LNG. The LNG terminals could be developed either as independent projects or as part of already existing sea ports depending on the suitability / convenience.

1.1 Ports & Harbours

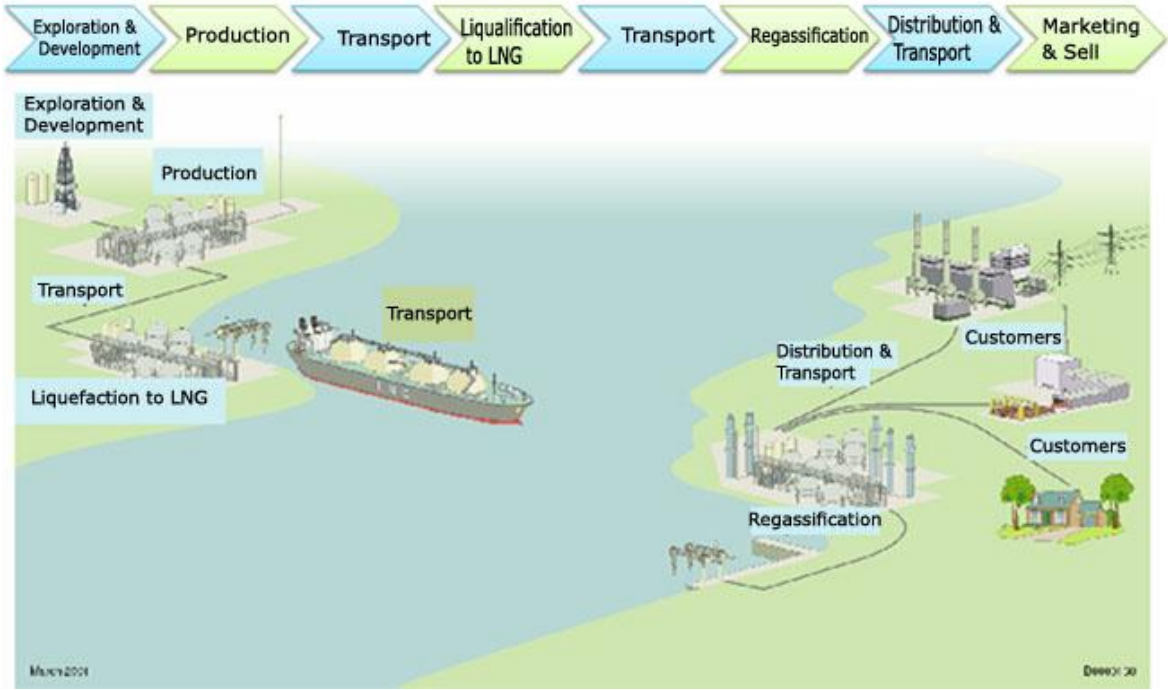
Ports and marine transport facilitate about 80% global trade by volume. So, Sea ports & Harbour activities are crucial part of transport system and also they play an important role in regional and national economic development. Sea ports are the gateways for national and international trade destinations for import and export of a vast range of goods / cargoes. The increase in global trade raises the demand for enhancement / expansions in ports and the shipping sector.

A harbour is a stretch of water where vessels / ships could be anchored, or secured to buoys or alongside wharves to obtain protection (by natural or artificial features) from storms and rough weather. A port is a commercial harbour or commercial part of a harbour with terminals, quays, wharves, enclosed docks, and facilities for transferring cargo from shore to vessel or vice versa. This includes onshore facilities and structures for receiving, handling, holding, consolidating, and loading or delivering waterborne shipments or passengers. Port may include terminals, which serve a single function (e.g. containers, bulk shipments of cement, iron ore, grain) or are operated by a single company. Ports may also provide ship support facilities and services, including waste management and effluent discharge, maintenance of vehicles and equipment, painting and other vessel maintenance.

Similar to any major industrial and resource development sectors, the development and operation of port and harbours including terminals also reflect typical conflict between human action and environment. In view of established influence / interference between port activities and environment, the design development and operation phases of ports / terminals shall duly include environmental protection / conservation measures for making them environmentally sustainable.

1.2 Natural Gas Supply Chain

Natural gas produced from oil &gas fields is liquefied at a liquefaction plant to produce LNG after removing the unwanted / interfering impurities (such as removal of higher hydrocarbons etc). LNG is then shipped through dedicated LNG carriers to the importing location. At the receipt / storage terminal LNG is regasified back through a forced vapourization process. Regasified LNG (RLNG) is then sent out from the terminal through pipelines to the consumers. A typical natural gas supply chain is shown in the following figure:



1.2.1 Liquefied Natural Gas (LNG)

LNG is the liquid form of natural gas containing methane as the main component. in the liquefied form, at atmospheric pressure, LNG occupies only 1/600th of its volume at gaseous state under normal temperature and atmospheric pressure and is therefore more economical to store and transport over long distances in contrast to the traditional pipeline delivery of natural gas.

LNG is produced by cooling natural gas to -161^{0}C (-260^{0}F) through a liquefaction process. Prior to cooling and condensing the natural gas into LNG, the impurities such as carbon dioxide, water, sulphur, mercury etc. are totally removed as they cause potential damage to tank / container walls (material) in long term storage. The end result of this process (liquefaction of natural gas to make LNG) is an odorless, colourless fuel consisting mostly of methane (approximate range 85% to 99%) with small amounts of ethane, propane, butane and pentane.

1.2.2 Benefits of Regasified LNG (RLNG)

- Re-gasified LNG is safe, cost effective and environment friendly as compared to other fuels.

- Re-gasified LNG is clean burning, producing virtually no particulates and less NOx and CO_2than other fossil fuels. Since sulphur is almost entirely removed as part of the liquefaction process, combustion of re-gasified LNG emits negligible or no sulphur dioxide.

- LNG is stored at near atmospheric pressure, reducing the storage hazard compared with pressurized fuels.

- In case of minor spillage LNG will evaporate and disperse quickly, leaving no residue behind and therefore requiring no environmental cleanup (thereby no impact on the environmental is envisaged)

- LNG vaporizes when warmed resulting to natural gas, which is less dense than air and therefore (natural gas) has tendency to move vertically upwards, i.e. away from ground level, in contrary to the denser gases (heavier than air), viz. Ammonia, LPG, chlorine etc. which have tendency to spread at ground level only.

- LNG is non-corrosive and non-toxic.

1.3 Project Proponent

Andhra Pradesh Gas Distribution Corporation Limited (APGDC) has been incorporated on 10.01.2011 under Companies Act 1956.APGDC is a Joint Venture Company between APGIC, an A.P. state govt. public sector enterprise and GAIL Gas Limited (A wholly owned subsidiary of GAIL (India) Ltd.), a central govt. public sector enterprise. The objective of the company is to Design, Develop natural gas supply / distribution network systems, Gas processing through Liquefaction, Re-gasification plants and to import, store, transport, distribute natural gas in the state of Andhra Pradesh.

GAIL (India)Limited, the promoter company of APGDC through GAIL Gas is a Maharatna Central PSU having business interest in supply chain of Natural Gas from exploration, production (as a JV partner with other OIL/Gas Majors) transportation and distribution of Natural Gas and LPG, fractionation of Natural Gas to produce LPG, Propane and other Liquid hydrocarbons. GAIL is operating one of the gas based biggest Petrochemical Complex at Pata in Uttar Pradesh meeting almost 1/4thof the Polyethylene requirement in India. GAIL is also having various Joint Venture Companies to promote City Gas Distribution. GAIL is having equity participation in LNG terminals in India.

GAIL is transmitting 3/4th of the Natural Gas demand in the country through pipeline with more than 50% of market share in Natural Gas business in India. GAIL is operating 8 LPG Recovery plants and producing more than 1 Million Tons of LPG.

M/s GDF SUEZ, a multinational company with its HQ in France, holds 38 MTPA (million tons per annum) of re-gasification capacity worldwide and it is the number two terminal operator in Europe with an overall re-gasification capacity of more than 20 MTPA. GDF SUEZ has over 40 years of operating and maintenance experience of the land based terminals and more recently expanded to floating (FSRU based) terminals. All of the GDF Suez terminals are operating without any significant incident which is due to continued integration of past experience in the new developments. APGDC has selected GDF Suez LNG UK Limited (GDF Suez) as strategic partner to implement the proposed project.

1.4 Proposed Project

M/s APGDC with M/s GDF SUEZ as technical partner, propose to develop a Floating Storage Re-gasification Unit (FSRU) based LNG terminal project. This project will facilitate import of LNG through an FSRU moored at an island jetty, transport RLNG through subsea pipeline to coast and supply to existing gas distribution grid. The proposed project, broadly comprise seawater front / marine facilities within the port, subsea pipeline to transfer RLNG to coast and land based developments as given below:

- Water front / marine facilities:
  - Development of island jetty with necessary facilities / equipment for ship berthing and mooring, LNG unloading and loading arms with all safety measures
  - Creation of necessary facilities (through capital dredging) for the movement of FSRU / LNG carrier ships (entry channel, turning circle, berthing / mooring pockets) to and from proposed jetty with required navigational aids
  - Long term berthing of FSRU (almost permanent) to import, store, regasify LNG and for sending out RLNG

- RLNG Transport
  - Subsea pipeline to transport RLNG to coast / landfall station / ORF
- Landfall Station / Onshore Receipt Facilities (ORF)
  - Control room
  - Pig receiver and Launcher/ filters
  - Gas reheating (depending on requirement)
  - Pressure reduction system
  - Gas metering
  - Pipeline for connectivity to existing gas distribution grid

While the detailed description of proposed project is given in next chapter, the abstract of project details are given in **Table 1.1** including design capacity.

1.4.1 Need of Proposed Project

Indian economy is growing at the rate of around 7-8% in the last few years and poised to grow at the same rate in the years ahead. At this growth rate, the demand of energy is also expected to grow at 6-7%. Already there is a wide gap in supply and demand of energy and it is expected to increase further as mentioned above. Natural Gas is only 8% of the total energy basket of our country at present as compared to world average of 24%. As the use of gas is safe, economical, fuel efficient and environmental friendly, share of natural gas in the energy sector will continue to grow. The government of India in his policy document “Hydrocarbon vision 2025” outlined India’s goal to significantly increase gas usage by 2025. This ambition is mainly an effort to wean the overall Indian economy off its dependence on coal for environmental reasons. Gas fired power generation currently comprises around 9% of total power production in India, well below world average of 22%.

As mentioned above, there is substantial gap in supply and demand of Natural Gas in India and it is higher particularly in Andhra Pradesh. The existing Gas based power plants in A.P. having total around 2700 MW capacity are running on very low plant load factor (PLF around 26%) due to non-availability of gas. In addition, new capacity to the tune of 1000 MW has been added and waiting for commissioning. Further additional capacity of Approx. 2800 MW power plants is under installation in the state. Apart from above natural gas demand exists from fertilizer, city gas distribution and other industries. As per the available industry data, it is found that domestic availability and productions are inadequate to meet the existing demand of natural gas in the country in general and Andhra Pradesh in particular. Import is going to be unavoidable to meet the growing demand. An LNG import terminal at Kakinada is planned by a Public sector enterprise with the partnership of Govt. of Andhra Pradesh and shall be having priority to supply natural gas within the State of Andhra Pradesh particularly in the coastal belt (first of its kind in Eastern coast of AP). Accordingly, the proposed project would address the need of natural gas in the region and the state in substantial way. LNG Import through a new terminal in east coast, will result in overall lower cost to the consumers in Andhra Pradesh compared existing LNG terminals in the west coast, in view of reduced transportation charges and saving the double taxation.

1.4.2 Project Location

The FSRU based LNG terminal is proposed to be develop at the existing Kakinada Deep Water Port (KDWP) within Kakinada bay, East Godavari district in Andhra Pradesh. Kakinada and neighbouring area in East Godavari district is part of Godavari river delta region predominantly covered with agriculture, horticulture with irrigation facilities; marine fisheries as well as coastal aquaculture activities. The surface topography of project region represents flat coastal terrain with (overall) gently sloping towards east, i.e. Bay of Bengal coast. The key map of proposed project location is shown in **Fig.1.1**, of which the details are:

- Village/Town : Kakinada
- Mandal : Kakinada
- District : East Godavari
- State : Andhra Pradesh
- Nearest railway station : Kakinada Port / Kakinada Town
- Nearest airport : Rajahmundry (Approx. 65 Km)
- Nearest city : Kakinada (Population – 0.312 million)

1.4.3 Kakinada Bay - Developments

Kakinada bay on the coast of Andhra Pradesh (Bay of Bengal sea) extends over an area of about 150km^2 (16^{0}51'-17^{0}05'N, 82^{0}15'-82^{0}23'E). Almost 20% of the bay area is covered with mud flats making it shallow in southern part. The southern coast line of the bay is enclosed by dense mangroves (Coringa Sanctuary) as well as Coringa & Gaderu discharges (distributaries of Godavari river – estuary zone). The bay is enclosed on the eastern side by about 15km long sand spit (natural formation), called Hope Island, which protects the Kakinada bay and the coastline on the west and northwest directions, from direct waves attack. The Upputeru flowing through Kakinada town (Kakinada canal) enters the bay from west side in southern part which facilitates Kakinada inner/ Anchorage port operations (old minor sea port), which is managed by Govt. of Andhra Pradesh through Department of Ports. This minor port has been in operation since 1937. The Kakinada Anchorage port handles mainly food grains and fertilizer cargoes.

The central part of Kakinada bay has been developed by Government of Andhra Pradesh in to an all-weather Kakinada Deep (draft) Water Port (16^{0}58.37'N, 82^{0}17.06'E) with assistance from Asian Development Bank and commissioned in 1997.The Kakinada deep water port (KDWP) consists constructed island breakwater, entry channel, general cargo berths etc. to facilitate movement & berthing of about 60,000 DWT (Dead Weight Tonnage) cargo ships. The KDWP was constructed with a quay length of 650m and also developed shallow berths for handling offshore supply vessels (OSV) on the north side of the cargo berths. In line with the National Policy on Ports privatization, Govt. of Andhra Pradesh has given concession to operate KDWP in November 1997. The Kakinada Deep Water Port is presently being operated by M/s Kakinada Sea ports Limited as concessionaire.

A full-fledged fishing harbour is also developed within Kakinada bay on the north side of KDWP and OSV, and on the leeward of constructed breakwater. The overall view of the Kakinada bay with KDWP, the Hope Island, the island breakwater (constructed), the fishing harbour and the Anchorage / inner port are shown in **Fig.1.2.**

1.5 Prior Environmental Clearance Process

The environmental protection is an important and essential requirement in the developmental process. It shall be duly integrated at every stage of proposed major developments to make them environmentally sustainable over the long term. In this direction, the Ministry of Environment and Forests (MoEF), Government of India formulated policies, enacted the Environment (protection) Act in 1986 and stipulated regulatory procedures governing all major developments including ports and harbours sector in the country to prevent and or mitigate the potential environmental & ecological hazards from indiscriminate exploitation of natural resources. The Ministry of Environment & Forests made prior environmental clearance (EC) mandatory for certain scheduled development projects through its first EIA notification dated 27.01.1994 and later it has been superseded by the latest notification dt.14.09.2006, which includes scoping of environmental impact assessment study through ToR approval as essential in the process of prior environmental clearance for scheduled development projects.

As per the Schedule given in MoEF (EIA) notification of 14.09.2006and subsequent amendments, the proposed development of FSRU based LNG terminal, falls in category 'A', project or Activity 7(e). The environmental clearance process for the Category 'A' projects in infrastructure / ports & harbours sector will comprise multiple stages as depicted in the form of flow chart in **Fig.1.3**, which are briefly described below:

i. Scoping

For the category 'A' projects, proponents are required to fill the Form-1 given in the notification and submit to Impact Assessment Authority-MoEF, New-Delhi along with respective pre-feasibility report. The MoEF Expert Appraisal Committee (EAC) will determine the ToR addressing all relevant environmental concerns for conducting EIA study and preparation of report in respect of the identified site as well as proposed project for which prior environmental clearance is sought.

ii. CRZ Clearance

The developments in ports and harbours sector require CRZ clearance apart from prior environmental clearance. As per the CRZ notification (2011), the CRZ demarcation map has to be prepared at the project site and vicinity and submit to respective state/ UT Coastal Zone Management Authority (SCZMA) along with duly filled Form -1 of CRZ notification.

iii. Public Consultation

"Public Consultation" refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project are ascertained with a view to taking into account as appropriate. In general the category 'A' projects are required to undertake Public consultation. After carrying out EIA study, the project proponent shall submit the Draft EIA report to the respective State Pollution iv. Control Board (SPCB) to undertake public consultation process in accordance with EIA notification.

iv. Appraisal

Detailed scrutiny of the Final EIA report, recommendation of SCZMA and outcome of the public consultations including public hearing proceedings, reports of special studies as per approved ToR etc. submitted by the proponents to MoEF (the Regulatory Authority) for grant of EC by MoEF- EAC.

1.5.1 Validity of Environmental Clearance

The "Validity of Environmental Clearance" is meant the period from which a prior environmental clearance is granted by the Regulatory Authority for the proposed project at the site identified. The prior environmental clearance granted for a project shall be valid for a period of five years except for River Valley and mining projects. This period of validity may be extended by the regulatory authority concerned by a maximum period of five years provided an application is made to the regulatory authority by the applicant within the validity period, together with an updated Form-1. In this regard the Regulatory Authority may also consult the Expert Appraisal Committee or State Level Expert Appraisal Committee as the case may be.

In terms of the above, EC for the proposed project shall be 5 years from the date of issue of EC.

1.5.2 Transferability of Environmental Clearance

A prior environmental clearance granted for a specific project to an applicant may be transferred during its validity to another legal person entitled to undertake the project or activity on application by the transferor, or by the transferee with a written "no objection" by the Transferor, to, and by the regulatory authority concerned, on the same terms and conditions under which the prior environmental clearance was initially granted, and for the same validity period.

The proposed project will be constructed and operated by a Special Purpose Vehicle (SPV). The SPV will be incorporated and owned by APGDC and its technical partner M/s GDF SUEZ LNG UK Limited. In accordance with the above provision, the EC will be transferred to the above mentioned SPV, who will have all the rights and obligations with the regard to compliance of EC.

1.5.3 Post Environmental Clearance Monitoring

After receipt of the prior environmental clearance for a particular project, it shall be mandatory for the project proponent to submit half-yearly compliance reports in respect of the terms and conditions stipulated in prior environmental clearance. All such compliance reports submitted by the project management shall be public Documents.

1.6 Terms of Reference (ToR)

The procedure applicable for category 'A' project has been followed in the f duly filled up Form-1 covering the brief details about proposed project, estimated usage of natural resources, identified project site surrounding environmental sensitivity etc. along with draft ToR for EIA studies (***Appendix-1)*** and submitted to EIA authority at MoEF, Govt. of India for approval of ToR.

In the first stage – scoping, the application with Form-1 was, duly scrutinized on 21st September, 2012 by the MoEF-EAC constituted for infrastructure and miscellaneous projects and CRZ. The MoEF approved additional ToR as given in **Table 1.2**along with point wise compliances. This EIA study report has been prepared in accordance with MoEF guidance manual as well as the approved ToR for proposed project to obtain prior environmental clearance.

1.7 Environmental Impact Assessment

In order to assess the likely impacts arising due to development of proposed FSRU based LNG terminal at Kakinada Deep Water Port (KDWP), M/s APGDC retained CSIR-National Environmental Engineering Research Institute (NEERI), Nagpur to undertake Environmental Impact Assessment study for all environmental components in accordance with MoEF requirements (EIA guidance manual & Approved ToR for EIA study) including marine environment, coordination of CRZ study and Rapid Risk Assessment (RRA) for proposed project.

1.7.1 Objectives & Scope of Work

Carryout environmental impact assessment study for proposed FSRU based LNG terminal at KDWP, Kakinada and preparation of report for obtaining prior environmental clearance from the environmental regulatory agencies. The study has been conducted as per the MoEF notification for Environmental Impact Assessment covering baseline data for marine as well as land based facilities.

The general scope of EIA study for a coastal marine development project includes detailed characterization of the existing status of environment in study area around the proposed project site for various environmental components viz. marine, water, land, air, noise, socio-economic and biological components; identification of significant impacts corresponding to proposed project at the identified site; prediction and evaluation of significant environmental impacts and formulation of detailed Environmental Management Plan (EMP) to mitigate the potential adverse impacts from proposed project along with post-project monitoring programme.

Coordination of CRZ study, i.e. Assessment of proposed terminal site based on latest coastal zone regulation to obtain the required clearance from Coastal Zone Management Authority.

Provide technical assistance in Public Hearing to be conducted for the project as per the EIA Notification 2006 and the compliance to the issues raised by the public and incorporation in the EIA-EMP (Environment Impact Assessment- Environment Management Plan) report and attend the Expert Appraisal Committee meeting at MoEF for Environmental Clearance (EC) and also attend the Expert Appraisal Committee (state level) meeting as per the requirement.

1.7.2 Methodology

i. Collection of primary data for assessment of baseline quality of marine environment including water, sediment and biological components in study area and supported by secondary data from state/local departments as well as previous studies in project region

ii. Collection of prevailing marine hydrography data in and around project site supported by secondary data already collected in project region during post-monsoon season

iii. Assessment of the present status of air, noise, water, land, biological and socio-economic components of environment within 10 km radial distance around the proposed LNG terminal site

iv. Identification of potential impacts on various environmental components due to activities envisaged during construction and operation phases of the proposed marine and land based facilities

v. Prediction of significant impacts on the various environmental components using appropriate mathematical/simulation models

vi. Preparation of environmental impact statement based on the identification, prediction and evaluation of impacts

vii. Delineation of pragmating Environmental Management Plan (EMP) outlining preventive and control strategies for minimising adverse impacts during construction and operation stages of the proposed LNG terminal along with the cost and time-schedule for implementation of EMP

viii. Delineation of Environmental Quality Monitoring Programme during construction phase as well as operation phase (post-project monitoring) to be pursued by the project proponent as per the requirements of statutory authorities

1.8 Structure of Balance part of this report

Chapter 2 deals with project description including analysis of alternatives, process description, project configuration, layout plan, list of relevant international / national standards / codes, details of project site, and surrounding study area covering 10 km radial distance around project site.

Chapter 3 corresponds to Description of Environment. It contains the data on pre-project environmental quality (baseline) status corresponding to different components, viz. water, marine, land, biology, air, noise and socioeconomics within the study area. The data provided in this chapter are primarily collected through field surveys by respective teams for individual components and substantiated by compilation of secondary data from authentic sources.

Chapter 4 covers Impact Assessment due to proposed project on individual components of environment including marine, water, land, biology, air, noise and socio-economic components. This chapter broadly consists of identification of significant impacts due to proposed project at the proposed site, prediction of impacts through mathematical models as per the requirement and an environmental impact statement by integrating the prediction results and the observed baseline status of individual components of environment.

Chapter 5 deals with the proposed environmental management plan to mitigate the potential adverse impacts from proposed project during construction as well as during operational phases. It also includes budgetary allocations for implementation and maintenance of EMP by project proponent

Chapter 6 deals with Environment Monitoring Programme. The chapter covers post-project monitoring details corresponding to land fall station (ORF) as well as the marine facilities i.e. FSRU, Jetty during construction as well as operation phases.

Chapter 7 Rapid Risk Assessment and Disaster Management Plan: This chapter covers analysis of past data about incidences / accidents of LNG ships, hazard identification, maximum credible accident analysis including consequences, an approach to disaster management plan, risk mitigation measures, emergency response plan etc. Additional studies, namely hydrodynamic studies and shoreline changes and CRZ demarcation studies are covered in this chapter.

Chapter 8 deals with project benefits

Chapter 9 deals with disclosure of EIA consultant engaged covering the organization profile, infrastructure facilities, human resources, organization chart, credentials, accreditation etc.

Chapter 10 deals with project summary comprising summary and conclusion

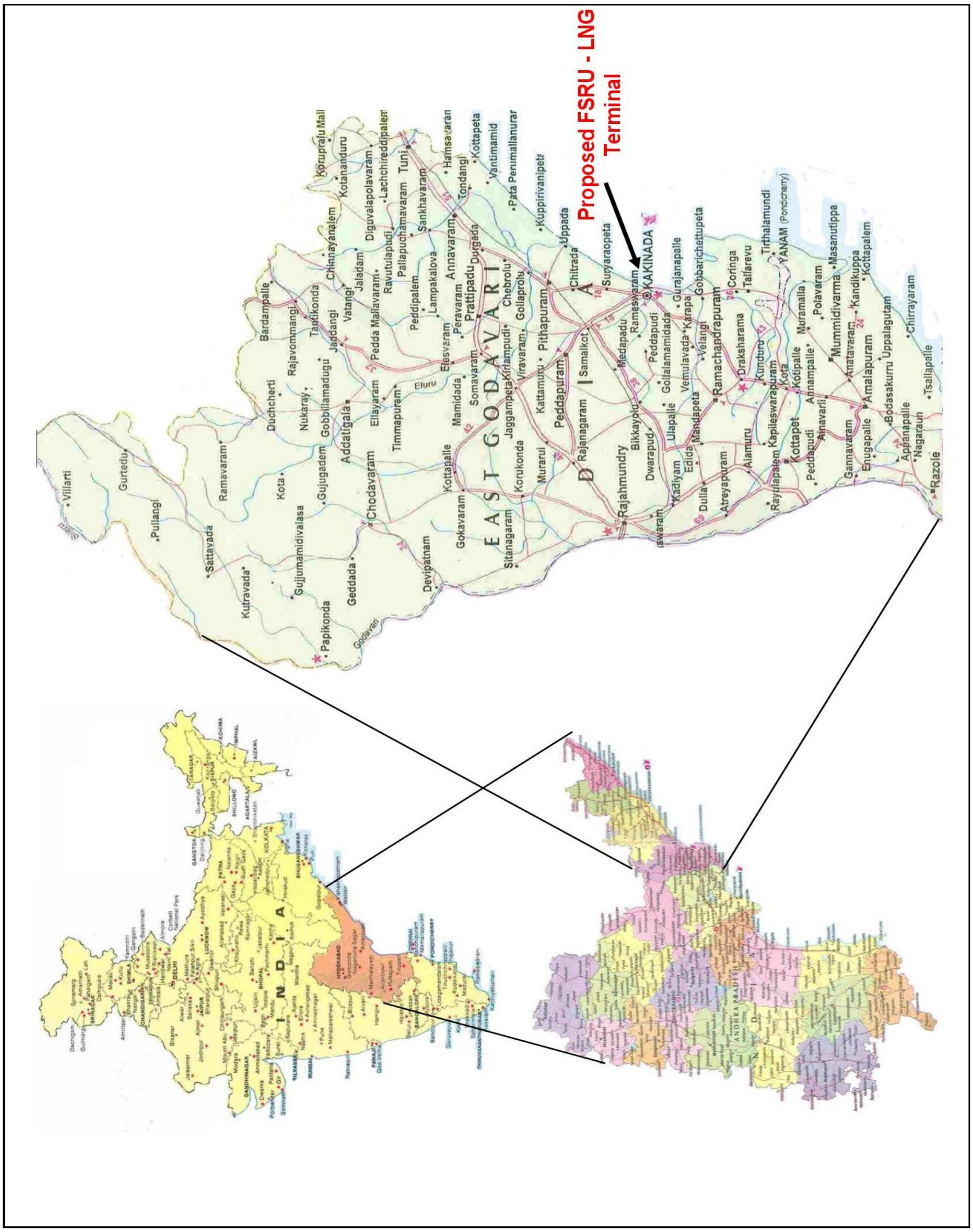


Fig.1.1: Project Location - Key Map

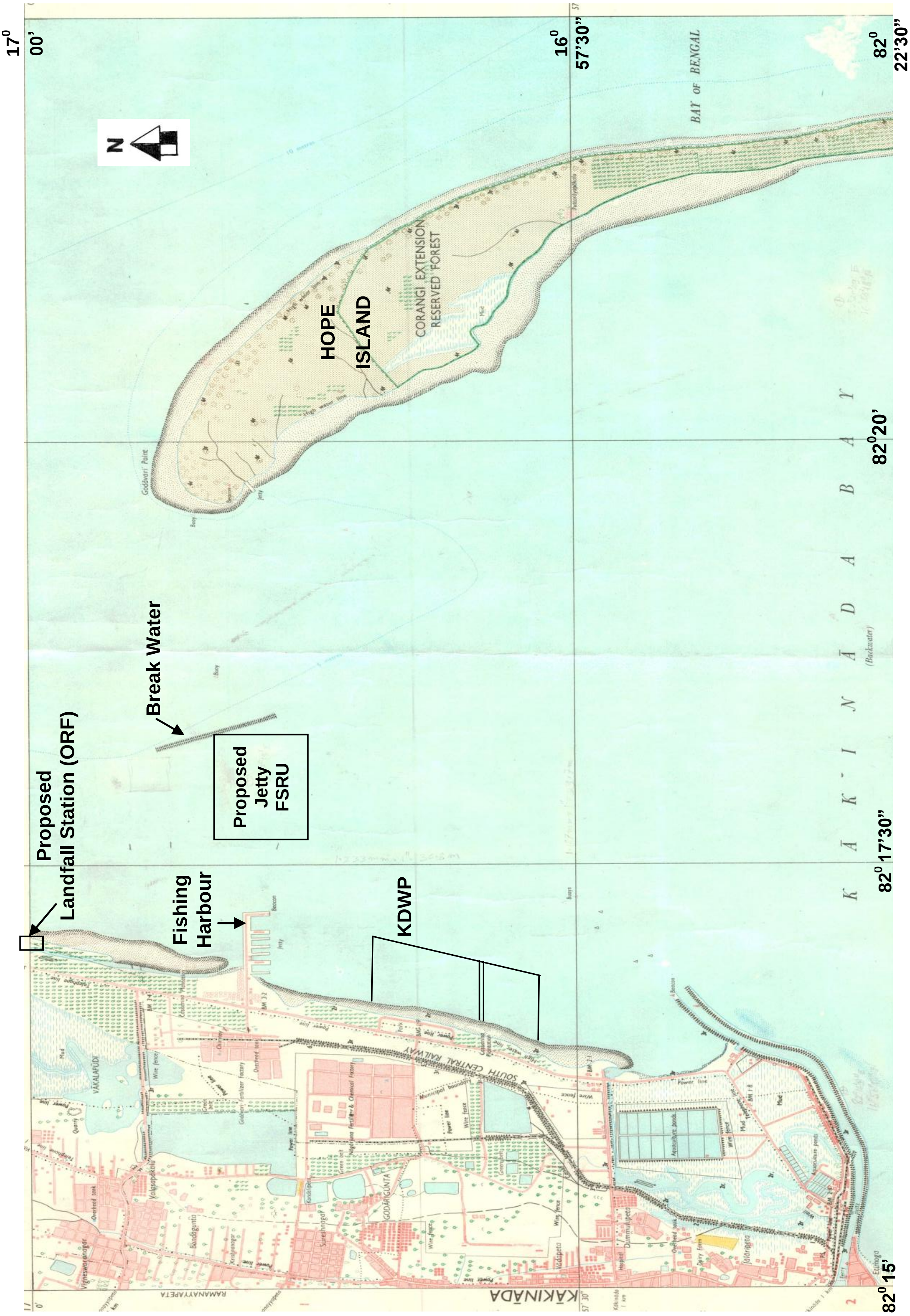


Fig.1.2: Proposed Project Location

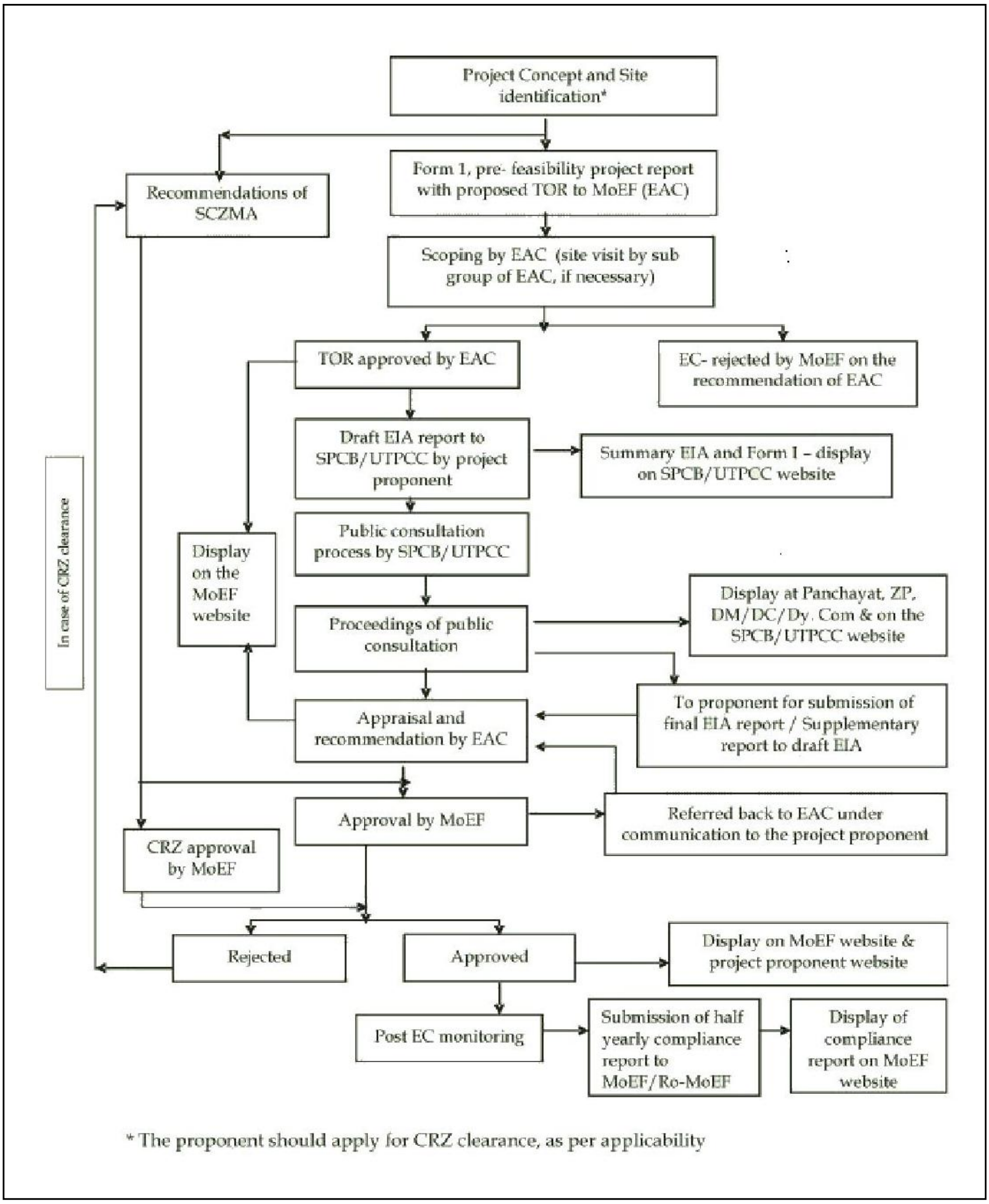


Fig.1.3: EC Process for Category 'A' Projects in Ports & Harbours Sector

Table 1.1: Summary of Project Design / Details

LNG Terminal Details	
• Location	Kakinada Deep water port, Kakinada (AP)
• Design capacity (Max)	5.25 mtpa (million tonne per annum)
• Peak send out	750 mmscfd / 21 mmscmd
• Operating Pressure	80-120 bar (g)
• Operating Temperature	0 to 50^{o} C
FSRU	
• LNG Storage Capacity	138,000m^3 - 215,000 m^3
• Regas technology	Open loop / close loop (as per availability of FSRU)
• HP Gas outlet temperature	0-50^{o}C
• Spare philosophy	O + S for critical equipment
• Flaring	Zero flaring
• Staff/crew composition	Operation phase – 32 persons on board FSRU
ISLAND JETTY AND LNG FACILITY	
• Location	16058'35"N, 82018'00"E 16058'53"N, 82017'42"E 16059'12"N, 82018'12"E 16058'53"N, 82018'23"E
• Marine area	35.4 Ha(approx.)
• Jetty Dimension	110 m x 70 m
• Jetty height	11.4 m from CD (initial studies)
• LNG unloading arm	2+1 (on each side- FSRU & LNGC sides)
• Vapour arm	1 (on each side- FSRU & LNGC sides)
• HP arm	1 (on each side- FSRU & LNGC sides)
• Power Requirement	290 KW
• Navigation Exclusion Zone	375 m
• Maritime Exclusion Zone (MEZ)	500 m
• Staff	Operation phase: 3 (2 operation+1 maintenance) in 24hrs shift
SUBSEA PIPELINE	
• Diameter	24”

• Max operating pressure	120 bar
• Pipeline Length (Jetty to ORF)	4.2 Km(approx.)
CONNECTIVITY TO EXISTING GAS GRID	
• Pipe Diameter	24”
• Operating Pressure	50-90 bar
• Pipeline length	1.1 Km (approx.)
ONSHORE RECEIPT FACILITY (ORF)	
• ORF location	17°0'34.605"N,82°17'3.720"E 17°0'32.121"N,82°17'2.913"E 17°0'31.094"N,82°17'6.867"E 17°0'33.415"N,82°17'7.674"E
• Plot Dimensions	185 m x 142.5 m (2.64 Hectare)
• Present Land Status	Presently with Revenue Department. Already applied for allocation of identified land.
• Gas Handling Capacity	21 mmscmd
• Power Requirement	290 KW (grid power)
• Fire water tank	2000 m^3storage capacity
• Staff	Operation phase – 8 (5 day shift and 3 night shift
DREDGING	
• Navigation channel width	250m (existing channel width 160 mts)
• Turning basin diameter	700m
• Navigation channel , Turning basin and berthing area Depth	14.5 m below CD
• Capital Dredging	Very soft clay : 9.6 million m^3 (approx.) Stiff clay : 4.2 million m^3 (approx.)
• Maintenance Dredging	FSRU basin : 0.9 m^3 (approx.)
Resource requirement	
• Cooling Water	At maximum operation: 370000 KLD sea water as heating medium for LNG vaporization and for machinery cooling (open loop mode)
• Potable water	20 KLD (to be generated on-board FSRU)
• Power	600 KW (for ORF and Jetty) to be taken from Grid Power. FSRU will be self-

	sustained for power.
• Construction Material : concrete	ORF – approx. 1000 m^3 Jetty - approx. 7000 M^3
: steel	ORF – approx. 250 MT Jetty - approx. 17000 MT
OTHER	
• Visiting LNG carrier Ships	138,000m^3 to 215,000m^3 (Q-Flex)
PROJECT COST AND SCHEDULE	
• Estimated Capital expenditure	Rs. 1571 crore
• Project Schedule	15 months from the date of financial closure (which will be after receipt of Environment Clearance)

Table 1.2

MoEF Approved Additional Terms of Reference (ToR) for EIA Study and Compliance

(MoEF 116th Meeting of the Expert Appraisal Committee, Dated 19th–21st September, 2012)

S.No	Approved ToR	Compliances
(i)	Submit MoU made between Port Authority for establishment of the proposed facility.	The proposed FSRU based LNG Terminal is planned within the harbor area of Kakinada Deep Water Port (KDWP), Kakinada, M/s Kakinada Seaports Limited (KSPL) is the present operator of the KDWP through concessionaire agreement executed with AP state Govt. of A.P. KSPL has given the consent for establishing the proposed project and MOU has also been signed between APGDC and KSPL on 13.05.2013.
(ii)	Submit the details of the various applicable regulations including safety regulations along with the proposed compliances. Also details of safety aspects associated with handling of LNG vis a vis other cargo in other facilities within the port.	The objective of proposed project is to import LNG, store and regasify on FSRU in the port harbour area and supply RLNG (design capacity max 5.25 mtpa) to consumers. The cold burns as well as fire hazard are expected in case of major leaks / spills (accidental case) only. The FSRU is nothing but a sea sailable LNG carrier ship (vessel) with LNG regasification facility (additional) provided on the deck. The FSRU will be permanently berthed at proposed jetty platform. In view of above a range of international, Indian / APPCB standards / regulations related to IMO, MARPOL, PESO, OISD,DGS Coastguards Regulations etc are applicable as listed in Chapter 2 (Section 2.3.6, page nos. 2.24-2.28). Project proponent is committed to comply all applicable standards/ regulations with preference to law of the land including port requirement.
(iii)	Submit the details of the Hazop analysis	In the present stage, the design details related to proposed project are available based on pre-FEED feasibility studies. The Rapid Risk Assessment, studies including HAZID, MCA analysis (damage distances, individual risk, F/N curve etc), approach to Disaster Management Plan, risk mitigation measures, oil spillage management plan etc. has been carried out and the study reports are included in Chapter 7 section 7.1, (page nos.7.2 - 7.43). The data required for HAZOP study shall be available on completion of detailed engineering package for the proposed project, which shall be initiated after obtaining prior environmental

		clearance for the project. The HAZOP study will be carried out before implementation of the project and the study report shall be submitted to MOEF as per the requirement.
(iv)	Submit details of Risk Assessment, Disaster Management Plan including emergency evacuation during natural and man-made disaster like floods, cyclone, tsunami and earth quakes etc.	Risk Assessment study has been carried out and the details are given in Chapter 7, Section 7.1 (Page nos. 7.2 – 7.43). Disaster Management Plan has been given in Chapter 7, Section no. 7.1.15 (page nos.7.24 - 7.38). Emergency Response Plan has been given in Chapter 5, Section no. 5.9 (page nos.5.13 – 5.23).
(v)	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA.	Demarcation of HTL/LTL has been carried out and map prepared through M/s National Institute of Oceanography, regional office at Vishakhapatnam.Summary of the study is given Chapter 7, Section 7.3 (page nos. 7.46 – 7.48). Report enclosed as Appendix- IV. The APCZMA directed the project proponent to submit the application for CRZ clearance to MoEF in view of the expiry of present expert committee tenure and till the reconstitution of new committee. Accordingly the duly filled form-1 for CRZ clearance is submitted to MoEF along study with CRZ study and EIA study report.
(vi)	Submit details of storage and regasification, distribution network etc. and vulnerability of human habitation vis a vis LNG associated risks.	The design capacity of the proposed project will be 5.25 million tons per annum (Max.). The proposed FSRU will have the capacity to store 1,78,000m^3 LNG. The FSRU will be berthed permanently at proposed jetty within the port harbor area. The Rapid Risk Assessment study for proposed project is carried out for different facilities including LNG storage and handling operations. The study results including LNG Risk mitigation measures are provided in Chapter 7, Section no.7.1.13 (page 7.12 – 7.23). The marine exclusion zone of 500 m radius will be maintained as shown in Fig. 2.6 in Chapter 2 (page no. 2.43) (layout map). Majority of the potential risk scenarios / MCA analysis / consequence analysis indicate the damage distances contained within marine exclusion zone. The nearest human habitat is at more than 1.5 Km distance from the jetty location, which is at safe distance.
(vii)	Type of LNG carriers proposed	Type of LNG Carriers, along with future growth are

	taking into account the future growth in vessel sizes beyond the present day market trend and the handling aspects of such vessels from environmental considerations.	detailed in the Chapter 2 FSRU / jetty/ LNG
(viii)	Submit the Hydrodynamic study as required under OM dated 3.11.2009.	The detailed Hydrodynamic study has been carried out by M/s CWPRS, Pune as per requirement of OM dated 03.11.2009. The summary of study included in Chapter 7, Section 7.2 (page nos. 7.44-7.45) The study Report enclosed as Appendix-III
(ix)	Submit the details of the reclamation along with the source of materials and its quantity & quality.	At present, no reclamation is envisaged. However, a bund wall has been proposed around the ORF site to protect the ORF facilities from natural disasters like Wave surges, due to Cyclone, Tsunami, earthquake etc.
(x)	Submit the details of shore line changes along with the shore protection if nay required.	Details given in Hydrodynamic study, carried out by M/s CWPRS.The summary of study included in Chapter 7, Section 7.2 (page nos. 7.44-7.45) The study Report enclosed as Appendix-III.
(xi)	Submit details of Environmental Management Plan and Environmental Monitoring Plan with parameters and costs.	Details of Environmental Management Plan given in chapter 5 and Environmental Monitoring Plan given in chapter 6.
(xii)	Submit the details of the fishing activity and likely impact due to the activity.	Details given in Chapter 4, Section 4.2.6 (page nos. 4.12 -4.15).
(xiii)	Details of land breakup along with land use plan and Details of green belt development.	Details given in Chapter 4, Section 4.2.7 (page nos. 4.15).
(xiv)	Details of solid / liquid wastes generation and their management.	Details given in Chapter 4, Section 4.3.3 and 4.3.4 (page nos. 4.25 - 4.26).
(xv)	Water requirement, source, impact on competitive users.	Estimated water requirement:During construction – 60 KLD (to be supplied by port operator / Third party supplier), During operation on FSRU – 20 KLD (Self-production on Board FSRU), ORF < 5 KLD : to be supplied by port operator / Third party supplier Please see Chapter 4 Section 4.2.8 (Page no. 4.16) and Section 4.3.4 (page nos. 4.26).

(xvi)	Submit the details of the eco-sensitive areas, if any.	Coringa Wildlife Sanctuary (Dense Mangrove forest), notified by A P State Govt. is located at 12.5 km distance in south direction from proposed jetty and FSRU site. CorangiExtension Reserve Forest on Hope Island is located at 4 km distance in south east direction from proposed jetty and FSRU site. Please refer Chapter 4Section 4.3.5 (page no. 4.27)
(xvii)	Submit the details of Oil Spill Contingent Management Plan.	Details given in Chapter 5 Section 5.9.1 (page no.5.15 – 5.23).
(xviii)	Submit the details of dredging sludge quantity quality in terms of its toxic metals (at least Cr+6, Arsenic, Mercury, and lead) and its disposal with quantity (reclamation/ dredging disposal site) If disposal is in sea, location, the justification for selecting such location, the dispersal of dumping material, its effect on marine environment, effect of fishes.	The total capital Dredging for proposed project is estimated as 13.8 Million $m^3$and the annual maintenance Dredging is estimated about 1 million m^3 . The characteristics of seabed sediment in Dredging area (Dredge material) quality are given in Chapter 3 Section 3.2.5 (Page nos. 3.13 – 3.15). Details regarding Dredge material disposal, prediction of impact on marine environment are given in Chapter 4, section 4.2.1 – 4.2.6 (page nos. 4.7 – 4.13).
(xix)	The General guidelines as per the annexure-II to this Minutes shall also be considered for preparation of EIA/EMP.	Noted and Complied

Chapter 2

Project Description

Chapter 2

Project Description

2.1 Proposed Project

To meet the natural gas demand primarily in Andhra Pradesh and neighbour states, Andhra Pradesh Gas Distribution Corporation Limited (APGDC), a Joint Venture Company between APGIC, an A.P. state govt. public sector enterprise and GAIL Gas Limited (A wholly owned subsidiary of GAIL (India) Ltd.), a central govt. public sector enterprise, proposes to develop LNG terminal facilities at Kakinada, East Godavari District (A.P) with M/s GDF SUEZ LNG UK Ltd as technical partner. Based on the pre-feasibility study, a near shore island jetty & FSRU based LNG terminal has been found to be suitable to meet the immediate requirement of natural gas demand in the state at the earliest possible time, with an optimum Capital Expenditure (CAPEX) and with appropriate safety aspects.

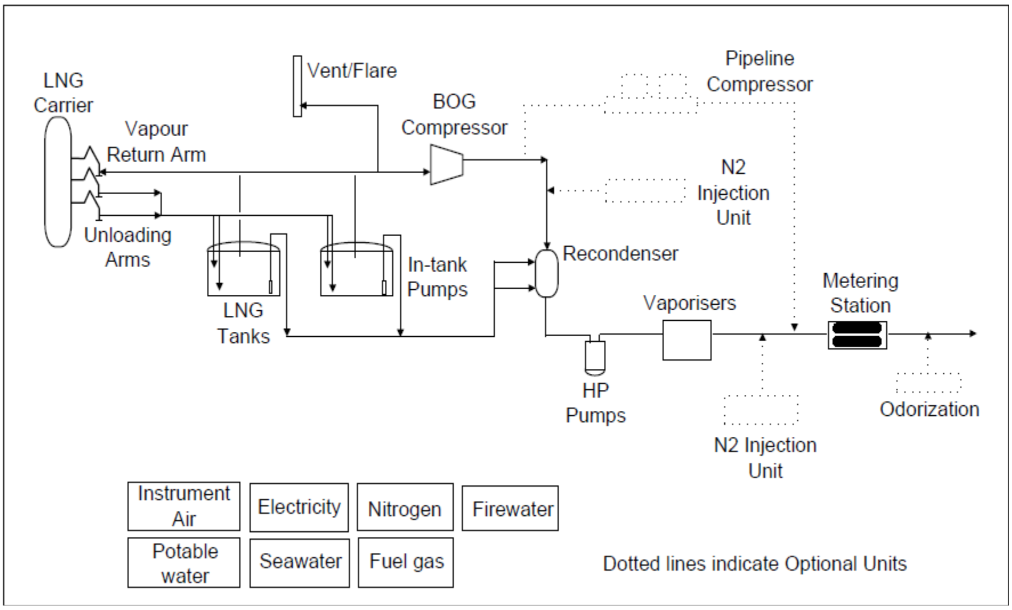
2.2 Analysis of Alternatives

2.2.1 LNG Terminal Configurations

2.2.1.1 Land- Based Terminal

The LNG import / receiving marine facilities are essential part of a land based LNG terminal. LNG unloading from carrier ship shall be accomplished via hard-piped cryogenic liquid unloading arms located on the jetty platform, transferred to the LNG storage tank(s) at land-based terminal through cryogenic liquid pipeline located on the trestles running to shore. Vapour displaced from the land-based storage tanks whilst the ship is unloading is also returned to the ship via a vapour return line and a vapour return arm. The Boil off Gas (BOG) from the LNG tanks shall be compressed and routed to a recon denser where the BOG vapours are condensed with LNG from the storage tank at about5-10 bar pressure to achieve total condensation of the BOG. The LNG is pressurised by the High Pressure (HP) pumps up to send-out pressure and then vaporised in the heat exchanges at high pressure.

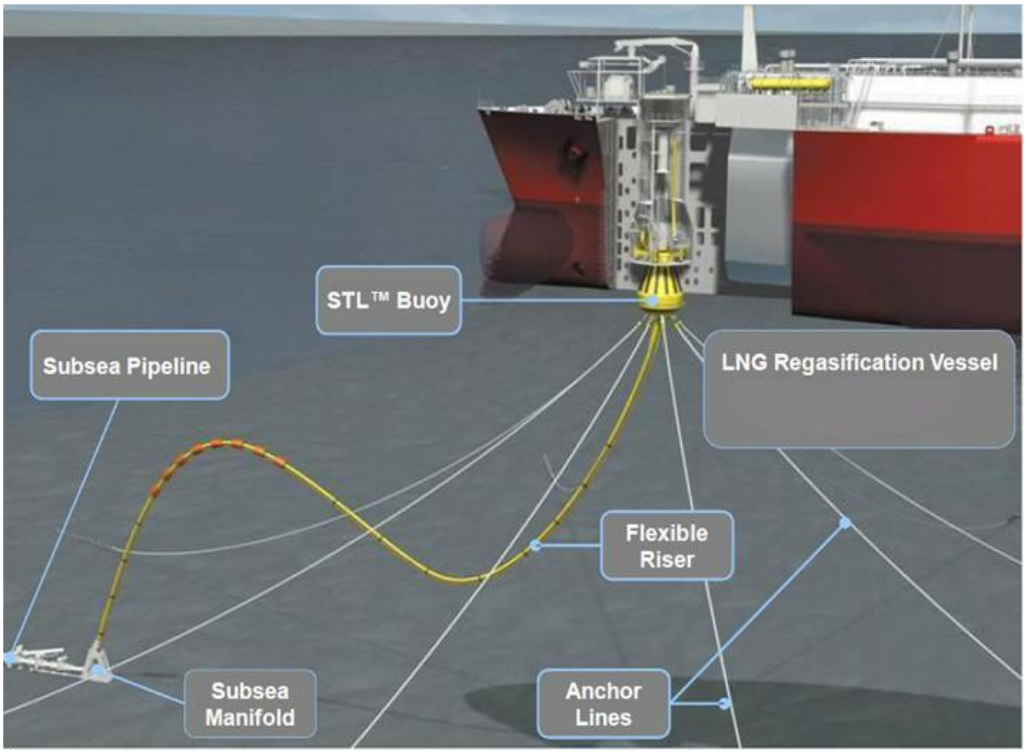
The main process sections and the supporting utilities of the land-based LNG Receiving Terminal are shown in the block diagram below.



About 50-55 ha land would be required to accommodate the land-based terminal of about 5 million TPA gas throughput capacity. The surface area of the marine jetty platform shall be of sufficient size for operation of the land-based facilities taking into account lay-down and working space for construction. In order to accommodate LNG vessels, berth structure, breakwater and dredging are also required.

2.2.1.2 Open Sea Buoy Solution

This solution would consist of utilising the available FSRU in global market with a storage capacity about 145,000 m^3. In this case, the FSRU would be anchored in the open sea. It would deliver regasified LNG via a Submerged Turret Loading (STL) buoy into a Pipe Line End Manifold (PLEM) on the seabed from where it will be sent onshore via a subsea pipeline. The LNG from carrier ship would be unloaded into the FSRU by ship-to-ship transfer arrangement. The following figure provides an overview of this system.



Two options have been considered:

- One located at about10kmoffshore from the land-based tie-in point at an average depth of 12m, referred to as the “Shallow Water” solution.
- The other located approximately 20km offshore from the land-based tie-in point at a depth of about 40m, referred to as the “”Deep Water” solution.

They are technically similar but differ by the fact that the “Shallow Water” solution requires dredging and a 10km pipeline up to shore whereas the “”Deep Water” solution does not need dredging but requires about20km subsea pipeline.

2.2.1.3 FSRU or FSU solution

The floating storage and regasification unit (FSRU), moored at the near shore jetty, provides all the functionalities of a land-based terminal and thus includes LNG storage, regasification facilities and related utilities, metering and gas sample analyzing unit, cargo transfer systems, safety systems etc. An island jetty platform structure and a breakwater are required in this solution to accommodate the FSRU and the incoming LNG carrier ship.

For this solution a HP gas subsea pipeline from the jetty to the landfall point (relatively shorter length) would be required to transfer natural gas.

In the case of an FSU (floating storage unit), regasification facilities along with related utilities, metering, safety systems etc. shall be constructed separately either on jetty platform or at landfall terminal. The other aspects remain same as for FSRU solution.

2.2.1.4 Screening of Design Concepts

APGDC and GDF SUEZ have reviewed the options for the proposed LNG terminal and carried out initial screening based on prescribed criteria, the first of which was an early implementation schedule as this was deemed a key requirement.

Due to the land reclamation and LNG tank construction requirements, 2017 would be a realistic start-up date for a conventional onshore LNG terminal. Note in particular that LNG tanks require at least 33 months to build. In addition, the CAPEX is much higher than that for an FSRU solution. This immediately eliminated the fully land-based solution.

The remaining options were then:

- FSRU
- Open sea buoy terminal
- Hybrid solution which is a temporary floating terminal during construction of an on-shore facility

These were further assessed based on the following criteria:

- Schedule risks
- Cost
- Expandability
- Proximity to selected site
- Throughput flexibility

The hybrid solution meets the schedule but the cost of a land terminal is significantly higher compared to the floating solutions, without major benefits for this phase of LNG imports. At this stage it is preferred to opt for a floating installation with a land based terminal to follow at a later date once the throughput capacity justifies this solution.

The preferred solution was therefore sought in the FSRU based solutions.

The open sea buoy FSRU terminal:

- Has to be located too far away from the selected site due to shallow water around Kakinada
- Presents little opportunity to add extra LNG storage capacity
- Did not bring Capital Expenditure (CAPEX) advantage compared to a near shore floating terminal.
- Limited available FSRU's with se buoy compatibility hence the daily charter rate would be high due to lack of competition
- Expansion was more costly as a second FSRU would have to be used and significant CAPEX would be required to add another STL Buoy system
- Downtime caused by delayed ship to ship LNG transfer in open sea in a cyclone prone area was anticipated to be unacceptable by RLNG bulk consumers.

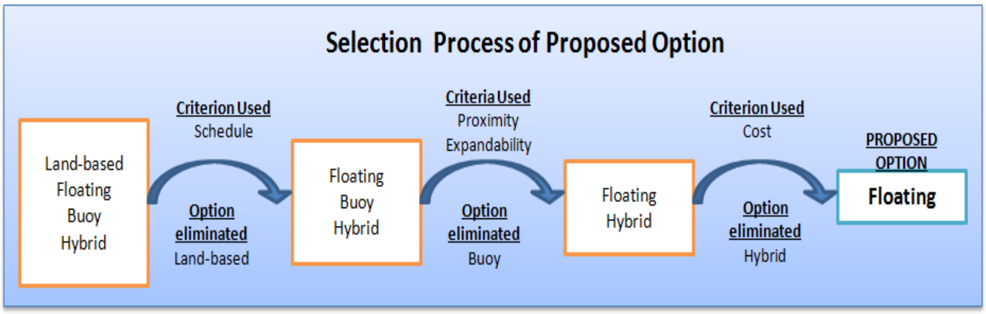
Hence the open sea buoy FSRU Terminal is eliminated.

The floating FSRU terminal within Kakinada Deep Water Port:

- Will have the least schedule risks
- At the lowest CAPEX
- It will be relatively a safe and reliable solution providing a high availability level
- Offers expandability options

Accordingly the near shore FSRU terminal was therefore selected as the preferred solution.

This decision process can also be visualized in the following figure:



Summary of selection process for the preferred near shore floating solution

Other parameters were also considered during this above evaluation exercise such as:

- Reliability to meet gas demand
- Logistics
- Impact on port operation

Based on the above criteria, APGDC and GDF/SUEZ have concluded that a near shore island jetty & FSRU based terminal as the optimal solution at Kakinada for the following reasons.

- The sheltered near shore location for the jetty reduces construction costs for the pipeline, and reduces the chance of weather related delay to construction schedules;
- A near shore jetty allows port services (dredger, tugs, pilot, channels etc) to be pooled with existing port operations.
- This solution meets all the project criteria, is the most cost efficient and allows for a seamless expansion to increase the capacity if required in the future.

2.2.2 LNG Regasification Technology

FSRUs are designed to incorporate certain equipment and processes on board to accomplish the task of offshore LNG vaporization. There exist two distinct types of re-gas concept, with a number of manufacturers. The two re-gas concepts are either an open loop or a close loop system. The fundamental difference between the two systems is whether the medium used to heat the LNG and convert it from a cold liquid (-161^{o}C) to ambient temperature is fully contained within the FSRU (close loop) or is brought in from outside (in this case seawater) and sent out again to outside of the FSRU (open loop).

2.2.3 Project Site Alternatives

A statement showing the evaluaiton of the three ports under considerations taking into account the key apsects of the FSRU terminal is given in **Table2.1**.

The intention of the A.P.Government is to commission the terminal at the earliest to serve the demands of the local industry. It can be seen from this table that kakinada port satisifes this requirement without any constraint. The primary advantage is the proximity to the existing pipeline network for gas transmission to the consumers. The second advantage is the availability of a suitable berthing location within the protected basin with least hindrance to the existing port operations. The third advantage is the availabiltiy of sufficient land at the foreshore near the port for locating the onshore terminal at a later date.

In the case of other two ports, Visakhapatnam and Gangavaram the linkage to the existing gas pipeline network through cross country pipeline will be a bottleneck for early commissioning. In the case of Visakhapatnam port where the FSRU shall be located offshore, the terminal will be opertional only for 250 days in a year with the maximum downtime being during May to August, when the demand for gas will be peaking. This applies to Gangavaram port also in case the FSRU is located outside the northern breakwater. The location within protected waters will be only temporary at Gangavaram Port according to the port authorities until the time they take up the future expansion programme as per their master plan. Further constraint will be the non availability of suficient land nearby for locating the onshore terminal at a later date.

At Kakinada port, the construction of the jetty with platform facilites, installation of the interlinking gas pipeline and the dredging for widening and deepening the channel, manoeuvring and berthing areas all could be concurrently taken up and completed while the FSRU is being either newly built or converted.

It is the intention of APGDC to quick start the FSRU project within the shortest time to meet the shortfall in supply of natural gas. Kakinada Deep Water Port on the leeward of existing breakwater, combined with protected harbour area (**Fig.2.1**) is the most preferred location based on the following:

- Kakinada, Visakhapatnam, and Gangavaram Ports have been evaluated by APGDC/GDF SUEZ as part of their wider activities. It is thought that Kakinada presents the most cost-effective option at this stage compared to developing in the other two locations (breakwater requirements and land availability concerns at the other ports will increase development costs compared to Kakinada);
- Kakinada is close to the existing Andhra Pradesh gas transmission infrastructure, and the potential NG market thus reducing the cost of connectivity which will have a significant share of the overall CAPEX;
- Kakinada enjoys relatively mild metocean conditions with less cyclonic activity than other areas on the east coast of India;
- The sea traffic density at existing KDWP with existing 6 berths and around 10 mtpa cargo handling capacity looks compatible with proposed installation of a LNG terminal;
- Land at Kakinada looks suitable for a future on-shore expansion pending zoning consent;
- Kakinada is a sheltered port endowed with a natural protection (Hope Island) and an existing breakwater would further protect the FSRU from NE waves.

2.3 Description of Project

The proposed near shore FSRU based LNG terminal project consists of development and operation of marine facilities (satellite jetty & long term berthing of FSRU with necessary LNG unloading equipment), the subsea high pressure pipeline to transport regasified LNG (RLNG) to shore and onshore receipt facility/landfall station. The project will be configured for base load design capacity of 3.5 mtpa (million tons per annum), equivalent to 500 mmscfd/14 mmscmd average throughput of RLNG with +50% operational flexibility. That means the maximum peak design capacity will be about 5.25 mtpa (750 mmscfd/21 mmscmd). The proposed project is planned to handle the LNG with the characteristics complying the standard EN1160:1996 (**Table 2.2**). The project will ensure zero flaring.

The following two configurations/layouts have been identified for the proposed (5.25 mtpa peak design capacity) LNG terminal project due to the advantage that each solution will provide depending on how the market may develop. With respect to environmental impacts there will be no significant differences in these lay-out options as the construction and operation design capacities remain same in both configurations.

- Configuration-1: FSRU - Twin jetty with over the jetty transfer of LNG from LNG carrier to FSRU:

- Configuration-2: FSRU - Single jetty with LNG transfer directly from LNG carrier to FSRU like ship –to-ship transfer concept

In configuration-1, the FSRU and the LNG carriers are moored in a traditional manner each side of a twin jetty. LNG is transferred from the carrier to the FSRU across the jetty platform. Two sets of cryogenic hard arms shall be installed on the jetty. Configuration-1 is effectively set up as a jetty that would be ready for both for FSRU operations and also as conventional jetty. **Figs.2.2** and **2.3** show the Conceptual Schematic and layout of Configuration -1 which includes:

- Floating Storage and Regasification Unit(FSRU)

- Twin berth jetty with over the jetty transfer of LNG from carrier ship to the FSRU. Hard Loading Arms to be provided on jetty for unloading LNG from LNGC on to the LNG transfer pipeline on jetty and then to FSRU. Vapour return arms provided on jetty to be used for transferring boil off gas (BOG) from FSRU to LNG carrier ship.

- The high pressure re-gasified NG transfer/send out from FSRU to jetty by HP arms and then to onshore receiving facility (ORF)/ landfall terminal by sub-sea pipeline

- Pig launcher facility on the Jetty

- Onshore Receiving Facility (ORF) / Landfall station

In configuration–2 (**Figs.2.4** and **2.5**), the FSRU will be moored at single jetty and the visiting LNG carrier to be moored beside the FSRU. LNG will be transferred directly from the LNG carrier to the FSRU through cryogenic liquid unloading flexible / hard arms. The unloading arms are installed on the FSRU deck.

The obvious difference between these two configurations is the jetty structure itself and the arrangement of pipeline and arms which would be present at the start of the project.

2.3.1 Floating Storage and Re-gasification Unit (FSRU)

The FSRU will remain same for both the configurations. The FSRU facilitates the bulk storage of LNG. The LNG is contained at -161^{0}C temperature and at atmospheric pressure (or slightly above). There are no refrigeration facilities onboard the FRSU. Instead the cargo tanks are made of extremely high performing insulation material to prevent heat leak into the cargo. Temperature rise is extremely low and the typical amount of lost cargo per day (Called boil off gas or BOG) is less than 0.16% of the cargo tank volume. This excess gas is generally fed to the regas or power systems to use as fuel. Some modern FSRU's have the ability to re-condense the spare boil off gas and inject it into the re-gas system. No gas is vented to atmosphere at any point of time during normal operations. The broader specifications given in **Table 2.3** correspond to the FSRU planned to be used at proposed project.

The FSRU's make use of double barrier hull concepts. This means that there are two hull structures between the tanks and the outside sea (plus the layers of the containment system itself). Not only does this limit the risk of cargo spillage, but it also provide space for ballast water to be stored (only LNG is ever stored in the main cargo tanks)

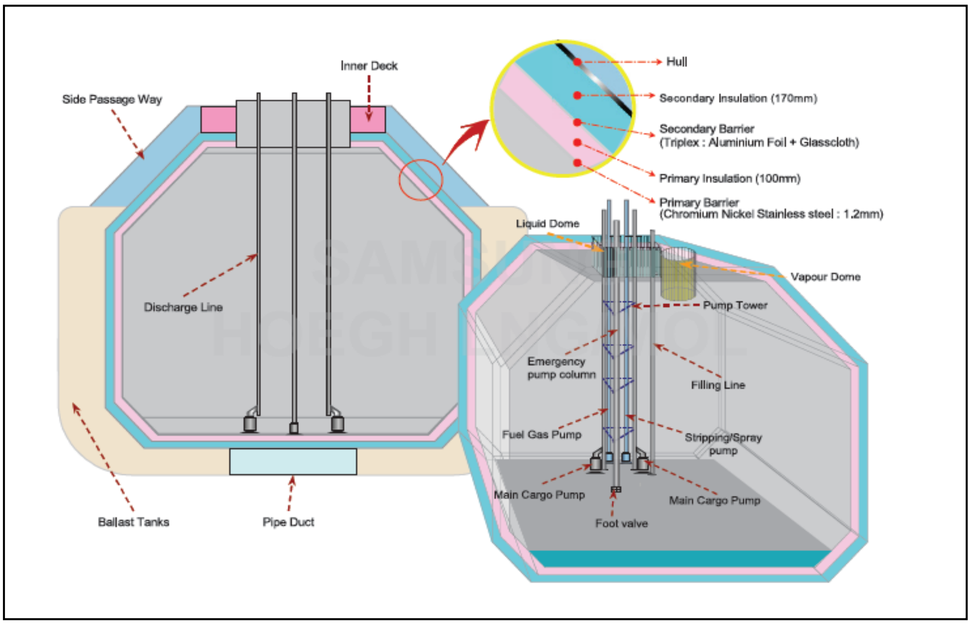
The FSRU will re-gasify stored LNG at controlled rate as per the requirement of send out demand and deliver natural gas via HP gas arm to the jetty and then to a subsea pipeline. As a key potential bottleneck in assuring uninterrupted gas supply to customers, two HP arms will be provided on jetty to allow suitable redundancy. Re-gasification will most likely be carried out with an open loop system using seawater as the primary heating medium. The seawater shall be pumped into shell and tube heat exchangers to vapourise the LNG, and then the outlet (colder) seawater shall be discharged back into the sea. At no point does the seawater mix with the LNG.

2.3.1.1 LNG Contaminant

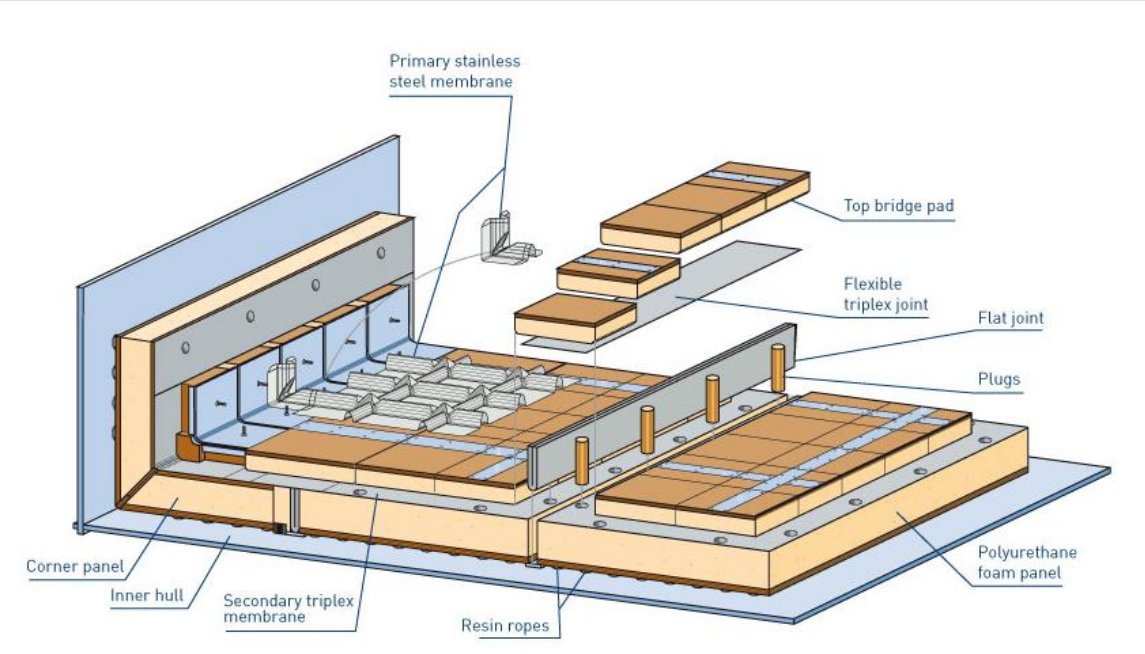
The cargo system has 4-6 nos. of reinforced membrane-type tanks. The LNG with a specific gravity of typically between 0.43 and 0.47 is stored at -261°F. The guaranteed daily boil-off rate is approximately 0.16% of the vessels total cargo capacity. The design chosen complies with all International Maritime Organization (IMO) requirements in accordance with a 40-year World Wide Trade operational lifespan.

The containement of the LNG may be ether in Mark III or No 96 membrane systems (as shown in following figures), both from the manufacturer GTT of France.The main components of the MARK-III Containment system are applied as follows :

- The insulation which consists mainly in rigid polyurethane foam with reinforcing glass fibers in between two (2) plywood sheets. Insulation transmits cargo pressure to the internal structure of the Vessel.
- The 1.2 mm thick stainless steel primary barrier whose main feature consists in an orthogonal system of corrugations which compensate for thermal contraction and mechanical ship's deflections.
- The secondary barrier, which are laminated composite material, and which are made of two (2) glass cloths (for the resistance) with an aluminium foil (hereinafter call "Triplex"), in between, for the tightness. The secondary barrier, whose purpose is to sustain LNG in case of any accidental leakage through primary barrier, are inserted in the insulating structure.

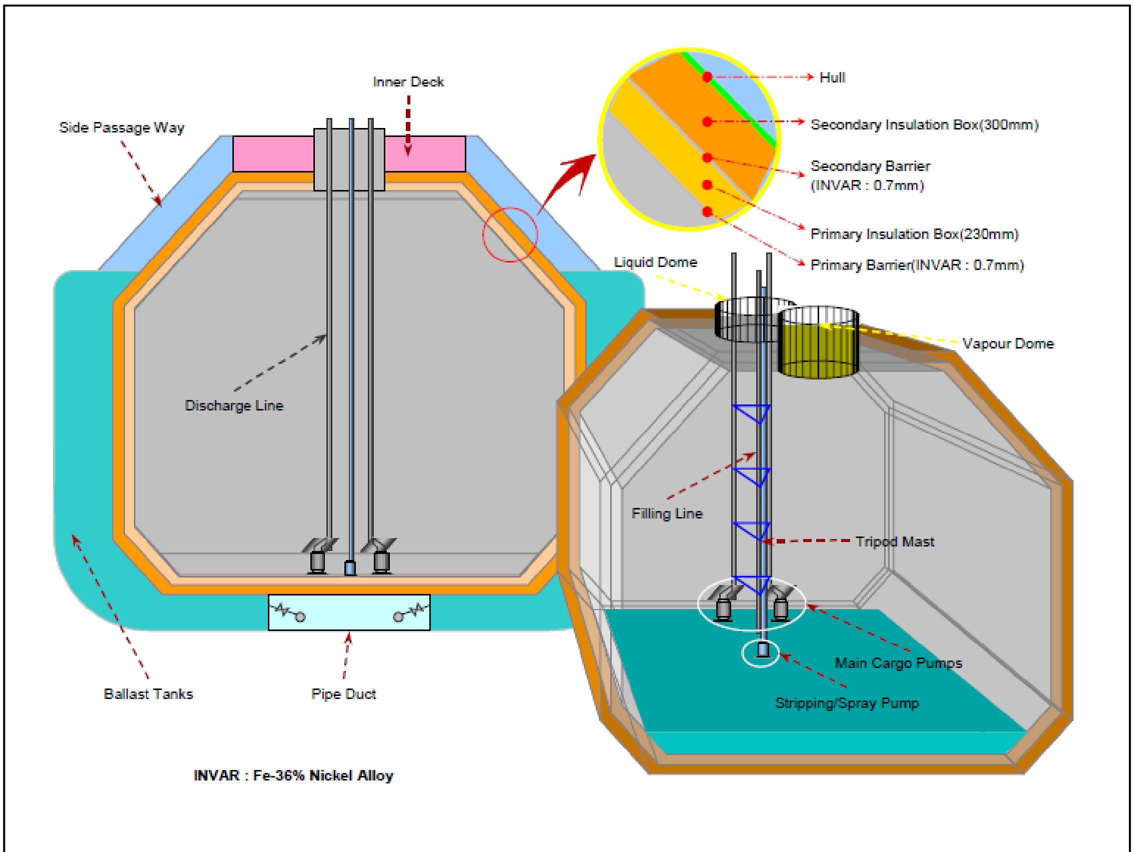


Mark III Containment Tank on FSRU

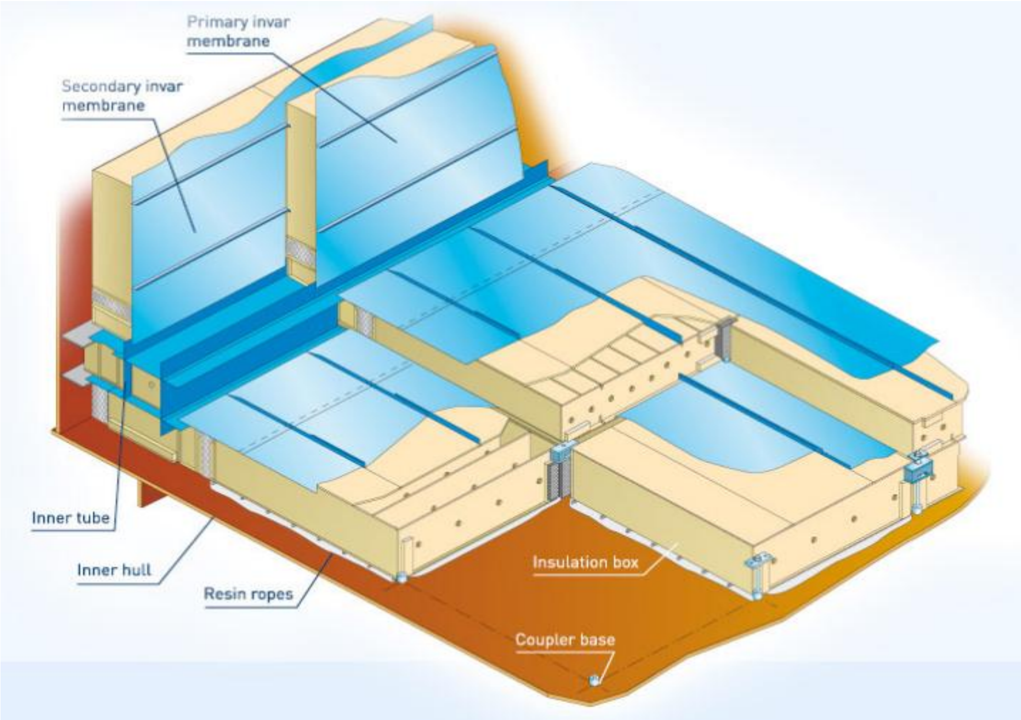


Layout of Mark III Containment System

Should a No96 system be chosen then it has the following layout



No96 Containment Tank on FSRU



Layout of No96 Containment System

2.3.1.2 LNG Vaporization

To accomplish the task of offshore LNG vaporization, regasification system may be operated in one of three ways:

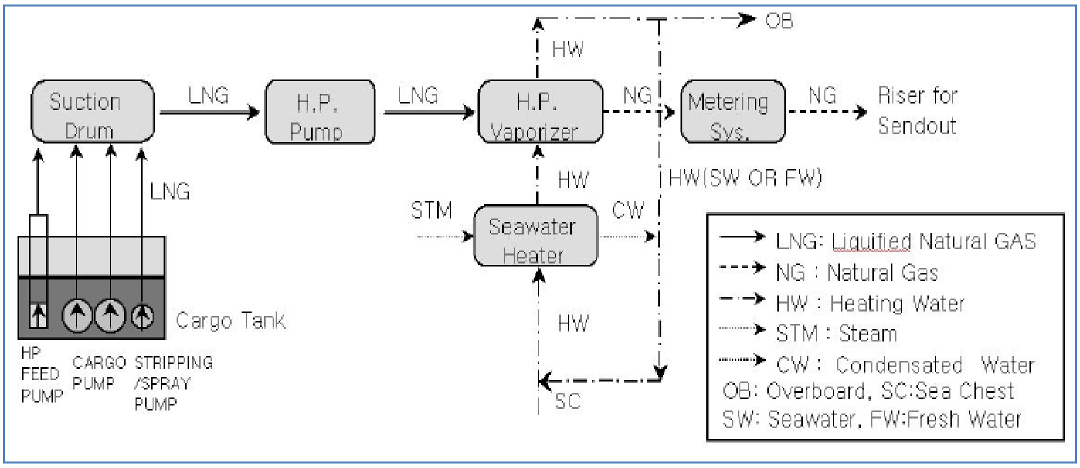
- Close-loop mode, in which LNG vapour is burnt in the FSRU boilers to produce steam which is then used to heat fresh water or glycol circulated through the shell-and-tube vaporizers in the re-gasification plant.

- Open-loop mode, in which ambient seawater is drawn in through the FSRU's sea chests. The seawater is used as heat source and passed through the shell of the shell-and-tube vaporizers (Heat Exchangers), causing the vaporization of the LNG. During this process, the temperature of the seawater will be lowered by approximately 7^{o}C. For this reason, the open-loop mode is not applicable for water temperatures below 45^{o}F (7.5^{o}C).

- Combined mode, in which seawater at temperatures between 45-58^{o}F (7.5-14.4^{o}C) can be used when heated by steam from the FSRU boilers to provide sufficient heat for the vaporization of the LNG

This reflects the system onboard the likely FSRU's that could be used at Kakinada.

Close loop systems must generate heat by burning LNG rather than use of the heat of seawater (natural resource). As such whilst close loop system will not interact with the surrounding sea water, it does produce larger amounts of air emissions than an open loop system. As such it is expected that an open loop system will be utilized in Kakinada in the long term. A flow diagram for the open loop system to be used for the long term FSRU option at Kakinada is shown below:



The newly built or conversion /modification of existing LNG ship shall strictly comply with all relevant international and national statutory norms /standards /guidelines. The specifications of FSRU for proposed LNG terminal project are given below:

The FSRU facility shall be designed, constructed, installed and surveyed in compliance with the DNV "Rules for Classification of LNG/LPG Floating Production and Storage Units or Installations", DNV-OSS-103 or equivalent.

The candidate vessel for conversion must have been built to an International Association of Classification Societies (IACS) members rules for vessels intended to carry Liquefied Gases in Bulk and to International Maritime Organization (IMO) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) requirements.

The FSRU shall perform "In service" continuous hull and machinery surveys after installation and commissioning, as required for the maintenance of Classification Society.

2.3.2 Marine Receiving Facility

The basis of design for the Jetty covers the criteria for civil and structural design of both jetty configurations 1 and 2 (viz. loading platform, dolphins) and the requirements for berthing and mooring. Design of Jetty top sides shall satisfy local extreme weather conditions. The jetty facilities encompass the following main structures, berth furniture, equipment and ancillaries:

2.3.2.1 Island Jetty

The proposed twin berth jetty (110mx70m) will include the following main equipment:

2.3.2.2 Jetty Platform

The platform for unloading LNG shall provide support for all topside facilities (110m x 70m) and resist all applied loads. The unloading platform shall have all necessary access space required for the operation of the berths and accommodate all items necessary for the operation of the marine facilities and as required by the topsides design.

There is no access road to the loading platform in this project. Maintenance and handling of heavy equipment shall be supported by marine barge. Clear pedestrian access to the walkway, stairways and ladders giving access to breasting dolphins and a gangway shall be provided.

2.3.2.3 Loading Arms

LNG loading arms are required to be installed on the jetty for Configuration 1 and on board the FSRU for Configuration 2. The LNG loading arms shall be designed to the following conditions:

- A minimum of 4 standard 16 inch LNG loading arms on each side of jetty platform, 2 for LNG, 1 for vapour return and 1 spare (hybrid) will be installed;
- Each loading arm flow rate shall not be less than 4000 m^3/h;
- The bearings and seals in the arms shall be designed for continuous oscillating

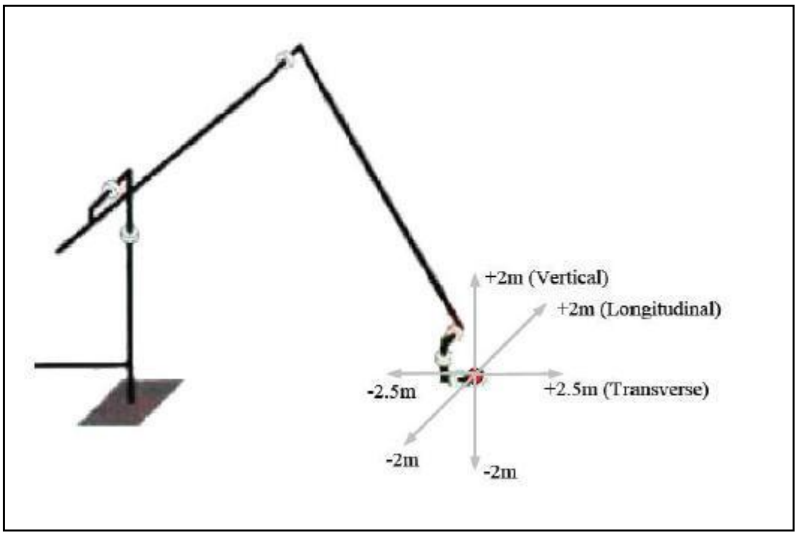
motions;

- The arms shall be equipped with double ball values/powered emergency release couplers and hydraulic type normal quick connect/disconnect;
- The arms shall be supplied with a comprehensive operating, control and alarm system integrated with the FSRU cargo handling and shutdown systems;
- A one day turnaround is assumed for common LNG carriers while at the FSRU site. Hence the system will be designed to unload the cargo taking into consideration the call duration period.
- The loading arms shall be operational for all required draft and loading conditions;

The actual motion envelope is to be assessed based on the range of LNGCs likely to offload at the FSRU. The indicative expected maximum longitudinal, transverse and vertical excursions allowable between the manifolds of the FSRU and LNGC are as follows:

- Longitudinal motion (surge) between the manifolds is -2.0m to +2.0m
- Athwartships motion (sway) between the manifolds is -2.5m to +2.5m
- The vertical motion (heave) between the manifolds is -2.0m to +2.0m.

The following figure presents the loading arm typical motion envelope.



Loading Arm Allowable Envelope Motions

Arms should be designed to allow connection and operation of 1, 2, 3 or 4 arms simultaneously whichever the arm is considered. Draining, heating, inserting, and degassing purposes shall be considered for the LNG lines on the jetty.

2.3.2.4 Breasting Dolphins

Breasting dolphins shall be provided for the safe berthing and mooring of the range of LNG carriers and FSRU ("**Ships**"). The number and spacing of the breasting dolphins shall be in accordance with Oil Companies International Marine Forum (OCIMF) guidelines but ultimately proof of the adequate location is to be provided by detailed berthing and mooring analysis for the range of ships specified in this document. The fenders are to be aligned with the parallel mid-ship body of the ships in ballast. The location of the breasting dolphins shall take into consideration the manifold off-sets for the range of ships and un-obstructed mooring line handling. The fenders shall be mounted in a way that no diver access is required to remove and replace the fender. Each breasting dolphin shall as a minimum include the following items:

- Fender assembly, complete with chains
- Quick release hooks with motorized capstans
- Walkway/stairway supports
- Unimpeded access from one dolphin to another via walkways
- Handrails
- Adequate working and access space
- Edge protection to prevent abrasion by mooring lines
- Cable tray/ducts for services
- Lifebuoys
- Area lighting

Multiple hook assemblies shall be supplied to moor the ships. The capacity of each quick release hook assembly shall be fixed based on the mean breaking load of the vessel's mooring line. Each quick release hook assembly shall have a dual speed motorized capstan. The orientation of the hooks shall be in accordance with OCIMF guidelines.

Plinths, ducts and cable trays shall be provided as required for services and lighting. Handrail shall be fitted to the rear and sides of each dolphin platform and shall not impede mooring operations. Edge protection shall be provided to the front and sides of each dolphin platform.

2.3.2.5 Mooring Dolphins

Mooring dolphins shall be provided for the safe mooring of the range of LNG carrier Ships (LNGC) up to Q_{max}. Each mooring dolphin shall as a minimum include the following items:

- Quick release hook and motorized capstan
- Walkway supports
- Unimpeded access from one dolphin to another via walkways
- Handrails
- Edge protection to prevent abrasion by mooring lines
- Cable tray/ducts for services
- Lifebuoy
- Jetty end lights on extreme outer dolphins only
- Area lighting
- Intercom to control room and to ship via ship to shore connection

All mooring lines shall be equipped with nylon polyesters grommet and ensure that all mooring lines are insulated. Design mooring forces exerted by quick release hooks from the relevant analysis shall be considered concurrently with the operational environmental conditions.

Multiple hook assemblies shall be supplied to moor the vessel. The safe working load capacity of each hook of the quick release hook assembly shall be fixed based on the mean breaking load of the vessel's mooring line of the vessel. Each quick release hook assembly shall have a motorized capstan capable of being switched between high and low speeds. The orientation of the hooks shall be in accordance with OCIMF guidelines.

2.3.2.6 Walkways

The walkways shall be designed for carrying the mooring lines from the ships to the dolphins and the grating level within the walkway shall not exceed a slope of 1:10 and there shall be no steps between walkway terminations and the connecting structures. The minimum clear width of walkways connecting dolphins shall be 1.4m

The structural form shall ensure that no obstructions are present on the seaward side of the walkway at a height greater than 1.2m above grating level to enable easy handling of lines. All members along the uppermost limit of the structure shall be rounded so as not to chafe or abrade lines being passed along. Ends of handrails shall be detailed so that mooring lines cannot catch on the handrail.

2.3.2.7 Quick Release Hooks

The quick release hooks shall have as a minimum Safe Working Load (SWL) equal to or greater than the Minimum Breaking Load (MBL) of the mooring lines used on board the range of the Ships. A minimum of Triple Quick release hooks are to be provided on each mooring dolphin and double Quick Release Hooks shall be provided for the breasting dolphins. The hook release system shall be designed such that not all the hooks can be released at the same time as per the latest LNG industry best practices.

The quick release hook cluster at each dolphin shall be equipped with a mooring capstan with a minimum capacity of 5 ton, and shall be dual speed (i.e. full load speed of 18m/min and light load speed 36m/min). Mooring load monitoring systems shall include the following minimum system features:

- Audible alarm
- Emergency stop
- Foot pedal control
- Vertical bar chart display of load parameters
- Database

- Low / high load set point adjustments
- Hard copy printout
- Suitable for hazardous area

2.3.2.8 Navigational Aids

The following navigational aids shall be established:

- Buoys to mark the width of navigable channels and turning circle should be placed at suitable intervals.
- Leading marks or lit beacons, to mark channel centerlines and to facilitate rounding channel bends, should be appropriately placed. For the jetty structure, it is anticipated that beacons would be needed at least on the outermost dolphins (subjected to navigation study).
- Electronic navigational aids, to support navigation under adverse weather conditions should be provided.
- Lit navigational aids should be provided to allow ship movements at night.
- Berth monitoring system for weather, mooring tension, berthing speed and angle measurement.
- The jetty end lights which shall comply with the internationally accepted requirements of the International Association of Lighthouse Authorities (IALA). The local Port Authority shall be consulted for finalizing the navigation aids requirements.

2.3.2.9 Jetty Utilities

Instrument Air

For Configuration 1, air compressors will be common for supply of utility air and instrument air on the jetty. Instrument air is used for pneumatic process controls on the jetty i.e. the control of control valves as well as the on-off/ Emergency Shut Down (ESD) valves. Utility air is used for maintenance and cleaning on the jetty. The air demand on FSRU and LNGC is not considered.

For Configuration 2, instrument air is not required and hence no compressors will be considered on the jetty. The ESD valves will be MOVs and will be operated by electrical power.

Nitrogen

For Configuration-1, Nitrogen is required for the purging of the Marine Loading Arms after unloading. The Nitrogen will be provided by a Nitrogen Generation Unit (vendor package). Nitrogen cylinder bottles will also be provided as back up for the Nitrogen Generation Unit.

For Configuration 2, there is no continuous requirement of Nitrogen on jetty envisaged. The requirement of Nitrogen is low and will be provided by Nitrogen cylinders.

2.3.2.10 Potable Water

Potable water is used for domestic purposes on the jetty, at safety showers & eye wash purposes. The potable water requirement is estimated based on expected working personnel on the jetty. The potable water storage capacity will be based on 12 hours of supply. The potable water requirement of the ships (FSRU, LNGC) will be met by own resources through potable water generation on board the ship. Any potable water supply will be via sea-going vessels and unloaded onto the potable water storage tank on the jetty.

2.3.2.11 Fire Water and Protection System

Seawater will be used for firefighting purposes on the jetty. The fire water requirement is estimated based on fire water monitors and fire hydrants required on the jetty. Fire fighting system shall be designed as per code requirements and results from site-specific fire safety study.

2.3.2.12 Jetty Power Generation System

Consideration will be given to emergency backup generator (290kvA) on the jetty structure to meet the full power requirements.

2.3.2.13 Access Towers/ Gangway

Access towers / gangways are to be provided on the loading platform (jetty top) to allow boarding of personnel. The gangway design needs to take into consideration the range of design Ship sizes. The access towers and gangways and its components shall comply with national manned elevator codes, lifting appliance codes and shall meet all national working at heights requirements where applicable. The access tower shall also be equipped with a crane.

The location of the access towers and gangway shall be designed for safe access from the Ships to the platform and should be located at a safe distance from any Ship's mooring line or any equipment. The end steps from the gangway (i.e. on board the Ship) shall ensure safe step-down at all times on to the Ship's main deck.

2.3.2.14 Corrosion Protection

Cathodic protection combined with paint coating system according to international Codes and Standards shall be considered. Impressed current is proposed although sacrificial anodes are also acceptable.

2.3.2.15 LNG Spill Containment

The LNG spill containment system consists of a retention area at the platform, a trough that runs from the retention area to the LNG spill tank (6.50x6.50x5.00m) situated far from the unloading platform over a piled structure. The spill retention area is provided under the LNG unloading equipment.

2.3.3 Subsea Pipeline

Two HP gas arms (2x100%) installed on the jetty (1W+1S) will transfer gas from the FSRU to the subsea pipeline. An HP subsea gas pipeline of 24" diameter NPS will transfer RLNG from the FSRU jetty to the onshore receiving facility. The maximum send out pressure would be 120barg at the FSRU and design temperature as 50°C. The HP gas pipeline to the landfall station/ORF is estimated to be about 4.2 km as per proposed route. It will be buried pipeline. The pipe material grade DNV SAWL 415 with 16.9mm wall thickness for location class-1 and 2 is proposed.

The seabed profile along the proposed route is found to be even and flat with the maximum water depth of 5 m and minimum water depth of 0 m at the shore crossing. Horizontal Directional Drilling (HDD) is proposed as the base case for the shore crossing to provide mechanical protection and stability to the subsea pipeline. Alternatively it will be done through open trench method.

The on-bottom stability of the pipeline would be achieved by selecting a Concrete Weight Coating of 80mm with additional secondary stabilization with pre-trench and mechanical backfill.

Corrosion protection is achieved by 2.5 mm 3LPE external anti-corrosion coating, sacrificial Al-In-Zn bracelet anodes and an internal corrosion allowance of 3 mm. The subsea export pipeline has been designed for a design life of 20 years.

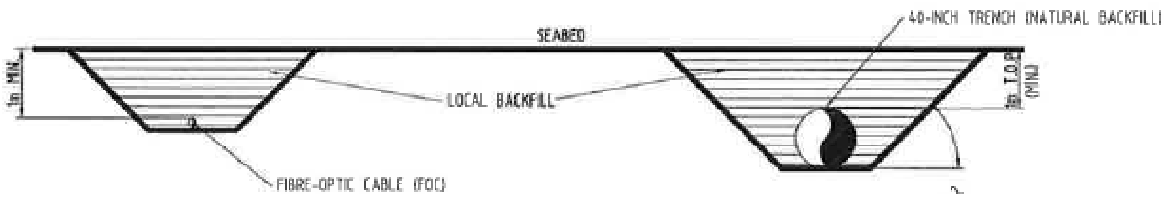


Illustration detail of HP subsea gas pipeline

The installation method assumed for the submarine pipeline section involves prefabrication of pipe sections on land and tow out to the proposed FSRU site. A preliminary estimate of corridor width for the main pipe string fabrication is around 10 -15 meters.

The same size (24” diameter) high pressure pipeline (buried) of about 1.1km length will be laid from ORF to existing gas grid tie-in-point.

2.3.4 Onshore Receiving Facility (ORF) – Landfall Station

Onshore Receipt Facility (ORF) will be located on land beside the shore on an approx. area of 2.64 Hectare. The ORF will receive the high pressure gas from the FSRU through the high pressure subsea pipeline system. The gas will pass through filters and then it will be heated in water bath heater, depending on process requirement. Subsequently pressure will be reduced in the Pressure Reduction System (PRS), as per requirement and will be metered through Ultrasonic metering system before sending out to the existing transmission pipeline grids. There will be suitable pressure safety system and provision for gas sampling and analysis. The entire facility will be armed with firefighting system. Based on send-out to two different pipeline grids, viz., GAIL and RIL, it has been proposed to have two sets of the above facilities with connectivity to RIL to be a future option. The ORF will include the following main items of equipment.

- Pig Receiver

- Filters
- Water Bath Heaters
- Pressure Let Down Station
- HIPPS
- Sampling
- Metering for GAIL Pipeline
- Metering for East-West Pipeline (Future)
- Pig Launcher for GAIL Pipeline
- Pig Launcher for East-West Pipeline (Future)
- Building (MCR, admin offices, rest room, power station, car park, security etc)
- Vent Stack
- Utilities (potable water, nitrogen, instrument air, electric power generators)
- Chromatograph
- Maintenance and craning area for jetty topsides

2.3.5 Summary of Proposed Project

The abstract (design summary) of proposed FSRU based LNG terminal details are given in Table 1.1 (***Chapter-1***), while the overall layout plan is shown in **Fig.2.6**.

2.3.6 Relevant Codes and Standards

Design, supply, construction, inspection, commissioning and operation of the Kakinada Regas Terminal will be done in accordance with appropriate applicable codes and standards. This section gives description regarding the approach, philosophy and a general concise listing of various codes. Various sub systems of the project will follow Indian and international industry standards although those will not be specifically mentioned here. Except where otherwise stated, the applicable codes and standards shall be the latest edition, including all amendments, as applicable at the Contract Award date. Indian codes and regulations wherever applicable will be followed.

The base code for the design of the LNG facility is BS EN 1473: 2007: Installation and Equipment for Liquefied Natural Gas – Design of Onshore Installations. The international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC code); classification society and marine statutory requirements.

All local Indian legal and regulatory requirements shall be strictly adhered to. The precedence applying the International Standards, Specifications, Codes and Regulatory requirements for this project is as follows:

- Indian Law
- Interpretation of Indian laws by the Indian approval and regulatory bodies
- Indian National Standards and Codes
- International Law applicable to an LNG Import Terminal
- Project Standards and Specifications
- International Standards
- Industry Standard Practice

In the event of a conflict between any of the Standards or Specifications, the above hierarchy will be adopted.

General Codes and Standards:

LNG CODES (List in order of precedence) and new section for Codes and Standards

- NFPA 59A (2013)
- EN1473: 2007

EARTHQUAKE CODES

- NFPA 59A (2013) and reference standard ASCE 7

CIVIL WORKS

- AWS D.1.1-92
- ISO 10319 (1993)
- ISO 12236 (2006)
- AISC-ASD 9th edition
- IBC
- Applicable Indian Standards – (TBA)
- ACI Standards
- ASTM Standards

Jetty / Berth:

- Applicable BS Standards

- Applicable DNV Standards
- SIGTTO standards
- OCIMF standards
- PIANC codes

EQUIPMENT VESSEL AND ROTATING MACHINES

- Associated API/ASME/ISO/EN Standards
- LNG UNLOADING ARMS & SHIP-SHORE LINK
- ASME B31.3
- ISO 28460
- OCIMF (3rd Edition 1999)
- SIGTTO
- EN 1474

VALVES

- Associated API/ASME codes
- MATERIALS
- ASTM
- SFA AWS
- EN 10204

INSPECTION & TESTING

- Associated ASTM and ANSI Standards

PIPING

- Associated ASTM and ANSI Standards

PAINTING & PROTECTION

- Associated ISO Standards

THERMAL INSULATION

- Associated ASTM Standards

INSTRUMENTATION

- Associated IEC, ISO, ASME and API Standards

COMMUNICATION STANDARDS

- Associated ISO/IEC: International Organization for Standardization.

ELECTRICITY

- Associated IEC, ISO, ASME and API Standards

Applicable Indian Codes

- OISD-STD-116 Fire Protection Facilities for Petroleum Refineries & Oil/Gas Processing Plants
- OISD-STD-117 Fire Protection Facilities for Petroleum Depots, Terminals, Pipeline Installations and Lube Oil Installations
- OISD-STD-118 Layouts for Oil and Gas Installations
- OISD-STD-194 Standard for the Storage and Handling of Liquefied Natural Gas (LNG)
- OISD-GDN-197 Guidelines for EIA
- OISD-GDN-196 Guidelines for Seeking Environment Clearance for development
- IS 456-2000 Indian Code of practice for plain and reinforced concrete
- IS 800- 2007 Indian Code of practice for Steel Structures
- IS 875 (Part 3) Indian code of practice for Wind Loads
- IS1893-2002 Indian Code of practice for Earthquake resistant design of structures
- IS 2911Indian code of practice for design and construction of pile foundations
- IS 15663:2006 Design and Installation of Natural Gas Pipelines-Codes of Practice
- IS 5572:2009 Classification of Hazardous Area

FSRU / Vessel: classification / Flag Requirements

- The FSRU facility shall be designed, constructed, installed and surveyed in compliance with the DNV "Rules for Classification of LNG/LPG Floating Production and Storage Units or Installations", or equivalent.

- Vessel construction : ACS members rules , IMO International Code, IGC Codes

- In addition to the certification required for the vessel to operate as a specialized fully refrigerated gas carrier for hull, machinery and cargo systems, the facility shall typically have the following DNV main Classification Society notation, or equivalent IACS Classification Society notation:

National Rules of the Flag of Registry

- International Convention on Load Lines;
- International Convention for the Safety of Life at Sea, incl. International Gas Code;
- International Convention for the Prevention of Pollution from Ships;
- International Convention for the Prevention of Collisions at Sea;
- International Telecommunication Union Radio Regulations;
- International Tonnage Measurement and Certification;
- Suez Canal Navigation Rules, incl. Regulations for Measurement of Tonnage; and
- Safety and Health Regulations for Long shoring, U.S. Department of Labor.

International Maritime Organization (IMO):

- IMO Publication No. 978 Performance Standard for Navigational Equipment;
- IMO Resolution A.665 (16) “Radio Direction Finding System;”
- IMO Draft Guidelines of Bridge Visibility;
- IMO Resolution A 468 (XII) “Code on Noise Levels on Board Ships;”
- IMO Resolution A343 “Recommendation on Methods of Measuring Noise Levels at Listening Posts;” and
- IMO Resolution MSC.35 (63) “Guidelines for Emergency Towing Arrangements on Tankers” (International Convention for the Safety of Life at Sea [SOLAS] Conference May 1994)

2.4 Project Site

Based on the alternative site analysis carried out by Indian Ports Association, the Kakinada Deep Water Port (KDWP) harbour area on lee side of existing breakwater

(**Fig.2.1**) has been identified as the most preferable site for proposed FSRU based LNG terminal.

The approximate coordinates of the proposed project facilities are:

- Jetty, FSRU, LNGC Location : $16^0$58'35"N, $82^0$18'00"E
  (Marine area approx.35.4 Ha) $16^0$58'53"N, $82^0$17'42"E
  $16^0$59'12"N, $82^0$18'12"E
  $16^0$58'53"N, $82^0$18'23"E
- ORF Location : $17^0$00'34.605"N, $82^0$17'3.720"E
  (Land area approx.2.64 Ha) $17^0$00'32.121"N, $82^0$17'2.913"E
  $17^0$00'31.094"N, $82^0$17'6.867"E
  $17^0$00'33.415"N, $82^0$17'7.674"E

Kakinada, a major coastal town and district H.Q, is well accessed through road, rail and sea (Bay of Bengal) routes. The KDWP is connected to NH-5 (East coast Highway) through a double line (wider) road developed with ADB funding (locally it is called ADB road), which bypass Kakinada town / local vehicular traffic. The port is connected to railway line and the nearest railway station is Kakinada Port (a coastal terminus of south central railway). The natural gas distribution network (M/s GAIL) is already existing at <1.5 km distance from proposed project location, i.e. KDWP. Hence, the project location is already provided with all necessary infrastructure facilitates. The overall project layout plan is shown in **Fig.2.6**.

2.4.1 Existing Kakinada Deep Water Port

Kakinada Deep Water Port (KDWP) located at $16^0$58.37'N, $82^0$17.06'E is at about 170km south of Visakhapatnam and 650km north of Chennai, both major port cities on east coast of India. The KDWP, commissioned in 1997, is the main gateway for the rich agricultural belt of East Godavari, West Godavari and Krishna Districts of Andhra Pradesh state. Moreover, in view of its strategic proximity to the Krishna-Godavari basin oil and gas exploration fields, there is significant traffic of Offshore Supply Vessels (OSV).

There are 6 berths for handling the general cargo. Four berths are 200m long each with a draft of 11.5m; while two berths are 300m long each with a draft of 13.0m. The berths are 25m wide and are RCC diaphragm wall by a combination of RCC slab and beams which in turn are supported by pile foundations. The piled platform, thus formed, in turn supports about 3.7m deep earth-fills on top without causing additional pressure on the soil below. The top of deck level is maintained at +5.7m CD. In addition, there are shallow berths for handling the Offshore Supply Vessels. The port handles liquid bulk imports of POL products, edible oil, phosphoric acid, sulphuric acid and ammonia. Dry bulk cargo imports include fertilizer raw material, coal and wood pulp. Exports of bulk cargo include iron ore, cement clinker, white minerals such as Bentonite, Feldspar and general cargo like steel coils, billets, slabs, granites, grains, OSV rings etc.

The port has also constructed two warehouse-cum-sheds in the reclaimed area near the berths, which are leased to Reliance Industries Ltd. for their offshore operations. Also, a plot of area near the entry gate is leased as a storage yard to RIL.

2.4.1.1 Kakinada Deep Water Port Particulars

Navigational Channel

Length	: 10000 m
Width	: 160 m
Depth	: 14 m
Turning Circle	: 350 m
Island Breakwater (constructed)	: 1050 m
Channel Buoys (Solar Powered)	: 16
Transit lights (Solar Powered)	: 2 nos.
Beacon Light	: 2 nos.

Modern Navigational Aids for round the clock navigation

Size of vessels for berthing	: 60,000 DWT

Berths

I) <u>MAIN JETTY</u>

Main Jetty has five cargo berths & one OSV berth

Total length of quay (five berths) : 1210 m

Total width of quay : 25 m

Permissible vessel dimensions at Main Jetty:

Max. LOA permissible : 230 m

Max. Beam permissible : 32.40 m

Max. Permissible draft : -13 m (during High tide)

II) <u>OSV JETTY</u>

Two Finger Jetties : a) 4 x 90 m

With berthing faces : b) 2 x 40 m

Length of OSV berth : 58 m

Width of OSV berth : 25 m

Permissible dimensions:

LOA permissible : 90 m

Beam permissible : No restriction

Permissible draught : 8.5 m

III) NRW Extension

Multipurpose berth : 635 m (North); 150 m (South)

Continuous wharf for two ships Length : 560 m

Alongside Depth : -13.5 m CD

Permissible dimensions:

LOA : 170 m

Draft : 10 m

2.4.1.2 Ship to Ship (STS) Transfer of Crude Oil

KSPL has been catering to this STS (Ship to Ship) transfer operations since 2001-02. The crude oil brought in ULCC (Ultra Large Crude Carriers) & VLCC (Very large Crude Carriers) off Kakinada and lightering the cargo into smaller daughter tankers and delivering at Chennai & Haldia

The operations of STS transfer are accomplished by experienced team of KSPL and conducive sea conditions throughout the year. M/s Indian Oil Corporation Ltd., and M/s. Hindustan Petroleum Corporation Ltd., are the major STS clients

2.4.1.3 Oil & Gas Exploration - Supply Support Base

- Since year 2000 KSPL attending on supply support base services for offshore exploration activities carried out from Kakinada Deep Water Port.
- Port provides mobile bulkers for supply of Bentonite, Barites & cement
- Navigation for offshore supply vessels is round the clock
- Pipe line supply of Bunkers & fresh water to OSVs facilitates quick turnaround.

The KDWP has 3 tugs of 22T bollard capacity and 2 tugs of 60T bollard pull capacity.

During 2010-‘11, KDWP handled about 10.8 million tons of total cargo. The cargo vessel traffic was 766 numbers; whereas, the traffic in other vessels including offshore supply vessels was 1466 numbers.

The KDWP is managed by Kakinada Sea Ports Limited (KSPL) (as concessionaire), a special purpose company set up in 1999 as part of the privatization initiative by Govt. of Andhra Pradesh. The company is promoted by Kakinada Infrastructure Holdings Pvt. Ltd. (KIHPL), owned by Mr.K.V.Rao, an industrialist and now the single largest shareholder in KSPL and is also its Managing Director. M/s KSPL at Kakinada is ISO 9001, ISO 14001 & OHSAS 18001 certified as well as ISPS certified port.

2.4.1.4 Environmental Management

As per the information provided by M/s KSPL, the relevant environmental standards as well as the conditions stipulated in the earlier EC and CFE are complied.

The post-project monitoring in study area around KDWP is being carried out through duly recognized environmental consultancy agency. In addition to the above, M/s KSPL is carrying out environmental management through necessary dust suppression, greenbelt development, maintenance etc.

2.4.1.5 Port Accessibility

Road: The KDWP is located directly at the ADB road, a two lane road without significant congestion at present. The Right of Way (ROW) connecting the ADB roads is wide enough for future four-laning if required. This road connects to Kakinada Town and the anchorage port to the south. Towards north, crossroads connect the ADB road to the National Highway-5 towards Visakhapatnam.

Railway : For facilitating movement of bulk cargo to the stacking yards behind the berths, railway connectivity to the port has been made, whereas for passenger trains, there are Kakinada Port and Kakinada town railway stations. The nearest railway station on the Chennai-Howrah (east coast) main railway line is Samalkot railway station.

Air: The nearest Airport is Rajahmundry airport which is about 60km from port, and Visakhapatnam airport is about 170km.

2.5 Geotechnical Details

The geotechnical conditions assumed for preliminary design and site evaluation are based on available geotechnical and geological information relating to the existing port development and dredging activities, including published geological maps and memoirs, and Draft Report on Geotechnical Investigation for LNG Terminal Area at Kakinada Deep Water Port, Andhra Pradesh, INDIA.

Additional information on the sediment type and properties in the proposed dredge area can be found in the COMACOE draft report on geotechnical investigation. The report presents the factual data arising from the drilling of 13 boreholes in the project area, and the associated laboratory testing.

Samples collected from Standard Penetration Tests (SPTs) in the upper 10m of sediment/soil carried out within boreholes in general have been recorded as silt and clay, where as grain size distribution tests recording little or no sand.

Additional site-specific geotechnical investigation will be undertaken for detailed design purposes. This will include deep coring with recovery of samples, description of the in situ and material characteristics and laboratory testing including tri-axial testing of hard soils and unconfined compression testing of rock cores, if encountered, along the line of the jetty structure.

2.5.1 Seismicity

For preliminary design at feasibility/FEED stage an Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) design spectra will be developed from IS1893. The spectra developed from IS1893 do not correspond with any specific probability of occurrence or return period, however:

- OBE - The design basis earthquake (or DBE) of IS1893 can be considered to be the equivalent of an OBE type event.

- SSE - The IS1893 design spectra (or Maximum Considered Earthquake - MCE) can be considered to be the equivalent of the SSE.

As the Project progresses, and for detailed design of the LNG facilities, a site specific seismic hazard assessment will be done.

As per US Geological Survey Seismicity map of the world, Kakinada is a long way from any major earthquakes that have occurred in the last 100 years.

2.6 Dredging

Based upon the existing data and the proposed dredge elevation of -14.5m CD, the dredging operation will be required to remove approximately 8m to 9m of very soft clay and a further 2m to 3mof stiff clay (Cu up to 200kPa). As such, when at the final dredge level, the base of the dredge is expected to be infirm or stiff clay, which is relatively resistant to disturbance from currents and propeller thrust. The sediment samples taken for the L&TR study indicate that there is a westward transition from>90% sand to <10% sand over a distance of approximately four to five kilometers.

For the assessment of dredge volumes in the shipping channel, examination of the existing bathymetry data indicates that from the start of the channel in the northeast, the first approximately0.7 km of channel is already dredged to a depth equal to or greater than the proposed dredge depth of -14.5m CD. The channel tends to become shallower approximately coincident with the northern tip of Hope Island. Between this point and the proposed shipping basin, the channel depth typically varies between 14.1m and 13.3m CD.

2.6.1 Capital Dredging

Capital dredging volumes have been estimated based on the November 2011 survey as per the table below.

Configuration	Very Soft Clay (Million m^3)	Stiff Clay (Million m^3)	Total Volume (Million m^3)
Double-sided Jetty Configuration 1	9.6	4.2	13.8
Single-sided Jetty Configuration 2	8.0	3.7	11.7

2.6.2 Maintenance Dredging

The breakwater shelters the FSRU Basin from waves and tidal currents. The calm conditions in this area encourage sedimentation which is predicted to be as high as 1m/year initially. Estimated maintenances dredging requirements in the FSRU Basin, channel and Hope Island sediment trap (excluding the port area inshore of the FSRU Basin) are approximately 1,610,000m3/yr.

The estimated annual maintenance Dredging Volumes are as follow :

Configuration	FSRU Basin (Million m3/yr)	Channel (including existing port and Hope Island sediment trap) (Million m^3/yr)	Total Volume (Million m_3/yr)
Double-sided Jetty Configuration 1	0.90	1.56	2.46
Single-sided Jetty Configuration 2	0.74	1.56	2.30

It is understood that the existing port generally utilizes a Trailer Suction Hopper Dredger (TSHD), and it is anticipated that a TSHD will be suitable for removing the upper-most layers of soil. However, TSHD is expected to be unsuitable for dredging in the stiff clay, and it is anticipated that a Cutter Suction Dredger would be required to excavate to the target elevation of -14.5m CD.

2.7 Surrounding Area

On the east side of jetty location in KDWP lies the Hope Island and farther is the Bay of Bengal. Further the Coringa Reserve Forest Extension on Hope Island is at 4 km distance from jetty / FSRU site. On western side the fishermen dwelling are at 2 km distance on the western side industries are located viz. Nagarjuna Fertilizers Ltd., Godavari Fertilizers Ltd., etc. Towards south west of the port, the nearest inhabitation is Dummulapeta about 5km from the subject area of port (**Fig.2.7**).

The coastal region has industrial development, particularly around Kakinada town there are few fertilizer industries and thermal power plants including gas based TPPs. Kakinada coastal area is also identified as art of proposed petrochemical & petroleum investment region (PCPIR) in Andhra Pradesh. There is an Industrial Estate by the Andhra Pradesh Industrial Infrastructure Corporation (APIIC) at Vakalapudi (Approx. 3.5 km distance from jetty / FSRU site).

2.8 Climatology and Sea Conditions in Project Region

The climate in the project region is tropical. December and January are the coolest months of the year, while the period from June to mid-November is the rainy season (average of 157 mm rainfall per month). More than half of the annual rainfall is caused by the southwest monsoon. The maximum and minimum temperature ranges are 32^0C – 40^0C and 12^0C-21^0C respectively. The average relative humidity is 76%.

2.8.1 Depressions / Cyclones in Bay of Bengal

The data on number of cyclones and depressions in Kakinada region for 80 years indicate that the risk of severe cyclones is highest in May and June and from September till November (**Fig.2.7**). The Hope Island acts as a barrier protecting the Kakinada bay from storms approaching from the southern directions. The number of storms and depressions that have developed in the Bay of Bengal in the Kakinada region during 1891-1971 are given in hereunder.

Month	Number of Occurrences		
	Storms	**Depressions**	**Total**
January	-	-	-
February	-	-	-
March	-	-	-
April	-	-	-
May	4	2	6
June	2	2	4
July	-	-	-
August	1	2	3
September	6	28	34
October	13	12	25
November	6	3	9
December	1	1	2
Total	**33**	**50**	**83**

It can be seen that 83 storms and depressions have been observed in the region of which 33 were cyclonic storms. During the cyclone of 1969, the maximum wind speed exceeded 12 on the Beaufort scale and wave heights exceeded 5m outside Kakinada bay. The sea level rise during the passage of the storm was reported to be 3.35m, which is 1.86m above the normal spring tide level.

2.8.2 Wind

The average wind speed does not exceed 19 kmph for about 87% of the time and the direction of the wind varies with the period of monsoon. In general, wind speeds are stronger in the evenings. Winds are mainly from the NE (29.6%), E (15.8%), S (11%) and SW (20.4%).

During SW monsoon the wind speeds are weak averaging 1.5m/s and during NE monsoon, the winds are moderate average 3m/s. The land and sea breeze effect is characteristic to the NE monsoon causing the average wind speed to increase from 1.5-2.5m/s at 0800 hrs to 2.5-3.5m/s at 1700 hrs. The direction is from landward during the day and from seaward during the night.

2.8.3 Sea Waves

During NE monsoon, the wave heights exceed 2m for 32% of the time and 58% of these waves approach from the N-NE. These affect the Bay of Kakinada, which is exposed in the north and NE to direct attach from deep water waves. As rough sea conditions prevail during SW monsoon, wave height exceeds 2m 68% of the time. These however do not affect the Bay of Kakinada, which is protected on the eastern and southern sides by the sand spit.

So the predominant offshore wave directions are mainly based on the monsoon variation and are as given below:

- From November till March, waves from the NE are predominant
- From March through September, waves from the SE are predominant
- In October, waves from the SW and the NE are equally common.

Significant wave heights during NE monsoon vary between 0.2m to 0.8m and the corresponding wave periods vary between 5 and 7 sec. Significant wave heights during SW monsoon are slightly higher with the heights varying between 0.4 to 1.2m, the corresponding wave periods being 6 to 9 sec. Long waves with periods between 9 to 11 sec are also observed during both the monsoons though their percentage of occurrence is only 11 and 18 during the NE and SW monsoons, respectively.

2.8.4 Tides

Tides in Kakinada are semi-diurnal with a mean spring range of 1.3m and mean neap tidal range of 0.5m. The maximum tidal current speeds are 0.4 m/s during spring tide and 0.15 m/s during neap tide. The tidal levels with respect to chart datum are as follows:

- Mean High Water Spring - 1.5 m w.r.t. CD
- Mean High Water Neap - 1.1m w.r.t. CD
- Mean Low Water Neap - 0.6 m w.r.t. CD
- Mean Low Water Spring - 0.2 m w.r.t. CD
- Mean Seal Level - 0.9 m w.r.t. CD

During October, the spring tide heights are notably higher reaching 2.0m mainly due to persistent northeast winds.

2.8.5 Currents

The currents are indirectly determined by large-scale circulation in the Bay of Bengal governed by the monsoon system and are predominantly north going from February to July and predominantly south going from September to December. In between these periods, the direction is varying. The speed of the fully developed coastal current may reach 1m/s. Tide flows do not have any impact on the coastal currents inside the bay, which is open only in the northern end, the circulation is tidal and the spring / flood and ebb/neap currents reach a maximum of 0.25m/s.

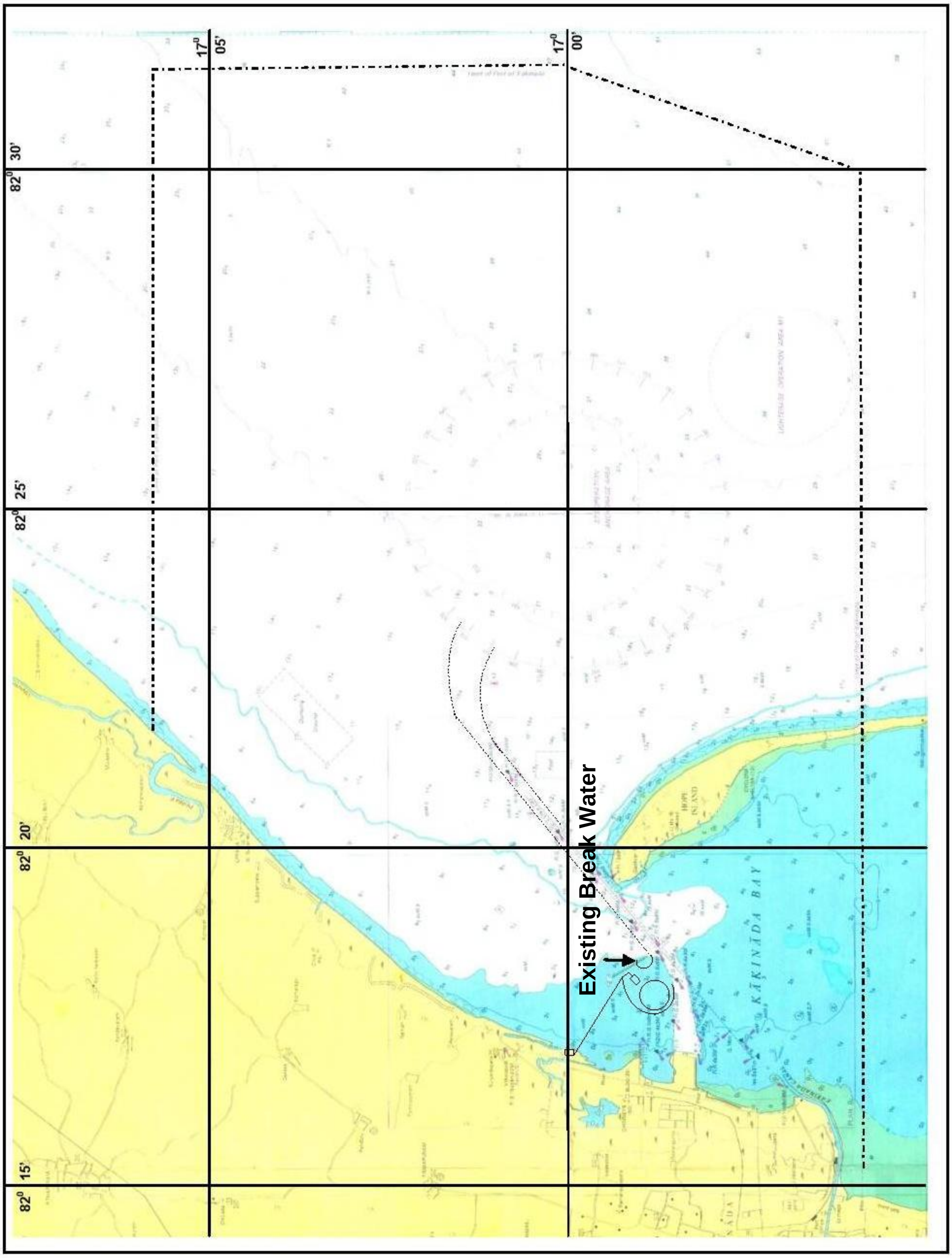


Fig.2.1: Proposed Project Location

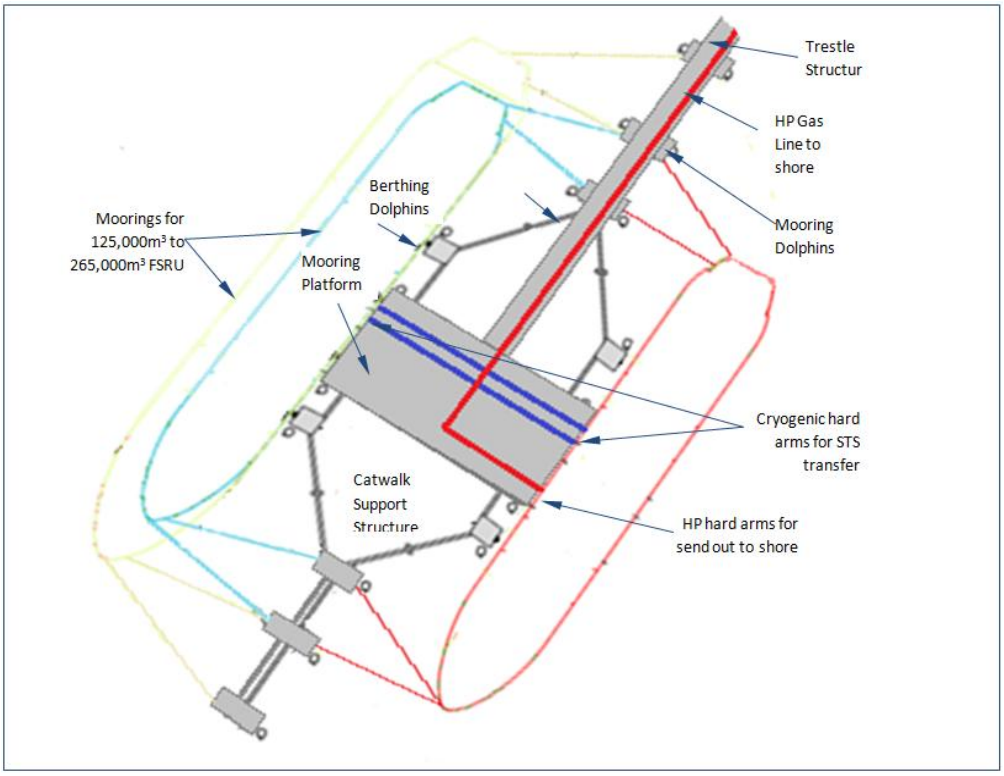


Fig.2.2: Proposed Twin Jetty Lay-out Configuration-1

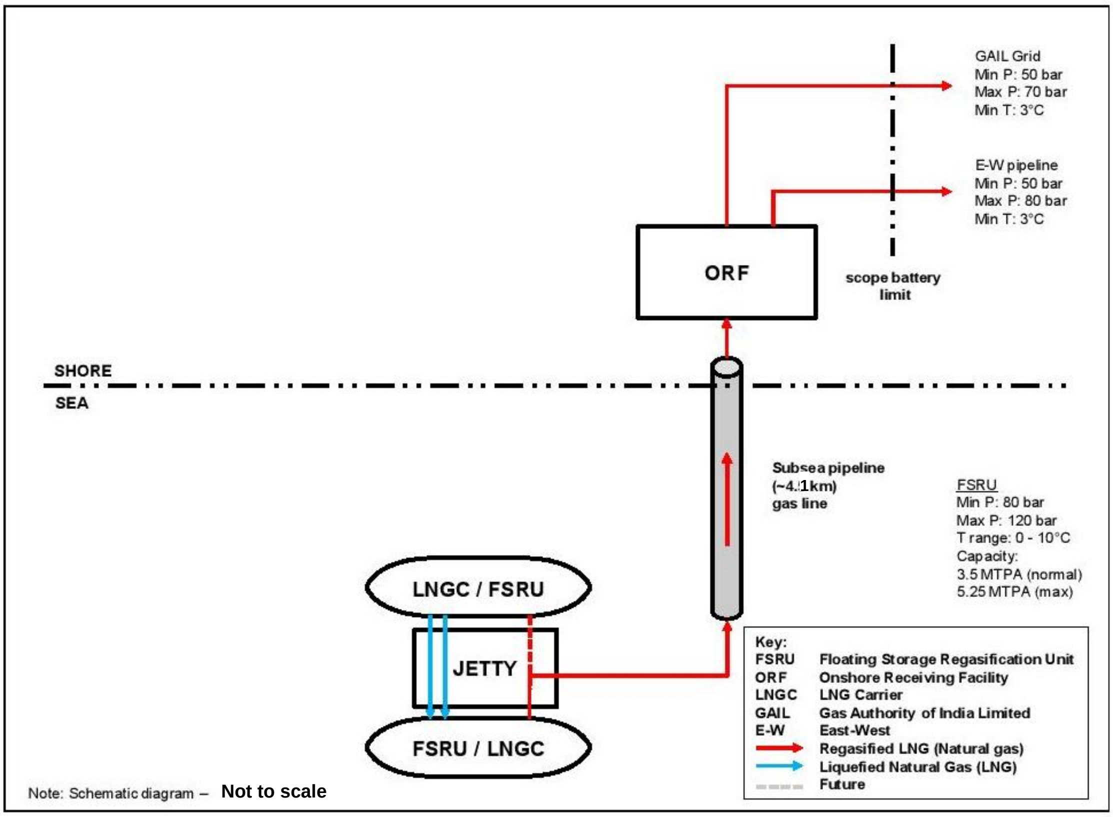


Fig.2.3: Proposed Project Conceptual Schematic of Configuration-1

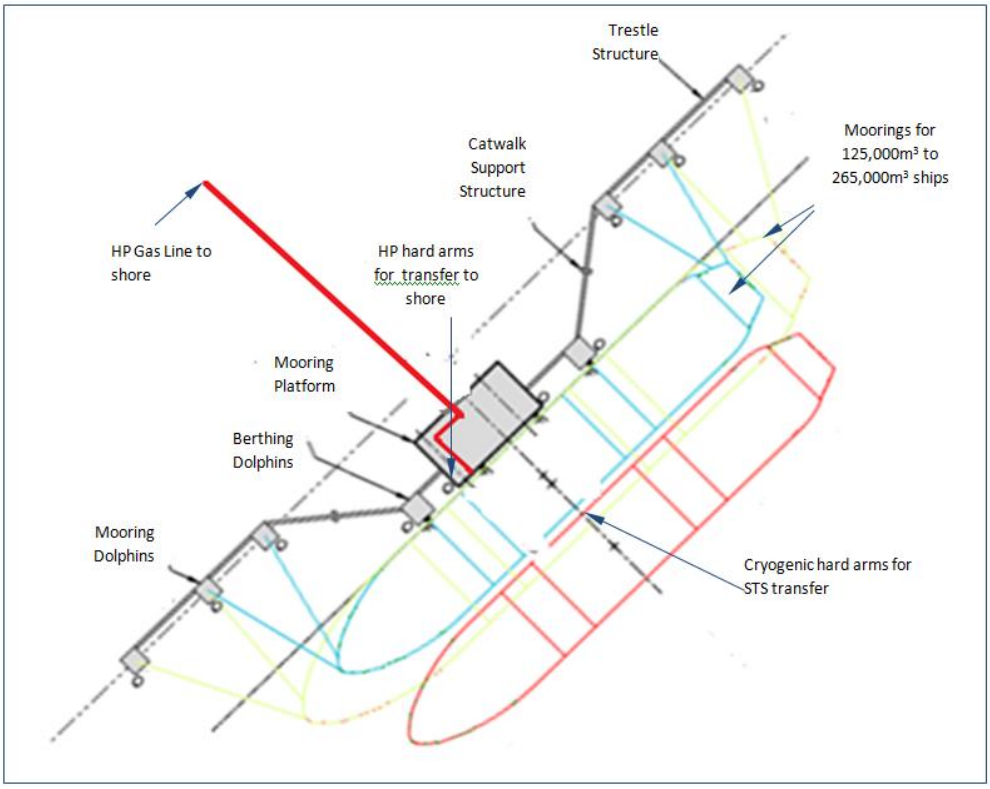


Fig.2.4: Proposed Single Jetty Lay-out Configuration-2

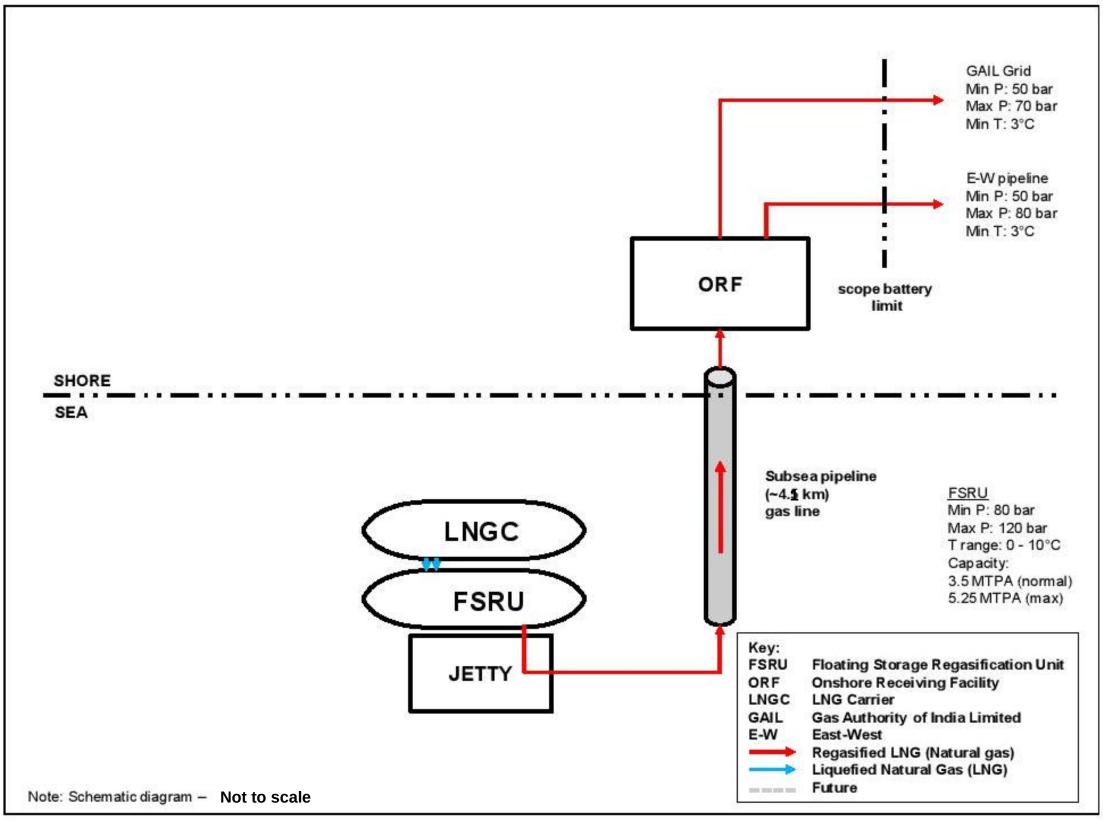


Fig.2.5: Conceptual Schematic of Configuration- 2

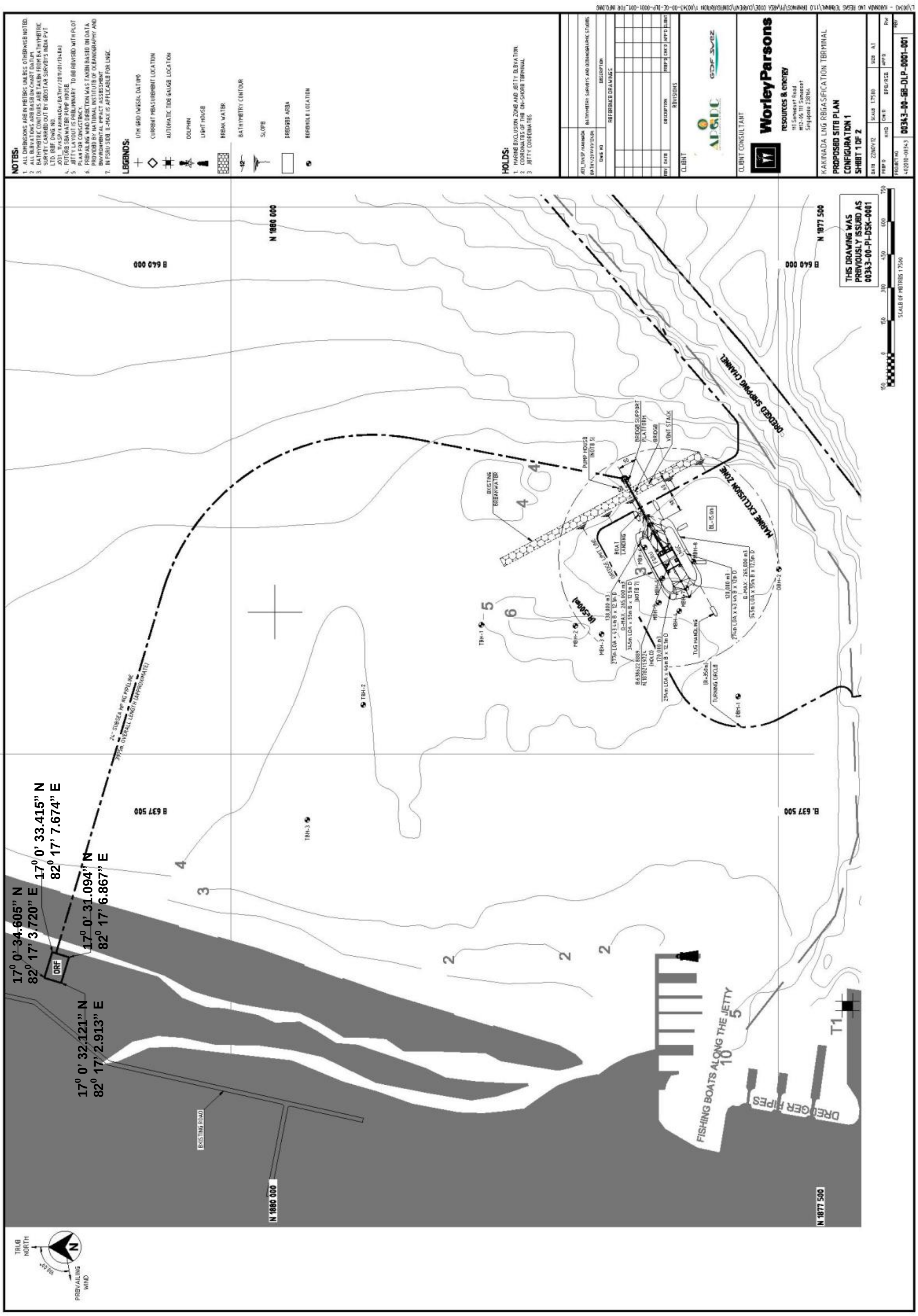


Fig.2.6: Overall Layout of Proposed LNG Terminal Project

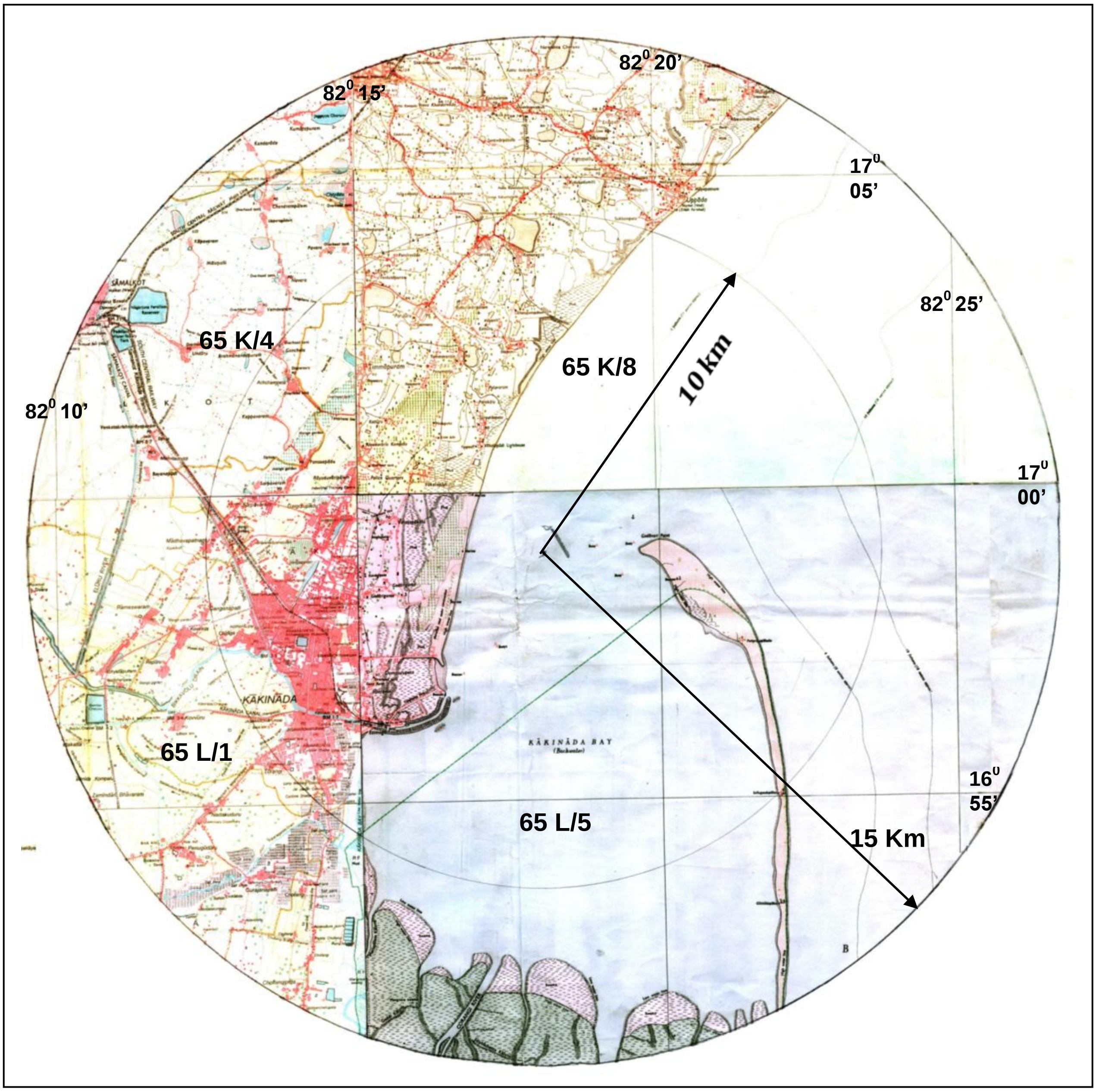


Fig.2.7: Proposed Project Site – Surrounding Area

Table 2.1: Evaluation of Alternative Ports in Respect of Key Aspects

S.No	Key Aspects	Kakinada Port	Visakhapatnam Port	Gangavaram Port
1	Management	Private	Quasi-Government	Private
2	Traffic Density	10 million tons per annum	68 million tons per annum	14 million tons per annum
3	Location for the FSRU	Conventional berth leeside of breakwater	Turret mooring offshore of eastern breakwater	Conventional berth inside port-temporary till future development Turret mooring outside northern breakwater
4	Operational days	350 days (except during cyclones)	250 days (most downtime May-August)	350 days for inside option 250 days for offshore option
5	Impact of terminal on port activities	Minimum impact	No impact	Minimum impact for inside No impact for offshore option
6	Availability of land for onshore terminal	Low lying area on the foreshore	No land near the port	Area to be reclaimed from sea
7	Distance to populated areas	More than 5 kms	More than 5 Km	More than 2 Kms to finishing village
8	Distance to existing gas transmission network	4 to 5 km from FSRU	No gas pipeline network	No gas pipeline network nearby

Table 2.2: LNG Specification as per EN 1160:1996

No	Composition	LNG Example 1 Lean	LNG Example 2 Average	LNG Example 3 Rich
	Molar content (%)			
1	N_2	0.5	1.79	0.36
2	CH_4	97.5	93.9	87.20
3	C_2H_6	1.8	3.26	8.61
4	C_3H_8	0.2	0.69	2.74
5	i-C_4H_{10}	--	0.12	0.42
6	n-C_4H_{10}	--	0.15	0.65
7	C_5H_{12}	--	0.09	0.02
8	Molecular weight (kg/kmol)	16.41	17.07	18.52
9	Bubble Point temperature (°C)	-162.6	-165.3	-161.3
10	Density (kg/m)^3	431.6	448.8	468.7
11	Volume of gas measured at0°C and 101325 Pa/volume of liquid (m^3 / m^3)	590	590	568
12	Volume of gas measured at0°C and 101325 Pa/mass of liquid (m^3 / 103 kg)	1367	1314	1211

Table 2.3: Typical FSRU Specifications

Parameter	Value
FSRU Dimensions	
Length overall	345 m
Length between Perpendiculars	333 m
Breath moulded	50 m
Depth moulded	27 m
Draft design	12.6 m
Ballast Draft	9 m
Air Draft	61 m
LNG storage tanks – Gross Capacity	138,000 –215,000 m^3
Guaranteed max. boil-off rate in storage mode	0.05 - 0.16%
Containment Type	Membrane (reinforced)
Design pressure	0.17bar/g Operating (0.25 -0.7bar/g design)
Sloshing limitations	Assume must meet conventional LNG ship limits if forced to go to sea
LNG Loading rate	6000 m^3/h guaranteed; 10,000 m^3/h peak
Ship-to-ship transfer constraints (significant wave height, wave period,)	1.5 m Hs
Regas Technology	Open loop / close loop (as per market availability)
Minimum send out	50 mmscfd (1.4 mmscmd)
Average/Nominal continuous	500 mmscfd (14 mmscmd)
Maximum Peak send out	750 mmscfd (21 mmscmd)
Boil-off management system	Handle up to 9 tph.; 6000-10,000 m^3/h transfer rates for BOG generated
Vaporisation Facilities	
Open loop or closed loop	Open loop / close loop (as per market availability)
Open loop : minimum sea water inlet temperature	7.5° C

Chapter 3

Description of Environment

Chapter 3

Description of Environment

The proposed project is to develop FSRU based LNG terminal for import, storage, re-gasification of LNG and supply of re-gasified LNG (RLNG) to consumers. The major part of proposed project, i.e. LNG import jetty platform, floating storage and LNG regasification unit (FSRU), subsea pipeline for transport of RLNG etc. will be developed and operated in harbour water (marine activity) within the existing Kakinada Deep Water Port, while the landfall station on the coast (within port area) will consist only control room, gas metering, water bath heaters, emergency backup generator set etc. The total gas (LNG & RLNG) handling will be through only pipelines and no road rail transport of RLNG is envisaged in operation phase of proposed project.

The pre-project environmental quality in study area around project site serves as the baseline status for assessing the impacts from proposed developments during construction and operation phases. The pre-project environmental monitoring data are also useful for identification of significant environmental concerns in project area. In view of major part of proposed project pertains to development and operation in marine area, the pre-project status of marine environment (marine water & seabed sediment characterization, fisheries activities and marine biology) becomes essential in this EIA study. The baseline environmental field studies were carried out for different components of environment, viz. Land, Water, Biology, Air, Noise and Socioeconomics apart from marine studies.

In this study the baseline status of individual environmental components has been assessed through field monitoring (primary data) as well as compilation of secondary data from authentic sources and past studies in the project region. The following sections comprise primary environmental quality data monitored during post-monsoon (October – December, 2012) for terrestrial components and the marine studies during NE monsoon / winter (February, 2013) season.

3.1 Study Area

The proposed FSRU based LNG terminal will be developed within the existing Kakinada Deep Water Port (KDWP) at Kakinada is situated in the coastal region of East Godavari district of Andhra Pradesh. The project site is on the coast line and the surrounding (10 km / 15 km radial distance) study area comprised more than 50% (eastern part) Bay of Bengal and less than 50% (western part) is land portion. The land part of the study area is in coastal area and largely covers Godavari river delta region, consisting multiple drains and irrigation canal network. The 10 km radius study area is flat terrain (<10 km above m.s.l. elevation) with gentle slope towards east, i.e. Bay of Bengal coast. The area is mainly dominated by agriculture through canal irrigation. The Godavari river water distribution through canal network originating from the Godavari Barrage near Rajahmundry extensively spreads in the deltaic region. Apart from irrigation purposes, the canal water is extensively used for domestic purposes and fishing activity. The river distributaries and irrigation canals in the region are also used for navigation purposes. Most of the villages in the deltaic area are primarily dependent upon agriculture where paddy, sugarcane, coconut, oil seeds and cereals are major crops. Fisheries is next major occupation for the inhabitants in coastal villages. The Fisheries in this region comprise marine fisheries, coastal / aquaculture and inland canal / freshwater fisheries including ponds in villages

3.1.1 Climate

The climate in the area is tropical monsoon type. Wind patterns are governed by the SW & NE monsoons and transition periods between them, dividing the year into four seasons. The two transition periods, March-May (pre-monsoon / summer) and October-November (post-monsoon) are characterized by occurrence of Cyclonic storms, the latter period being more active. The South-West monsoon (June-September) is characterized by strong, persistent wind and rough seas. Majority of the normal rainfall received in the region is during South-West monsoon (June-September).

North-East monsoon (December-February) is the fair weather season with light, variable winds and generally calm seas. The general climatological conditions recorded data from Kakinada is presented below:

- The highest recorded temperature is 47.2^{0}C (May-June) and lowest 13.9^{0}C (December)
- Relative humidity varies from 61% to 90%
- The average annual rainfall in Kakinada area is about 1115 mm (1100-1150 mm). The highest recorded monthly rainfall is 834.4 mm in October, 1994
- The predominant wind direction during North-East monsoon is from North through East. Wind speeds greater than 30 kmph are for about 22% of the time, while the transitional periods are characterized by low speed variable winds, when there are no storms.
- The tropical depressions / cyclones in Bay of Bengal occur very frequent especially during post -monsoon season (October-November). Though occur rarely, the cyclones during pre-monsoon and SW monsoon are generally more intense in nature. The most severe storm to affect the project region was in November 1996 which tracked across in the southern part with sustained wind speeds of 115 knots (59 m/s).

3.1.2 Geology / Soils

The study area is underlain by diverse geological formations ranging in age from Achaeans to recent and chiefly underlain alluvium, upper gondwana, sand stone, khondalities, unclassified crystalline gneiss, schist are the predominant revos in the study area.

Ferruginous sand stones with light gray to mottled clays in turn underlie Deccan traps. These formations are white to yellow or brownish red in colour. In the study areas the sandstones are concealed beneath the alluvium.

The Black cotton soil is common soil texture and is predominantly clay with aches of silty loam. Five soil samples were collected within 10 km radial distance of the study area and were analyzed to known the soil quality.

The important soils of the zone are soils with clay base (alfisols) black cotton soils which are heavy and deep to very deep (vertisols), red loamy soil also deep to very deep (Alfisols), coastal sands (Entisols). In the uplands, red and black soils are found. Besides the alluvial soil, in the eastern part of the study area, there is considerable area of uplands of both red and black soils where dry or irrigated dry crops are grown under well irrigation.

3.1.3 Industrial and infrastructure facilities:

Kakinada and the surrounding region are having some industrial development. There are few major industries in the vicinity of the project site, viz. Nagarjuna Fertilizers and Chemicals Ltd (NFCL), Godavari Fertilizers Ltd. and Corromondal International Ltd., the thermal power plants like Spectrum power plant, GMR Barge mounted gas based power plant within the study area apart from Kakinada Sea port (KDWP and Anchorage port) activities in the study area. With the availability of seaport (infrastructure) facilities, there are marketing terminals developed by M/s IOCL, HPCL and BPCL for petroleum oils and lubricants.

Agriculture related small and medium scale industries, e.g. boiled rice mills, sugar mills, Agro/ edible oils, coconut processing etc. Brick kilns, aquaculture, sea food processing, cold storages etc., are the other industrial activities in the project region. The Oil and Gas exploration and production facilities are located about 40-50 km distance from project site.

Kakinada is connected with double line broad gauge railway to Samalkot (about 15 Km track distance), a railway junction on east coast trunk link. The National Highway – 5 (east coast) is a about 15-20 km distance from Kakinada, connected by state highways / district roads.

3.1.4 Ecology

The eastern part of the study area, i.e., port harbour (Bay of Bengal sea, comprises a natural sand spit (about 15 km long) called Hope Island, which protects Kakinada bay area and dense mangrove forest on the south side of the study area, from strong waves in open sea. As per the Survey of Indi Toposheet (65 L/5) the Hope Island is covered under Coringa extension of reserve forest which is about 4 km away from project site ESW direction (as eastern coast / bank of Kakinada Bay). The Dense mangrove in the swamp of Godavari Distributaries, notified by AP State Department of forests, as Coring Wildlife Sanctuary exists at about 12 km distance from project site in south direction. However, there are no mangroves within the study area (10 km radial distance). The details about Coringa Wildlife Sanctuary are given in chapter 3 under Biological environment.

3.2 Marine Environment

3.2.1 Hydrography

Hydrographic measurements including bathymetry, currents and tidal variations were made for comprehending coastal hydrodynamics in proposed project study area. The total study area is divided into two parts, i.e. at and around proposed Jetty & FSRU location / KDWP harbour area / bay area and other is at and around the designated offshore dumping area (**Fig.3.2.1**). The coastal marine hydrographic studies have been carried out through M/s Coastal Marine Construction & Engineering Ltd., (COMACE), Mumbai/ Kakinada. The marine survey was conducted during February 9-24, 2013. The details of survey vessel, onboard equipment and survey crew are given in the study report prepared by COMACOE (attached as ***Appendix-2***). Data on water currents (speed and direction) and tidal variations were recorded on continuous basis using ADCP at two locations. The study period (February 9-26, 2013) was planned in such a way, that covers low (neap) tide as well as high (spring) tide periods.

3.2.2 Bathymetry

A bathymetry survey has been carried out covering the proposed project activities (dredging, marine construction and dredge material dumping area) in order to augment the available data through hydrographic chart. Odom Echotrac MK III single beam, dual frequency (24 and 200 KHz) echo sounder was utilised to acquire the bathymetric data with accuracy better than +0.10 m. It has the ability to minimize near-surface noise caused by transducer ringing while increasing sensitivity to echo return and hence is capable of both shallow and deep water operations. A value of 1530 m/s was used as the average velocity of sound in seawater based on the bar check calibration carried out at site. This was applied in the set-up of the echo sounder during acquisition. The data so obtained was then processed using NavEdit and reduced to chart datum using observed tides of Vakalpudi and contouring was done using Terra Model software. All data acquired was processed and reduced to chart datum by using established Vakalpudi observed tide. Legible representations of the sounding in the bathymetry panels of the drawings on scale 1:10000 were made, and contours were generated at 1m interval. **Fig. 3.2.2 and Fig. 3.2.3** depicts the observed Bathymetry of FSRU area and designated (offshore) dredge material dumping area respectively during study period.

3.2.2.1 Bathymetry at FSRU Area

Water depths within the surveyed area range between 1.2 m and 16.6m. A dredged channel observed having West Southwest (WSW) - Northeast orientation within the surveyed area. Water depths in this channel vary between 10.0m to 16.0m; the deeper 16m depths are observed towards Northeast part of dredged channel. Shallower water depths (ranging between 1.5m to 3.0) are observed on either side of the dredged channel towards western end of the surveyed area (parallel to shoreline).

3.2.2.2 Bathymetry at Dredge Material Dumping Area

Water depths within the surveyed area range between 3.1m and 18.2m. Seabed is devoid of any major topographical features, and in general water depths gradually increases from shoreline to seawards i.e. from west to east. From midpoint of shoreline to 2000m towards Southeast corner of surveyed area; water depth increases with a general gradient of 1:369; and hereafter towards end of Southeast corner, water depth increases with a general gradient of 1:725.

3.2.3 Waves & Tides

For detection of current velocities, Acoustic Doppler Current Profiler (ADCP) is used that relies on the Doppler effect. The sensor also tracks the water surface in the upward looking deployment mode there by collects tidal variation data due to the rise and fall of the water surface level.

The water surface level data collected by the device is extracted and the tidal curves generated. From the data set, four Low water springs and the intervening three High water springs are used with the Corresponding Low water springs and High water Springs of Kakinada which is an established tidal port to carry out a transfer of vertical datum to establish Chart Datum at Vakalpudi using the tide datum transfer form H.533. The ADCP data was collected using RDI Workhorse Sentinel deployed on seabed looking up at two locations: Vakalpudi and Uppada. The data was collected at 10 minutes interval during 09 February 2013 near Vakalpudi and Uppada Locations. The software module WinSC is used to download the data from the ADCP to the processing station and thereafter WinADCP is used for data viewing, analysis and exporting. The observed water level from ADCP and tidal variations in wave height near Vakalpudi during study period are depicted in **Fig. 3.2.4.**

The ADCP deployed in the FSRU Area (ADCP- Vakalpudi location), and during the measurement period, the variation of the current speed along the vertical profile varied from 0.2 knots on the Bottom to 0.7 knots at Surface; with an average stream of 0.50 Knots. The directions of the currents were distributed mainly towards South-southwest (SSW) to South-southeast (SSE) during Flood stream; and North northwest (NNW) to North-northeast (NNE) direction during Ebb stream. Whereas in the Dredge Dump Area (ADCP-Uppada location), the variation of the current speed along the vertical profile varied from 0.3 knots (0.15 m/s) on the Bottom to 0.7 knots (0.36 m/s) at Surface; with an average stream of 0.46 Knots (0.24 m/s). The directions of the currents distributed mainly towards North-northeast (NNE) during Flood stream; and Northeast (NE) to East-Northeast (ENE) direction during Ebb stream.

The currents vector rose diagram of the Flood and Ebb Streams near Vakalpudi and Uppada are presented in **Figs. 3.2.5 & 3.2.6.**

3.2.4 Marine Water Quality Assessment

Based on the reconnaissance, the type of water body, its relative importance as resource and its proximity to industry sampling locations were identified. Sampling procedure involves sample collection using Niskin water depth sampler, a device for obtaining samples of seawater at a specific depth. Linear polyethylene containers leached with 2 M reagent grade nitric acid for 48 hrs at room temperature and rinsing with double distilled water were used. Samples for hydrocarbon estimation were collected in glass bottles of one litre capacity, prewashed and rinsed with n-hexane. Similarly samples for biological analysis were collected by using standard plankton net. Finally all the samples were preserved as per standard preservation technique prior to its transportation to the laboratory. Field parameters viz. temperature, pH, dissolved oxygen were analyzed immediately after collection. Selected physico-chemical and biological parameters have been analyzed for assessing the existing water quality status in the study area.

3.2.4.1 Sea Water - Physico-chemical Characteristics

In order to generate the baseline sea water quality (physico-chemical and biological) of the region, a study was undertaken by employing MFV SIRI- a survey vessel and 24 sampling locations were identified with a grid pattern. Surface, Middle and Bottom samples were taken at High Tide from each location. The sampling locations are shown in **Table 3.2.1** and depicted in **Fig. 3.2.1**.

Analysis was carried out as per standard methods for examination of water and wastewater and data obtained on water column for various parameters are presented in **Tables 3.2.2-3.2.9**. The results of sea quality in February 2013 are summarized as follows.

The pH and temperature in total study area ranged between 7.2 and 8.1, 26.0-28.0^{o}C respectively (**Table 3.2.2**).The turbidity in FSRU and jetty area is relatively higher that the dumping area. The total suspended solids vary from 11-142 mg/l, whereas chlorides were found in the range of 17562-20355 mg/l. Salinity values have been found to vary between 32‰ and 37‰ (**Table 3.2.3**).

Dissolved Oxygen

Dissolved oxygen available in water at any given time is a result of amount consumed by aquatic organisms and replenishment through natural processes. In the marine area of study region, dissolved oxygen was found in the range of 6.1 to 7.7 mg/l (**Table 3.2.4**) Dissolved oxygen was stable throughout the season in this marine region. Surface water, however, was nearly saturated showing adequate dissolution of oxygen at the interface due to mass transfer.

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by microorganisms for stabilizing biodegradable organic matter present in wastewater under aerobic conditions. The test is widely used to determine the quantitative load of biochemically oxidizable organic matter and degree of organic pollution. The BOD values were less than 3 mg/l in the samples collected from study area (**Table 3.2.4**).

Nutrient

Nutrients determine the primary production potential of the water body and therefore, it is important to know their distribution and behavior in different geographical locations and seasons. Nitrogen and phosphorus compounds form major source of nutrients for growth of phytoplankton. Forms of nitrogen involved in the biogeochemical processes in aquatic systems are dissolved inorganic species viz. ammonia, nitrite and nitrate. Nitrate is an essential nutrient for the growth of many photosynthetic autotrophs and has been identified as the growth limiting nutrient. Nitrate levels in the region were found in the rage of 0.4 to 1.1 mg/l. Low concentrations were observed in sea away from the coast whereas high levels were detected near the coast. Uptake of nitrates by planktons during the production period could be the reasons for low levels of nitrates in deep area during sampling period **(Table 3.2.4)**.

Heavy Metals

Inorganic elements such as metals even at trace levels invite attention due to their persistence in water bodies. Some of the heavy metals viz. cadmium, chromium, copper, lead are toxic at very low concentrations and can affect the prey and predator equilibrium in water body. The heavy metals were determined by using method 3120-B (Apha 21st edition) by acid digestion and analysed at ICP-OES. The heavy metals, viz. cadmium, chromium, lead, copper, iron, manganese and zinc were estimated in water column and results are presented in **Table 3.2.5**. Chromium concentration was reported in the range of ND-0.0112 mg/l and iron reported in the range of 0.0072 -1.57 mg/l. Cadmium values are in the range of ND- 0.0276 mg/l. The results indicating that there is no pollution due to heavy metals in the region.

The overall physico-chemical characteristics indicate homogeneity in terms of salinity and dissolved oxygen. Slight variations in turbidity and nutrient values in terms of nitrogen, phosphate and nitrate may be attributed to the tidal currents and flow pattern in the region. The overall water quality in the study area is good with respect to levels of organics and heavy metals indicating that the area is relatively free of pollution.

3.2.4.2 Biological Characteristics

Biological species viz. phytoplankton and zooplankton specific for a particular environmental condition are the best indicators of environmental quality. Studies on biological aspects of ecosystem are important in environmental impact assessment in view of the conservation of environmental quality and safety of natural flora and fauna including human-beings. Information about the impact (environmental stress) on the community structure serves as inexpensive and efficient "early warning and control system" to check the effectiveness of control measures to prevent damage to a particular ecosystem (e.g. adjustments of emission norms, management of installations and sanitation etc.) Planktons (phytoplankton and zooplankton) being good indicators of environmental stress have been included in the study.

The nature and quality of biological species in a water body is dependent on various physico-chemical characteristics of water such as pH, conductivity, nutrients, BOD, alkalinity etc. and also on the type of water body such as flowing waters (canals), stagnant water (lakes) and saline water (sea). Thus the quality and quantity of plankton obtained in any water body is an indicator of the physico-chemical quality of water as well as the type of water body. The estimation of plankton community structure in water bodies is thus helpful to assess the baseline status. Details are as follows:

(a) Total biomass

The total biomass (expressed as count or by weight) increases with the increase in levels of nutrient and BOD in water and vice versa, and serves as a good indicator of trophic status of water body.

(b) Quality

Presence of different organisms has been listed in standard publications according to increasing trophic levels in aquatic environment. Similarly, many organisms have been listed to favour certain physico-chemical conditions, viz. silicates for diatoms etc. Hence presence of certain groups is also indicative of trophic conditions.

Desmids and Diatoms indicate highly eutrophic conditions. Planktonic rotifers are usually abundant in fresh water. It is believed that when crustacean (copepoda, cirripedia, ostracoda etc.) and insects outnumber other groups, the situation reflects the enriched organic condition of water. Thus presence of certain organisms helps in classifying water body in trophic levels in knowing its physico-chemical characteristics.

(c) Diversity

Diversity of planktons depends on physico-chemical characteristics of water especially on trophic levels. In oligotrophic water diversity of plankton is high. While with increasing levels of pollution such as mesotrophic and eutrophic condition diversity of planktons decreases. Shannon Weaver Index is a measure of diversity of planktons which takes into account the total count and individual species count in a water sample.

$$d = - \Sigma \, (ni/n) \log_2 (ni/n)$$

where,

d = Shannon Weaver Diversity Index

ni = number of individual of each individual species in a sample

n = total number of individual and of all species in the sample

It should also be noted that the diversity is also susceptible to other parameters such as turbidity, colour and flow rate particularly in hilly rivers. Thus the results should be interpreted with caution. A widely accepted ecological concept is that communities with large number of species (i.e. with high diversity) will have high stability that can resist adverse environmental factors. The maximum value of Shannon Weaver Index of Phytoplankton for clean waters has been reported to be around 6, though it may differ slightly in different locations. Decrease in the value of index may thus be taken as indicator of pollution.

In the present study, 24 water samples were collected from Sea water. For Phytoplankton analysis surface, middle and bottom samples were collected from high tide conditions and for Zooplankton analysis only surface water samples were collected, to establish diversity index to assess biological quality.

(d) Phytoplankton

The count as number of organism per ml of sea water varied between 200 to 3200 nos. / ml. Bascillariophyceae was found to be the dominant group present. SWD Index varies between 1.47 to 5.05, indicating moderate to healthy water body (**Table 3.2.6**). The phytoplankton species identified are given in **Table 3.2.7**

(e) Zooplankton

The productivity is more in open sea, which is due to uplifting of nutrients from the bottom to surface. This is called upwelling phenomena observed more in summer.

The zooplankton species / groups, its population dynamics and community composition at each sampling location are shown in **Table 3.2.8**. The count as number of organisms per m^3 of sea water varied between 100 to 1550. Decapoda was found to be the dominant group followed by Copepoda **(Table 3.2.8)**. The SWD index varies between 0.76-2.72, which indicates moderate to good productivity except in sample WS18 i.e. from Dredge material dump area. Zooplankton species identified are shown in **Table 3.2.9**

3.2.5 Seabed Sediment Quality

3.2.5.1 Sediment Characterization – Baseline Status

19 sediment samples were collected as per the standard procedure using Van Veen Grab Sampler to evaluate the existing status of sediment quality. 13 samples were collected from proposed jetty and FSRU area and 6 samples were from Dredge Material Dump area. The locations identified within project area are given in **Table 3.2.1** and **Fig. 3.2.1.**

Representative sediment samples were collected from the project site for evaluation of the physico-chemical characteristics of sediment. Standard methods have been followed for the analysis of sediment samples.

The international pipette method (Black, 1965) was adopted for determination of particle size distribution and texture based on the United States Department of Agriculture (USDA).

The chemical characteristics of sediments were determined by preparing saturated sediment paste by adding distilled water (Agri. Hand book 60 USDA) and determine sediment reaction and salinity level. Organic carbon content was also determined by Walkley and Black method (1973), Total nitrogen was determined by Kjeldhal method and total phosphorus was determined by Vandomolybdo phosphoric yellow Colour method (spectrophotometric) (Jackson ML 1967). Potassium was determined by flame photometer (Jackson ML 1967).

Heavy metals in sediment samples were determined by extracting sediment by Hydrochloric acid and Nitric acid mixture digestion and analysed on ICP-OES (SW-846-6010-B / EPA).

3.2.5.2 Physical and chemical Characteristics of sediment

Physical characteristics of sediment samples are delineated through specific parameters, viz., particle size distribution. The data indicated that the sand (0.02 – 2mm) are in the range of 31.6- 57.2% in Proposed Jetty and FSRU Area and a higher range (39.2-79.2 %) of total sand is observed in Dredge material Dump Area. The particle size distributions in terms of sand, silt & Clay particles are furnished in **Table 3.2.11**.

The collected sediment samples were analysed for various chemical parameters, viz. pH, dissolved salts - carbonate, bicarbonate and chlorides, total nutrients content, organic carbon content, heavy metals content are presented in **Tables 3.2.12 -3.2.14.**

pH is an indicative of the alkaline or acidic nature of the sediments and greatly affects the microbial population, solubility of metal ions as also regulating nutrient availability. Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent. Optimal pH range for sustainable aquatic life is 6.5 - 8.2. The pH of sediment within the study area is presented in **Table 3.2.12** and it was observed that the sediment are neutral to mildly alkaline in reaction as their pH is in the range of 7.04- 7.56.

Dissolved salts were determined from sediment water extract. The dissolved salts chloride, carbonate and bicarbonate in the sediments are in between 7952 to 32944 mg/kg, 60 to 360 mg/kg and 122 to 732 mg/kg respectively.

Organic matter present in sediment influences its physical and chemical properties. Sediment analysis shows lower to higher values of organic carbon content in the sediment which is in the range of 0.01 to 4.17 % (**Table 3.2.13**) except in sediments samples from WS04 with very high TOC i.e. 11.82%. The rich condition of TOC may be due to organic matter from natural sources such as plant materials deposited on sediments or anthropogenic inputs to sea water. Amongst the nutrient parameters, Total Nitrogen showed low to high value, ranging from 0.019 – 0.142 %. Total Phosphorus and Total Potassium was found in the range from 0.058 - 0.428 % and 0.014 – 0.040 % respectively. (**Table 3.2.13**)

3.2.5.3 Heavy Metals

Selected Sediment samples from Jetty and FSRU area and Dredge Material Dump area were analyzed for heavy metals such as Chromium (Cr), Zinc (Zn), Lead (Pb), Nickel (Ni), Cadmium (Cd), Manganese (Mn), Iron (Fe), Copper (Cu) ,Cobalt (Co), Mercury (Hg), Arsenic (As) and Hexavalent Chromium (Cr^{+6}) , their concentrations in mg/kg are presented in **Table 3.2.14.** Amongst these metals, Iron and Manganese concentrations were more as compared to other metal levels. The heavy metals occur in the sediment as cations and are adsorbed by the negatively charged sediment particle. They are held strongly as complex on the surface of clay alumino silicates hydrated oxide and humus. In general, adsorption increases with pH. Heavy metals pollution is serious because it can persist for many decades. The heavy metals also create problems in the nutrient utilization of aquatic life.

3.2.5.4 Macrobenthos

Sediment samples were collected through vin-ven grab samplers. The collected samples were homogenized and portion of the sample was transferred to the fresh, washed polyethylene bottle and 10% formalin was added. The preserved samples were brought to the laboratory and sieved with Ruse Bengal for identification of the macrobenthos. The identified macro benthoses are shown in **Tables 3.2.15 & 3.2.16**.

3.2.6 Fisheries

The marine fisheries are prominent traditional occupation of fishermen community in coastal belt of East Godavari district. The marine fishing is prohibited within the port limits as defined in Hydrographic chart. However, a full-fledged fishing harbour is developed in Kakinada bay area on the north of existing Kakinada deep water port. The details regarding fishing as obtained from district statistics are presented in **Tables 3.2.17 & 3.2.18**. As per these details the coastal marine as well as inland (aquaculture) fisheries contribute to considerable component of local economy.

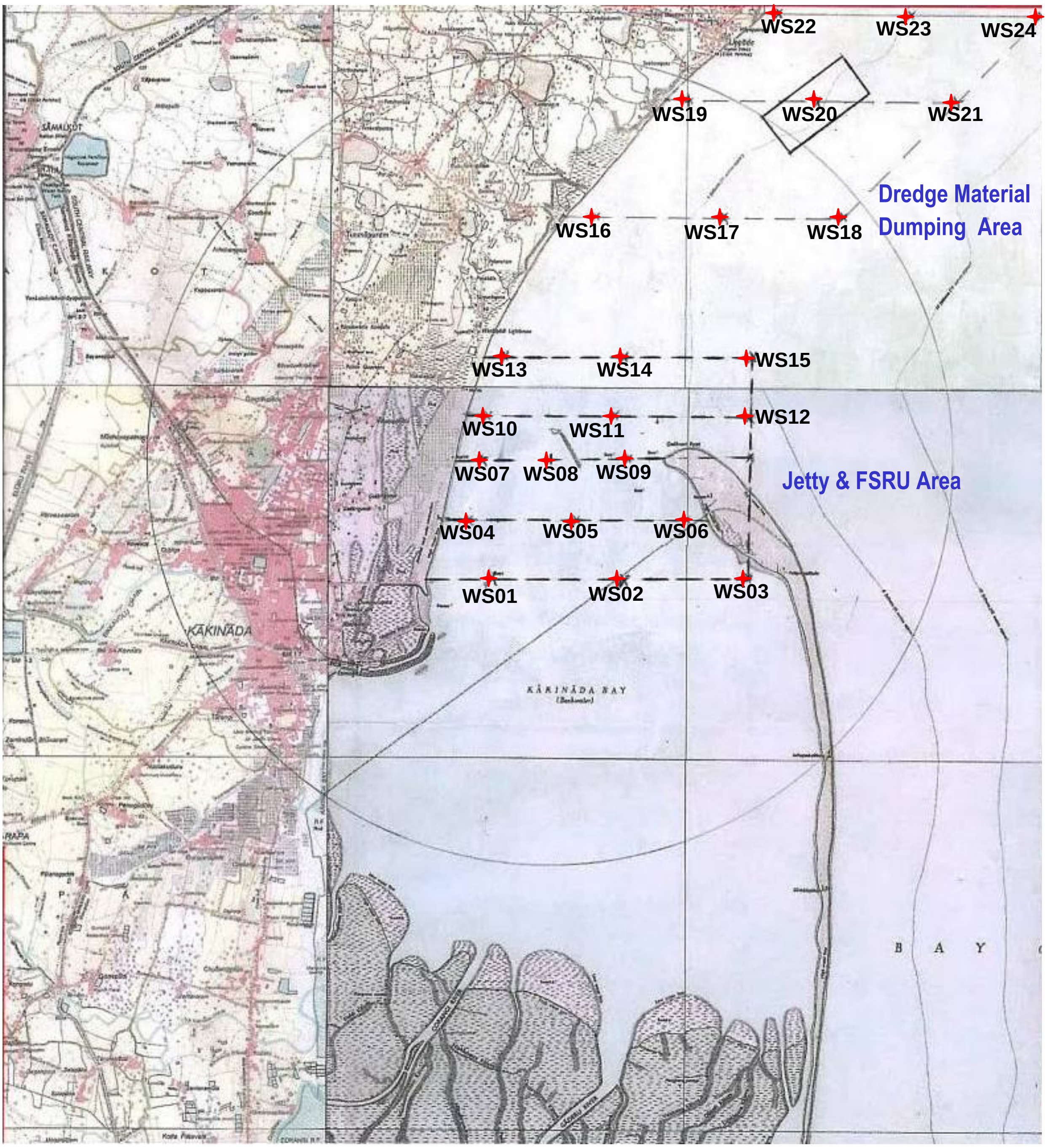
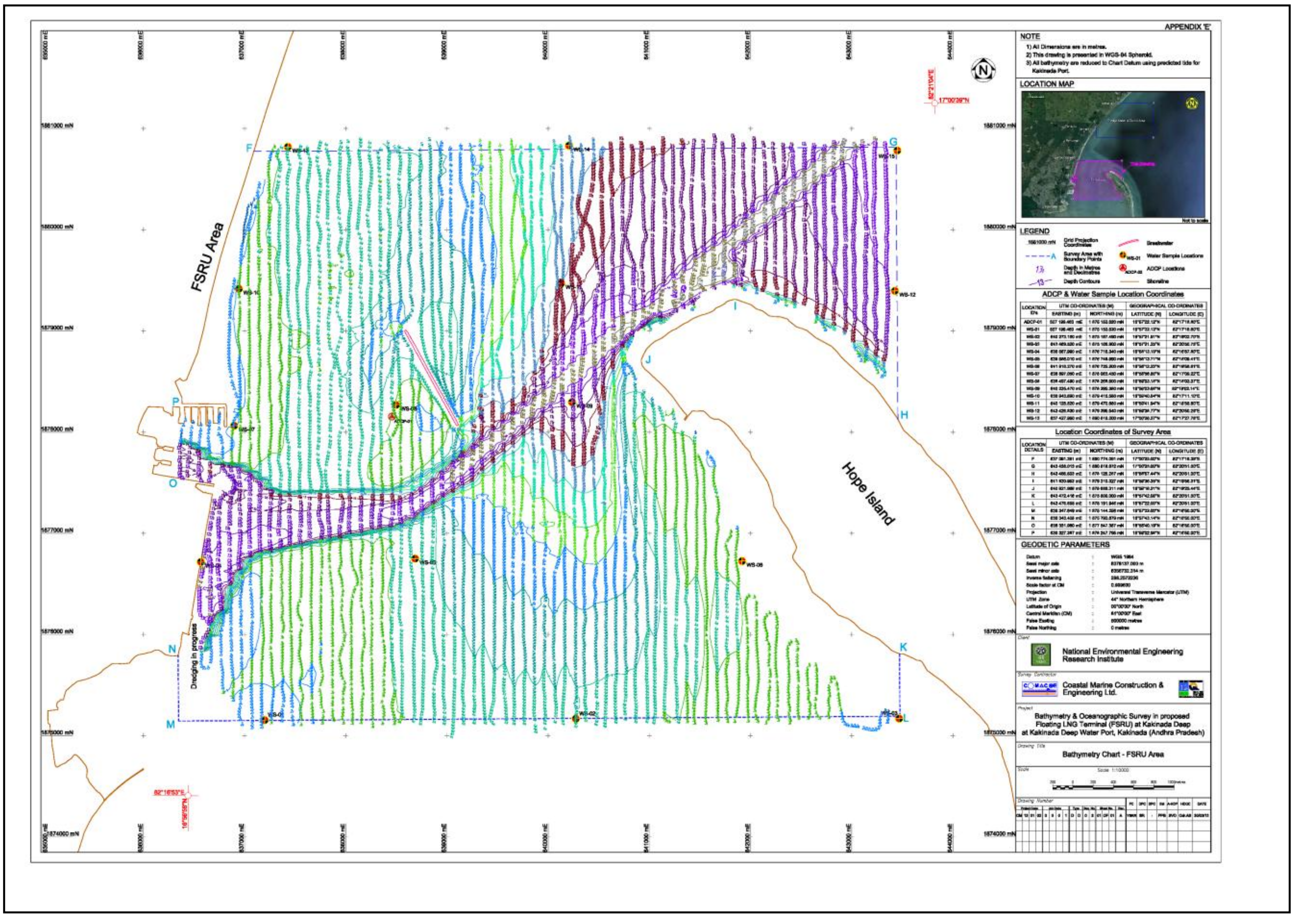
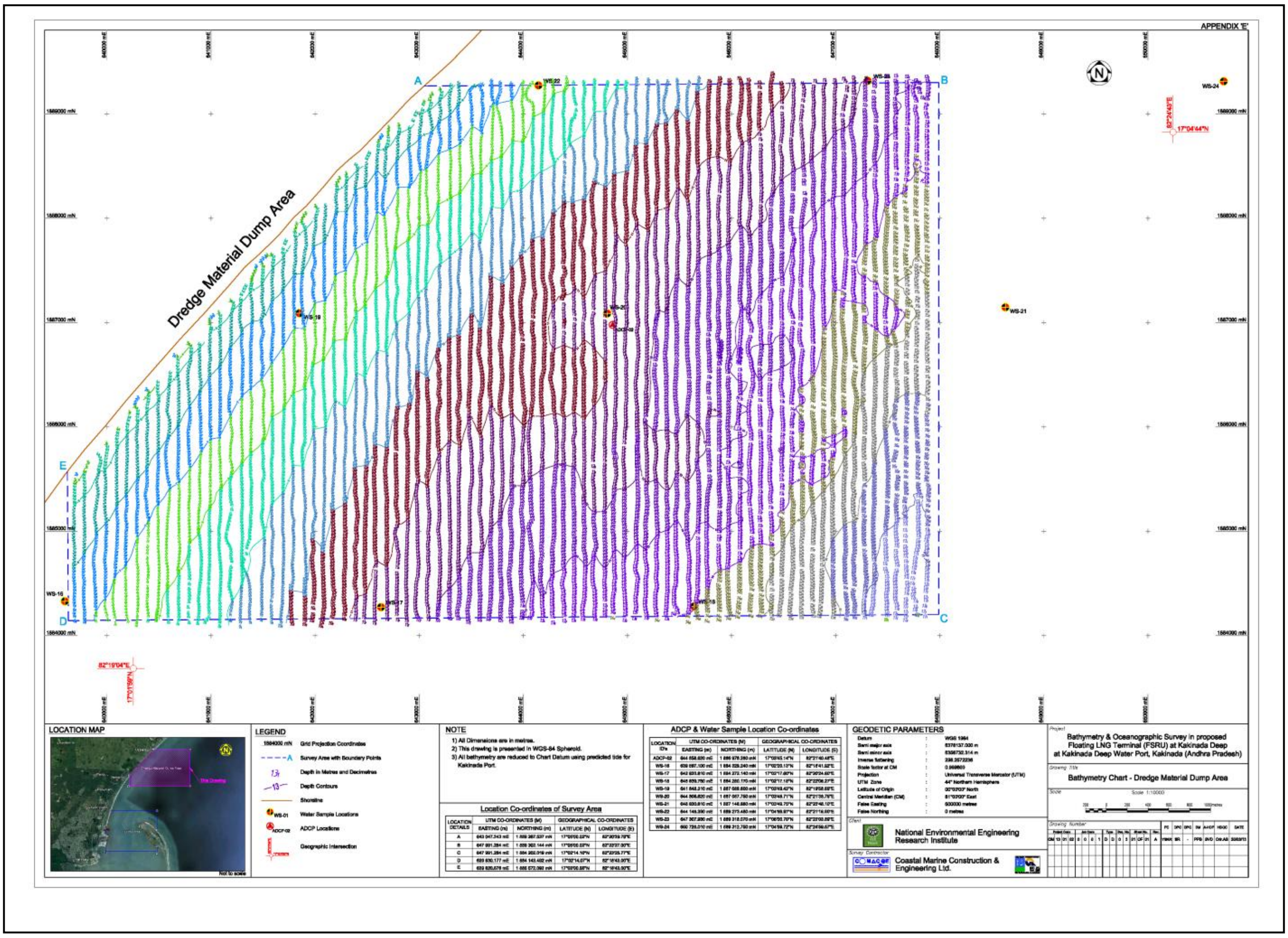


Fig. 3.2.1 : Marine Study Area with Sampling Locations



. **Fig. 3.2.2 : Observed Bathymetry in Jetty & FSRU Area**



. **Fig. 3.2.3 :Observed Bathymetry in Dredge Material Dump Area**

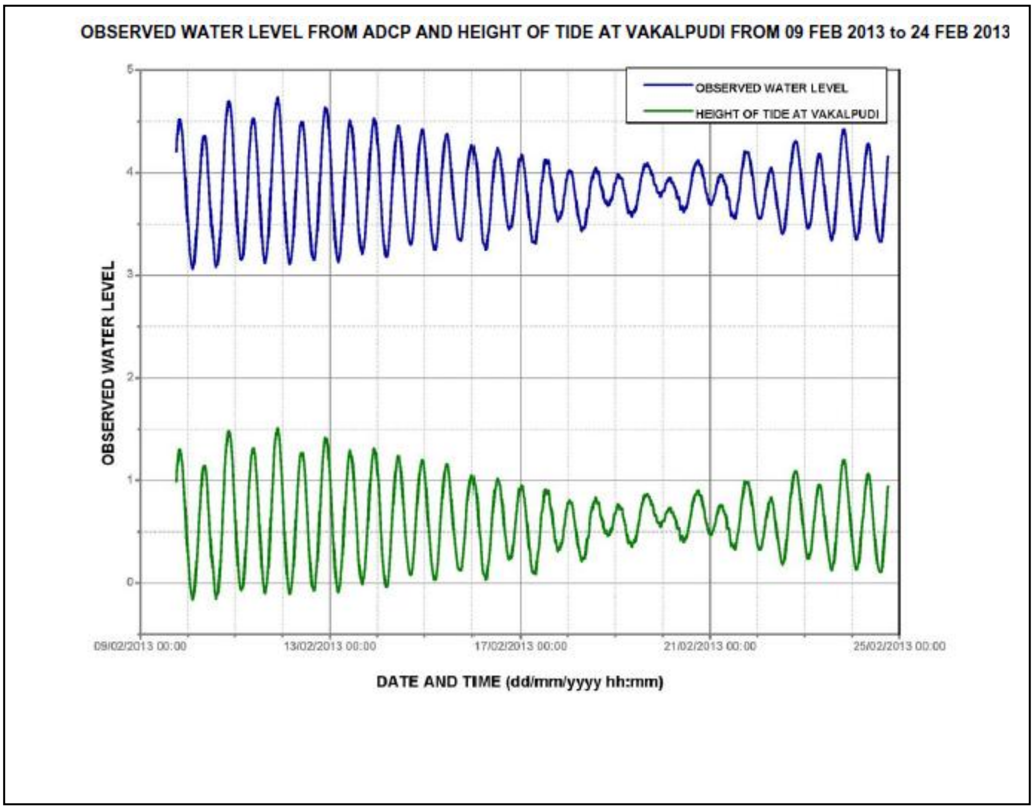
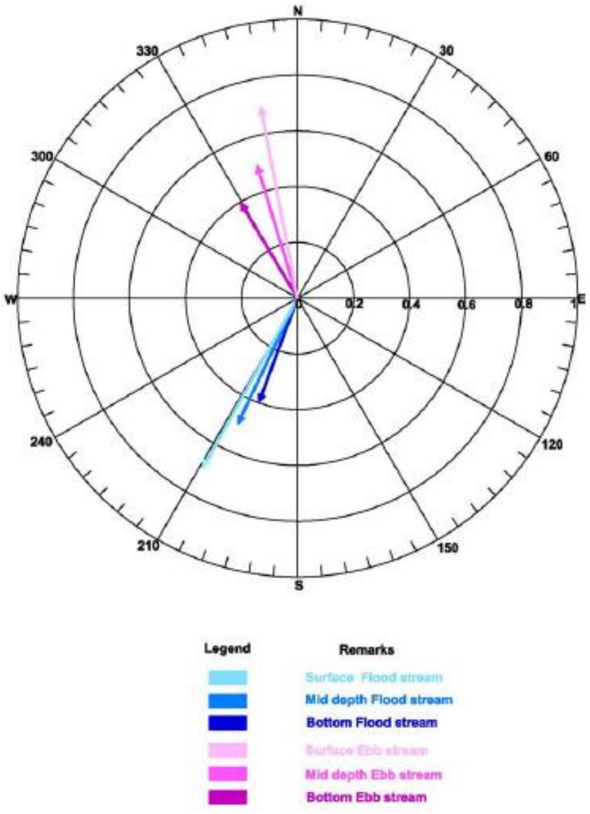
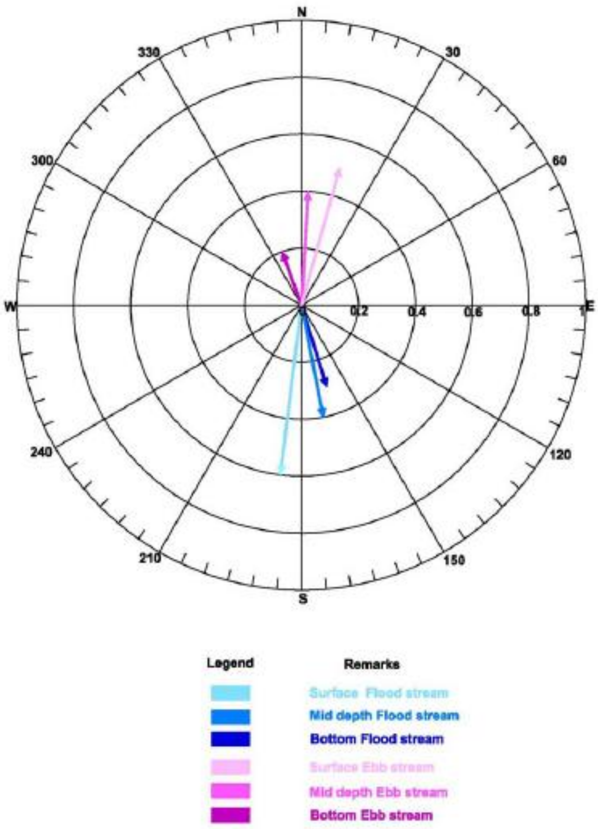


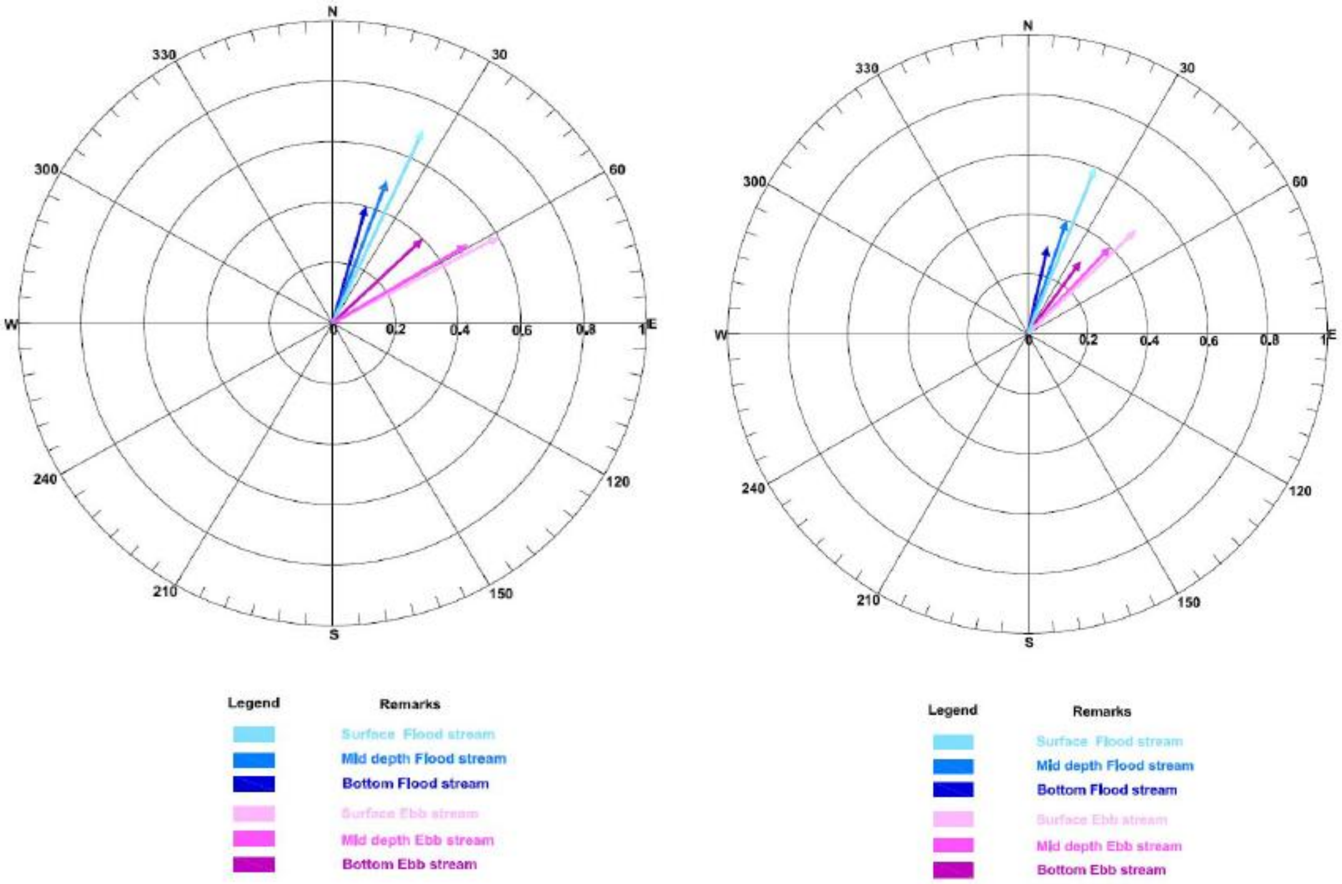
Fig. 3.2.4 : Observed Tidal variations near Vakalpudi





a) Tidal Stream- SPRING **b) Tidal Stream- NEAP**

Fig. 3.2.5 : Currents Vector Rose near Vakalpudi



a) Tidal Stream- SPRING **b) Tidal Stream- NEAP**

Fig. 3.2.6 : Currents Vector Rose Diagram near Uppada

Table 3.2.1: Marine Sampling Locations

Sr. No.	Sample Identity	Sampling Locations (Centre of grid) Latitudes- Longitudes	Depth (m)	Sampling level	Sediment Collection
1.	WS01	16^{O}57'22.123"N 82^{O}17'18.797"E	3.7	S,-,B	Y
2.	WS02	16^{O}57'21.911"N 82^{O}19'02.705"E	6.0	S,M,B	Y
3.	WS03	16^{O}57'21.252"N 82^{O}20'50.753"E	3.7	S,-,B	Y
4.	WS04	16^{O}58'13.100"N 82^{O}16'57.796"E	13.9	S,M,B	Y
5.	WS05	16^{O}58'13.708"N 82^{O}18'09.407E	4.4	S,-,B	Y
6.	WS06	16^{O}58'12.229"N 82^{O}19'58.605"E	4.9	S,-,B	Y
7.	WS07	16^{O}58'56.857"N 82^{O}17'09.219"E	2.5	S,-,-	Sample Spoiled
8.	WS08	16^{O}59'03.185"N 82^{O}18'03.374"E	3.8	S,-,B	Y
9.	WS09	16^{O}59'03.682"N 82^{O}19'02.140"E	12.5	S,M,B	Y
10.	WS10	16^{O}59'40.837"N 82^{O}17'11.096"E	3.4	S,-,B	Sample Spoiled
11.	WS11	16^{O}59'41.942"N 82^{O}18'58.801"E	10.9	S,M,B	Y
12.	WS12	16^{O}59'38.768"N 82^{O}20'50.291"E	13.8	S,M,B	Y
13.	WS13	17^{O}00'26.374"N 82^{O}17'27.782"E	4.6	S,-,B	Y
14.	WS14	17^{O}00'26.178"N 82^{O}19'01.732"E	9.6	S,M,B	Y
15.	WS15	17^{O}00'23.899"N 82^{O}20'51.425"E	14.4	S,M,B	Y
16.	WS16	17^{O}02'20.125"N 82^{O}18'41.924"E	7.5	S,M,B	Y

Contd...

Contd...**Table 3.2.1**

Sr. No.	Sample Identity	Sampling Locations (Centre of grid) Latitudes- Longitudes	Depth (m)	Sampling level	Sediment Collection
17.	WS17	17^{O}02’17.598”N 82^{O}20’24. 601”E	12.5	S,M,B	Y
18.	WS18	17^{O}02’17.181”N 82^{O}22’06.266”E	14.9	S,M,B	Y
19.	WS19	17^{O}03’49.434”N 82^{O}19’58.694”E	7.1	S,M,B	Y
20.	WS20	17^{O}03’48.709”N 82^{O}21’38.752”E	11.6	S,M,B	Y
21.	WS21	17^{O}03’49.748”N 82^{O}23’48.102”E	17.2	S,M,B	No Sediment
22.	WS22	17^{O}04’59.967”N 82^{O}21’16.900”E	7.6	S,M,B	Y
23.	WS23	17^{O}05’00.695”N 82^{O}23’03. 888”E	12.1	S,M,B	No Sediment
24.	WS24	17^{O}04’59.723”N 82^{O}24’59.573”E	16.9	S,M,B	No Sediment

S- Surface, M- Middle, B- Bottom
‘-’ Sample could not be collected due to lower depth

Table 3.2.2: Sea Water - Physical Parameters

Sample Identity	Secchi Disk Depth (m)	Sampling Levels	pH	Temp. (^{o}C)	Turbidity (NTU)	Total suspended solids (mg/l)
WS01	0.75	S	7.6	27.5	10.5	36
		M	-	-	-	-
		B	7.9	27.0	0.5	38
WS02	1.5	S	8.0	27.0	0.5	52
		M	7.9	26.5	1.0	82
		B	7.9	26.5	1.0	33
WS03	1.0	S	8.0	28.0	2.0	81
		M	-	-	-	-
		B	7.7	26.5	2.5	52
WS04	1.0	S	7.7	28.0	1.0	60
		M	7.5	27.0	2.5	142
		B	7.6	26.0	0.5	74
WS05	1.0	S	7.3	27.5	3.0	101
		M	-	-	-	-
		B	7.3	26.5	3.0	42
WS06	1.0	S	8.1	27.0	1.0	51
		M	-	-	-	-
		B	8.1	27.0	1.0	40
WS07	0.75	S	7.8	28.0	1.5	102
		M	-	-	-	-
		B	-	-	-	-
WS08	1.0	S	7.5	26.5	20	88
		M	-	-	-	-
		B	7.7	26.5	25	107
WS09	1.25	S	7.8	26.5	4.0	91
		M	7.6	26.5	5.0	90
		B	7.9	26.0	8.0	72
WS10	1.0	S	7.7	27.5	0.5	96
		M	-	-	-	-
		B	7.9	27.5	3.0	47
WS11	1.0	S	8.1	27.5	5.0	72
		M	7.9	27.0	0.5	45
		B	8.1	27.0	2.0	37
WS12	2.0	S	7.7	27.5	0.5	66
		M	7.6	27.0	1.0	73
		B	7.8	26.5	0.5	21

Contd...

Contd...**Table 3.2.2**

Sample Identity	Secchi Disk Depth (m)	Sampling Levels	pH	Temp. (^{o}C)	Turbidity (NTU)	Total suspended solids (mg/l)
WS13	0.75	S	7.6	27.0	3.5	78
		M	-	-	-	-
		B	7.6	26.0	4.0	24
WS14	1.25	S	7.7	27.0	3.5	79
		M	7.2	27.0	2.5	49
		B	7.7	26.5	10.5	65
WS15	2.0	S	7.0	27.5	0.5	58
		M	7.1	27.0	1.0	55
		B	7.5	26.5	3.0	107
WS16	1.0	S	7.6	27.5	7.5	65
		M	7.8	27.0	15	61
		B	7.4	27.0	2.0	94
WS17	1.5	S	7.3	27.0	3.5	68
		M	7.5	26.5	1.5	80
		B	7.5	26.5	20	82
WS18	1.5	S	7.5	27.0	0.5	53
		M	7.5	26.5	1.5	77
		B	7.7	25.5	2.0	15
WS19	1.2	S	7.4	27.0	2.5	61
		M	7.4	26.0	6.5	88
		B	7.5	26.0	3.5	40
WS20	1.5	S	7.2	27.0	1.5	69
		M	7.2	26.5	1.0	61
		B	7.2	26.5	4.0	117
WS21	4.0	S	7.3	27.0	0.5	42
		M	7.6	26.5	0.5	78
		B	7.5	26.0	0.5	30
WS22	1.25	S	7.4	27.0	1.5	51
		M	7.5	26.5	4.0	50
		B	7.4	26.5	6.5	63
WS23	2.0	S	7.3	26.5	0.5	39
		M	7.4	26.0	1.0	43
		B	7.2	26.0	2.5	11
WS24	3.25	S	7.3	26.0	0.5	47
		M	7.3	25.0	0.5	18
		B	7.2	25.0	0.5	25

S- Surface, M- Middle, B- Bottom
"- "Sample could not be collected due to lower depth

Table 3.2.3: Sea Water - Inorganic Parameters

Sample Identity	Sampling Levels	Total Alkalinity (as $CaCO_3$) (mg/l)	Chloride (mg/l)	Salinity ‰
Jetty & FSRU Area				
WS01	S	124	20355	37
	M	-	-	-
	B	116	19769	36
WS 02	S	152	18951	34
	M	124	18185	33
	B	112	18430	33
WS 03	S	120	19860	36
	M	-	-	
	B	116	19536	35
WS 04	S	128	18260	33
	M	120	17681	32
	B	116	17898	32
WS 05	S	128	19091	35
	M	-	-	
	B	116	18915	34
WS 06	S	116	19302	35
	M	-	-	
	B	116	19419	35
WS 07	S	112	19313	34
	M	-	-	-
	B	-	-	-
WS 08	S	128	19102	34
	M	-	-	-
	B	116	18845	33
WS 09	S	120	19377	34
	M	120	18893	34
	B	136	18366	33
WS 10	S	132	19260	34
	M	-	-	-
	B	120	19015	34
WS11	S	116	18416	33
	M	132	17562	32
	B	128	17664	32
WS12	S	108	19834	35
	M	132	19809	35
	B	116	19536	35
WS13	S	132	19494	35
	M	-	-	-
	B	116	19121	34
WS14	S	128	19781	35
	M	124	19621	35
	B	124	19283	34

Contd...

Contd...**Table 3.2.3**

Sample Identity	Sampling Levels	Total Alkalinity (as $CaCO_3$) (mg/l)	Chloride (mg/l)	Salinity ‰
WS15	S	120	19483	35
	M	132	19255	34
	B	124	19165	34
WS16	S	120	20015	36
	M	116	19625	35
	B	116	19600	35
Dredge Material Dumping Area				
WS17	S	112	20355	36
	M	116	19589	35
	B	116	19653	35
WS18	S	120	19183	34
	M	116	18562	33
	B	120	18185	32
WS19	S	124	18600	33
	M	120	18359	33
	B	124	17958	32
WS 20	S	132	19132	34
	M	120	18103	32
	B	116	18089	32
WS21	S	128	19536	35
	M	112	19689	35
	B	124	19072	34
WS22	S	124	19068	34
	M	136	18758	33
	B	120	18651	33
WS23	S	132	19185	34
	M	134	18997	34
	B	124	18547	33
WS24	S	120	19302	35
	M	120	19218	35
	B	96	18717	34

S- Surface, M- Middle, B- Bottom

Table 3.2.4: Sea Water - Nutrient and Demand Parameters

Sample Identity	Sampling Levels	Nitrate as N	Total Phos-phates	Dissolved oxygen	Total Nitrogen	Biochemical Oxygen Demand	Oil & Grease
		(mg/l)					
Jetty & FSRU Area							
WS01	S	0.64	0.04	6.9	22.4	<2	0.6
	M	-	-	-	-	-	-
	B	0.51	0.03	6.5	26.2	<2	0.4
WS02	S	0.51	0.06	7.0	26.0	<2	0.9
	M	0.46	0.05	6.5	21.3	<2	0.7
	B	0.48	0.02	6.6	25.9	<2	0.9
WS03	S	0.51	0.10	6.8	11.2	<2	0.8
	M	-	-	-	-	-	-
	B	0.64	0.02	6.8	12.8	<2	0.9
WS04	S	0.593	0.06	7.7	10.2	<2	0.6
	M	0.53	0.08	6.3	10.3	<2	1.4
	B	0.77	0.02	6.1	12.2	<2	1.1
WS05	S	0.85	0.09	6.5	12.2	<2	1.2
	M	-	-	-	-	-	-
	B	0.75	0.13	7.0	14.7	<2	0.6
WS06	S	0.49	0.08	6.8	11.2	<2	1.0
	M	-	-	-	-	-	-
	B	0.49	0.04	6.7	12.3	<2	0.7
WS07	S	0.75	0.11	6.7	14.2	<2	0.9
	M	-	-	-	-	-	-
	B	-	-	-	-	-	-
WS08	S	0.779	0.14	6.8	13.2	<2	0.6
	M	-	-	-	-	-	1.0
	B	1.05	0.04	6.5	12.3	<2	0.9
WS09	S	0.63	0.14	6.5	11.2	<2	1.1
	M	0.80	0.12	6.7	12.2	<2	1.0
	B	0.65	0.03	6.5	11.5	<2	0.8
WS10	S	0.57	0.06	7.5	22.4	<2	0.5
	M	-	-	-	-	-	-
	B	0.96	0.03	7.2		<2	1.0
WS11	S	0.69	0.04	6.8	16.8	<2	0.8
	M	0.46	0.07	6.5	13.4	<2	1.4
	B	0.47	0.04	6.6	17.1	<2	0.8
WS12	S	0.48	0.07	7.0	16.8	<2	1.2
	M	0.48	0.09	6.6	14.5	<2	0.4
	B	0.44	0.04	5.9	17.9	<2	1.1

Contd...

Contd...Table **3.2.4**

Sample Identity	Sampling Levels	Nitrate as N	Total Phos-phates	Dissolved oxygen	Total Nitrogen	Biochemical Oxygen Demand	Oil & Grease
		(mg/l)					
WS13	S	0.77	0.03	6.8	11.2	<2	1.1
	M	-	-	-	-	-	-
	B	0.93	0.15	6.5	10.9	<2	1.3
WS14	S	0.60	0.05	6.9	18.0	<2	1.0
	M	0.55	0.14	6.7	15.6	<2	0.6
	B	0.52	0.02	7.0	19.7	<2	0.8
WS15	S	0.48	0.04	7.1	11.2	<2	0.7
	M	0.48	0.16	6.6	12.3	<2	1.4
	B	0.60	0.04	6.7	12.8	<2	0.8
WS16	S	0.69	0.13	6.5	16.8	<2	1.0
	M	0.44	0.13	7.0	15.2	<2	0.8
	B	0.55	0.02	7.7	15.8	<2	0.8
Dredge Material Dumping Area							
WS17	S	0.65	0.03	7.7	12.4	<2	0.3
	M	0.48	0.14	7.2	13.4	<2	1.0
	B	0.53	0.03	6.2	13.3	<2	0.7
WS18	S	0.49	0.05	7.1	12.8	<2	0.8
	M	0.47	0.20	7.0	12.4	<2	0.6
	B	0.47	0.01	6.6	12.9	<2	0.9
WS19	S	0.69	0.11	6.5	13.9	<2	0.6
	M	0.63	0.12	6.7	13.6	<2	0.9
	B	0.54	0.04	6.6	13.8	<2	0.8
WS 20	S	0.58	0.04	7.0	18.0	<2	0.7
	M	0.55	0.14	6.8	17.7	<2	-
	B	0.57	0.02	6.6	16.9	<2	9
WS 21	S	0.45	0.11	6.8	12.4	<2	0.7
	M	0.48	0.20	6.8	11.5	<2	1.0
	B	0.46	0.02	6.9	12.6	<2	1.0
WS 22	S	0.57	0.03	7.3	12.6	<2	0.6
	M	0.61	0.20	7.0	12.8	<2	0.9
	B	0.62	0.03	7.0	12.3	<2	0.6
WS 23	S	0.48	0.03	6.4	15.6	<2	1.5
	M	0.52	0.15	6.5	14.4	<2	1.0
	B	0.48	0.07	6.5	15.6	<2	0.9
WS 24	S	0.46	0.05	7.1	13.0	<2	0.3
	M	0.47	0.20	6.7	13.5	<2	0.8
	B	0.46	0.05	6.5	13.4	<2	0.4

S- Surface, M- Middle, B- Bottom

Table 3.2.5: Sea Water - Heavy Metals

Sample Identity	Sampling Levels	Ni	Cd	Cr	Cu	Pb	Fe	Mn	Zn	Co
						mg/L				
Jetty & FSRU Area										
WS01	S	0.0006	0.0002	ND	ND	0.0056	0.8013	0.0243	ND	0.0054
	M	-	-	-	-	-	-	-	-	-
	B	0.0010	ND	ND	0.0065	ND	0.0829	0.0136	0.0209	0.0020
WS02	S	ND	0.0028	0.0027	ND	ND	0.2834	0.0061	ND	0.0042
	M	0.0096	ND	ND	0.0100	0.0261	0.5252	0.0235	0.0314	ND
	B	ND	0.0007	0.0006	0.0143	0.0080	0.6206	0.0019	0.0250	0.00019
WS03	S	0.0091	ND	ND	0.0778	ND	0.5758	0.0093	ND	ND
	M	-	-	-	-	-	-	-	-	-
	B	ND	ND	ND	0.0084	0.0223	0.4135	0.0161	ND	ND
WS04	S	0.0003	ND	ND	ND	0.0012	0.2997	0.0119	ND	0.0013
	M	ND	ND	ND	ND	0.0146	0.6207	0.0149	0.0292	ND
	B	ND	ND	ND	ND	0.0059	0.6586	0.0156	ND	0.0029
WS05	S	ND	ND	ND	0.0041	ND	0.7035	0.0284	ND	ND
	M	-	-	-	-	-	-	-	-	-
	B	ND	ND	0.0059	0.0054	0.0114	1.4251	0.0531	ND	0.0017
WS06	S	ND	0.0003	ND	ND	ND	0.2410	0.0147	ND	ND
	M	-	-	-	-	-	-	-	-	-
	B	ND	ND	0.0082	ND	0.0226	0.5969	0.0101	ND	ND
WS07	S	0.0001	ND	ND	ND	ND	0.2311	0.0277	ND	0.0032
	M	-	-	-	-	-	-	-	-	-
	B	ND	0.0010	0.0018	0.0029	ND	1.2021	0.03	ND	0.0025
WS08	S	0.0066	0.0020	0.0011	0.0053	0.0069	1.5793	0.0466	ND	0.0010
	M	-	-	-	-	-	-	-	-	-
	B	ND	0.0012	0.0276	0.0085	0.0348	1.4211	0.0398	ND	0.0002
WS09	S	0.0027	0.0002	0.0099	ND	ND	0.2966	0.0095	ND	ND
	M	ND	0.0050	ND	ND	ND	0.4351	0.0087	0.0074	ND
	B	ND	0.0006	ND	ND	ND	0.4852	0.0080	ND	0.0009
WS10	S	ND	0.0014	ND	0.0056	ND	0.3322	0.0471	ND	0.0021
	M	-	-	-	-	-	-	-	-	-
	B	0.0018	0.0004	0.0090	0.0135	0.0054	0.5520	0.0518	ND	0.0014
WS11	S	ND	ND	ND	ND	ND	0.3314	0.0101	ND	0.0053
	M	0.0014	ND	ND	ND	0.0266	0.0140	ND	ND	ND
	B	ND	0.0113	ND	ND	0.0810	0.1419	0.0168	ND	0.0015
WS12	S	ND	0.0009	ND	0.0062	0.0023	0.0736	ND	ND	0.0019
	M	ND	ND	ND	0.0011	ND	0.0259	0.0063	ND	ND
	B	0.0095	ND	0.0114	0.0344	0.0465	0.7263	0.0215	ND	0.0004

Contd...

Contd...Table **3.2.5**

WS13	S	ND	0.0006	ND	ND	ND	0.5241	0.0091	ND	ND
	M	-	-	-	-	-	-	-	-	-
	B	0.0016	ND	ND	0.0095	0.0094	0.7764	0.0252	0.0067	0.0006
WS14	S	ND	ND	0.0020	0.0175	0.0082	0.1980	0.0008	ND	0.0018
	M	0.0065	ND	ND	0.0056	0.0315	0.3077	0.0058	0.7596	ND
	B	0.0070	0.0003	ND	0.0623	0.0650	0.9074	0.0234	0.1902	0.0043
WS15	S	ND	ND	ND	0.0034	ND	0.2099	ND	ND	0.0057
	M	ND	0.0004	0.0034	0.0086	ND	0.3070	0.0107	ND	0.0007
	B	ND	ND	ND	0.0059	0.0479	0.6303	0.0132	0.0042	0.0042
WS16	S	ND	0.0005	ND	0.0069	0.0138	0.1290	ND	ND	0.0008
	M	ND	ND	ND	0.0097	ND	0.5144	ND	0.0124	0.0017
	B	0.0109	0.0002	0.0112	0.0097	0.0323	0.7471	0.0218	0.0496	0.0007
Dredge Material Dumping Area										
WS17	S	ND	ND	ND	0.0027	ND	0.0457	0.0077	ND	ND
	M	ND	ND	ND	0.0036	ND	0.3834	ND	0.0088	ND
	B	ND	0.0001	ND	0.0142	0.0359	0.4225	0.0078	0.0133	0.0026
WS18	S	ND	0.0008	ND	ND	ND	0.0603	ND	ND	ND
	M	0.0039	ND	0.0050	0.0048	ND	0.396	ND	0.0163	0.0044
	B	0.0041	ND	ND	0.0095	0.0267	0.2152	0.0070	ND	0.0014
WS19	S	ND	ND	ND	0.0093	ND	0.2937	0.0001	ND	0.0011
	M	0.0079	ND	0.0046	ND	0.0236	0.429	ND	0.0140	0.0005
	B	0.0049	0.0005	ND	0.0022	0.0090	0.2259	0.0076	0.3029	0.0008
WS20	S	ND	ND	ND	0.0157	0.0188	0.0444	0.0020	ND	0.0023
	M	0.0006	ND	ND	0.0089	ND	0.326	ND	0.0128	0.0034
	B	ND	0.0004	ND	0.0133	0.0102	0.6205	0.0195	ND	0.0009
WS21	S	ND	ND	ND	0.0020	0.0020	0.2043	ND	0.005	ND
	M	ND	ND	ND	ND	0.0146	0.6207	0.0149	0.0292	ND
	B	0.0013	ND	ND	0.0088	0.0372	0.0225	0.0036	ND	0.0003
WS22	S	ND	0.0020	ND	ND	0.0150	0.2763	0.0007	ND	ND
	M	0.0030	0.0017	ND	0.0105	0.0052	0.4320	0.0158	0.0464	ND
	B	ND	0.0009	ND	0.0157	0.0202	0.5382	0.0232	ND	0.0003
WS23	S	ND	ND	ND	ND	ND	0.0072	ND	ND	ND
	M	ND	ND	ND	0.0084	0.0053	0.526	ND	0.0135	0.0035
	B	0.0050	0.0010	ND	0.0032	0.0129	0.2254	0.0108	0.0036	ND
WS24	S	ND	ND	0.0097	0.0026	0.0048	0.2328	0.0096	0.000	ND
	M	0.0007	ND	ND	0.0079	ND	0.269	ND	0.0330	0.0009
	B	0.0008	0.0001	ND	0.0040	0.0060	0.1241	0.0023	ND	0.0047

S- Surface, M- Middle, B- Bottom

Table 3.2.6: Sea Water – Bacteriology

Sample Identity	Total Viable Count (x 10^4) CFU/ml	Vibrio sp. (x 10^2) CFU/ml
Jetty & FSRU Area		
WS01	17	15
WS02	01	32
WS03	08	20
WS04	03	06
WS05	63	21
WS06	05	01
WS07	ND	ND
WS08	ND	ND
WS09	55	ND
WS10	ND	ND
WS11	05	06
WS12	213	33
WS13	186	37
WS14	39	35
WS15	03	15
Dredge Material Dumping Area		
WS16	01	50
WS17	40	28
WS18	51	30
WS19	08	03
WS20	01	ND
WS21	53	32
WS22	ND	ND
WS23	45	21
WS24	01	ND

CFU- Colony Forming Unit

Table 3.2.7: Sea Water – Phytoplankton

Sample Identity	Phyto-plankton No. /ml	% Composition					Shannon Wiener Diversity Index
		Bascillario-phyceae	Coscinodisc-ophyceae	Dinophy-ceae	Codonell-idea	Mediophy-ceae	
Jetty & FSRU Area							
WS01	1250	72	8	16	-	4	2.48
WS02	1900	66	-	18	-	16	3.15
WS03	2425	55	8	21	-	16	3.95
WS04	1300	50	31	19	-	-	2.88
WS05	1750	86	-	14	-	-	3.13
WS06	1175	43	9	4	2	43	2.98
WS07	1675	73	21	3	-	3	3.69
WS08	1950	69	8	10	-	13	3.34
WS09	2500	72	12	6	-	10	3.42
WS10	1850	65	16	5	-	14	2.68
WS11	2050	73	-	17	-	10	2.43
WS12	1850	49	-	22	3	27	4.42
WS13	3200	58	11	19	-	13	5.05
WS14	2450	63	8	16	-	12	4.93
WS15	2375	69	13	13	1	4	4.28
Dredge Material Dumping Area							
WS16	1050	90	5	-	5	-	2.91
WS17	550	64	-	18	-	18	1.75
WS18	800	50	13	19	13	6	3.06
WS19	700	86	7	7	-	-	3.17
WS20	450	89	11	-	-	-	1.47
WS21	200	75	-	-	-	25	1.99
WS22	500	60	10	10	20	-	2.65
WS23	650	85	8	-	-	8	2.15
WS24	900	83	6	6	6	-	2.86

Ranges of Shannon Wiener Diversity Index

<1: Indicate maximum impact of pollution or adverse factor
1-2: Indicate medium impact of pollution or adverse factor
>2: Indicate lowest or no impact of pollution or adverse factor

Table 3.2.8: Phytoplankton Species in Sea Water Samples

Bacillariophyceae

Amphora sp.

Biddulphia sp.

Bacillaria sp.

Chaetoceros sp.

Chaetoceros socialis

Gunardia sp.

Gyrosigmaa sp.

Fragilaria sp.

Skeltonema sp.

Navicula sp.

Nitzschia sp.

Melosira sp.

Hemiaulus sp.

Coscinodiscophyceae

Eucampia sp

Rhizosolenia sp.

Dinophyceae

Ceratium furca sp.

Protoporidinium sp

Dinophysis sp.

Codonellidae

Tintinnid sp.

Mediophyceae

Ditylum sp.

Table 3.2.9: Sea Water – Zooplankton

Sample Identity	Zooplanktons No. /m³	% Composition							Shannon Wiener Diversity Index
		Copepoda	Decapoda	Tintinnida	Cyclostomata	Gastropoda	Isopoda	Copelata	
Jetty & FSRU Area									
WS01	1550	48	23	-	6	13	-	10	2.62
WS02	1200	50	21	-	4	8	4	13	2.72
WS03	1210	26	29	21	8	17	-	-	2.65
WS04	775	39	48	-	6	-	-	6	2.12
WS05	500	-	70	-	10	4	16	-	1.77
WS06	100	-	100	-	-	-	-	-	0
WS07	1405	46	32	2	18	0	2	-	2.37
WS08	1300	31	31	12	2	-	2	23	2.42
WS09	1190	20	50	25	1	1	-	2	2.60
WS10	1260	21	60	4	4	4	-	8	2.63
WS11	910	38	37	-	3	5	5	11	2.21
WS12	715	35	31	7	5	1	14	7	2.43
WS13	1320	42	52	-	2	1	-	4	2.41
WS14	1340	37	54	-		3	2	3	2.39
WS15	1025	48	23	-	6	13	-	10	1.84
Dredge Material Dumping Area									
WS16	505	53	14	-	6	8	-	8	2.48
WS17	1350	76	12	-	3	1	1	3	1.46
WS18	295	-	85	8	-	-	-	7	0.76
WS19	500	20	53	8	7	5	3	4	2.23
WS20	515	29	50	5	4	-	5	7	2.26
WS21	550	59	25	5	-	5	-	5	2.12
WS22	505	40	31	9	5	9	2	5	2.60
WS23	345	3	54	12	9	7	12	4	2.70
WS24	385	18	58	9	-	12	-	3	2.59

Ranges of Shannon Wiener Diversity Index : <1 Indicate maximum impact of pollution or adverse factor : 1-2 Indicate medium impact of pollution or adverse factor : >2 Indicate lowest or no impact of pollution or adverse factor

Table 3.2.10: Zooplankton Species Identified in Water Samples

Copepoda	Decapoda	Tintinnida	Cyclostomata	Gastropoda	Isopoda	Copelata
-Copepod *-Nauplii*	*-Decapod larvae* *-Prawn larvae* *-Zoea*	*Tintinnida*	*Bryozoan cyphonautes*	*Gastrpod larvae*	*Isopods*	*Fritillaria sp*

Table 3.2.11: Particle Size Distribution

Sample Identity	Particle Size Distribution (%)		
	Total Sand (0.02-2mm)	Silt (0.002-0.02 mm)	Clay (<0.002mm)
Jetty and FSRU Area			
WS01	38.0	10.8	51.2
WS02	49.2	8.0	42.8
WS03	42.6	8.16	49.2
WS04	40.6	8.56	50.8
WS05	38.64	10.16	51.2
WS06	49.6	6.16	44.2
WS08	31.6	6.16	62.2
WS09	46.6	9.12	44.2
WS11	38.6	13.12	48.22
WS12	57.2	2.56	40.2
WS13	54.8	12.4	42.4
WS14	45.2	4.4	50.4
WS15	60.0	3.52	36.4
Dredge material Dump Area			
WS16	63.2	6.0	30.8
WS17	39.2	14.4	46.4
WS18	79.2	1.0	19.8
WS19	72.64	2.2	25.2
WS20	77.2	1.6	21.2
WS22	73.6	3.2	23.2

Table 3.2.12: Physico-Chemical Characteristics of Sediment

Sample Identity	pH	Dissolved Salt		
		Cl^-	CO_3^{2-}	HCO_3^-
		mg/kg		
Jetty and FSRU Area				
WS01	7.17	23856	180	366
WS02	7.34	24992	120	244
WS03	7.36	24850	120	244
WS04	7.49	14626	180	366
WS05	7.24	24708	300	610
WS06	7.04	16188	360	732
WS08	7.54	25418	180	366
WS09	7.45	15904	300	610
WS11	7.46	21300	60	122
WS12	7.41	17182	300	610
WS13	7.24	17040	240	488
WS14	7.11	32944	240	488
WS15	7.41	15336	180	366
Dredging Material Dump area				
WS16	7.56	13916	180	366
WS17	7.42	15080	300	610
WS18	7.40	7952	240	488
WS19	7.51	13916	240	488
WS20	7.44	8094	300	610
WS22	7.40	7952	288	683

Table 3.2.13: Nutrient and Organic Contents of sediment

Sample Identity	Total Organic Carbon	Total Nitrogen	Total Phosphorus	Total Potassium
	(%)			
Jetty and FSRU Area				
WS01	0.36	0.083	0.003	0.036
WS02	1.58	0.090	0.428	0.034
WS03	4.17	0.042	0.243	0.028
WS04	11.82	0.140	0.208	0.037
WS05	0.01	0.120	0.220	0.032
WS06	1.92	0.042	0.127	0.028
WS08	1.13	0.019	0.394	0.036
WS09	1.07	0.011	0.266	0.029
WS11	1.11	0.015	0.220	0.030
WS12	0.84	0.140	0.174	0.027
WS13	1.19	0.093	0.058	0.031
WS14	0.42	0.061	0.266	0.040
WS15	0.67	0.078	0.289	0.024
Dredge material Dump Area				
WS16	0.79	0.069	0.104	0.019
WS17	1.20	0.120	0.058	0.033
WS18	0.56	0.142	0.035	0.014
WS19	1.17	0.093	0.069	0.018
WS20	0.01	0.068	0.046	0.016
WS22	0.01	0.075	0.127	0.024

Table 3.2.14: Heavy Metals in Marine Sediment

Sample Identity	Ni	Cd	Cr	Cu	Pb	Fe	Mn	Zn	Co	Hg	As	Cr^{6+}
	mg/kg											
Jetty and FSRU Area												
WS04	42.8	1.8	58.0	46.8	24.5	15193	517.9	76.4	26.1	BDL	2.0	BDL
WS05	50.4	0.9	53.2	53.4	23.4	15813	571.4	76.7	36.6	BDL	3.0	BDL
WS08	36.1	0.7	22.3	37.9	16.5	15323	426.7	52.6	33.1	BDL	3.5	BDL
WS09	49.2	1.0	30.0	50.9	23.8	15702	501.6	73.5	36.3	BDL	2.4	BDL
Dredge material Dump Area												
WS17	41.8	1.2	25.9	47.1	27.9	15722	532.5	71.9	24.0	BDL	4.8	BDL
WS19	24.0	1.3	25.9	33.0	32.1	15447	521.0	66.0	20.3	BDL	3.5	BDL
WS20	13.0	1.2	12.0	18.2	29.5	14482	403.1	36.2	17.8	BDL	3.0	BDL

BDL: Below Detection Limit

Detection Limit - Cr^{+6}- 0.05 mg/kg ; Hg- 1 mg/kg;Co-0.2 mg/kg,; Cd- 0.04 mg/kg;As-0.5 mg/kg,Ni-0.4 mg/kg

Table 3.2.15: Diversities of Macrobenthos in Sediment Samples

Family	Composition %																			
	WS01	WS02	WS03	WS04	WS05	WS06	WS07	WS08	WS09	WS10	WS11	WS12	WS13	WS14	WS15	WS16	WS17	WS18	WS19	WS20
Fustiariidae	-	-	-	-	-	-	-	40	-	40	-	-	15	-	-	-	5	19	-	-
Pharidae	-	24	-	7	6	16	-	40	-	40	-	-	15	-	-	-	2	12	3	-
Nuculidae	-	-	-			8	-	-	-		-	-		-	-	5	2	9	35	5
Mytilidae	-	28	85	80	23	40	-	-	-	50	-	-		-	-	50	16	-	30	12
Limacinidae	-	-	-	-	-		-	20	-	-	-	-		-	-	-	2	-	-	-
Rissoidae	-	-	-	-	-	4	-	-	-	-	-	-		-	-	-	-	-	-	-
Pomatiopsidae	-	-	-	-	-		-	-	-	-	-	-		-	67	-	-	-	-	-
Trochidae	-	-	-	-	-		-	-	-	-	-	-	11	19		25	7.5	-	-	-
Architectonicidae	-	-	-	-	-	20	-	-	-	-	-	54	73	61		11	38	47	-	54
Marginellidae	-	-	-	-		-	-	-	-	-	-		-	13	33	-	-	-	-	-
Dentaliidae	50	-	-	6.5	10	-	-	-	-	-	-	13	-	6	-	-	-	-	-	-
Sabellidae	-	-	15		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Glyceridae	-	-	-	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphiuridae	-	-	-	-	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-
Corophiidae	-	8	-	-	-	-	-	-	50	-	33	-	-	-	-	-	-	-	-	-
Ungulinidae	25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtyidae	25		-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Phyllodocidae	-	3.5	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Opheliidae	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellinidae	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philinidae	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-
Gadilidae	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naticidae	-	-	-	-	6	8	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Epitoniidae	-	-	-	-	-		-	-	-	-	67	11	-	-	-	4	12	13	12	18
Aclididae	-	-	-	-	-	4	-	-	-	-	-		-	-	-	-	-	-	-	-
Pyramidellidae	-	-	-	-	-		-	-	-	-	-	22	-	-	-	-	-	-	-	-
Veneridae	-	-	-	-	-		-	-	-	-	-		-	-	-	-	3.5	-	-	-
Columbellidae	-	-	-	-	-		-	-	-	-	-		-	-	-	-	-	-	10	-
Nereididae	-	1	-	-	-		-	-	-	10	-		-	-	-	-	-	-	-	-
Pulsellidae	-		-	-	-		-	-	-		-		-	-	-	5	-	-	-	-
Total Counts/m^2	**40**	**280**	**70**	**150**	**310**	**250**	-	**50**	**20**	**100**	**30**	**630**	**1030**	**1450**	**450**	**1070**	**2020**	**640**	**860**	**840**
SWI	**1.83**	**2.86**	**0.06**	**3.53**	**26**	**4.1**	**-**	**1.83**		**2.8**	**1.19**	**4.83**	**6.34**	**6.85**	**5.12**	**7.34**	**6.68**	**4.85**	**5.02**	**5.44**

Note: **# - There was no sea bed sediment available (hard bottom) at sampling locations** ***- Sample spoiled**

Table 3.2.16: Macro benthos Observed in Sediment Sample

Family/ Group	Species
Fustiariidae	*Fustiaria rubescens*
Pharidae	*Ensis ensis .*
	Phaxas pellucidus
Nuculidae	*Nucula sulcate*
Mytilidae	*Musculus sp*
Limacinidae	*Limacina sp*
Rissoidae	*Schwartziella peregrina*
Pomatiopsidae	*Neotricula sp*
Trochidae	*Diloma nigerrima*
Architectonicidae	*Discotectonica acutissima*
Marginellidae	*Granulina sp*
Dentaliidae	*Pictodetalium vernedei.* *Antalis vulgaris.* *Paradentalium hexagonum.*
Sabellidae	*Bispira crassicornis*
Glyceridae	*Glycera alba*
Amphiuridae	*Amphipholis squamata*
Corophiidae	*Leptocheirus pinguis*
Ungulinidae	*Diplodonta trigona*
Nephtyidae	*Nephtys incisa.* *Nephtys hombergii.*
Phyllodocidae	*Eumida sanguinea*
Opheliidae	*Ophelia limacine*
Tellinidae	*Strigella pisiformis*
Philinidae	*Philine angasi.* *Philine angasi.*
Gadilidae	*Cadulus unilobatus*
Naticidae	*Polinices lunatia*
Epitoniidae	*Epitonium multistriatum.* *Amaea decussate.*
Aclididae	*Aclis ascaris.*
Pyramidellidae	*Chrysallida sigmoidea.*
Veneridae	*Dosinia discus.*
Columbellidae	*Alia unifasciata*
Nereididae	*Alitta succinea*
Pulsellidae	*Pulsellum bushi*

Table 3.2.17 : Marine Fish Production

Sr. No	Name of Species	2008 – '09		2009 – '10	
		Production (Tonnes)	Value (Rs. in lakhs)	Production (Tonnes)	Value (Rs. in lakhs)
1.	**Elasmobranches**				
	a) Sharks	2456.00	40.00	100.00	40.00
	b) Skates	634.00	35.00	75.00	35.00
	c) Rays	1640.00	40.00	110.00	40.00
2.	Eels	2016.00	35.00	140.00	30.00
3.	Cat Fish	2272.00	20.00	275.00	40.00
4.	Clupeoids				
	a) Wolf Herrings	0.00	0.00	0.00	0.00
	b) Sardines	2157.00	35.00	1428.00	35.00
	c) Hilsa Shades	0.00	0.00	1857.00	25.00
	d) Anchovies	3096.00	40.00	1695.00	40.00
	e) Other Clupeoids	1447.00	20.00	0.00	0.00
5.	Bombay Duck	0.00	0.00	0.00	0.00
6.	Half & Full Beaks	0.00	0.00	0.00	0.00
7.	Flying Fish	0.00	0.00	0.00	0.00
8.	Perches	2516.00	18.00	1250.00	18.00
9.	Goat Fish	2362.00	20.00	0.00	0.00
10.	Thread Fins	2237.00	20.00	0.00	0.00
11.	Ribbon Fish	2081.00	20.00	2560.00	20.00
12.	Carangids	2552.00	20.00	840.00	20.00
13.	Silver Bellies	2253.00	20.00	0.00	0.00
14.	Big Jawed Jumped	0.00	0.00	0.00	0.00
15.	Promferts	4225.00	150.00	650.00	150.00
16.	**Mackerel**				
	a) Kanagantha	2162.00	30.00	620.00	30.00
	b) Other Mackerels	2169.00	20.00	850.00	20.00
17.	Seer Fish	2253.00	20.00	1470.00	20.00
18.	Tunnies	0.00	0.00	0.00	0.00
19.	Baracudas	0.00	0.00	0.00	0.00
20.	Mullets	2643.00	50.00	0.00	0.00
21.	Flat Fish	0.00	0.00	300.00	20.00
22.	Miscellaneous	9743.00	15.00	37937.00	0.00
Total (1 To 22)		**52914.00**	**668.00**	**52157.00**	**583.00**
23.	**Shrimp**				
	a) Panaeid Shrimp	9952.00	250.00	5445.00	250.00
	b) Non – Panaeid Shrimp	2104.70	100.00	2756.00	100.00
	Marine Shrimp	12056.70	0.00	8201.00	0.00
	Marine Fish	52844.00	0.00	52157.00	0.00
Total		**129871.40**	**1018.00**	**120716.00**	**933.00**

Source: Hand Book of Statistics East Godavari District 2010

Table 3.2.18 : Inland Fish Production

Sr.No	Name of the Species	2008 – '09		2009 – '10	
		Quantity (Tonnes)	Value (Rs in Lakhs)	Quantity (Tonnes)	Value (Rs in Lakhs)
1.	Barbus	750.00	10.00	367.00	15.00
2.	Carps (Catla / Rohu / Mrigala)	8800.50	30.00	8887.00	60.00
3.	Cat Fishes	25.60	10.00	15.00	0.00
4.	Common Carbs	0.00	0.00	0.00	0.00
5.	Murrel	110.00	60.00	476.00	75.00
6.	Mullets	1413.00	30.00	1475.00	20.00
7.	Prawns	8889.11	100.00	6793.00	150.00
8.	Hilsa	1029.00	80.00	195.00	90.00
9.	Miscellaneous	3051.45	7.00	8354.00	10.00
	Total	**24068.66**	**327.00**	**26562.30**	**420.00**

Source: Hand Book of Statistics East Godavari District 2010

3.3 Land Environment

The baseline (pre-project) status of land environment has been assessed through reconnaissance in the project area, characterization of soil in study area through analysis of field samples and land use pattern by satellite data analysis. The pre-project soil characteristics are studied in the form of physical, chemical and microbiological characteristics.

3.3.1 Reconnaissance

The study area (10 km radius) around the project site is part of Godavari river delta in East Godavari District. Kakinada town and few major industries in the coast belt (in the vicinity of port) fall in study area. Agriculture and Fishing activities are the major occupations of the people inhabiting in coastal area. The climatic conditions and soil conditions in this area are conducive for the growth of paddy, pulses, coconut crops etc. Paddy is prominent crop during Kharif and Rabi crop seasons and rice is staple food for local people. Irrigation water through canal network is available in all the villages; However Sarpavaram village has 18.2 ha of land to be irrigated by other sources. The main agriculture produce in study area are paddy, ragi, maize, pulses, groundnut, cotton, sesame, cashew nut, coconut, mango, and banana. Avenue plantations with cashew nut, coconut, mango etc. trees have been observed in study area.

3.3.1.1 Climate and Rainfall

Kakinada has a tropical climate. The weather is hot and humid in most of the year. The hottest part of the year is May & 1st week of June with maximum temperatures around 38–42°C. The coolest part of the year is January, with minimum temperatures around 18–20°C. The project area gets most of annual rainfall during southwest monsoon period (June-September) although a good deal of rains greets this area during the northeast monsoon from mid-October to mid-December. Tropical Depressions & Cyclones in Bay of Bengal are frequent, few of which effect project area. Prevailing winds in Kakinada are usually southwesterly for most part of the year except during October to January when they blow from north-east and east. Kakinada recorded an average annual rainfall between 1100 and 1150 mm.

3.3.2 Baseline Soil Quality

Soil samples were collected from Nine (9) locations in study area as shown in **Fig. 3.3.1** and summarized in **Table 3.3.1**. Representative soil samples were collected from 10-15 cm depth. Air-dried and Sieved soil samples have been used for determination of physico-chemical as well as bacteriological characteristics and parameters related to agricultural productivity. Standard methods have been followed for the analysis of soil samples.

The International Pipette Method (Black, 1964) was adopted for determination of particle size analysis. The textural diagram was generated using "SEE Soil Class 2.0 version based on United States Department of Agriculture (USDA) classification of soils. Physical parameters such as bulk density, porosity and water holding capacity were determined by following KR Box Method (Keen and Raczkowski, 1921).

The chemical characteristics of soil were determined by preparing soil extract in distilled water in ratio 1:2 (as per Jackson procedure, 1967).

Organic carbon was determined by Walkley & Black method (1972). Fertility status of soil in terms of available nitrogen was determined by Kjeldhal method and available phosphorus was determined by Chloro stanus Reduced Molydo Phosphorus Blue clour olsen's method (1954) and available potassium was determined by flame photometer method (Jackson M.L. 1967).

Heavy metals in the soil were determined from soil extract through acid digestion followed by ICP analysis (EPA, SW-846).

3.3.2.1 Physical Properties of Soil

Soil characteristics such as the particle size distribution in terms of percentage of sand, silt and clay are presented in **Table 3.3.2**. Loamy sand is the prominent textural class followed by sandy loam in the impact zone. Sand content in the soil of the study area varies from 48.4 to 90.7%.

The physical characteristics of soils such as bulk density; porosity and water holding capacity are presented in **Table 3.3.3**. Bulk density of soil relates to the combined volumes of the solids and pore spaces. Soil with a high pore space with loose solid particles will have lower bulk density than those that are more compact and have less pore space. This is directly related to the movement of air and water through soil thus affecting the productivity. The soil being of friable consistency, the bulk density of the soil is in the range of 1.08 - 1.67 g/cm^3.

Soil porosity is described in terms of air filled pore spaces is indicative of storage and movement of gases & inherent moisture and development of root systems, soil strength etc. The porosity and water holding capacity were found in the ranges 36.49 – 56.88% and 24.27 - 39.12% respectively.

3.3.2.2 Chemical Properties of Soil

The collected soil samples were analysed for various chemical properties. The parameters selected were pH, electrical conductivity, soluble cations, exchangeable cations, exchangeable sodium percentage (ESP), organic carbon content, nutrient status and heavy metals content in soil. These results are presented in **Tables 3.3.4 - 3.3.8**.

pH is an important parameter which indicative of the neutral and alkaline nature of soil. It severally affects the microbial population as well as the solubility of metal ions and regulates nutrient availability. The pH of the soil in the study area is slightly acidic (in land) to slightly alkaline (along sea coast) in reaction having pH is in the range of 5.8 – 8.0 (**Table 3.3.4**).

The soluble salts were determined from soil extract (1:2). The soluble salts are expressed in terms of electrical conductivity (EC). The Electrical Conductivity of the soil extract in the study area is in the range of 0.04 to 1.02 mS/cm (**Table 3.3.4**). The soluble salt content in most of the soils are low < 1mS/cm. Chemical analysis shows that the soils are normal (EC<1mS/cm).

The most important cations present in soluble state are calcium and magnesium. In the soil samples within study area it is observed that calcium and magnesium are in the range of 1.8 - 9.0 meq/100 gm and 2.6 - 20.3 meq/100 gm respectively (**Table 3.3.4**). Whereas, Sodium and potassium varies from 0.04 to 12.19 meq/100gm and 0.01 to 3.28 meq/100 gm respectively.

Exchangeable cations were estimated from the leachate of soil with Ammonium acetate and potassium chloride. Amongst the different exchangeable cations in the soil samples within the concentrations of calcium and magnesium vary from 3.08-13.8 cmol (P^+) kg^{-1} and 2.80-13.4 cmol(P^+) kg^{-1} of soil respectively. Sodium and potassium are in the range of 0.23-2.02 cmol (P^+) kg^{-1} and 0.06-2.24 cmol (P^+) kg^{-1} of soil respectively.

Exchangeable sodium percent (ESP) is calculated using the relationship:

$$ESP = \frac{\text{Exchangeable Sodium}}{(\text{Ex.Ca} + \text{Ex.Mg} + \text{Ex.Na} + \text{Ex.K})} X100$$

Where all exchangeable cations are in cmol (p+) kg^{-1}

Exchangeable sodium percentage (ESP) of the soil samples in the study area was found to vary from 1.66-11.46 (**Table 3.3.5**). The presence of sodium in exchangeable form may have deterious effect on the chemical and physical properties of soil. Soils from all the villages are normal with respective to alkalinity as exchangeable sodium percentage of soil is below 15.

3.3.2.3 Nutrient Status of Soil

Organic matter present in the soil influences its physical and chemical properties. It commonly accounts as one third or more of the cation exchange capacity of surface soil and is also responsible for stability of soil aggregates.

Organic carbon and available nitrogen, phosphorous and potassium of the soil samples are found to be in the range of 0.80 -1.32% and 62-289 kg/ha, 14.74-85.49 kg/ha and 29.92 to 293.9 kg/ha (**Table 3.3.6**) respectively. Soil samples are poor to medium level in nitrogen content.

3.3.2.4 Heavy Metal Content in the Soil

The heavy metals occur in the solution as cations and are adsorbed by the negatively charged soil particle. They are held strongly as complex on the surface of clay, alumino silicates, hydrated oxide and humus. In general adsorption increases with pH, heavy metals pollution is serious because it can persist for many decades. The heavy metals also create problems in the nutrient utilization in plant and also marked reduction in chlorophyll content.

Soil samples were also analyzed for heavy metals such as Arsenic (As), Mercury (hg), Hexavalent Chromium (Cr^{6+}), Chromium (Cr), Zinc (Zn), Lead (Pb), Nickel (Ni), Cadmium (Cd), Cobalt (Co), Manganese (Mn), Iron (Fe) and Copper (Cu) at EPTRI, Hyderabad (NABL & NABET accredited laboratory). The results provided by EPTRI in the form of observed concentrations are presented in **Table 3.3.7**. The presence of heavy metals at proper pH enhances the microbial activity in soil. The heavy metal concentrations in the study area are found normal.

3.3.2.5 Soil Microbiology

Soil organisms play a key role in nutrient transformation, organic form are transformed into their respective inorganic forms and plants are able to absorb them for their growth. Physical, chemical and physico-chemical characteristics of soil and its nutrient status influence the microbial population. Pour plate method is used for the quantification of total number of microorganisms in the given sample. Microorganisms present in samples of soil are presented in **Table 3.3.8**.

Various ecological cycles in the Rhizosphere zone of the plant depend upon microbiological population. The population of bacteria, fungi and actinomycetes are the vital components of soils and they help in maintaining their stability.

Azotobactor are non-symbiotic nitrogen fixing micro-organisms and improve soil fertility by fixing nitrogen in soil. Fungi also constitute an important part of the microflora of normal soil. They are active in initial stages of decomposition of plant residues and actively participate in the process of soil aggregation. The total viable count (TVC) at different locations were observed in the range of $12x10^6$ – $36x10^6$ CFU/gm. Fungal count is $3x10^4$ – $9x10^4$ CFU/gm. Actinomycetes ranged from $1x10^4$ – $5x10^4$ CFU/gm, Rhizobium $1x10^4$ – $5x10^4$ CFU/gm and Azotobacter 1x10 – $9x10^4$ CFU/gm of soil (**Table 3.3.8**). The soil collected from agriculture fields shows rich in all types of micro-organisms indicating that soil is rich from nutritional point of view. The high count of nitrogen fixing bacteria enhances the availability of nitrogen in soil, which is very essential for plant growth.

From textural data of soils collected from study area, it is observed that this area is covered by various types of soils such as sandy clay, sand, loamy sand and sandy loam. pH of the soil is slightly neutral to slightly alkaline, soluble salt content as indicated by the electrical conductivity is less than 1mS/cm. Based on the ESP, nutrient levels and microbiological characteristics, the soils are considered to be moderate in microflora and fauna. This could be due the characteristics of deltaic depositional environment and large scale application of fertilizers to agricultural fields in the area.

3.3.3 Satellite Data Analysis for Land use / Land Cover

Remote Sensing technology has emerged as a powerful tool in providing reliable information on various natural resources at different levels of spatial details, it has played an important role in effective mapping and periodic monitoring of natural resources including environment. With the availability of high resolution remote sensing data, newer areas of remote sensing applications have been identified, techniques of data processing have been improved and computer based image processing systems have become more effective.

In order to strengthen the baseline information on existing land use pattern, the following data are used.

A. Remote sensing data

The spatial resolution and the spectral bands in which the sensor collects the remotely sensed data are two important parameters for any land use survey. IRS P6 LISS III data offers spatial resolution of 23.5 m with the swath width of 141 x 141 km. The data is collected in four visible bands namely green (Band 2) (0.52-0.59μ), red (Band 3) (0.62-0.69μ), near Infrared (NIR) (Band 4) (0.77-0.89μ), Short wave infrared band (Band 5) (1.55-1.75μ) with orbit repeat period of 24 days (three days revisit). The shapes, sizes, colours, tone and texture of several geomorphic features are visible in IRS data. Four spectral bands provide high degree of measurability through band combination including FCC generation, bands rationing, classification etc. These features of the IRS data are particularly important for better comprehension and delineation of the land use classes. Hence, IRS P6 LISS-III data has been used for land use mapping.

- IRS P6 LISS III Scene
- Path 100- Row 061 (covering approx. 16°45'00"N -17°10'00"N latitude and 82°05'10"E - 82°27'00"E longitude)
- Dated 04-APR-2012; CD format

B. Collateral data

Survey of India Toposheets bearing No.**65K/5, 65K/8, 65L/1, 65L/5** (1:50,000 scale) and field observations in study period.

C. Methodology

Salient features of Methodology are given below:

- Acquisition of Satellite data
- Data loading
- Data processing

- Geo-referencing the Image
- Rectification
- Supervised Classification for Land use / Land cover
- Ground Truth / field checks using Global Positioning System
- Masking

The digital image processing was performed using PCI GEOMATICA 10.1 System on high-configured computer. This software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification, contrast stretching etc.. Arc Map 10 is used for final layout presentation.

The satellite data from the compact disc is loaded on the hard disk and by studying quick looks (the sampled image of the appropriate area); the sub-scene of the study area is extracted.

Supervised classification using all the spectral bands can separate fairly accurately, the different land use classes at level II on the basis of the spectral responses, which involve the following three steps:

1. Acquisition of ground truth
2. Calculation of the statistics of training area
3. Classification using maximum likelihood algorithm

The training areas for classification were homogeneous, well spread throughout the scene with bordering pixels excluded in processing. Several training sets have been used through the scene for similar land use classes. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting no congruous training sets and creating new ones.

3.3.3.1 Results

Land use refers to man’s activities on land, utilitarian in nature whereas land cover denotes the vegetation cover, water body cover and artificial constructions etc.

The land use / land cover classification system standardized by Department of Space, for mapping different agro-climatic zones has been adopted. This classification system has six major land use classes at level I and twenty-eight at level II **(Table 3.3.9)**. The six major classes at level I was further enunciated in the following six categories:

- **Built up land**: It is defined as an area of human habitation developed due to non-agricultural use and that which has a cover of buildings, transport, communication utilities in association with water, vegetation and vacant lands.

- **Land with or without scrub:** They occupy (relatively) higher topography like uplands or high grounds with or without scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain.

- **Fallow land:** It is described as agricultural land which is taken up for cultivation but is temporarily allowed to rest un-cropped for one or more seasons, but not less than one year. These lands are particularly those which are seen devoid of crops at the time when the imagery is taken of both seasons.

- **Dense Evergreen Forest:** It is described as a forest, which comprises of thick and dense canopy of tall trees, which predominantly remain green throughout the year. It includes both coniferous and tropical broad-leaved evergreen trees. Semi-evergreen forest is a mixture of both deciduous and evergreen trees but the latter predominate

- **Water bodies:** Area persistently covered by water such as river and Reservoir, lakes.

Land use / land cover distribution in the study area has been estimated as given below using the above classification system and digital analysis techniques.

3.3.3.2 15 Km Radius Study Area

Plate 3.3.1 is the LISS III Image (False Colour Composite / FCC) showing 15 km radial distance around proposed project site at Kakinada, Andhra Pradesh. In the image, vegetation (plantation, shrub, forest) appears red, water bodies and river as blue. Attributes such as colour, tone, texture, shape and size are used to interpret the image visually. Morphologically, the area is a flat terrain showing river. In the FCC vegetation cover shows with red colour. The Built-up area visible clearly which reflect bluish colour in FCC.

Plate 3.3.2 is the colour-coded output of supervised classification with colours assigned to various classes of land use / land cover. In this image, colours are assigned to various classes as given in legend .The land use / land cover classification indicates 1.71% area covered by Vegetation, 4.82% area covered by Mangroves and 1.08 % area covered by Waste land, whereas 2.01% area is covered by Water as well as River and Sea water showing 47.33%. (**Table 3.3.10**).

Ten different classes are identified within study area. Water is indicated by blue colour. The Fallow Land present spread all over the area is assigned by orange colour covered 13.94%. The Crop land is present in the study area 22.05 % and assigned by the yellow colour. Built up land covers 5.81%, presented in **Table 3.3.10** and **Plate 3.3.1**

3.3.3.3 10 Km Radius Study Area

Plate 3.3.3 is the LISS III Image showing 10 km radial distance around project site. In this image, vegetation (plantation, shrub, forest) appears red, water bodies and river as blue. Attributes such as colour, tone, texture, shape and size are used to interpret the image visually. Morphologically the area is a flat terrain, showing river. In the FCC vegetation cover shows with red colour. The Built-up area visible clearly which reflect bluish colour in FCC.

Plate 3.3.4 is the colour-coded output of supervised classification within the study area. In this image, colours are assigned to various classes as given in legend. The land use / land cover classification indicates 4.99% area covered by Vegetation, 0.74% area covered by Mangroves and 0.69 % area covered by Waste land, whereas 5.21% area is covered by Water as well as river and Sea water showing 50.63%.

Ten different classes are identified within study area. Water is indicated by blue colour. The Fallow Land present spread all over the area is assigned by orange colour covered 13.30%. The Crop land is present in the study area 12.60 % and assigned by the yellow colour. Built up land shows 8.84%.Showing in **Table 3.3.10** and **Plate 3.3.4.**

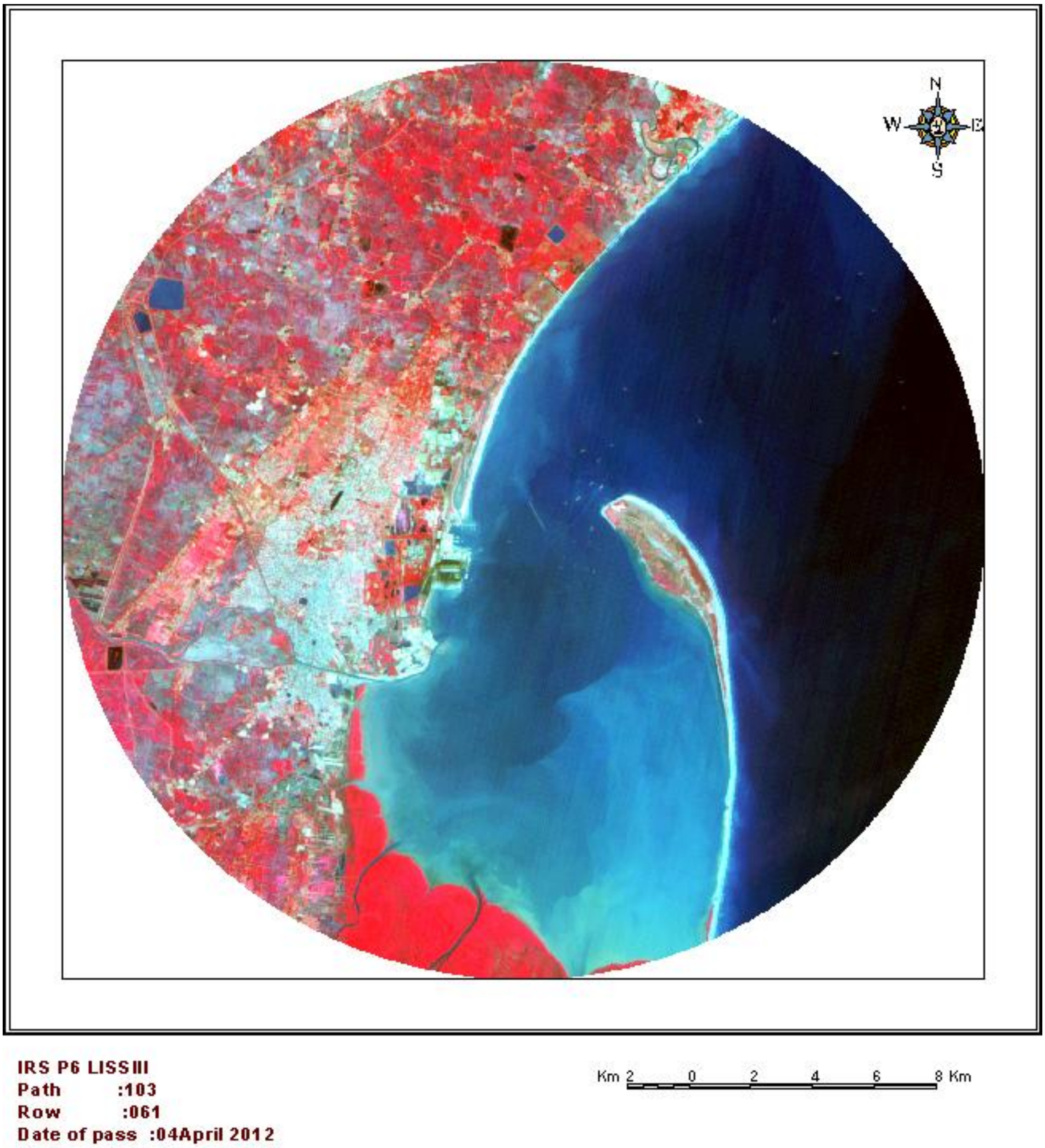


Plate 3.3.1 : False Colour Composite of 15 km Radius around Project Site

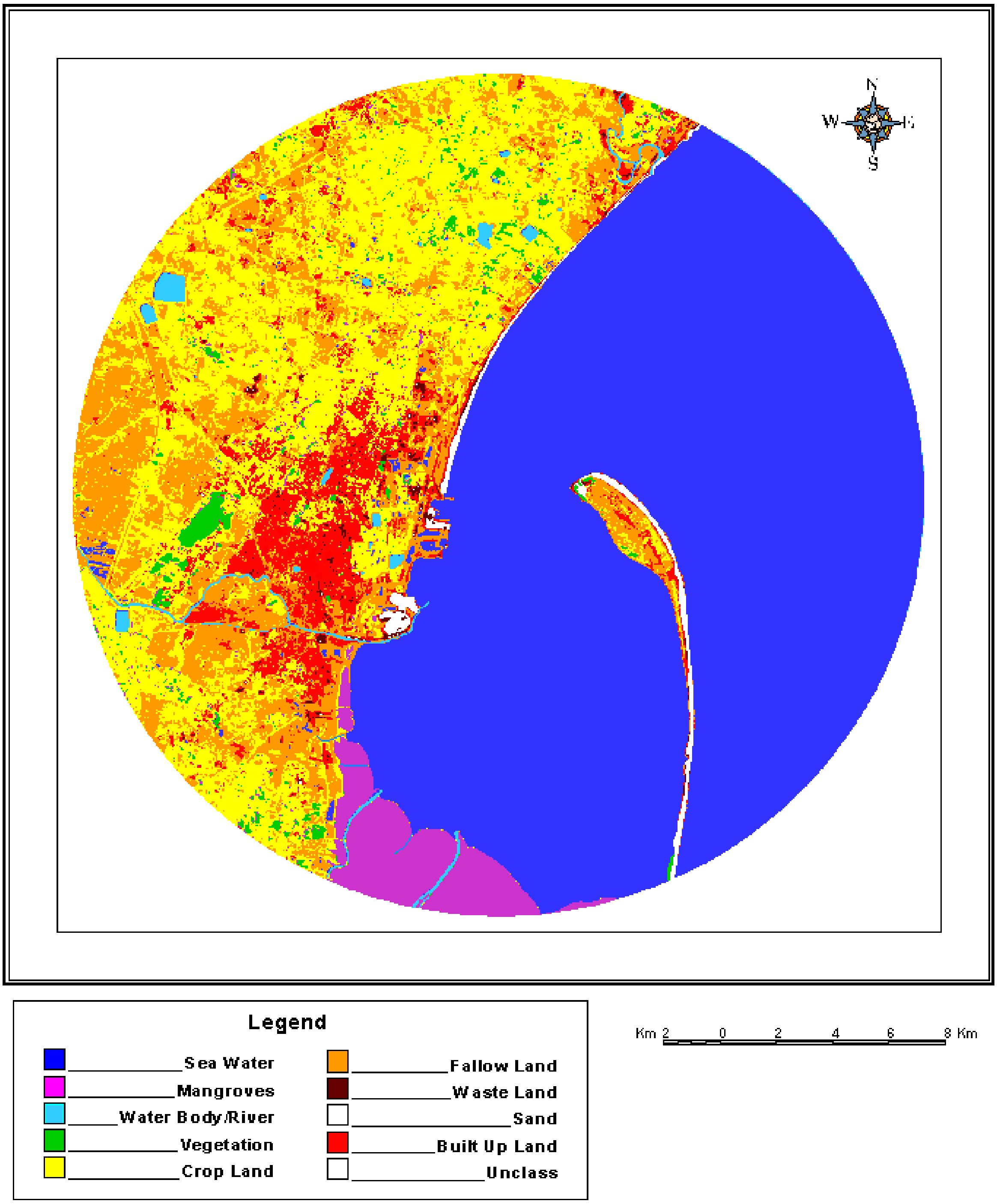


Plate 3.3.2 : Landuse/ Land cover Classified Image - 15 km Radius

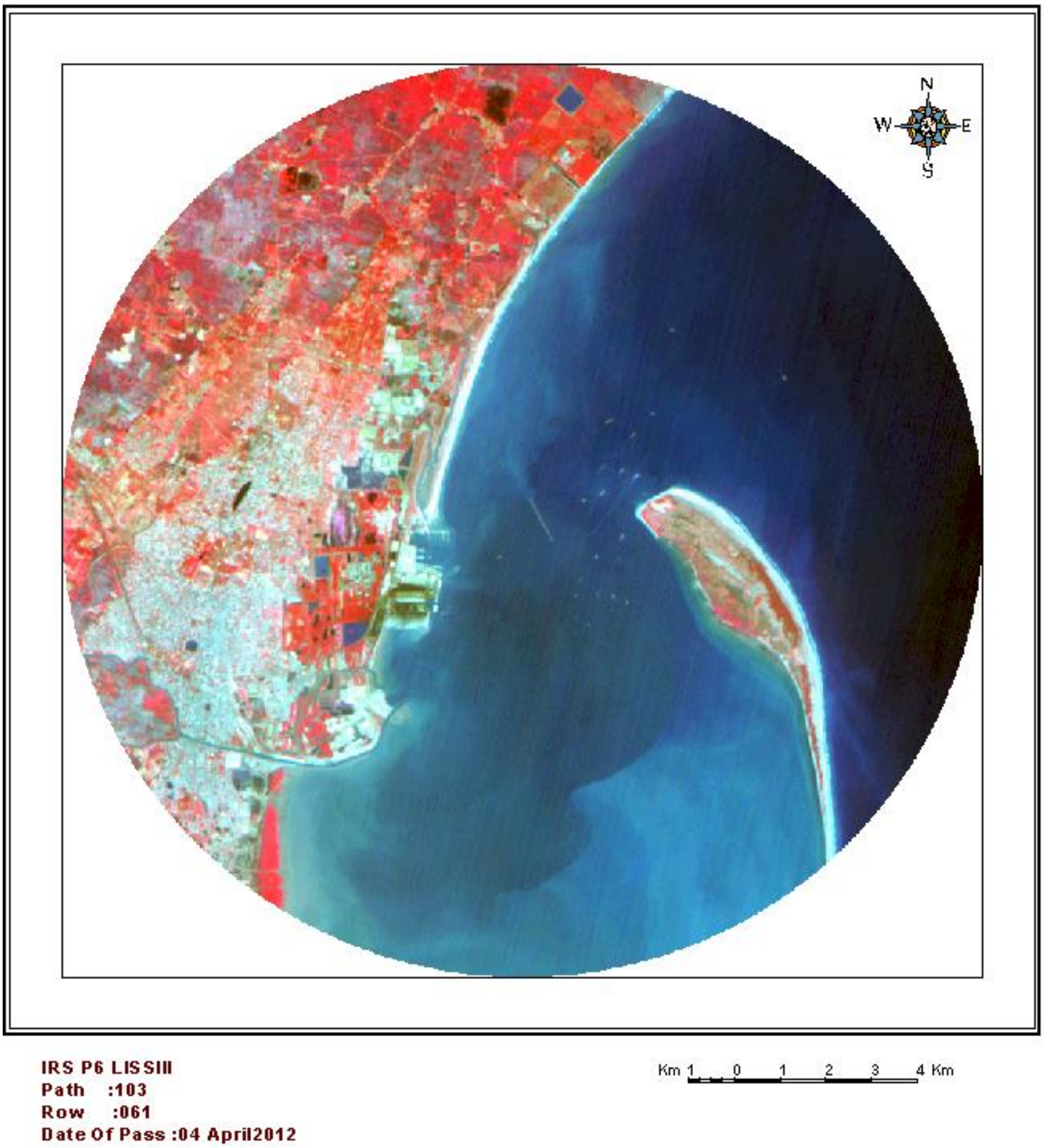


Plate 3.3.3 : False Colour Composite of 10 km Radius around Project Site

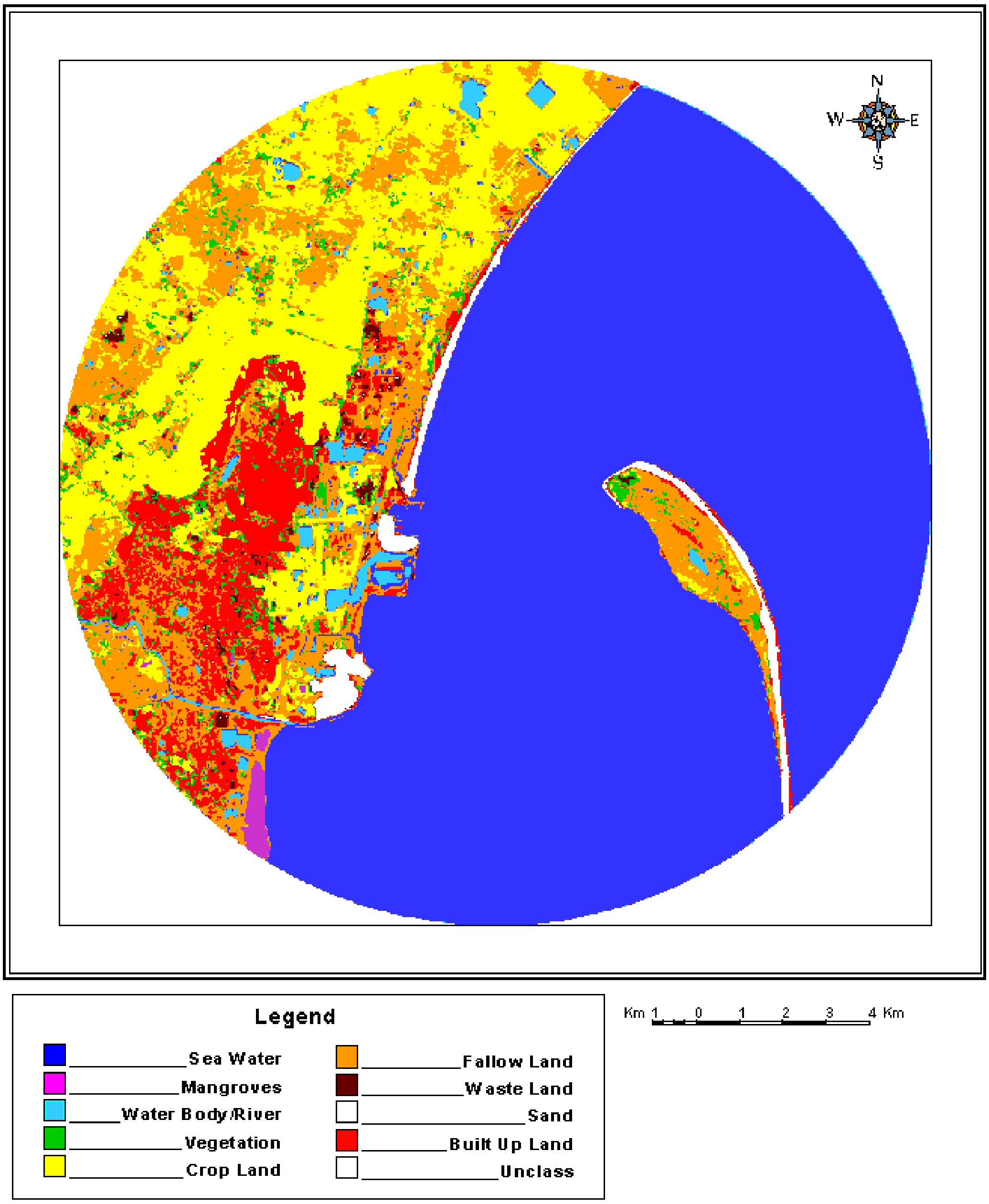


Plate 3.3.4 : Landuse/Landcover Classified Image - 10 km Radius

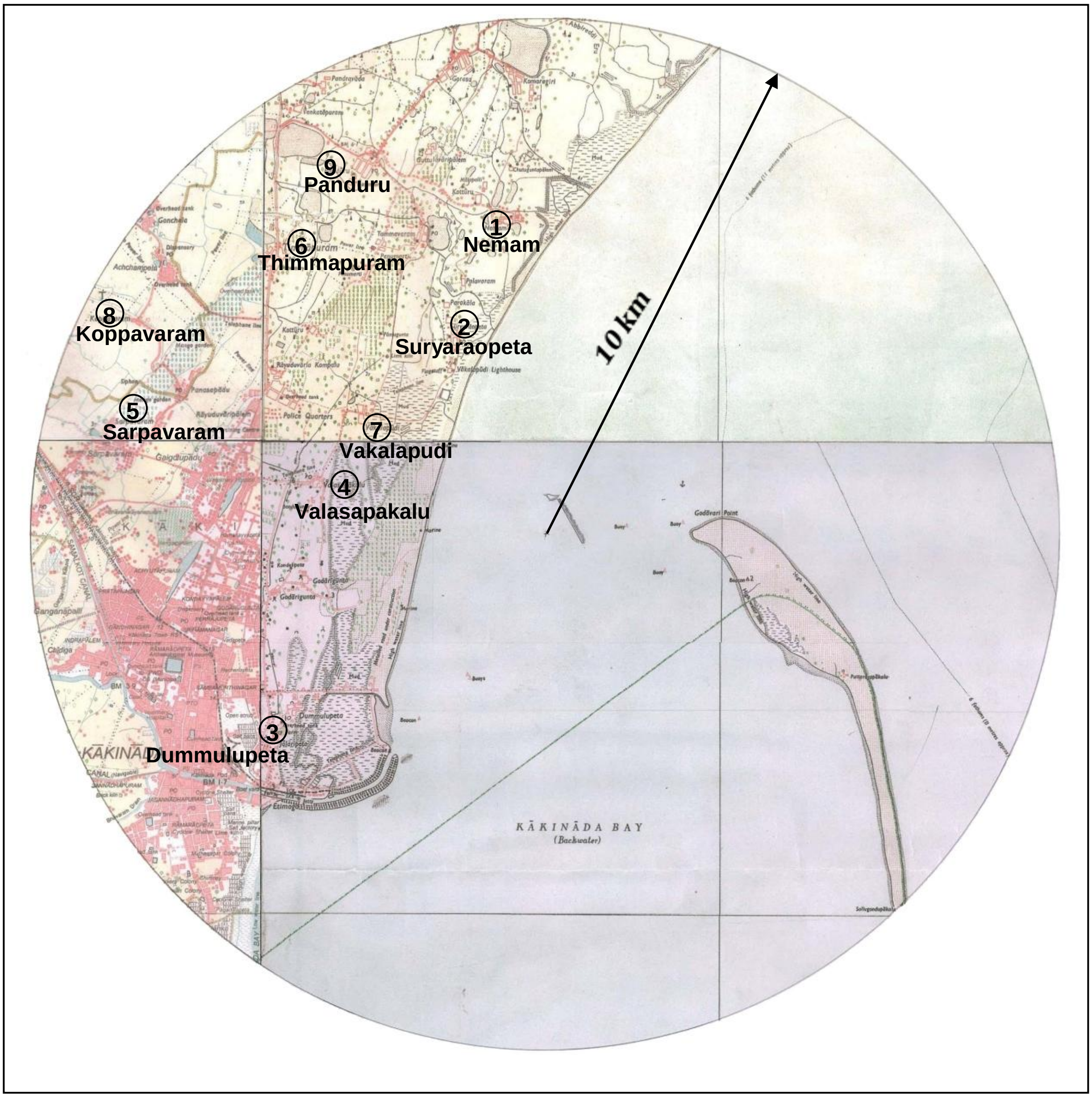


Fig. 3.3.1 : Soil Sampling Locations

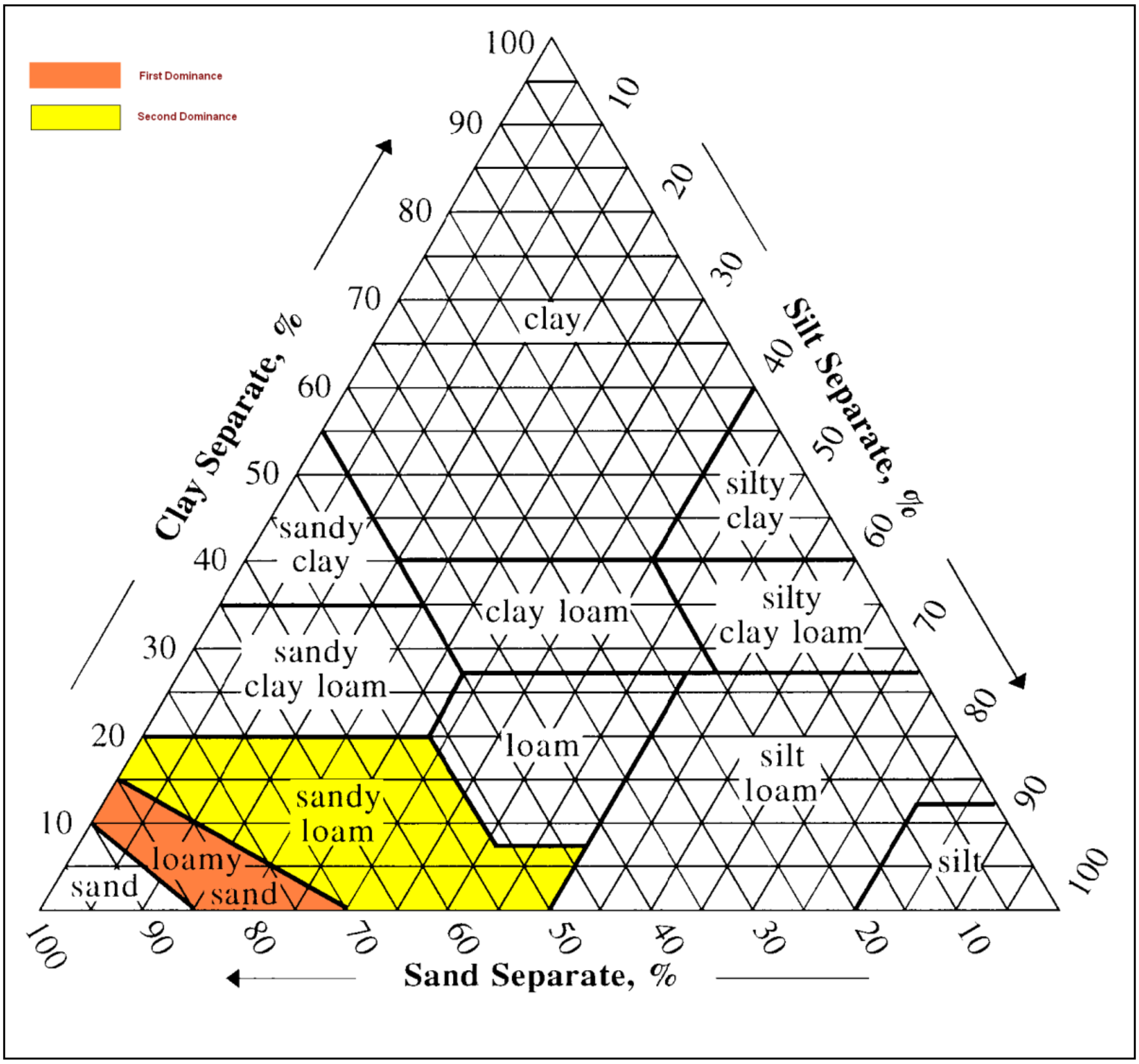


Fig. 3.3.2: Predominant Soil Texture in Study Area

Table 3.3.1 : Soil Sampling Locations

S.No.	Sampling Locations	w.r.t. Jetty / FSRU	
		Direction	Distance (km)
1.	Nemam	NNW	5.9
2.	Suryaraopeta (Near Landfall station)	NNW	4.0
3.	Dummulapeta	SW	6.6
4.	Valasapakalu	W	3.9
5.	Sarpavaram	WNW	8.3
6.	Thimmapuram	NW	7.2
7.	Vakalapudi	WNW	4.1
8.	Koppavaram	W	9.5
9.	Panduru	NW	8.2

Table 3.3.2 : Soil Samples Particle Size Distribution

S. No.	Sampling Locations	Particle Size Distribution (%)			Soil Texture
		Total Sand	Silt	Clay	
1.	Nemam	48.4	4.08	47.52	Sandy Clay
2.	Suryaraopeta Near Landfall Station)	86.4	6.08	7.52	Loamy Sand
3.	Dummulapet	88.8	0.96	10.2	Loamy Sand
4.	Valashapakalu	89.0	0.80	10.2	Loamy Sand
5.	Sarpavaram	82.0	3.80	14.2	Sandy Loam
6.	Thimmapuram	84.2	6.00	9.8	Loamy Sand
7.	Vakalapudi	88.7	3.44	7.8	Loamy Sand
8.	Koppavaram	82.0	4.20	13.8	Sandy Loam
9.	Panduru	90.7	2.44	6.8	Sand

Table 3.3.3 : Soil Physical Properties

S. No.	Sampling Locations	Density (g/cc)		Porosity Percent (%)	Water Holding Capacity (%)
		Bulk (b)	Particle (p)		
1.	Nemam	1.37	2.50	45.32	37.13
2.	Suryaraopeta (Near Landfall Station)	1.49	2.78	46.52	26.24
3.	Dummulapet	1.50	2.78	45.87	24.42
4.	Valashapakalu	1.46	2.78	47.53	28.56
5.	Sarpavaram	1.34	2.78	51.67	33.26
6.	Thimmapuram	1.08	2.50	56.88	39.12
7.	Vakalapudi	1.47	2.63	44.24	25.46
8.	Koppavaram	1.67	2.63	36.49	31.07
9.	Panduru	1.48	2.78	46.25	24.27

Table 3.3.4 : Chemical Properties Saturated Soil Extract

S. No.	Sampling Locations	pH	EC mS/cm	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
				←---------(meq/100gm)---------→			
1.	Nemam	7.0	1.02	9.0	15.0	0.08	0.12
2.	Suryaraopeta (Near Landfall Station)	7.8	0.86	3.8	3.6	0.04	2.34
3.	Dummulapet	8.0	0.43	4.0	16.6	0.16	0.23
4.	Valashapakalu	7.4	0.42	1.8	5.0	6.19	0.46
5.	Sarpavaram	7.3	0.96	5.8	10.3	12.19	3.28
6.	Thimmapuram	6.6	0.52	8.0	5.66	0.41	0.21
7.	Vakalapudi	5.8	0.04	2.8	20.3	0.18	0.01
8.	Koppavaram	7.6	0.88	3.0	2.6	11.64	2.69
9.	Panduru	7.2	0.10	2.8	4.0	0.94	0.12

Table 3.3.5 : Cation Exchangeable Properties of Soil

Sr. No.	Sampling Locations	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	ESP%
		cmol (p^{+}) kg^{-1}				
1.	Nemam	13.8	13.4	2.02	0.56	6.78
2.	Suryaraopeta	4.50	3.30	1.30	2.24	11.46
3.	Dummulapet	12.6	6.60	1.68	0.67	7.80
4.	Valashapakalu	3.08	6.40	0.5	0.06	4.65
5.	Sarpavaram	13.6	7.80	1.05	0.27	4.62
6.	Thimmapuram	6.66	7.40	1.48	0.09	9.47
7.	Vakalapudi	4.20	2.80	0.23	0.12	3.13
8.	Koppavaram	11.5	7.60	2.1	0.11	9.85
9.	Panduru	8.20	7.60	0.27	0.24	1.66

Table 3.3.6 : Soil Fertility Status

S.No.	Sampling Locations	Organic Carbon (%)	Available		
			N	P_2O_5	K_2O
			Kg/Ha		
1.	Nemam	1.08	289	59.24	293.9
2.	Suryaraopeta	0.80	63	14.74	249.3
3.	Dummulapet	1.05	251	17.49	33.63
4.	Valashapakalu	0.66	225	11.65	29.92
5.	Sarpavaram	1.02	251	20.95	141.52
6.	Thimmapuram	0.61	62	16.21	49.72
7.	Vakalapudi	0.90	108	85.49	47.98
8.	Koppavaram	1.32	168	45.48	106.38
9.	Panduru	0.87	285	18.73	127.81
Poor soil		**< 0.5**	**< 280**	**< 23**	**< 133**
Medium soil		**0.5-0.75**	**280-560**	**23-57**	**133-337**
Fertile soil		**>0.75**	**> 560.0**	**> 57.0**	**> 337.0**

Table 3.3.7 : Heavy Metals in Soil Samples

Sr. No.	Test Method →	As	Cd	Cr	Cr^{+6}	Co	Cu	Fe	Pb	Mn	Hg	Ni	Zn
		6010.B	6010.B	6010.B	7196- A	6010.B	6010.B	6010.B	6010.B	6010.B	7471-A	6010.B	6010.B
	Sampling Location ↓	mg / kg											
1.	Nemam	BDL	BDL	62.5	BDL	17.7	47.6	35714	8.8	668	BDL	33.9	64.6
2.	Suryaraopeta (Project site)	0.7	BDL	13.9	BDL	BDL	12.9	10704	4.3	127	BDL	BDL	24.3
3.	Dummulapet	BDL	BDL	8.7	BDL	BDL	13.5	5973	6.7	106	BDL	BDL	21.6
4.	Valashapakalu	BDL	BDL	8.2	BDL	BDL	7.1	5140	3.2	116	BDL	BDL	12.6
5.	Sarpavaram	BDL	BDL	17.8	BDL	1.0	16.6	15367	3.7	287	BDL	BDL	26.3
6.	Thimmapuram	BDL	BDL	30.2	BDL	3.9	41.6	17675	7.4	508	BDL	BDL	77.2
7.	Vakalapudi	BDL	BDL	9.1	BDL	BDL	3.6	4829	1.8	128	BDL	BDL	9.4
8.	Koppavaram	BDL	BDL	34.5	BDL	3.7	18.8	21920	4.0	415	BDL	1.5	21.5
9.	Panduru	BDL	BDL	15.8	BDL	BDL	8.0	7399	2.8	165	BDL	BDL	18.0

BDL: Below Detection Limit

Detection Limit - Cr^{+6}- 0.05 mg/kg ; Hg- 1 mg/kg;Co-0.2 mg/kg,; Cd- 0.04 mg/kg;As-0.5 mg/kg,Ni-0.4 mg/kg

Table 3.3.8 : Microbiological Characteristics of Soil

S. No.	Sampling Location	TVC	Fungi	Actinomycetes	Rhizomium	Azotobacter
		CFU/g of soil				
1.	Nemam	25 $x10^6$	6 $x10^4$	3 $x10^4$	2 $x10^4$	7 $x10^4$
2.	Suryaraopeta (Near Landfall station)	18 $x10^6$	4 $x10^4$	3 $x10^4$	1 $x10^5$	1 $x10^4$
3.	Dummulapet	$12x10^6$	3 $x10^4$	$2x10^4$	4 $x10^5$	1 $x10^4$
4.	Valashapakalu	25 $x10^6$	5 $x10^4$	4 $x10^4$	1 $x10^5$	1 $x10^4$
5.	Sarpavaram	22 $x10^6$	7 $x10^4$	1 $x10^4$	3 $x10^5$	9 $x10^4$
6.	Thimmapuram	36 $x10^6$	9 $x10^4$	5 $x10^4$	3 $x10^5$	5 $x10^4$
7.	Vakalapudi	32 $x10^6$	3 $x10^4$	4 $x10^4$	4 $x10^5$	4 $x10^4$
8.	Koppavaram	36 $x10^6$	7 $x10^4$	3 $x10^4$	5 $x10^5$	6 $x10^4$
9.	Panduru	$18x10^6$	$7x10^4$	3 $x10^4$	2 $x10^5$	2 $x10^4$

TVC : Total Viable Count, CFU : Colony Forming Unit

Table 3.3.9: Land use/Land Cover Classification System (NRSC)

Sr. No.	Level - I		Level – II
1.	Built-up Land	1.1	Built-up land
		1.2	Road
		1.3	Railway
2.	Agriculture Land	2.1	Crop land
		2.2	Fallow (Residual)
3.	Forest	3.1	Evergreen/Semi-evergreen forest
		3.2	Deciduous forest
		3.3	Degraded/Scrub land
		3.4	Forest blank
		3.5	Forest plantation
		3.6	Mangrove
		3.7	Cropland in forest
4.	Wasteland	4.1	Salt affected land
		4.2	Waterlogged land
		4.3	Marshy/Swampy land
		4.4	Gullied/Ravinous land
		4.5	Land with or without scrub
		4.6	Sandy area (coastal and desert)
		4.7	Barren rocky/Stony waste/sheetrock area
5.	Water bodies	5.1	River/Stream
		5.2	Lake/Reservoir
		5.3	Tank/Canal
6.	Others	6.1	Grassland/Grazing land
		6.2	Shifting cultivation
		6.3	Snow cover/Glacial area

Table 3.3.10: Inventory of Land use / Land cover in study area

Sr. No.	Land use/Land cover Classes	15 km radius		10 km radius	
		Area in (Sq. Km)	Area in (%)	Area in (Sq. Km)	Area in (%)
1	Sea Water	334.40	47.33	158.97	50.63
2	Mangroves	34.07	4.82	2.34	0.74
3	Water Body/River	14.18	2.01	16.36	5.21
4	Vegetation	12.09	1.71	15.66	4.99
5	Crop Land	155.76	22.05	39.55	12.60
6	Fallow Land	98.46	13.94	41.77	13.30
7	Waste land	7.60	1.08	2.17	0.69
8	Sand	8.86	1.25	9.39	2.99
9	Builtup Land	41.07	5.81	27.77	8.84
	Total	**706.50**	**100.00**	**314**	**100.00**

3.4 Water Environment

Water is necessary for any major development project in its construction and operation phase. Depending on the type of proposed project, the effluent generated may also cause potential impacts on receiving body due to discharge of effluents from the project. These impacts may correspond to either or both surface and groundwater resources in the proposed project area depending on the specific situation. To address these issues it is necessary to take a stock of available water resources in the project area with respect to prevailing quality. This data represent the baseline status of water environment as part of impact assessment study.

The existing water resources, both surface and ground water with the corresponding significance are identified within the study area (10 km radial distance) around project site. The representative sampling locations for surface and groundwater are selected through reconnaissance to assess the existing (pre-project) status of water quality in the impact zone. Physico-chemical, nutrient, demand, bacteriological and biological parameters having relevance to public health and aesthetic significance are selected to assess the water quality status with special attention to raw water resources. The standard methods prescribed for surface and groundwater sampling as well as the analytical procedures for individual parameters are followed in this study.

3.4.1 Reconnaissance

Kakinada forms the main gateway port for the rich agricultural belt of East Godavari, West Godavari and Krishna Districts of Andhra Pradesh state. The study area consists of Samalkot canal in west south west part of the study area, Panduru cheruvu at north- west part and sea coast in eastern part. Groundwater is the principal resource for domestic purpose in almost all villages in the study area. However from Samalkot canal drinking water is supplied to Kakinada town and surrounding area.

M/s Nagarjuna Fertilizers and chemicals, M/s Coramandel International, Godavari Fertilizers Ltd., Barge mounted power plant (GMR) etc. are situated in the coastal belt near the port area. The Kakinada Deep Water Port handles import of oil, coal, export of Granite and general cargo etc.

The pre-project of water quality status has been assessed during December 2012 by collecting water samples and analyzing them for different parameters. The standard methods prescribed for surface and groundwater sampling, preservation as well as the analytical procedures for individual parameter is followed in this study.

3.4.2 Baseline Status - Water Quality

The surface water samples were collected from two resources and ground water samples at thirteen (13) locations (**Table 3.4.1**) within the study area (**Fig.3.4.1**). The groundwater samples are collected from dug / open wells as well as bore wells / hand pumps.

Physico-chemical parameters along with biological indicators of pollution have been identified for assessing the baseline status of water environment and identification of impacts due to proposed developmental activities at proposed site. In order to assess the water quality, standard methods (APHA, AWWA 2007) were followed for sample collection, preservation and analysis in the laboratory.

3.4.2.1 Physico-chemical Characteristics

Surface Water

Samalkot canal (Godavari River) and Panduru Cheruvu falling in study area have been identified for surface water quality assessment. The Canal and Cheruvu water samples collected during study period have been analyzed for phyisco-chemical parameters and the corresponding results are presented in **Tables 3.4.2-3.4.4**. During study period, the Samalkot canal and Panduru cheruvu water sample collected showed moderate water quality in terms of Turbidity - 0.3 & 4 NTU and total dissolved solids - 280 & 240 mg/l respectively. Buffering capacity in terms of alkalinity was found to be 73 mg/l and 58 mg/L respectively, whereas pH was 7.6 in Samalkot canal sample and Panduru sample with a pH of 8.0. Nutrient load in terms total phosphates was found to be 0.15 & 0.17 mg/l whereas Nitrate was below detectable limit in both the surface water samples. Levels of DO and COD were observed to be 6.9 & 7.6 mg/l and 4 & 24 mg/l respectively. The level of oil and grease were 0.02 & 1.03 mg/l which may be due to anthropogenic activities.

Groundwater

The sampling locations of 13 groundwater resources are listed in **Table 3.4.2**. Some of the ground water samples were pumped out from ground and stored in tanks. The results obtained for physico-chemical parameters, nutrient, demand and organic parameters, heavy metals, bacteriological and biological characteristics of groundwater samples collected during winter season are presented in **Tables 3.4.5-3.4.7**. During study period, the physico-chemical characteristics of the groundwater samples for pH, turbidity, total alkalinity, total hardness, chloride, sulphate, sodium, potassium and Fluoride contents are in the ranges of 6.8-8.1; 0.1-0.3 NTU; 48-120 mg/l; 252-648 mg/l; 78-362 mg/l; 7.8 -52 mg/l; 69-508 mg/l ; 2-129 mg/l and 0.8-1.2 mg/ respectively. The concentrations of oil & grease were not detectable in ground water samples.

3.4.2.2 Heavy Metals

Water samples were analysed for heavy metals in ICP-OES using standard method (APHA 21st edition).The heavy metal concentration observed in surface and ground water samples during study period are presented in **Table 3.3.8**. The Heavy metals concentrations were observed below detection limit for As, Cd, Cr, Cr^{+6}, Co, Cu, Pb, Hg, Ni, and Zn in all the samples except Fe and Mn.

3.4.2.3 Bacteriology

The presence of coliform group of organisms in water is recognized as evidence of faecal pollution. Surface and ground water samples were collected in sterilized bottles in winter season which were preserved and analyzed for total and faecal coliforms at laboratory by membrane filtration technique. The results of bacteriological analysis of surface and ground water samples are presented in **Table 3.4.9**.

During study period, samples from Panduru cheruvu (surface water) showed total coliform counts 32 CFU/100 ml and Samalkot canal water showed too many colonies. In groundwater total coliforms are observed in the range: 3 - TMC CFU/100 ml. There was no faecal contamination found in both the surface & ground water samples.

3.4.2.4 Biological Characteristics

The nature and population of biological species in water depends on physico-chemical characteristics, i.e. pH conductivity, alkalinity, BOD, nutrient etc. and also depends on the nature of the water body, i.e. dynamic or static as well as fresh or saline water. Thus, the type and number of plankton species may serve as indicators of physico-chemical quality and trophic levels of water body.

Standard procedures were adopted for zooplankton and phytoplankton counts. Analysis of zooplankton is done by Sedwick-Rafter (SR) cell method whereas phytoplanktons were estimated by Lacked drop (microtransect) method (APHA, 1998). The results of phytoplankton and zooplankton are expressed as counts/l and counts/m^3 respectively. In order to evaluate baseline biological characteristics, total 8 samples were collected from surface water bodies (6 pond water and 2 lake water) 1 river water and six ground water samples were collected.

Species Composition

Organisms have been listed in standard publications according to increasing trophic levels in aquatic environment. Similarly, many organisms have been listed to favour certain physico-chemical conditions, viz. silicates for diatoms. Presence of desmids and Diatoms indicate clean water conditions. Dominance of diatoms, protozoa, ciliates, chlorophyceae and cyanophyceae indicate progressively increasing trophic conditions. Planktonic rotifers are usually more abundant in fresh waters than in estuarine waters. It is believed that when crustacean such as copepoda, cirripedia, ostracoda etc. insects outnumber other groups, the situation reflects enriched organic content of water. Thus it is evident that presence of certain organisms also helps in classifying water body into trophic levels based on its physico-chemical characteristics.

Species Diversity

Diversity of plankton depends on physico-chemical characteristics of water or rather the trophic levels. In oligotrophic waters, diversity of plankton is high, while in mesotrophic and eutrophic conditions indicating increasing pollution loads, diversity of plankton decreases. Shannon Weiner Index is a measure of diversity of plankton that takes into account the total as well as individual species count in a water sample.

$$D = \Sigma - (n_i/n) \log_2 (n_i/n)$$

Where,

d = Shannon Weiner Diversity Index
n_i = Number of each individual species in the sample
n = Total number of individuals of all species in the sample

It should be noted that the diversity is also susceptible to other parameters such as turbidity, colour and flow rate particularly in hilly rivers. Thus, the results should be interpreted with caution. A widely accepted ecological concept is that communities with large number of species (i.e. with high diversity) will have high stability that can resist adverse environmental factors. The maximum value of Shannon Weiner Index of phytoplankton for clean waters has been reported to be around 6, though it may differ slightly in different locations. Decrease in the value of index may thus be taken as indicator of pollution.

Phytoplankton & Zooplanktons

Data generated for biological characteristics, pertaining to phytoplankton observed in sampling locations are presented in **Table 3.3.10**. The phytoplankton species identified are *Nitzschia, Microcystis aeruginosa.* Total count represents approximate measure of quantity of plankton in the water samples. Samalkot canal water samples showed total phytoplankton count of 15 nos./ml and Panduru showed total phytoplankton count 25 no. s/ml and 10 nos./ml in the samples from Indrapalem and 20 nos./ml of Sarpavarm sample. Shallow dug well may be reason for presence of phyto plankton in Sarpavarm and Indrapalem samples.

Zooplankton in water samples of the study area are presented in **Table 3.3.11** *Daphnia*, is the prominent sp observed in the collected samples. Samalkot Canal and Panduru Cheruvu and showed total zooplankton count of 250 and 304 nos./m^3 respectively, whereas Dug well samples from Sarpavaram and Indrapalem showed 14 and 78 nos./m^3 of total count.

Nitschia

Microcystis aeruginosa

Daphnia

Phytoplankton

Zooplankton

Due to very poor diversities of phyto and zooplanktons, the calculation of biological / pollution indices is not possible.

Though no guideline value has been set for presence of free living organisms in drinking water, it is desirable that these free living organisms should be absent in drinking water. The potability of water may be aesthetically affected due to presence of these organisms leading to alteration in its colour, odour, taste, turbidity etc. The contaminated well waters can be used for drinking purpose only after appropriate treatment.

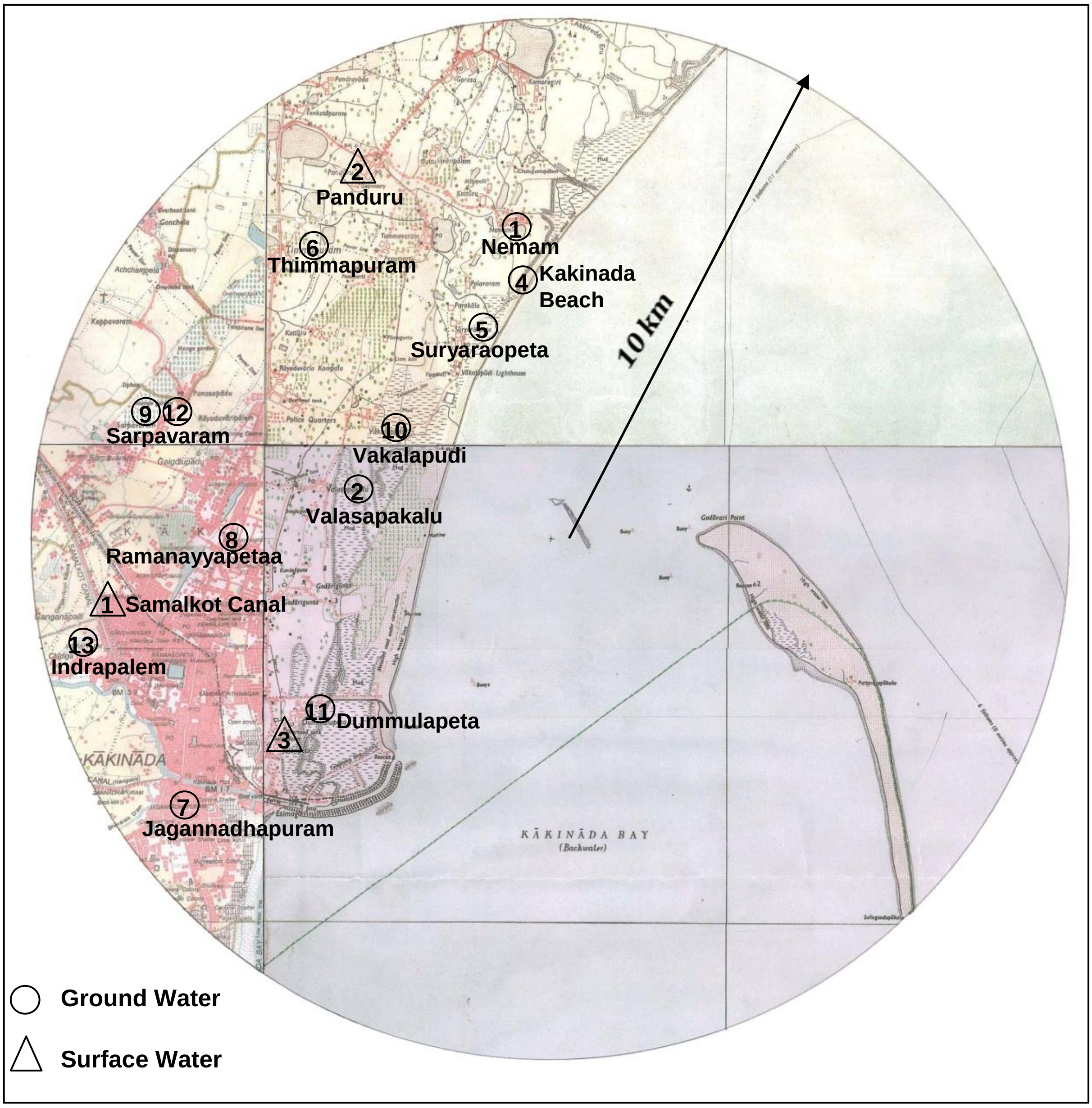


Fig. 3.4.1: Water Sampling Locations

Table 3.4.1 : Water Quality Sampling Locations

Sr. No.	Sampling Location	Direction from Project site	Project Site / study area
Surface Water			
1.	Samalkot Canal	SW	Raw water sources in study area
2.	Panduru (Cheruvu)	NW	
Ground water – Borewell /Open well			
1.	Nemam	NNE	Villages in study area
2.	Valasapakalu	SW	
3.	Dummulapeta	SSW	
4.	Kakinada Beach	NE	Villages in study area
5.	Suryaraopeta (Near Landfall Station)	--	
6.	Thimmapuram	WNW	
7.	Jagannadapuram	SSW	
8.	Ramanayapeta	SW	
9.	Sarpavaram	WSW	
10	Vakalpudi	SW	
11	Dummulapeta	SSW	
12	Sarpavaram	WSW	
13	Indrapalem	SW	

Table 3.4.2: Surface Water Quality – Physical Parameters

Sr. No.	Sampling Location	pH	Temperature (^{0}C)	Turbidity (NTU)	Total Dissolved Solids (mg/l)	Conductivity (µS/cm)
1.	Samalkot Canal	6.6	29	0.3	280	340
2.	Panduru (Cheruvu)	7.4	29	4.0	240	370
'A' Class as per BIS : 2296-1982		**6.5-8.5**	**-**	**-**	**500**	

Table 3.4.3: Surface Water Quality – Inorganic Parameters

Sr. No.	Sampling Location	Total Alkalinity	Total Hardness	Calcium Hardness	Chloride	Sulphate	Fluoride	Sodium	Potassium
		as $CaCO_3$ (mg/l)			mg/l				
1.	Samalkot Canal	73	248	176	30	10	1.14	3.9	1.0
2.	Panduru (Cheruvu)	58	156	110	46	27	1.01	4.0	1.0
Standard (IS:2296-1982) A' Prime class category		**-**	**300**	**-**	**250**	**400**			**-**

Table 3.4.4 : Surface Water Quality – Nutrient & Demand Parameters

S. No.	Sampling Location	Nitrate as NO_3	Total Phosphates as P	Dissolved Oxygen	Chemical Oxygen Demand	Bio-Chemical Oxygen Demand at 27^0C	Oil & Grease
		(mg/l)					
1.	Samalkot Canal	1.4	0.15	6.9	4	<2	0.2
2.	Panduru (Cheruvu)	1.6	0.17	7.6	24	<2	1.03
Standard (IS:2296-1982) A' Prime class category		**20**	-	**Minimum 6**	-	**Maximum 2**	**-**

Table 3.4.5 : Ground Water Quality – Physical Parameters

Sr. No.	Sampling Location	pH	Temp. (^0C)	Turbidity (NTU)	Total Dissolved Solids (mg/l)	Conductivity (µS/cm)
Hand pump / Borewell / Dugwell						
1.	Nemam	6.9	29	0.3	1089	1440
2.	Valasapakalu	7.4	29	0.2	744	1270
3.	Dummulapeta	6.9	29	0.15	2010	3000
4.	Kakinada Beach	7.3	29	0.1	1208	1650
5.	Suryaraopeta	7.0	29	0.2	1378	2300
6.	Timmapuram	7.2	28	0.26	840	1400
7.	Jagannadapuram	7.0	29	0.12	762	1320
8.	Ramanayapeta	7.4	28	0.1	1144	1530
9.	Sarpavaram	7.0	29	0.2	880	1090
10.	Vakalpudi	8.1	29	0.2	685	1300
11.	Dummulapeta- well	7.2	30	0.1	1182	1770
12.	Sarpavaram -well	7.2	29	0.1	702	900
13.	Indrapalem - well	6.8	29	0.1	652	790
Standard(IS:10500-2012)		**6.5-8.5**	-	**1.0**	**500**	-

NTU : Nephelometric Turbidity Unit

Table 3.4.6 : Ground Water Quality – Inorganic Parameters

Sr. No.	Sampling Location	Total Alkalinity	Total Hardness	Calcium Hardness	Chloride	Sulphate	Fluoride	Sodium	Potassium
		as $CaCO_3$ (mg/L)				mg/L			
1.	Nemam	88	428	380	218	11.23	BDL	220	3
2.	Valasapakalu	62	640	416	120	10.42	BDL	134	2
3.	Dummulapeta	100	648	400	476	25.56	1.1	508	129
4.	Kakinada Beach	86	252	188	262	14.57	BDL	345	4
5.	Suryaraopeta	120	408	308	362	52	1.1	353	12
6.	Thimmapuram	72	352	268	262	14.12	1.2	54	2
7.	Jagannadapuram	82	388	232	142	10.69	BDL	198	88
8.	Sarpavaram	64	636	408	94	8.8	1.1	69	23
9.	Ramanayapeta	76	392	220	256	21.14	BDL	153	12
10.	Vakalpudi	70	428	326	150	9.16	0.8	95	11
11.	Dummulapeta (Dugwell)	86	360	248	210	9.88	1.6	202	39
12.	Sarpavaram (Dugwell)	48	468	316	78	9.43	0.9	70	12
13.	Indrapalem (Dugwell)	68	488	356	98	7.81	BDL	100	39
Standard (IS:10500-2012)		**200**	**200**	**-**	**250**	**200**	**1.0** (Max.1.5)		

Table 3.4.7 : Ground Water Quality – Nutrient & Demand Parameters

S.No.	Sampling Location	Nitrate as NO_3	Total Phosphates as P	Dissolved Oxygen	Chemical Oxygen Demand
		(mg/L)			
Hand pump / Borewell /Dugwell					
1.	Nemam	0.035	0.10	6.1	4.0
2.	Valasapakalu	1.28	1.67	7.0	7
3.	Dummulapeta	2.85	1.23	4.0	5
4.	Kakinada Beach	0.71	0.05	6.2	12
5.	Suryaraopeta	7.18	1.85	5.1	14
6.	Thimmapuram	2.80	0.37	7.8	4
7.	Jagannadapuram	1.70	0.88	6.2	10
8.	Ramanayapeta	1.60	0.27	7.0	8
9.	Sarpavaram	4.81	2.34	3.9	4
10.	Vakalpudi	0.97	1.51	6.2	18
11.	Dummulapeta (Dug well)	1.88	2.1	6.2	18
12.	Sarpavaram (Dug well)	1.86	1.87	8.1	12
13.	Indrapalem (Dug well)	0.62	0.35	6.6	14
Standard(IS:10500-2012)		45	-		

Table 3.4.8: Water Quality - Heavy Metals

Sr. No.	Sampling Location ↓ / Test Method →	As	Cd	Cr	Cr^{+6}	Co	Cu	Fe	Pb	Mn	Hg	Ni	Zn
	Test Method →	3120.B	3120.B	3120-A	3500- $Cr^{+6.B}$	3120.B	3120.B	3120.B	3120.B	3120.B	3500-Hg.B	3120.B	3120.B
		mg / L											
Surface Water													
1.	Samalkot Canal	BDL	BDL	BDL	BDL	BDL	BDL	1.03	BDL	0.03	BDL	BDL	BDL
2.	Panduru (Cheruvu)	BDL	BDL	BDL	BDL	BDL	BDL	0.09	BDL	BDL	BDL	BDL	BDL
Ground Water													
	Hand pump / Borewell /Dugwell												
1.	Nemam	BDL	BDL	BDL	BDL	BDL	BDL	0.90	BDL	0.15	BDL	BDL	BDL
2.	Valasapakalu	BDL	BDL	BDL	BDL	BDL	BDL	0.64	BDL	0.49	BDL	BDL	BDL
3.	Dummulapeta	BDL	BDL	BDL	BDL	BDL	BDL	0.19	BDL	0.46	BDL	BDL	BDL
	Borewater												
4.	Kakinada Beach	BDL	BDL	BDL	BDL	BDL	BDL	0.06	BDL	BDL	BDL	BDL	BDL
5.	Suryaraopeta	BDL	BDL	BDL	BDL	BDL	BDL	0.10	BDL	BDL	BDL	BDL	BDL
6.	Thimmapuram	BDL	BDL	BDL	BDL	BDL	BDL	0.08	BDL	0.15	BDL	BDL	BDL
7.	Jagannadapuram	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.17	BDL	BDL	BDL
8.	Ramanayapeta	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	0.13	BDL	BDL	BDL
9.	Sarpavaram	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.09	BDL	BDL	BDL
10.	Vakalpudi	BDL	BDL	BDL	BDL	BDL	BDL	0.10	BDL	0.33	BDL	BDL	BDL
11.	Dummulapeta (Dugwell)	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	0.03	BDL	BDL	BDL
12.	Sarpavaram (Dugwell)	BDL	BDL	BDL	BDL	BDL	BDL	0.13	BDL	0.18	BDL	BDL	BDL
13.	Indrapalem (Dugwell)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.04	BDL	BDL	BDL
Standard (IS:10500-2012)		**0.01**	**0.003**	**0.05**	**-**	**-**	**0.05**	**0.3**	**0.01**	**0.1**	**0.001**	**0.02**	**5.0**

BDL: Below Detection Limit

Detection Limit - Cr^{+6}- 0.05 mg/L ; Hg- 20 µg/L;Fe-0.02 mg/L; Cu- 0.02 mg/L;Co-0.01 mg/L,;Mn-0.01 mg/L;Cd- 0.01 mg/L;Pb-0.04 mg/L;As-0.02 mg/L; Cr-0.02 mg/L;Zn-0.01 mg/L,Ni-0.03 mg/L

Table 3.4.9 : Water Quality – Bacteriology

S.No.	Sampling Location	Total Coliform (CFU/100 ml)	Faecal Coliform (CFU/100 ml)
Surface Water			
1.	Samalkot Canal	TMC	NC
2.	Panduru (Cheruvu)	32	NC
Standard(IS:2296-1982) A' Prime class category		**50 max.**	**-**
Groundwater - Hand pump / Borewell /Openwell			
1.	Nemam	NC	NC
2.	Valasapakalu	NC	NC
3.	Dummulapeta	TMC	NC
4.	Kakinada Beach	20	NC
5.	Suryaraopeta	NC	NC
6.	Thimmapuram	24	NC
7.	Jagannadapuram	3	NC
8.	Ramanayapeta	3	NC
9.	Sarpavaram	3	NC
10.	Vakalpudi	8	NC
11.	Dummulapeta (Dugwell)	TMC	NC
12.	Sarpavaram (Dugwell)	16	NC
13.	Indrapalem (Dugwell)	TMC	NC

CFU: Colony Forming Unit ; NC: No Colony Found ; TMC: Too Many to Count

Table 3.4.10 : Water Quality –Phytoplankton

S.No.	Sampling Location	Total Count /ml	Relative percentage of Organism Groups	
			Bacillariophyceae (*Nitschia Sp.*)	**Cyanophyceae** **(***Microcystis aeruginosa)*
1.	Samalkot Canal	75	-	100
2.	Panduru (Cheruvu)	125	-	100
3.	Sarpavarm (Dugwell)	100	50	50
4.	Indrapalem (Dugwell)	50	-	100

Notes**: '-' indicate Absent**

Due to very poor diversities of phyto and zooplanktons, the calculation of biological / pollution indices is not possible

Table 3.4.11 : Water Quality –Zooplankton

S.No.	Sampling Location	Total Count /m^3	Relative percentage of Organism Groups		
			Rotifera *Keratella sp. Brachionus sp.*	**Cladocera** *Daphnia Sp*	**Copepoda** *Nauplius larva*
1.	Samalkot Canal	250	50	50	-
2.	Panduru (Cheruvu)	304	33	33	34
3.	Sarpavarm (Dugwell)	140	50	50	
4.	Indrapalem (Dugwell)	78	-	100	-

3.5 Biological Environment

Biological environment is one of the most important components for environmental impact assement. Ecological system shows inter relationship between biotic and abiotic components including dependence, competition and mutualism. Biotic component comprises of both plants (Flora) and animal (Fauna) communities, which interact not only within and between them but also with the abiotic components, viz. physical and chemical components of the environment.

Generally biological communities are the indicator environmental condition and resource of its distribution and survival.The species of flora and fauna are organized into natural communities with mutual dependencies and show various responces and sensitivies to anthropogenic influences in biosphere. The changes in biotic community are studied in the pattern of distribution, abundance and diversity.

3.5.1 Reconnaissance

The project site is located within Kakinada Deep Water Port. The study area, i.e. 10 km radius around the project site mostly comprises of open scrub vegetation. Eastern portion of the study area is covered by Bay of Bengal and Western portion is occupied by urban area, rural area, agriculture fields, social forestry and limited natural vegetation. There is no forest land or mangroves within 10 km radial distance except extension of Corangi reserved forest on Hope Island at 4 km distance in SE direction.

Selection of sampling locations has been made with the reference of topography and landuse and existing vegetation pattern. A total of 9 sampling locations were selected for study on biological aspects.

The biological observations were made in different categories of land cover, viz. agriculture fields, around canal & drains, in plain area, village, unutilized waste land etc. Sampling locations selected for the biological survey are listed in **Table 3.5.1** and shown in **Fig. 3.5.1**.

3.5.2 Survey Methodology

The field observations on vegetation were made by surveying different locations. The information were collected by visual observation and discussion with villagers. The secondary data related to this region were also obtained from District Forest Department, District Fisheries Department, District Agriculture office and Social Forestry Division.

The assessment of wildlife / fauna was carried out by field observations, inquiring with local people and on the basis of secondary data collected from different Government offices like Forest Department, Wildlife Department, Fisheries Department etc. The birds were sighted using binoculars and recorded at different places in study area.

3.5.3 Biodiversity in study area

The vegetation in the study area falls under tropical savannah evergreen type as per the Champion and Seth. This type of forests occurs in a much localized manner in small pockets. The list of plant species compiled from Forest Working Plan of East Godavari District is depicted in **Table 3.5.2**.The project region consists of total 277 plant species out of which189 trees species, 47shrubs species and 41 climber species. During survey period 36 trees species and 5 shrubs species observed in the study area by survey team. The most dominant trees in this region are *Cocis nucifera, Casuarina equisetifloia, Cassia siamea*, *Azadirachta indica*, *Borasus flabelhifer*, *Butea monosperma*, *Eucalyptus* sps., *Ailanthus excelsa, Albizzia lebbeck* and *Albizzia procera.*

The coast of Bay of Bengal is dominated by *Casuarina equisitifolia* and *Eucalyptus sp*., Aquatic plant species, *Eichhornia crassipes, Ipomoea carnea*, Impomoed aquatica etc. were observed near the pond, nalas and small water reservoirs.

3.5.4 Floral Characteristics

The floristic structure and composition in study area is mainly dominated by *Cocis nucifera, Casuarina equisitifolia* and other trees observed in and around the villages are *Borasus flabellifer*, *Azadirachta indica,Ficusbengalensis* and *Ziziphus mauritiana, Ficus regusa,Tamarindus indica, Magnifera indica,Phoenix sylvestre, Calotropis procera,Tectona* *grandis,Bogan welia, Syzygium cumini, Eucalyptus* sp.,*Prosopis chilensis*, *Acacia nilotica,Macaranga peltata* etc*.,* were observed in study area.

Few medicinal plants were recorded amongst which *Azadirachta indica,Ficus bengalensis,Ficus retusa, Sygygium cumini, Ocimum sanctum,Dendrocalamus Strictus, Leucas cephalotes, Ziziphus regusa* are common.

Dominant trees are *Cocis nucifera, Casurina equisitifolia*, *Anogeissus latifolia, Prosopis chilensis, Acacia nilotica*, *Eucalyptus sps., Aegle marmelos, Azadirachta indica, Borasus flabellifer, Areca catechu, Cassia siamea*, *Butea monosperma*, *Ailanthus excelsa, Albizzia lebbeck* and *Albizzia procera.* Other tree species found in this area are *Ficus religiosa, Delonix regia, Tamarindus indica, Syzygium cumini, Tectona grandis,Ficus bengalensis,Ziziphus mauritiana, Phoenix sylvestre, Acacia auriculiformis, Caccia tarota* and *Saraca indica. Other tree species found in this area are Delonix regia, Tamarindus Indica, Syzygium cumini, Tectona grandis, Azadirachta indica , Pheonix sylvestre, Acacia auriculiformis, Caccia tarota and Saraca indica.*

Most dominant shrubs are *Calotropis procera*, *Ipomoea carnea, Ricinus communis, Ixora* sp., Andrographis paniculata, Agave americana, Tephrosia purpurea, Lantana camara, Dodonaea viscose in case of herbs Vernonia cineria, Tridax procumbens, Cynodon dactylon and Corchorus tiliafolia. The common climbers are Pergularia daemia, Abrus precatorius, Cocculus hirsutus, Asparagus racemosus and Stigmaphylon ciliari, Cyperus rotundus, Ipomoea pestigridis and Aerva lanata. Horticulture crops grown in the district are Coconut, Mango & Cashewnut. In the recent past the cultivation of citrus was increased. Mango orchards were observed on the way to the Thammavaram. Most of the area was covered by the Coconut grove & the paddy cultivation

Azadirachta indica, Polyalthia pendula, Pongamia pinnata, Ceasalpinia pulcherima, Ficus sp,*. Cocos nucifera* etc. plant species were mostly observed on roadside.

Dominant families of plants recorded in the study area (**Table 3.5.3**) are: Fabaceae, Rubiaceae, Euphorrbiaceae, Combretaceae, Apocyaceae, Rutaceae, Ploraceae, Anacardiceae, Plalvaceae, Acanthaceae, Meliaceae, Laminaceae, Rhizophoraceae, Ebenaceae etc..

3.5.5 Mangroves

Mangroves are a unique ecosystem found along sheltered coasts where they grow abundantly in saline soil and brackish water. Mangrove forest is a very dynamic and highly productive ecosystem. It plays multiple ecological functions essential to its surrounding habitats and also as an important resource for coastal inhabitats.

Mangroves are critical elements of coastal area and stand out as an ecosystem with high economic potential and often subjected to severe exploitation. They act as a barrier against cyclonic winds and storms and avoid coastal erosion. They support breeding and feeding of a variety of fish, prawn and crab, thereby enhance the potential of adjacent coastal waters. The role of mangroves in the economy of the local fishery community is significant.

Apart from the economic value, the mangroves are rich in biodiversity, supporting a variety of flora and fauna including migratory birds and endangered species such as salt- water crocodiles, otters etc. The current status of these critically important mangroves is threatened due to degradation from unsustainable exploitation by commercial interests, genuine basic needs of the poor and diversion for aquaculture, tourism and other changing land use patterns.

Mangroves are observed in the marshy environment of muddy flats. The survey on southern coast of kakinada bay (out side study area) showed presence of mangroves species, viz.*Avicennia marina, var marina, Acanthus ilicifolius, Suaeda maritima, Sesuvium portulacastrum* and *Salicornia brachiata*.

Coringa sanctuary (northern boundary) is located at 13 km away from the project site in south direction. Coringa Wildlife Sanctuary is confined to tidal forest area in the estuarine areas of Godavari and Bay of Bengal. Coringa sanctuary comprises of Reserve Forests of Coringa, Coringa extension and Bhiravapalem, extending over an area of 23,570 ha. It has got a unique ecosystem, characteristic of tidal forests that exist at part of Godavari river mouth, along with the special habitat that hosts various fauna and multifarious organisms. The area was declared by A.P. state government as Coringa Wildlife Sanctuary under section 26A of the wildlife Protection Act, 1972 (Central Act No. 53 of 1972) vide G.O.Ms.No.45 EFS & Technology (For.III) 13th April, 1998.

3.5.6 Medicinal Plants

The study area of East Godavari District have sparse occurrence of medicinal plants. The common medicinal flora of the study area are *Azadirachta indica, Syzygium cumini, Tectona grandis, Ficus religious, Eucalyptus sp. Ficus bengalensis, Tamarindus indica, Emblica officinalis, Albizzia lebbeck, Andrographis paniculata, Mangifera indica, Mimosa pundica, Ziziphus regusa,* etc. The list of medicinal plant recorded from Forest Division shown in **Table 3.5.4**.

3.5.7 Threatened Plant Species

No threatened plant species have been either recorded or observed at project site as well as within the study area.

3.5.8 Social Forestry

The main aim of Social Forestry Department is to increase the plantation and to motivate the people for planting trees and to provide the source of daily income for the villagers.

Social Foresrty Division of East Godavari District has carried out plantation in few areas on the road side and in villages. Various schemes have been started to develop village forest, fuel wood resources and rehabilition of degraded forest land.

Trees species used in social forestry are all local and native species. Some of the species recorded in that area are *Peltoforum,Pongamia glabra* (kanuga), Rain tree, *Macaranga peltata* (badam).

Albizia lebbeck (dirrisena) *Bauhinia variegata (*devakan chanamu), *Terminalia tomentosa* (maddi), Spathodia etc. A view of Avenue plantation is shown in **Fig.3.5.2**.

3.5.9 Agriculture

East Godavari District is one of the most agriculturally prominent districts in Andhra Pradesh. The main crops are paddy (*Oriza sativa*), Maize (*Zea mays*), Urid (*Vigna radiata*), Mung (*Vigna mungo*), Sugarcane (*Saccharum officinarum*) and Tobaco (*Nicotiana tobacum*).

The common Kharif crops of this region are Paddy, Maize, Mung cotton, Chillies, Jowar, Sesamum etc.; because of favorable climatic conditions and the availability of irrigation facilities. Paddy is grown in different seasons (**Fig.3.5.3**). Other commercial crops are Coconut, Cashew, Mango, Banana, Cotton and Tobacco in surrounding villages. Casuarina as well as Cashew nut plantations are found mainly in sandy coastal plains and sea beaches. Mango plantation is also observed in Chidiga village. Commonly grown kitchen gardening/ horticulture plants in the urban area near project site were Guava, Mango, Lemon, Banana, Grapes etc. as well as some vegetables. The agriculture field is bordered or barricaded by *coccus nucifera.*The list of area; productivity and production of different agriculture crops for recent available data presented in **Table 3.5.5**.

3.5.10 Green Belt

The existing major industries in study area as well as the Kakinada deep water port have developed green belts as per statutory requirement (**Fig.3.5.4 & Fig.3.5.5**). Objectives of the master plan for greenbelt are :

- The green belt and overall vegetation act as a further safety buffer physically arresting particulate matter and through transpiration releasing oxygen and water vapour.
- It serves as a dust curtain and arrestor.
- The green belt maintains ecologically conductive conditions for bird, animal life and for a safe, healthy enjoyable environment for the human population.

3.5.11 Fauna

The list of Wildlife fauna recorded from Forest Department, East Gadavari District are presented in **Table 3.5.6**.

3.5.11.1 Avifauna

Assessment of Avifaua was carried out in the study area. Birds were counted at each sampling site by travelling and observing the birds with the help of 7× 15 x35 binocular.

The common species of birds observed were swallow, blue rock pigeon, myna, house crow and house sparrow. The most dominant bird species observed were pond heron, house crow, myna, little egret, cattle egret, little green bee eater, pond heron, black drongo, and other birds species are red vented bulbul, wagtail, cuckoo, Indian rollar, little cormonant jungle crow, myna, parrot, kingfisher. Thelist of avifauna observed by NEERI team in study area are presented in **Table 3.5.7**.

3.5.11.2 Fisheries

Study area is nearer to the sea coast and Godavari River distributeries (estuary zone) flowing through the study area, therefore fishery is an important business in this area. According to the information collected from Fisheries Department of East Godavari Disrtict, the marine commercial fishes and inland fishes which are found in the study area, are Bombay duck, mullet, mud skipper, hilsa, catfish, clupeids, coilia, catla, rohu, mrigal, murrels, barbus, prawn, miscellaneous fishes, shrimps and crabs.

Fish and fisheries of the Kakinada region can be divided into two broad categories viz. marine and inland fisheries. Marine fisheries cover the entire coastal area whereas estuarine fisheries are spread over the tidal portion of Godavari river. The commercial fishing is permitted outside the port limits. Kakinada has fullfledged fishing harbour. The marine fishing activities are undertaken mostly at deep sea. Marine fisheries are very important for their commercial value.

Important fishing centres in the Kakinada region are Polavaram, Suryaraopeta, Fishing harbour (KDWP), Dummulapeta, kumbhabhishekam, chollangi bridge. Specieswise and craftwise marine fish landing in Kakinada Division for the year 2008-‘09 is presented in **Table 3.5.8**. Fishermen in this region use country boats as well as mechanized boats. As per the district statistics, during 2008-2010, the marine fish and shrimp catch has been recorded at about 52000 tons per annum, with an economic value of about Rs. 10 crore.

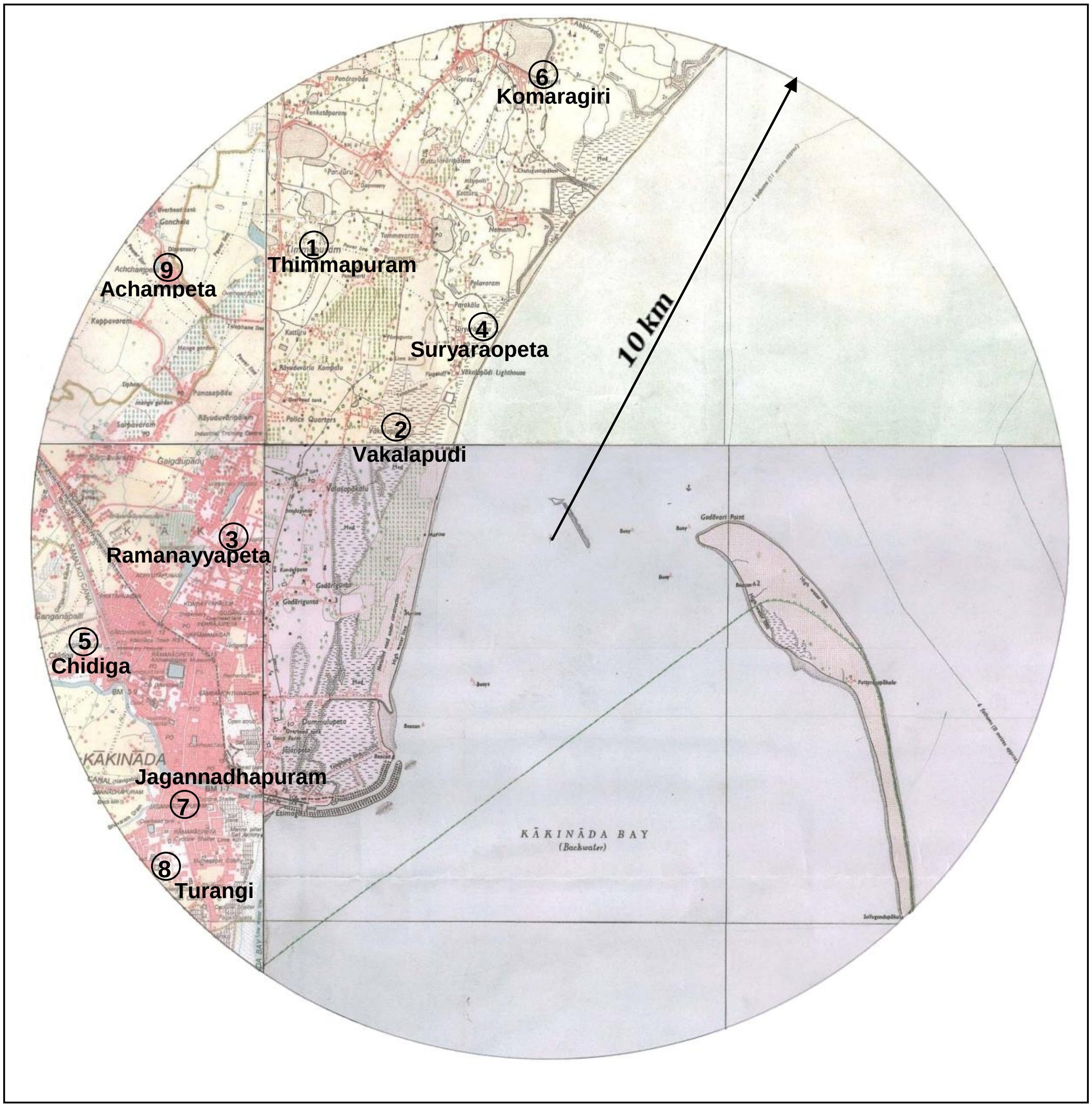


Fig. 3.5.1: Sampling Locations for Biological Environment

Fig.3.5.2 : Avenue Plantation by Social Forestry Division

Fig. 3.5.3 : A View of Paddy Cultivation

Fig.3.5.4 : A View of Greenbelt in and around NFCL

Fig.3.5.5 : A View of Greenbelt Showing Dense Vegetation

Table 3.5.1

List of Sampling Locations in the Study Area

Sr. No.	Name of the Villages
1.	Thammavaram
2.	Vakalapudi
3.	Ramannaypeta
4.	Suryaraopeta
5.	Chidiga
6.	Komaragiri
7.	Jagannadhapuram
8.	Turangi
9.	Achmpeta

Table 3.5.2

Flora in Project Region
(East Godavari district,Forest office)

Sr. No.	Vernacular Name	Botanical Name	Natural Order
1.	Adavi-mamidi	*Spondias mangifera*	Anacardiaceae
2.	Adavi-munaga	*Moringa concanensis*	Moringaceae
3.	Adavi-nimma Yerra munukudu	*Atalantia monophylla*	Rutaceae
4.	Akasa-malli, Kavuki	*Millingtonia hortensis*	Bignonianceae
5.	Akupala, Tellapala	*Wrightia tinctoria*	Apocynaceae
6.	Alamanda	*Macaranga peltata**	Euphorbiaceae
7.	Alli	*Memecylon edule*	Melastomaceae
8.	Anepu	*Bridelia retusa*	Euphorbiaceae
9.	Ari	*Bauhinia racemosa*	Leguminosae
10.	Atti	*Ficus glomerata*	Moraceae
11.	Baditha	*Erythrina indica*	Leguminosae
12.	Balli	*Bridelia tomentosa*	Euphorbiaceae
13.	Bandaru	*Adina cordifolia*	Rubiaceae
14.	Banka - nakkari	*Cordia oblique*	Boraginaceae
15.	Barrinki	*Streblus asper*	Moraceae
16.	Battaganapa	*Mitragyna parvifolia*	Rubiaceae
17.	Bhutankusam, Nirija	*Elaeodendron glaucum*	Celastraceae
18.	Billudu	*Chloroxylon swietenia*	Rutaceae
19.	Bodda marri	*Ficus hispida*	Moraceae
20.	Boggu chettu	*Trema orientalis*	Ulmaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
21.	Botruga	*Mitragyna parvifolia*	Rubiaceae
22.	Bodda dudduga	*Saccopetalum tomentosum*	Annonaceae
23.	Buruga	*Bombax malabaricum*	Malvaceae
24.	Busi, Puska	*Schleichera trijuga*	Sapindaceae
25.	Chennangi	*Lagerstroemia parviflora*	Lythraceae
26.	Chikkudu, Tella motku	*Ougenia dalbergioides*	Leguminosae
27.	Chilaka dudduga	*Polyalthia cerasoides*	Annonaceae
28.	Chilla	*Strychnos potatorum*	Leguminosae
29.	Chinduga	*Albizia odoratissima**	Leguminosae (Fabaceae)
30.	Chinni, Dank	*Gymnosporia Montana*	Celastraceae
31.	Chinta	*Tamarindus indica*	Leguminosae (Fabaceae)
32.	Chirumanu	*Anogeissus latifolia*	Combretaceae
33.	Chitreka	*Protium serratum*	Burseraceae
34.	Dadduga	*Adina cordifolia*	Rubiaceae
35.	Devadari	*Erythroxylon monogynu**	Linaceae (Erythroxylaceae)
36.	Devakanchanamu	*Bauhinia variegate**	Leguminosae (Fabaceae)
37.	Dirisena	*Albizia lebbeck**	Leguminosae (Fabaceae)
38.	Divi divi	*Caesalpinia coriaria*	Leguminosae (Fabaceae)
39.	Dudippa	*Hymenodictyon excelsum*	Rubiaceae
40.	Errajuvvi	*Ochna Squarrosa*	Ochnaceae
41.	Erraponaku	*Sterculia urens*	Sterculiaceae (Malvaceae)
42.	Errapurugudu	*Breynia rhamnoides*	Euphorbiaceae
43.	Gangaravi	*Thespesia populnea*	Malvaceae
44.	Gara	*Balanites roxburghii*	Simarubaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
			(Zypophyllaceae)
45.	Garugudu	*Garuga pinnata*	Burseraceae
46.	Getha	*Diospyros sylvatica*	Ebenaceae
47.	Gedara	*Ceriops roxburghiana*	Rhizophoraceae
48.	Giruguday	*Casearia tomentosa*	Samydaceae (Flacourtiaceae)
49.	Goddari	*Bauhinia retusa*	Leguminosae or Fabaceae
50.	Gorintha	*Lawsonia inermis*	Lythraceae
51.	Gotti	*Ziziphus xylopyrus**	Rhamanaceae
52.	Guggilam	*Aegiceras corniculatum*	Myrsinaceae
53.	Gummadi	*Gmelina arborea*	Verbenaceae (Laminaceae)
54.	Gumpena	*Odina wodier*	Anacardiaceae
55.	Gundu mada	*Avicennia alba**	Verbenaceae (Acanthaceae)
56.	Illinda	*Diospyros chloroxylon*	Ebenaceae
57.	Indupa	*Strychnos potatorum*	Loganiaceae
58.	Ippa	*Bassia latifolia*	Sapotaceae
59.	Isikarai	*Stereospermum tetragonum*	Bignoniaceae
60.	Ita	*Phoenix sylvestris**	Palmae
61.	Jammi	*Prosopis spicigera**	Leguminosae (Fabaceae)
62.	Jeedi mamidi	*Anacardium occidentale*	Anacardiaceae
63.	Jeeluga	*Caryota urens*	Palmae (Arecaceae)
64.	Jittegi	*Dalbergia latifolia**	Leguminosae (Fabaceae)
65.	Juvvi	*Ficus tomentosa**	Moraceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
66.	Kadam	*Barringtonia acutangula**	Lecythidaceae
67.	Kalinga	*Sonneratia apetala**	Sonneratiaceae
68.	Kanchana u	*Bauhinia purpurea*	Leguminosae (Phyanthaceae)
69.	Kandilla	*Bruguiera cyllindrica*	Rhizophoraceae
70.	Kanuga	*Pongamia glabra**	Leguminosae (Phyanthaceae)
71.	Karaka	*Terminelia chebula**	Combretaceae
72.	Karinguva	*Gardenia latifolia*	Rubiaceae
73.	Kattimandu	*Euphorbia trigona*	Fuphorbiaceae
74.	Kavva gummadi	*Gmelinia asiatica*	Verbenaceae
75.	Kodavali	*Dolichandrone falcate*	Bignoniaceae
76.	Kodisa	*Cleistanthus collinus*	Euphorbiaceae (Phyanthaceae)
77.	Konda gogu	*Cochlospermum gossypium*	Bixaceae (Cochlospermaceae)
78.	Konda pothari	*Kydia calycina*	Malavaceae
79.	Konda thangedu	*Xylia xylocarpa*	Leguminosae
80.	Konda vepa	*Chukrasia tabularis*	Meliaceae
81.	Koramanu	*Bridelia retusa*	Euphorbiaceae (Phyanthaceae)
82.	Korivipala	*Ixora parviflora**	Rubiaceae
83.	Kumhi	*Careya arborea*	Lecythidaceae
84.	Kummarapanaku	*Sterculia villosa*	Sterculiaceae (Malvaceae)
85.	Konkudu	*Sapindus emarginatus*	Sapindaceae
86.	Kontichinta	*Pleurostylia wightii*	Celastraceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
87.	Koluga	*Pterospermum heyneanum*	Sterculiaceae
88.	Maddi	*Terminalia tomentosa**	Combretaceae
89.	Mamidi	*Mangifera indica**	Anacardiaceae
90.	Manchi bikki	*Gardenia gummifera*	Rubiaceae
91.	Maredu	*Aegle marmelos*	Rutaceae
92.	Marri	*Ficus bengalensis or benghalensis**	Moraceae
93.	Moduga	*Erythrina suberosa*	Leguminosae (Fabaceae)
94.	Moduga	*Butea frondosa**	Leguminosae (Fabaceae)
95.	Mogali	*Pandanus tectorius*	Pandanaceae
96.	Mokkam	*Schrebera swietenioides*	Oleaceae
97.	Mollem	*Bambusaarundinacea*	Gramineae (Poaceae)
98.	Mullu moduga	*Erythrina suberosa*	Leguminoseae (Fabaceae)
99.	Munuti karaka	*Melia composite*	Meliaceae
100.	Musti	*Strychnos nux vomica*	Loganiaceae
101.	Nagalla pachari	*Dalbergia lanceolaria*	Leguminosae (Fabaceae)
102.	Nalla jeedi	*Semecarpus anacardium*	Anacardiaceae
103.	Nalla mada	*Avicennia officinalis**	Verbenaceae (Acanthaceae)
104.	Nalla maddi	*Terminalia tomentosa*	Combretaceae
105.	Nalla manga	*Randia uliginosa*	Rubiaceae
106.	Nalla regu	*Albizia amara*	Leguminosae (Fabaceae)
107.	Nalla tumma	*Acacia Arabica*	Leguminosae (Fabaceae)
108.	Naramamidi	*Litsea deccanensis*	Lauraceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
109.	Nevuru	*Premna tomentosa*	Verbenaceae
110.	Neeralli	*Plectronia didyma*	Rubiaceae
111.	Neredu	*Syzygium jambolanum**	Myrtaceae
112.	Nemali	*Holoptelea integrifolia*	Ulmaceae
113.	Nemali adugu	*Vitex altissima*	Verbenaceae
114.	Nidara ganneru	*Samanea saman*	Leguminosae (Fabaceae)
115.	Nimma	*Citrus medica*	Rutaceae
116.	Pacha ganneru	*Thevetia neriifolia*	Apocynaceae
117.	Pala	*Holarrhena antidy senterica*	Apocynaceae
118.	Pala	*Mimusops hexandra*	Sapotaceae
119.	Pampini	*Oroxylum indicum*	Bignonianceae
120.	Panbasa	*Artocarpus inte grifolia*	Moraceae
121.	Pandi ja ruga	*Buchanania lenceolata*	Anacardiaceae
122.	Pantangi	*Bridelia hamiltoniana*	Euphorbiaceae
123.	Parivili	*Tamarix gallica*	Tamaricaceae
124.	Pasi	*Anogeissus acuminate*	Combretaceae
125.	Peda chilaka duduga	*Miliusa velutina*	Annonaceae
126.	Peda Kalinga	*Sonneratia alba**	Sonneratiaceae (Lythraceae)
127.	Peda Bikki	*Gardenia latifolia*	Rubiaceae
128.	Peddamanu	*Ailanthus excels*	Simaroubaceae
129.	Pisiniki	*Maba buxifolia*	Ebenaceae
130.	Pitta juvvi	*Ficus tsiela*	Moraceae
131.	Pogada	*Michelia champaca*	Magnoliaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
132.	Pogada	*Mimusops elengi*	Sapotaceae
133.	Pogada (Kersha)	*Nyctanthes arbortristis*	Oleaceae
134.	Pogada pachari	*Dalbergia Paniculata**	Leguminosae
135.	Pullari	*Antidesma ghaesembilla*	Euphorbiaceae (Fabaceae)
136.	Puthika thada	*Flacourtia ramontchi*	Bixaceae (Salicaceae)
137.	Rawi	*Ficus religiosa**	Moraceae
138.	Regu	*Zizyphus jujube**	Rhamnaceae
139.	Rela	*Cassia fistula**	Leguminoseae (Fabaceae)
140.	Revadi	*Dillenia pentagyna*	Dilleniaceae
141.	Rudraksha	*Guazuma tomentosa*	Sterculiaceae
142.	Sadanam	*Dendrocalamus strictus**	Graminae (Poaceae)
143.	Sara	*Buchanania lanzan*	Anacardiaceae
144.	Sarugudu	*Casuarina equisetifolia**	Casuarinaceae
145.	Senuga	*Xylocarpus obovatus*	Meliaceae
146.	Sima Chinta	*Pithecelobium dulce*	Leguminosae (Fabaceae)
147.	Sithaphalam	*Annona squamosa*	Annonaceae
148.	Somi	*Soymida febrifuga*	Meliaceae
149.	Sundra	*Acacia sundra*	Leguminosae (Fabaceae)
150.	Teku	*Tectona grandis**	Verbenaceae (Laminaceae)
151.	Thada	*Grewia tiliaefolia*	Tiliaceae (Malvaceae)
152.	Thadi	*Borassus flabillifer*	Palmae (Arecaceae)
153.	Thanduga	*Lumnitzera racemosa*	Combretaceae
154.	Thana	*Terminalia bellerica*	Combretaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
155.	Thanuku	*Gyrocarpus americanus*	Hernandiaceae
156.	Thapasi	*Sterculia urens*	Sterculiaceae
157.	Thedlapala	*Wrightia tomentosa*	Apocynaceae
158.	Thella chinduga	*Albizia procera**	Leguminosae (Mimosaceae)
159.	Tella mada	*Avicennia marina**	Verbenaceae (Acanthaceae)
160.	Thella maddi	*Terminalia arjuna*	Combretaceae
161.	Thella puniki	*Givotia rottleriformis*	Euphoribaceae
162.	Thella purugudu	*Flueggea virosa*	Euphorbiaceae (Phyllanthaceae)
163.	Thella thumma	*Acacia leucophloea*	Leguminosae (Fabaceae)
164.	Thogaru	*Morinda tinctoria*	Rubiaceae
165.	Thoprrivelaga	*Limonia crenulata*	Rubiaceae (Rutaceae)
166.	Thumki	*Diospyros melanoxylon*	Euphorbiaceae (Ebenaceae)
167.	Thuraka vepa	*Melia azedarach*	Meliaceae
168.	Tilla	*Excoecaria agallocha*	Euphorbiaceae
169.	Udgva	*Alangium salvifolium*	Alangiaceae
170.	Uppu ponna	*Rhizophora mucronata*	Rhizophoraceae
171.	Uppu ponna	*Rhizophora candelaria*	Rhizophoraceae
172.	Urudu	*Bruguiera conjugate*	Rhizophoraceae
173.	Usirika	*Phyllanthus emblica*	Euphorbiaceae (Phyllanthaceae)
174.	Vanna sundra	*Acacia ferruginea*	Leguminosae (Fabaceae)
175.	Vasantagunda	*Mallotus philippinensis*	Euphorbiaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
176.	Vata narayana	*Delonix elata*	Leguminosae (Fabaceae)
177.	Vavili	*Vitex negundo*	Verbenaceae (Laminaceae)
178.	Velaga	*Feronia elephantum*	Rutaceae
179.	Velthuru	*Dichrostachys cinerea*	Leguminosae (Fabaceae)
180.	Vepa	*Azadirachta indica**	Meliaceae
181.	Vilava mada	*Avicennia alba**	Verbenaceae (Acanthaceae)
182.	Viruguduchava	*Dalbergia latifolia**	Leguminosae (Fabaceae)
183.	Vulimi	*Crataeva religiosa*	Capparidaceae (Capparaceae)
184.	Yegisi	*Pterocarpus marsupium*	Leguminosae (Fabaceae)
185.	Yepi	*Hardwickia binata*	Leguminosae (Fabaceae)
186.	Yerra gatha	*Diospyros Montana*	Ebenaceae
187.	Yerra juvvi	*Ficus retusa*	Moraceae
188.	Yerri bikki	*Gardenia lucida*	Rubiaceae
189.	Teti maddi	*Terminalia arjuna*	Combretaceae
B – Shrubs			
190.	Adavi chamanti	Helicteres isora	Sterculiaceae
191.	Adavi mayuram	*Ardisia solanacea*	Myrsinaceae
192.	Adavi pasupu	*Zingiber cassumunar*	Zingiberaceae
193.	Addasaram	*Adhatoda vasica*	Acanthaceae
194.	Alohi	*Acanthus ilicifolius*	Acanthaceae
195.	Balusu	*Plectronia parviflora*	Rubiaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
196.	Bandedu	*Dodonaea viscose*	Sapindaceae
197.	Chillanki	*Dalbergia Spinosa*	Leguminosae (Fabaceae)
198.	Chitramulam	*Plumbago zeylanica*	Plumbaginaceae
199.	Chitteetha	*Phoenix humilis*	Palmae
200.	Chitteetha	*Phoenix acaulis*	Palmae (Arecaceae)
201.	Chitti jana	*Grewia hirsute*	Tiliaceae (Malvaceae)
202.	Edakulapala	*Alstonia scholaris*	Apocynaceae
203.	Golugu	*Glycosmis cochin chinensis*	Rutaceae
204.	Illakura	*Suaeda monoica*	Chenopodiaceae
205.	Illakura	*Suaeda maritime*	Chenopodiaceae (Amaranthaceae)
206.	Jana	*Grewia populifolia*	Tiliaceae
207.	Jeluga	*Aeschynomene aspera*	Leguminosae (Fabaceae)
208.	Jilledu	*Calotropis gigantean*	Asclepiadaceae (Apocynaceae)
209.	Karubenda	*Pavonia zeylanica*	Malvaceae
210.	Karuvepaku	*Murraya Koenigii*	Rutaceae
211.	Kasinda	*Cassia occidentalis*	Leguminosae (Fabaceae)
212.	Kithanara	*Aloe vera***	Tiliaceae (Asphodelaceae)
213.	Kommu papidi	*Chomelia asiatica*	Rubiaceae
214.	Konda kasintha	*Toddalia asiatica*	Rutaceae
215.	Konda titha	*Desmodium pulchellum*	Laguminosae (Fabaceae)
216.	Konda vempali	*Indigofera parviflora*	Leguminosae (Fabaceae)
217.	Krishna tulasi	*Ocimum sanctum**	Labiatae (Laminaceae)

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
218.	Manga	*Randia dumetorum*	Rubiaceae
219.	Nasa golugu	*Murraya exotica*	Rutaceae
220.	Nasa golugu	*Ximenia Americana*	Olacaceae
221.	Nalla purugudu	*Kirganelia reticulate*	Euphorbiaceae
222.	Nalla vuppi	*Capparis sepiaria*	Capparidaceae (Capparaceae)
223.	Vakabu	*Solanum Xanthocarpum*	Solanaceae
224.	Papidi	*Pavetta indica*	Rubiaceae
225.	Pedda nepalem	*Jatropha curcas*	Euphorbiaceae
226.	Pisingi	*Clerodendron inerme*	Verbenaceae
227.	Rama tulasi	*Ocimum gratissimum*	Labiatae (Lamiaceae)
228.	Seema neepalem	*Croton lawianus**	Euphorbiaceae
229.	Sugandhi pala	*Hemidesmus indicus*	Asclepiadaceae (Apocynaceae)
230.	Thangedu	*Cassia auriculata*	Leguminosae (Fabaceae)
231.	Thantepu	*Cassia tora**	Leguminosae (Fabaceae)
232.	Vaka	*Carissa spinarum*	Apocynaceae
233.	Vempala	*Tephrosia purpurea*	Leguminosae
234.	Vuchinta	*Solanum trilobatum*	Solanaceae
235.	Vummetta	*Datura stramonium**	Solanaceae
236.	Verra chitramulam	*Plumbago rosea*	Plumbaginaceae
C – Climbers			
237.	Adavi chemma	Canavalia virosa	Leguminosaae (Fabaceae)
238.	Adavi draksha	Ampelocissus latifolia	Vitaceae
239.	Adavi gunusuthega	Dioscorea pentaphylla	Dioscoreaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
240.	Adavi malli	Jasminum arborescens	Oleaceae
241.	Adavi nabhi	Gloriosa superb	Liliaceae (Calchicaceae)
242.	Adda theega	Bauhinia Vahlii	Leguminosaae (Fabaceae)
243.	Bandi guruvenda	Adenanthera pavonina	Leguminosaae (Fabaceae)
244.	Bankanoddu	Cissus vitiginea	Vitaceae
245.	Betham	Calamus rotang	Palmae (Arecaceae)
246.	Bontha theega	Calycopteris floribunda	Crassulaceae (Combretaceae)
247.	Chevulapilli theega	Ipomoea pescaprae	Convolvulaceae
248.	Dustapu teega	Pergularia extensa	Asclepiadaceae (Apocynaceae)
249.	Enugu dulagunda	Mucuna pruriens	Leguminosaae (Fabaceae)
250.	Erra chirathali	Ventilago calyculata	Rhamnaceae
251.	Gecha	Caesalpinia crista	Leguminosaae (Casalipiniaceae)
252.	Guravenda	Abrus precatorius	Leguminosaae Dioscoreaceae
253.	Iswara theega	Aristolochia indica	Aristolochiaceae
254.	Kodimadusu	Ougenia dalbergioides	Leguminosaae (Papilionaceae)
255.	Korintha	Acacia caesia	Leguminosaae Dioscoreaceae
256.	Kummari theega	Smilax zeylanica	Liliaceae (Smillaceae)
257.	Modugu theega	Spatholobus roxburghii	Leguminosaae Dioscoreaceae
258.	Mukkurhummudu theega	Leptadenia reticulate	Asclepiadaceae

Contd…

Contd…Table 3.5.2

Sr. No.	Vernacular Name	Botanical Name	Natural Order
259.	Naguru theega	Symphorema involucratum	Verbenaceae
260.	Nalla boddu	Cissus repens	Vitaceae
261.	Nalla theega	Derris uliginosa	Leguminosaae Dioscoreaceae
262.	Nalla theega	Derris scandens	Leguminosaae Dioscoreaceae
263.	Nalleru	Cissus quadrangularis	Vitaceae
264.	Palasamudra theega	Argyreia speciosa	Convolvulaceae
265.	Pala theega	Ichnocarpus frutescens	Apocynaceae
266.	Periki	Ziziphus oenoplia	Rhamnaceae
267.	Pilli theegalu	Asparagus racemosus	Liliaceae (Asparagaceae)
268.	Pippinda theega	Calycopteris floribunda	Combretaceae
269.	Ravanasurudumeesalu	Spinifex squarrosus	Gramineae
270.	Seethmmasavaram	Cuscuta reflexa	Convolvulaceae
271.	Seekayi	Acacia concinna	Leguminosaae (Fabaceae)
272.	Theega moduga	Butea superb	Leguminosaae (Fabaceae)
273.	Theegi nakkiri	Olax scandens	Olacaceae
274.	Thella gini	Dioscorea hispida	Dioscoreaceae
275.	Thippa theega	Dioscorea esculenta	Dioscoreaceae
276.	Ungarala pedmi	Hugonia mystax	Linaceae
277.	Vedla theega	Combretum ovalifolium	Combretaceae

***: Species observed by NEERI Team**

Source: District Forest Department, East Godavari District, Andhara Pradesh.

Table 3.5.3

Flora Dominant Families in Project Region
(District Forest office, East Godavari district)

Sr. No.	Dominant Family	Total Nos.
1	*Leguminosae (Fabaceae)*	51
2	*Rubiaceae*	17
3	*Euphorbiaceae s*	12
4	*Combretaceae*	12
5	*Rutaceae*	10
6	*Apocynaceae*	10
7	*Moraceae*	9
8	*Anacardiaceae*	7
9	*Malvaceae*	7
10	*Acanthaceae*	6
11	*Meliaceae*	6
12	*Ebenaceae*	5
13	*Rhizophoraceae*	5
14	*Laminaceae*	5
15	*Verbenaceae*	5
16	*Vitaceae*	4
17	*Bignoniaceae*	4
18	*Annonaceae*	4
19	*Arecaceae*	4
20	*Phyllanthaceae*	4
21	*Sterculiaceae*	4
22	*Spaindaceae*	3
23	*Lythroceae*	3
24	*Loganiaceae*	3
25	*Celasteaceae*	3
26	*Sapotaceae*	3
27	*Olerceae*	3
28	*Solanaceae*	3
29	*Dioscaroeaceae*	3
30	*Convolvarceae*	3

Table 3.5.4

Medicinal Plants in Project Region
(District Forest office, East Godavari district)

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
1	*Abrus precatorius*	Guruvinda	Fabaceae	Seed	Abortifacient
2	*Abutilon indicum*	Tutturubenda	Malvaceae	Root	Aphrodisiac
3	*Acacia pennata*	Korinta	Mimosaceae	Flower	Scorpion sting
4	*Acalypha indica*	Muripinda	Euphorbiaceae	Leaves	Eczema
5	*Achyranthes aspera*	Uttareni	Amaranthaceae	Root	Scorpion Bite
6	*Adina cordifolia*	Bandaru	Rubiaceae	Bark	Veterinary
7	*Aegle marmelos*	Maredu	Rutaceae	Leaves	Skin diseases
8	*Aerva lanata*	Pindichettu	Amaranthaceae	Leaves	Wounds
9	*Aerva scandens*	Konda pindi	Amaranthaceae	Whole plant	Urinary troubles
10	*Albizia lebcck**	Dirisana	Mimosaceae	Stem bark	Conjunctivitis
11	*Amaranthus spinosus**	Mullatotakura	Amaranthaceae	Leaves	Appetizer
12	*Amorphophallus campanulatus**	Manchikanda	Araceae	Tuber	Rheumatism
13	*Andrographis paniculata**	Nelavemu	Acanthaceae	Leaves	Wounds,Ulcers
14	*Anogeissus latifolia*	Chirumanu	Combretaceae	Stem bark	Ephemeral fever
15	*Argemone mexicana*	Brahmadandi	Papaveraceae	Latex	Skin diseases
16	*Aristolochia indica*	Ishwari	Aristolochiaceae	Root	Snake Bite
17	*Asparagus racemosus*	Pillitegalu	Liliaceae	Tuber	Aphrodisiac
18	*Azadirachta indica*	Vepa	Meliaceae	Leaves,	Fever,Skin diseases
19	*Baliospermum montanum*	Nela jidi	Euphorbiaceae	Leaves	Wounds,cuts

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
20	*Bauhinia racemosa*	Are chettu	Caesalpiniaceae	Bark	Leucoderma
21	*Bixa orellana*	Japhara	Bixaceae	Bark	Scorpion sting
22	*Blepharis maderaspatana*	Balli noraaku	Acanthaceae	Root	Scorpion Bite
23	*Blumea virens*	Adavi pogaku	Asteraceae	Leaves	Skin diseases
24	*Bombax ceiba**	Burugu	Bombacaceae	Stem bark	Leucorrhoea
25	*Buchanania lanzan*	Morri	Anacardiaceae	Gum	Back pain
26	*Caesalpinia crista*	Gachhakaya	Caesalpiniaceae	Leaves	Tumours on the body
27	*Calotropis gigantea*	Jilledu	Apocynaceae	Latex, Ripe leaves	Rotting of teeth, Migrane
28	*Calycopteris floribunda*	Bontha	Combretaceae	Leaves	Scorpion Bite
29	*Capparis zeylanica*	Adonda	Capparaceae	Root	Dyspepsia
30	*Casearia elliptica*	Chilakaduddi	Flacourtiaceae	Bark	Fish poision
31	*Cassia auriculata*	Konda tangedu	Fabiaceae	Tender tips	Constipation
32	*Cassia fistula*	Rela	Fabiaceae	Fruit	Diarrhoea
33	*Cassia occidentalis*	Kasinda	Fabiaceae	Fruit	Appetizer
34	*Cassia tora**	Tantemu	Caesalpiniaceae	Leaves	Insect Bite
35	*Centella asiatica*	Saraswatiaku	Mackinlayaceae	Leaf	Memory power
36	*Chloroxylon swietenia*	Billudu	Rutaceae	Bark	Skin diseases
37	*Cissampelos pareira*	Adavibankatiga	Menispermaceae	Root	Cardiac stimulant
38	*Cipadessa baccifera*	Pisangi	Meliaceae	Leaves	Whitlow
39	*Cleome gynandra*	Vaminta	Cleomaceae	Leaves	Rheumatic pains
40	*Cleome viscosa*	Kukkavaminta	Cleomaceae	Whole plant	Skin diseases
41	*Cleistanthus collinus*	Nalla kodisha	Phyllanthaceae	All parts	Suicide

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
42	*Cocculus hirsutus*	Dusaritiga	Menispermaceae	Leaves	Excesses of heat
43	*Cocculus hirsutus*	Konda gogu	Cochiospermaceae	Stem bark	Skin diseases
44	*Cordia dichotoma*	Nakkera	Boraginaceae	Fruit	Dyspepsia
45	*Combretum albidum*	Yada teega	Combretaceae	Bark	Veterinary
46	*Crinum asiaticum*	Adavi ulli	Amaryllidaceae	Tuber	Swellings due to wounds
47	*Curculigo orchioides*	Nelatadi	Amaryllidaceae	Tuber	Arthritis
48	*Cynodon dactylon*	Garikagaddi	Poaceae	Aerial parts	Dog bite
49	*Cyperus rotundus*	Tungamustalu	Cyperaceae	Tuber	Tonic
50	*Dalbergia sissoo**	Egisa	Fabaceae	Leaves	Maggot infested sores
51	*Datura innoxia **	Ummetta	Solanaceae	Stem	Asthma
52	*Dendrophthoe falcata*	Badanika	Loranthaceae	Leaves	Anthrax,trypanos omiass
53	*Dendrocalamus strictus**	Sanna veduru	Poaceae	Leaves	Retained placenta
54	*Diospyros virginiana*	Tumukiaku	Ebenaceae	Fruit	Dyspepsia
55	*Dillenia pentagyna*	Kalinga	Dilleniaceae	Bark	Tonic
56	*Dioscorea oppositifolia*	Adda dumpa	Dioscoreaceae	Tuber	Rheumatism
57	*Diplocyclos palmatus*	Linga potla	Cucurbitaceae	Leaves	Skin diseases
58	*Eclipta alba*	Guntagalagara	Asteraceae	Whole plant	Hair tonic,Odaema
59	*Elephantopus scaber*	Kukkapogaku	Asteraceae	Leaves	Scorpion bite
60	*Eupatorium odoratum*	Indiragandhi chettu	Asteraceae	Leaves	Cuts,wounds
61	*Euphorbia hirta*	Reddivarinanu balu	Euphorbiaceae	Leaves	Wounds

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
62	*Evolvulus alsinoides*	Vishnukrantam	Convolvulaceae	Whole plant	Aphrodisiac
63	*Ficus benghalensis**	Marri	Moraceae	Latex	Wounds
64	*Ficus gibbosa**	Adavi Barrenka	Moraceae	Bark	Veterinary
65	*Ficus retusa**	Juvvi	Moraceae	Leaves	Fed
66	*Ficus hispida*	Bommedu	Moraceae	Leaves	Bone fracture
67	*Gardenia resinifera*	Karinga	Rubiaceae	Bark	Neck pains
68	*Gloriosa superba*	Nabhi	Liliaceae	Tuber	Skin diseases
69	*Gymnema sylvestre*	Podapatri	Asclepiadaceae	Leaves	Diabetes
70	*Helicteres isora*	Gubatada	Sterculiaceae	Stem bark	Skin diseases
71	*Hemidesmus indicus*	Sugandipala	Apocynaceae	Root	Blood purifier
72	*Hemigraphis latebrosa*	Akkala	Acanthaceae	Root	Anti-alcoholic agent
73	*Hyptis suaveolens**	Maha beera	Lamiaceae	Leaves	Cuts,wounds
74	*Holoptelea integrifolia*	Nemalichettu	Ulmaceae	Leaves	Skin diseases
75	*Holarrhena pubescens*	Istari pala	Apocynaceae	Bark	Dysentery
76	*Hybanthus enneaspermus*	Ratnapurusha	Violaceae	Whole plant	Aphrodisiac
77	*Ipomoea quamoclit*	Kasiratnalu	Convolvulaceae	Root	Tonic
78	*Jatropha curcas*	Adavi Nepalam	Euphorbiaceae	Latex	Eczema,Skin eruptions
79	*Justicia montana*	Maha nilambaram	Acanthaceae	Root	Mental disorders
80	*Kydia calycina*	Konda patti	Malvaceae	Bark	Dyspepsia
81	*Lagerstroemia parviflora*	Chennangi	Lythraceae	Bark	Veterinary
82	*Lannea*	Gumpena	Anacardiaceae	Bark	Antiseptic

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
	coromandelica				
83	*Leucas aspera*	Tummi	Lamiaceae	Whole plant	Snake bite
84	*Leucas cephalotes*	Tummi	Lamiaceae	Leaves	Wounds
85	*Madhuca indica*	Ippa	Sapotaceae	Flower	Dyspepsia
86	*Limonia acidissima*	Torrelega	Rutaceae	Leaves	Rheumatism
87	*Ludwigia parviflora*	Erri lavangalu	Onagraceae	Whole plant	Wounds
88	*Macaranga peltata*	Konda tamara	Euphorbiaceae	Gum	Venereal sores
89	*Mallotus philippensis*	Sinduri	Euphorbiaceae	Seed	Leucoderma
90	*Mangifera indica**	Mamidi	Anacardiaceae	Bark	Appetizer
91	*Melastoma malabathricum*	Mantramu chettu	Melastomataceae	Leaves	Scorpion bite
92	*Merremia hederacea*	Talantu teega	Convolvulaceae	Fruit	Hair wash
93	*Mimosa pudica**	Attipatri	Fabaceae	Whole plant	Retained placenta
94	*Mitragyna parvifolia*	Battagenike	Rubiaceae	Bark	Ephemeral fever
95	*Moringa pterygosperma*	Konda mulga	Moringaceae	Leaves	Rheumatism
96	*Mucuna pruriens*	Dulagondi	Fabaceae	Seed	Abortifacient
97	*Murraya koenigii*	Karivepaku	Rutaceae	Leaves	Cancer
98	*Passiflora foetida*	Tellajumiki	Passifloraceae	Fruit	Narcotic
99	*Pavetta indica*	Papita	Rubiaceae	Stem bark	Scorpion bite
100	*Pedilanthus tithymaloides*	Yerra chitramoolam	Euphorbiaceae	Latex	Skin diseases
101	*Phoenix humilis*	Jitteetha	Arecaceae	Fruit	Laxative
102	*Piper nigrum**	Miriyalu	Piperaceae	Fruit	Cough,malaria
103	*Polyalthia*	Chilaka duddi	Annonaceae	Bark	Veterinary

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
	cerasoides				
104	*Pterocarpus marsupium*	Yegisa	Fabaceae	Wood	Blood pressure
105	*Randia uliginosa*	Guvvenka	Rubiaceae	Bark	Veterinary
106	*Scoparia dulcis*	Oosari	Scrophulariaceae	Whole plant	Oestrous pains
107	*Sida acuta*	Bala	Malvaceae	Root	Mental disorders
108	*Solanum surattense*	Vakudu	Solanaceae	Fruit	Laxative
109	*Stemona tuberosa*	Kondatamara	Stemonaceae	Tuber	Gynocological disease
110	*Strychnos nux-vomica*	Visha musthi	Loganiaceae	Bark	Snake bite
111	*Strychnos potatorum*	Indupa,chilla	Loganiaceae	Seed	Water purifier
112	*Syzygium cumini**	Jinna	Myrtaceae	Bark	Tonic
113	*Tamarindus indica**	Chinta	Fabaceae	Bark	Scorpion bite
114	*Terminalia tomentosa**	Nalla maddi	Combretaceae	Stem bark	Ephemeral fever
115	*Thysanolaena maxima*	Konda cheepuru	Poaceae	Root	Ulcers
116	*Tinospora cordifolia*	Tippatiga	Menispermaceae	Stem bark	Ephemeral fever
117	*Triumfetta rhomboidea*	Marla Benda	Malvaceae	Root	Lactation
118	*Urena lobata*	Peddibenda	Malvaceae	Root	Skin diseases
119	*Vanda tessellata*	Kodakalla chettu	Orchidaceae	Root	Fever
120	*Woodfordia fruticosa**	Jaji	Lythraceae	Bark	Tonic
121	*Wrightia tinctoria*	Palavara	Apocynaceae	Tender tips	Ephemeral fever
122	*Xylia xylocarpa*	Bojja	Fabaceae	Bark	Skin diseases

Contd…

Contd…Table 3.5.4

Sr. No.	Botanical Name	Vernacular Name	Family	Part	Uses
123	*Ziziphus oenoplia*	Pariki	Rhamnaceae	Fruit	Constipation
124	*Ziziphus rugosa**	Enuga pariki	Rhamnaceae	Leaves	Bone fracture
125	*Ziziphus xylopyrus*	Gotti	Rhamnaceae	Leaves	Skin diseases

Source: Forest Department, East Godavari District, Andhara Pradesh.

Table 3.5.5

Agriculture Production inEast Godavari District

Area, Production and Productivity for the year 2009 -10										
S. No.	Crops	Area in Ha.			Production in MT.			Productivity in Kg./ ha.		
		Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Annual Average
1	Rice	197894	103649	301543	590120	468390	1058510	2982	4519	3751
2	Jowar	652	48	700	482	36	518	740	750	745
3	Bajra	523	152	675	549	160	709	1050	1050	663
4	Maize	1052	6102	7154	7953	48822	56775	7560	8001	7781
5	Redgram	965	3104	4069	729	1940	2669	755	625	660
6	Greengram	1271	7695	8966	882	1224	2106	694	159	427
7	Blackgram	7764	40266	48030	7104	2939	10043	915	73	494
8	Sesamum	874	870	1744	546	522	1068	625	600	613
9	Groundnut	130	465	595	179	884	1062	1375	1900	1638
10	Cotton	6769	58	6827	3750	0	3750	554	0	361
11	Sugarcane	13242	0	13242	1265935	0	1265935	95600	0	88078
12	Tobacco	3087	2926	6013	6637	8374	15011	2150	2862	2346

Source: District Agriculture Department, East Godavari District, Andhara Pradesh.

Table 3.5.6

List of Animals Project Region

Sr. No.	Common Name	Scientific Name
1.	Common langur	*Presbytis entellus*
2.	Common mongoose*	*Herpestes edwardsi*
3.	Five striped palm squirrel	*Funambulus pennant*
4.	Hare*	*Lepus nigricollis*
5.	Jackal	*Canis aureus*
6.	Sambar*	*Cervus unicolor*
7.	Spotted deer*	*Axis axis*
8.	Three striped squirrel	*Funambulus palmarum*

Source: District Forest Department, East Godavari District, Andhara Pradesh.

(Forest Department of East Godavari District)

* Animals existing in the mini Zoo of NFCL at Kakinada

Table 3.5.7

List of Fauna (Avifauna) Observed in study Area

Sr. No	Common Name	Scientific Name
1	House sparrow	*Passer domesticus*
2	House crow	*Corvus splendens*
3	Common swallow	*Hirunds rustica*
4	Koel	*Eudynamys scolopacea*
5	Indian myna	*Acridotheres tristis*
6	Indian roller	*Coracias benghalensis*
7	Blue rock pigeon	*Columba livia*
8	House swift	*Apus affinus*
9	Indian black drongo	*Dicrurus adsimilis*
11	Jungle crow	*Corvus macrorhynchus*
12	Purple sunbird	*Nactarinia asiatica*
13	Roseringed parakeet	*Psittacula krameri*
14	Small blue kingfisher	*Alcedo atthis*
15	Redvented bulbul	*Pycronotus cafer*
16	Small green bee eater	*Merops orientalis*
17	Pond heron	*Ardeola grayii*
18	Common babbler	*Turdoides caudatus*
19	Little egret	*Egretta garzetta*
20.	Cattle egret	*Bubulcus ibis*

Table 3.5.8

Species Wise Craftwise Marine Fish Landings In Kakinada Division : April 2008-March 2009

Sr. No.	Species	Craft wise Marine Fish Landings (Tonnes)							Country craft	Total landing col	Price per Kg Rs.
		Mechaniszed			Motorized					Col. 5+9+10	
		Trawal	*Gill-net*	*Total*	*IBM*	*OBM*	*BLC*	*Total*			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	Shark	1470	—	1470	558	148	175	881	75	2426	40
2	Skates	102	---	102	270	80	110	460	72	634	35
3	Rays	850	---	850	425	85	118	628	162	1640	40
4	Oil Sardine	986	---	986	385	290	210	885	286	2157	35
5	Other Sardine	----	---	---	---	---	---	---	---	---	---
6	Hilsa Shad	---	---	---	---	---	---	---	---	---	---
7	Other Shad	---	---	---	---	---	---	---	---	---	---
8	Thrisocies	---	---	---	---	---	---	---	---	---	---
9	Anchovies	1500	---	1500	328	332	486	1146	450	3096	40
10	Other clupeods	594	---	594	178	138	252	568	285	1447	20
11	Harpodennerus	---	---	---	---	---	---	---	---	---	---
12	Chriocentrus	---	---	---	---	---	---	---	---	---	---
13	Ploynemids	325	---	325	470	512	610	1592	320	2237	50
14	Chorinemus	556	---	556	596	485	620	1701	295	2552	20
15	Trichlurodae	456	---	456	536	456	589	1581	325	2362	20
16	Carangidae	---	---	---	---	---	---	---	---	---	---
17	India Makeral	475	---	475	385	396	486	1267	420	2162	30
18	Other Makeral	318	---	318	486	420	395	1301	510	2129	20
19	S.Commorsoii	---	---	---	---	---	---	---	---	---	---
20	S.Gutatus	420	---	420	398	376	402	1176	485	2081	15
21	S.Laneoitus	290	---	290	498	415	515	1428	535	2253	20
22	Tunnies	---	---	---	---	---	---	---	---	---	---

Contd…

Contd…Table 3.5.8

Sr. No.	Species	Craft wise Marine Fish Landings (Tonnes)							Country craft	Total landing col	Price per Kg Rs.
		Mechaniszed			Motorized					Col. 5+9+10	
		Trawal	*Gill-net*	*Total*	*IBM*	*OBM*	*BLC*	*Total*			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
23	Mugil (Mullets)	575	---	575	523	510	489	1522	546	2643	50
24	Eels	284	---	284	465	384	394	1243	489	2016	35
25	Cat Fish	510	---	510	478	410	396	1284	478	2272	20
26	Threadfish Bream	580	---	580	523	489	510	1522	516	2618	25
27	Pigface bream	425	---	425	478	395	402	1275	398	2098	18
28	Other Perches	605	---	605	515	402	516	1433	478	2516	18
29	Sclsenids	---	---	---	---	---	---	---	---	---	---
30	Leignathus	---	---	---	---	---	---	---	---	---	---
31	Block Pomfret	426	---	426	456	398	523	1377	496	2299	100
32	Siver Pomfret	665	---	665	298	287	326	911	350	1926	150
33	Sole (Flat Fish)	---	---	---	---	---	---	---	---	---	---
34	P.Monodon	3606	---	3606	264	260	360	884	460	4950	250
35	P.Indicus	1000	---	1000	269	220	226	1715	715	3430	120
36	Mela Penius	150	---	150	226	212	274	862	560	1572	75
37	Non-Penoid Prawn	500	---	500	180.7	210	289	1179.7	425	2104.5	100
38	Monnecrustcans (Crabs)	178	---	178	150	187	125	462	287	927	50
39	Other Crustaceans	589	---	589	445	473	502	1420	586	2595	300
40	Lobster		---								---
41	Molluses	510	---	510	485	398	489	1372	478	2360	15
42	Squids& Cuttle Fish		---								
43	Misc. Fish	550	---	550	186	153	159	498	350	1398	15
	Total	**13789**	**....**	**13789**	**10329**	**8466**	**9648**	**28444**	**9332**	**64900.70**	

Source: District Fisheries Department, East Godavari District, Andhara Pradesh.

3.6 Air Environment

The studies of existing, i.e. baseline status for air environment include reconnaissance, identification of specific air pollutants due to proposed developmental activity apart from criteria pollutants and measurement of their existing levels within the study area prior to implementation of the project. The data required to assess the baseline (pre-project) status can be collected, analysed and evaluated through a well-designed Ambient Air Quality Monitoring (AAQM) network.

3.6.1 Reconnaissance

The study area (10 km radius) around project site, about more than 50 is covered by sea (Bay of Bengal). The land part of study area is a coastal belt with flat terrain with gentle slope towards Bay of Bengal in the east. The study area comprises Kakinada town, existing port, large scale industries like Fertilizers, Thermal power plants, medium and small scale industries. The inland part of study area is predominantly agriculture fields. The air pollution sources in study area are industries, automobile exhausts and domestic as well as fugitive emissions.

3.6.2 Air Quality Surveillance

The criteria pollutants such as Respirable Particulate Matter($PM_{10} \leq 10$ microns) and fine particulate matter($PM_{2.5}$), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_X), CO, Ozone (O_3) and specific pollutants like Hydrocarbons (methane and Non-methane)were identified as significant parameters for air quality assessment in study area.Nine ambient air quality monitoring locations (AAQM)were identified, in study area around project site (**Fig.3.6.1**)based on prevailing wind directions (upwind & downwind), residential dwellings and ecological sensitive area in project region. The details of individual locations are described in **Table 3.6.1**. The AAQ study was carried out during (October-December 2012) to collect primary data representing post-monsoon season and the secondary data has been compiled from the previous studies carried out by NEERI in the project area during 2010-11.

The ambient air samples for measuring $SO_2$and NOx levels were collected on 24 hourly basis by drawing air at a rate of 0.5 to 1.0 l/min through the respective absorbing media and analysed by standard wet chemical methods **(Table 3.6.2)**. Whereas the sampling for ozone (O_3) was carried out for 1 hour by drawing air at 0.5 l/minthrough absorbing media and analysed by chemical method. The PM_{10} samples were monitored on 24 hourly by drawing air flow rate of 0.9 to 1.4 m^3/min through glass fibre filters placed downstream of cyclone separator. $PM_{2.5}$ samples were monitored on 24 hourly by drawing air at <1 m^3/hr flow rate through PTFE filters and the separation is based on cascade impactor principle. The filtered samples of PM_{10} and $PM_{2.5}$ were analysed by gravimetric methods and the results are reported in µg/m^3 of air.

3.6.3 Micrometeorology

With an objective of determining the prevailing micrometeorological conditions during the study period a micro-processor based weather monitoring station (Watch Dog) was installed near project site. The hourly meteorological data such as wind speed, wind direction and temperature were continuously recorded during the study period. **Fig. 3.6.2** shows the windrose corresponding to study period. It shows that predominant winds are from NE, E and NNW directions during the study periodwith 2.04% calm condition. Accordingly the impact zone will spread in W-SW-SSE sector.

The meteorological data recorded by European weather satellite (compatible with AERMOD air quality model) has been used in this study. The hourly surface meteorological data corresponding to Kakinada area for one year period (January-December, 2012) was procured from M/s LaGa systems, Hyderabad and was analysed to draw seasonal and annual wind roses (**Fig.3.6.3**) applicable to project area. There are distinct seasonal variations in predominant wind pattern like in winter season the predominant winds are from NE-E-SE sector (**Fig.3.6.3 (a)**), while in summer season the predominant winds are from SE-S-SW sector (**Fig.3.6.3 (b)**).The annual windrose reflects monsoon phenomenon, in predominant wind directions (SW and NE) with insignificant calm condition.

3.6.4 Air Quality Baseline Status

The observed ambient air quality data within the study area around the project site is reported in **Table 3.6.3**. The post-monsoon season air quality in terms of individual parameters is described in the following sections:

3.6.4.1 Respirable Particulate Matter (PM_{10})

The observed24 hourly concentration at study area ofPM_{10}at different locations varied between 5-59 µg/m^3while the location average concentrations varied between 17 and 47µg/m^3(**Table 3.6.3**). The highest concentration among all the monitored locations was observed at Jagannadhapuram which may be due to windblown dust, unpaved road etc. The PM_{10} concentrations at all locations within study area were observed well within prescribed standards; NAAQS-2009 (24 hourly PM_{10}=100 µg/m^3).

The observed$PM_{2.5}$ concentrations in study area varied in the range 20-47µg/m^3 (24 hourly). The average concentrations of $PM_{2.5}$ ranged between 14-27µg/m^3 (**Table 3.6.3**). The highest concentration among all the locations was observed at Dummulapeta and lowest at Ramannapalem locations. At all monitoring locations, the $PM_{2.5}$levels were within stipulated standards(24 hourly $PM_{2.5}$ =60 µg/m^3).

3.6.4.2 Gaseous Pollutants

The observed concentrations of SO_2 and NO_x at different locations were observed in the range of 3-14 µg/m^3 and 12-22 µg/m^3 respectively and average concentrations ranged between 2-3µg/m^3 (natural background levels) and 6-9 µg/m^3 respectively.

The observedobserved1 hourly O_3concentrations at all locations varied from 28 µg/$m^3$to 41µg/m^3 (**Table 3.6.3**).The highest concentration among all the locations was observed at Vakalpudi and lowest at Ramannapalem(R.F).

The grab air samples were collected in Tedler bags during morning as well as in evening hours and analysed in the laboratory using FID based HC analyser for methane and total hydrocarbons. The non-methane hydrocarbons are derived from the instrument results and presented in **Table 3.6.4**. The HC monitoring results during study period indicate the methane (spot) concentrations in study area varied from 0.62 ppm to 1.08 ppm, while the non-methane levels varied from 0.01 ppm to 0.06 ppm. The results indicate that methane is major content of total hydrocarbons during study period.

Carbon Monoxide was monitored through collection of grab samples in Tedlar bag as put the samples protected from sunlight by keeping sampled tedlar bags in black colour polythene cover / early till the samples carried to field laboratory. The field samples were analysed on CO analyser (Model: CO11M, Make: Environments. a., France). The CO detection in the instrument is based on Gas filter correlation technique and it can detect up to minimum 0.1µg/m^3. The baseline CO observations at all locations within study area varied in the ranges : 0.2 – 0.94 µg/m^3 and 0.2 – 0.96 µg/m^3 (**Table 3.6.4**) respectively during morning and evening hours.

3.6.5 Air Quality Secondary Data

The ambient air quality data monitored by NEERI during winter season (Dec.2010 – Feb.2011) in proposed project area for different EIA study has been compiled and presented in this report as **Table 3.6.5**.

3.6.5.1 Winter Season Baseline Status

The maximum PM_{10} values on 24 hourly basis were varied between 30-94 µg/m^3 while average PM_{10} concentrations varied in the range of 37-76 µg/m^3 respectively.

The minimum and maximum values on 24 hourly average $PM_{2.5}$ concentrations varied in the range 15-31 µg/m^3 and average concentration ranged between 18-27 µg/m^3 respectively.

The minimum and maximum concentrations of SO_2 and NO_x were observed in the range of 5 - 13 µg/m^3 and 7 - 16 µg/m^3 and average concentration ranged between 7 - 10 µg/m^3 and 10 - 14 µg/m^3 respectively (**Table 3.6.5**).

The mean, minimum and maximum concentrations of O_3at all the locations ranged between 12 - 35 µg/m^3 and average concentration ranged between 13.3 – 33.3 µg/m^3 respectively are were below the stipulated standards.

The overall AAQ baseline status in study area complied the prescribed NAAQ standards – 2009 (***Annexure-I***) during study period.

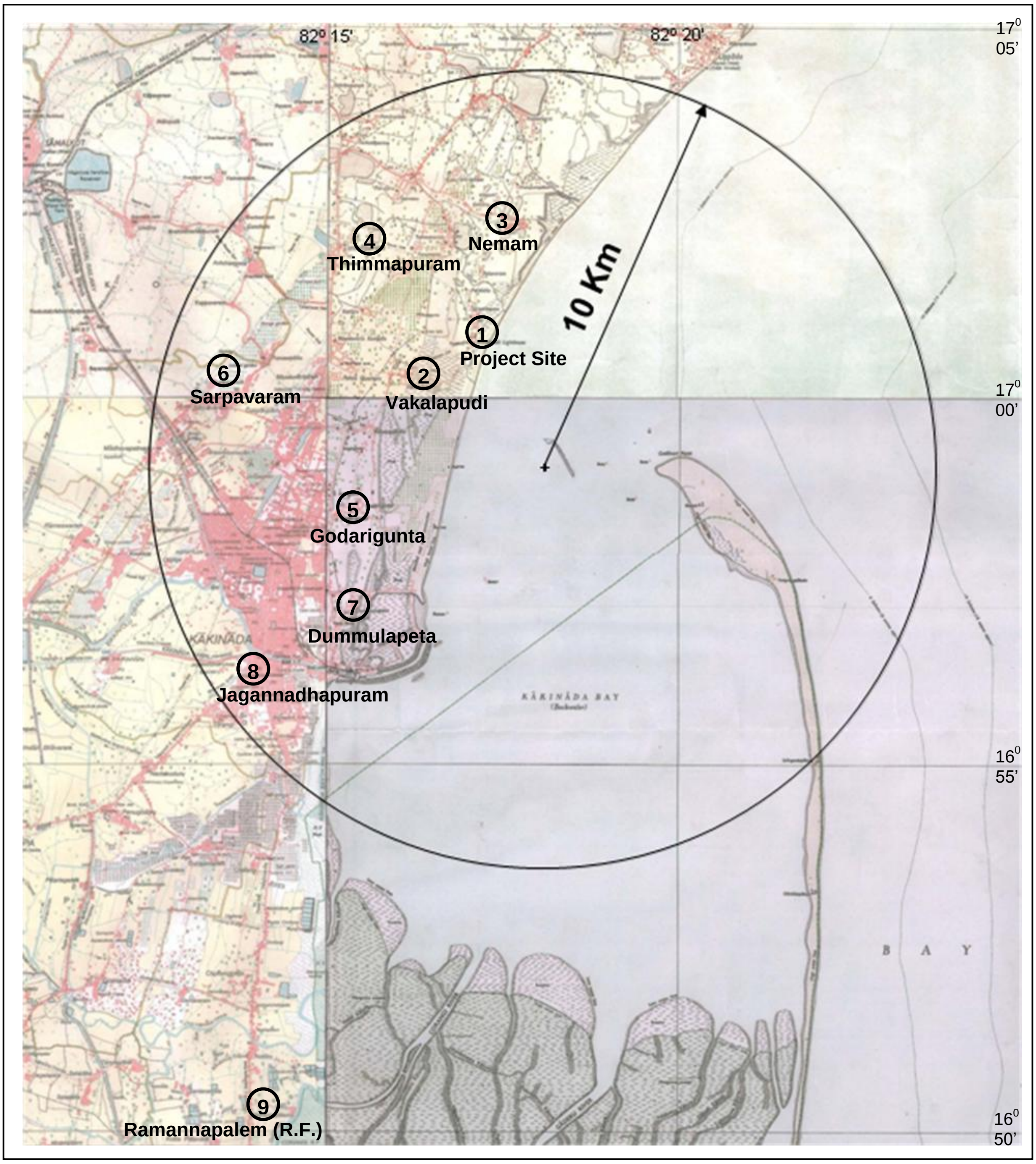


Fig. 3.6.1: Ambient Air Quality Monitoring Locations in the Study Area

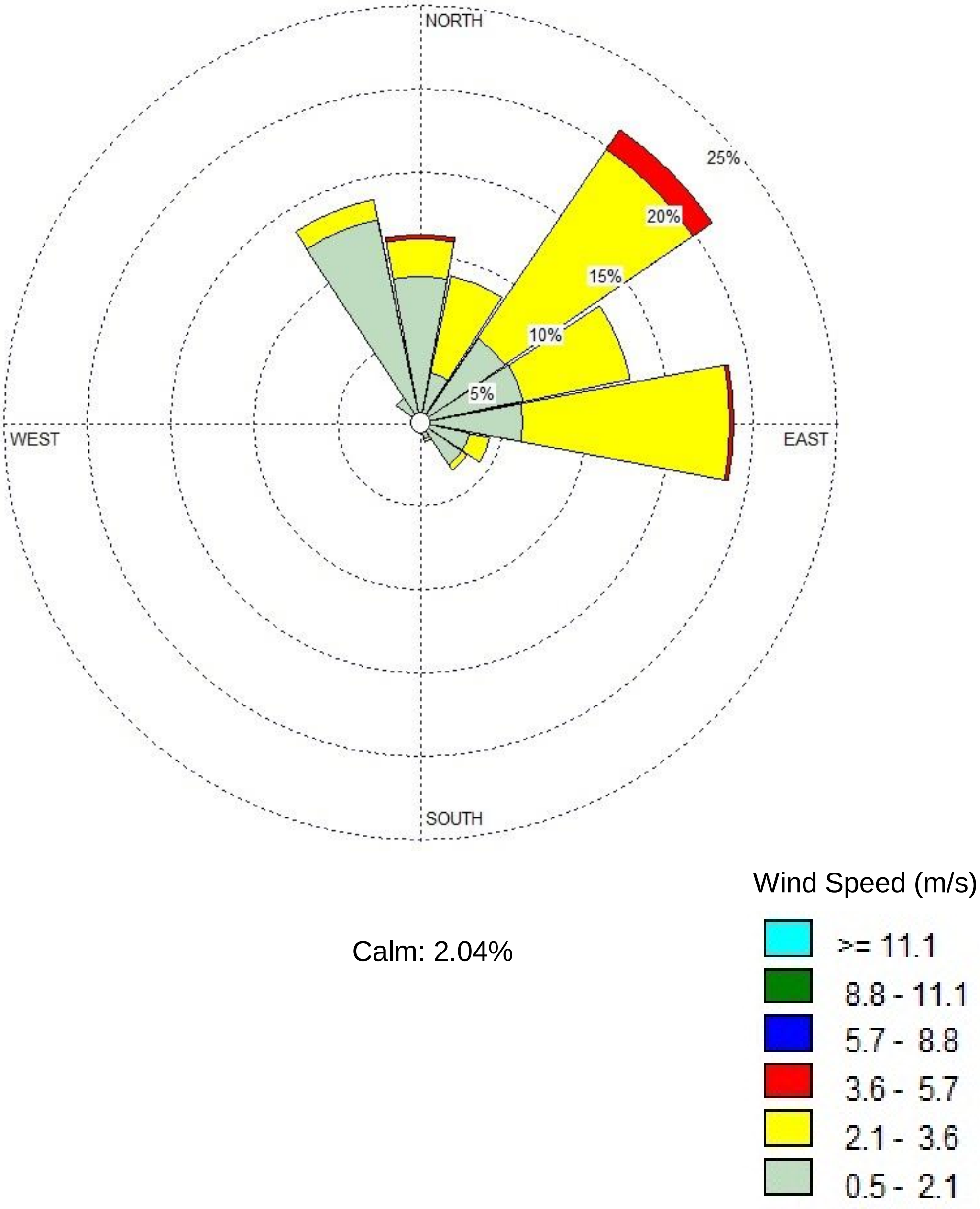
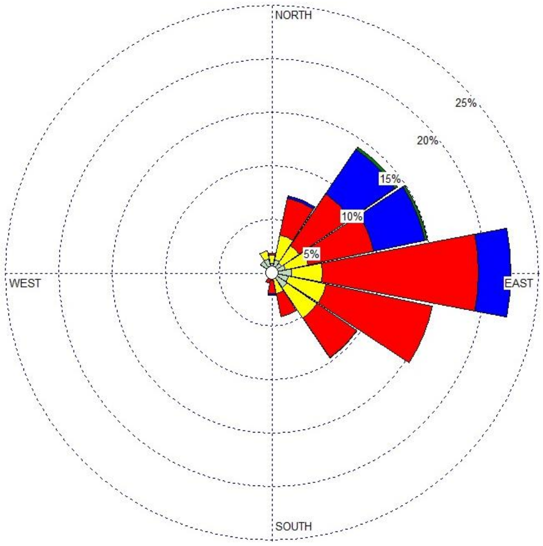
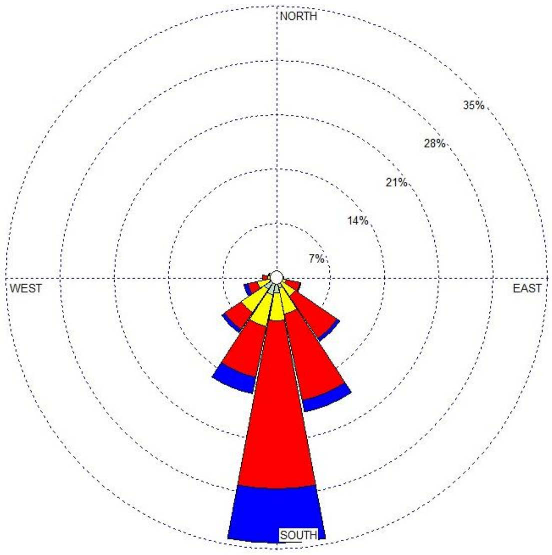


Fig.3.6.2: Windrose at Project Site during Study Period



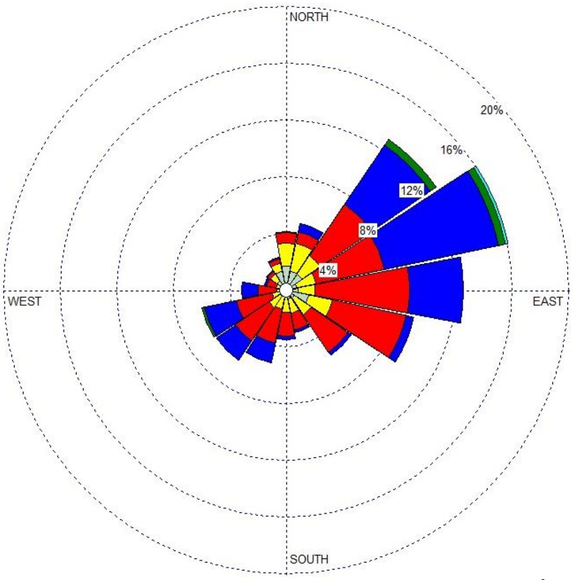
Calm : 2.04%

(a) Winter



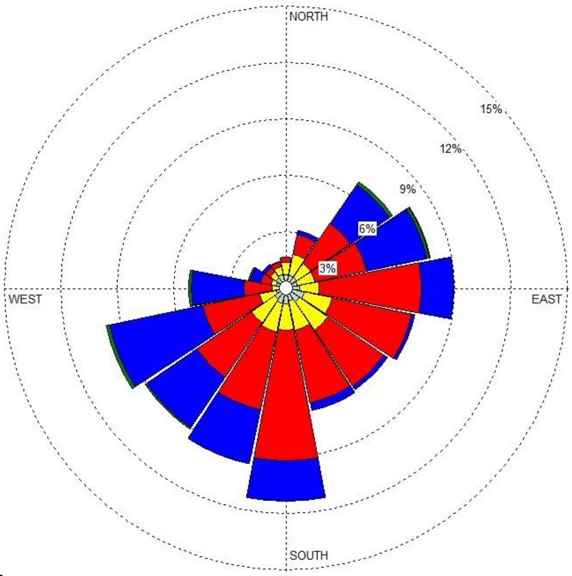
Calm :1.36%

(b) Summer



Calm : 2.11%

(c) Post Monsoon



Calm :1.41%

(d) Annual

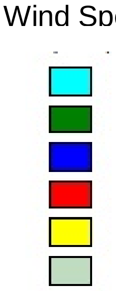


Fig.3.6.3: Seasonal Windrosesin project Area

(Source: Weather Satelliate Data During Jan.-Dec., 2012)

Table 3.6.1: Details of Locations for Ambient Air Quality Monitoring

S. No.	Monitoring Locations	Direction
1.	Project site	Reference
2.	Vakalapudi	SW
3.	Nemam	NNE
4.	Thimmapuram	NW
5.	Godarigunta	SW
6.	Sarpavaram	WSW
7.	Dummulapeta	SSW
8.	Jagannadhapuram	SW
9.	Ramannapalem (R.F)	SSW

Note: Directions with respect to Project site

Table 3.6.2: Techniques Used for Ambient Air Quality Monitoring

S.No.	Parameter	Monitoring Technique	Min. Detectable Conc.
1	Particulate Matter-PM_{10}	High Volume Sampler with Cyclone separator; Gravimetric	<10 µg/m^3
2	Particulate Matter- $PM_{2.5}$	Fine Particulate Sampler, Gravimetric	<2.5 µg/m^3
3	Sulphur Dioxide (SO_2)	EPA Modified West and Gaeke Method	2.0 µg/m^3
4	*Oxides of Nitrogen (NOx)*	Jacobs - HochheiserMethod Sensor: Gas filter correlation	5.0 µg/m^3
5	Oxidants Ozone (O_3)	Wet chemical colorimetric method	2.0 µg/m^3
6	Carbon Monoxide (CO)	Model: CO11; Make: Environnements.a.	0.1 µg/m^3
7	Hydro carbons – Methane and Total HCs	FID based HC analyser with catalyst separation Model: HC51	0.01ppm

Table 3.6.3: Ambient Air Quality Status within the Study Area

Units: µg/m^3 Sampling Time: 24 hrs.

S.No.	Locations	PM_{10}	$PM_{2.5}$	SO_2	NO_X	O_3*
		Avg. ± S.D. (Min. – Max.)				
1.	Project site	43±10 (13-55)	25±5 (11-33)	2±1 (2-4)	7±3 (5-18)	29±3 (23-35)
2.	Vakalapudi	43±10 (22-58)	22±4 (13-30)	2±1 (2-6)	7±3 (5-22)	35±4 (26-41)
3.	Nemam	25±4 (11-30)	21±6 (9-27)	2±1 (2-5)	7±2 (5-12)	22±4 (12-29)
4.	Thimmapuram	28±16 (5-59)	16±11 (3-47)	2±0 (2-3)	6±2 (5-16)	22±5 (10-30)
5.	Godarigunta	23±10 (6-38)	17±7 (3-28)	2±1 (2-5)	7±3 (5-18)	24±4 (15-30)
6.	Sarpavaram	27±5 (18-36)	23±5 (12-29)	2±1 (2-6)	9±5 (5-20)	21±5 (10-30)
7.	Dummulapeta	35±16 (10-58)	27±14 (8-47)	3±3 (2-14)	9±3 (5-19)	22±7 (10-32)
8.	Jagannadhapuram	47±10 (20-59)	24±5 (14-32)	2±1 (2-4)	9±4 (5-22)	24±6 (10-31)
9.	Ramannapalem (R.F)	17±3 (10-22)	14±3 (8-20)	3±1 (2-5)	8±2 (5-14)	21±5 (11-28)

*Sampling time for Ozone (O_3) is 1 hour

Table 3.6.4: Total Hydrocarbons within the Study Area

S.No	Monitoring Locations	Morning Time				Evening Time			
		MHC (ppm)	NMHC (ppm)	THC (ppm)	CO ($\mu g/m^3$)	MHC	NMHC	THC	CO ($\mu g/m^3$)
1.	Project Site	0.86	0.02	0.88	0.20	0.80	0.01	0.81	ND
2.	Vakalpudi	0.81	0.01	0.82	0.62	0.64	0.06	0.70	0.68
3.	Nemam	0.77	0.01	0.78	0.47	0.76	0.01	0.77	0.46
4.	Thimmapuram	0.75	0.04	0.79	0.38	0.75	0.01	0.76	0.42
5.	Godarigunta	0.86	0.01	0.87	0.76	0.61	0.03	0.76	0.89
6.	Sarpavaram	0.78	0.01	0.79	0.94	0.62	0.06	0.68	0.96
7.	Dummulapeta	1.08	0.04	1.12	0.86	0.73	0.03	0.76	0.90
8.	Jagannadhapuram	0.98	0.02	1.00	0.75	1.01	0.03	1.04	0.78
9.	Ramannapalem	0.96	0.03	0.99	0.24	0.71	0.06	0.77	0.20

Note: The concentration measured in ppm

MHC : Methane Hydrocarbons

NMHC : Non Methane Hydrocarbons

THC : Total Hydrocarbons

Table 3.6.5

Ambient Air Quality Status within the Study Area (December 2010 – February 2011)

Unit: µg/m^3 Average. : 24 hrs

Sr. No.	Sampling Location	PM_{10}	$PM_{2.5}$	SO2	NOx	O_3
		Average ± Standard Deviation (Range)				
	CPCBLimits (Industrial/Residential)	100	60	80	80	100
1.	Chidiga	50 ± 3 (45 - 55)	26 ± 2 (23-30)	8 ± 2 (5-10)	12 ± 2 (10-15)	22.3 ± 1.5 (21 - 24)
2.	Jaganadhapuram	44 ±7 (32-51)	23 ±4 (18-28)	7 ± 1 (5-8)	10 ± 1 (9-12)	14 ± 2 (12 - 16)
3.	Turangi	45 ± 6 (36-54)	25 ± 4 (18-3)	7 ± 1 (6-9)	10 ± 1 (8-12)	26.7 ± 2.1 (25 - 29)
4.	Surayaraopeta	43 ± 4 (35-49)	22 ± 2 (18-25)	7± 2 (6-10)	12± 2 (10-14)	17.7 ± 3.8 (15 - 22)
5.	Kakinada	48 ± 4 (42-56)	24 ± 2 (22-28)	10± 2 (7-13)	14± 1 (12-15)	23.7 ± 2.1 (22 - 26)
6.	Vakalpudi	42 ± 5 (34-48)	21 ± 3 (18-26)	8± 1 (6-9)	12-2 (9-15)	33 ± 1.7 (32 - 35)
7.	Kowuru	44 ± 4 (39-54)	23 ± 2 (20-26)	7 ± 1 (6-10)	11±2 (8-13)	17.7 ± 1.5 (16 - 19)
8.	Challangi	76 ± 10 (62-94)	23 ± 4 (17-28)	8±1 (6-9)	11±2 (7-13)	19 ± 1 (18 - 20)
9.	Ramanayapeta	38 ± 5 (30-43)	18 ± 2 (15-22)	8±1 (6-9)	11±2 (8-14)	21.3 ± 3.2 (19 - 25)
10.	Godarigunta	40 ± 0 (31-49)	20 ± 4 (15-25)	7±1 (5-9)	12±2 (9-13)	20 ± 2 (18 - 22)

3.7 Noise Environment

3.7.1 Reconnaissance

The objective of study is to establish the prevailing baseline status with respect to ambient noise levels in the study area. A reconnaissance was conducted with a view to identify major activities contributing to ambient noise levels within the study area. The commercial, traditional social / religious activities, vehicular movement in Kakinada town as well as existing industrial activities in the neighbour area are in the major noise sources.

3.7.2 Ambient Noise Levels

Noise standards have been designated for different types of land use, i.e. residential, commercial, industrial and silence zones, as per 'The Noise Pollution (Regulation and Control) Rules, 2000, Notified by the Ministry of Environment and Forests, New Delhi on February 14, 2000.

The noise rating method as Leq i.e. equivalent sound pressure level has been adopted for the measurement of noise level in various selected sampling locations of this region. It is the energy mean of the noise level over a specified period and is expressed in terms of decibels.

$$L_{eq} = 10\log\left(\frac{1}{T}\int_0^T 10^{LP(t)/10}\right)dt dB(A)$$

The noise scale A-weighted network in dB(A) was used for monitoring of noise level. Leq in dB(A) denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of human ear. The average of Leq at each location is calculated using energy average formula :

$$Energy.average = 10\log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{Lpi/10}\right]$$

Equivalent noise level (Leq) is a scale for the measurement of long-term noise exposure. Equivalent noise levels (Leq) during day time and night time are often used to describe the community noise exposure.

The equivalent noise levels (Leq) on hourly basis were monitored using a precision Integrated sound level meter (Quest, USA make), which has capability to measure (online) sound pressure level (SPL) on continuous basis and screen / compute Max., Min., Leq along with different statistical modules octave barn analysis, L_{90} etc.. The ambient noise levels were monitored at 19 locations in study area in the form of Min., Max. SPL as well as Leq in dB(A) units.

3.7.3 Ambient Noise Baseline Status

The identified ambient noise levels monitoring locations (19 Nos.) in study area are shown in **Fig. 3.7.1** and the locations are presented in **Table 3.7.1**. Equivalent noise levels, Leq (Day) and Leq (Night) were monitored for few residential, industrial, commercial areas and silence zones. Noise levels, min, max and Leq measured during day and night at sampling locations are given in **Table 3.7.2**. The observations related to equivalent noise levels in study area varied in the range of 50.9-71.9 dB(A) and 41.8-63.4 dB(A) during day and night times respectively. Vehicular traffic is the major noise source and contributes mainly to background noise levels in the villages. The following are summary of category /area wise results. The ambient noise levels during study period within prescribed limits (***Annexure-II***).

	Day Time (dB(A)) Leq.	**Night Time (dB(A)) Leq.**
Residential	42.1 - 53.4	40.1 - 43.8
Commercial	56.4 - 62.1 (Vehicular Traffic)	43.2 - 51.7
Industrial	50.8 - 71.9	56.7 - 67.5

3.7.4 Vehicular Traffic Survey

Three locations have been identified in study area for counting vehicular movement in three categories; light (two and three wheels), medium (4 wheelers + lev.), heavy (trucks, buses etc.) vehicles. The traffic survey was conducted during day time and night time on different days during study period. The data on vehicle counts recorded by field survey team are summarized in the following table

Survey Location	Day Time (No.Vehicles/ hr.)			Night Time (No.Vehicles/ hr.)		
	Light	Medium	Heavy	Light	Medium	Heavy
Dummulapeta Junction	50-75	30-40	35-40	30-40	25-30	15-20
Sarpavaram Junction	40-50	25-35	30-35	30-35	20-30	15-20
ADB Road-Vakalapudi	20-30	20-30	40-55	15-20	<10	20-30

As per the above results, the maximum total road traffic in the study area was about 150 vehicles per hour. There was no distinct peak traffic period in the study area. The road traffic in study area is light to moderate without any significant traffic congession / traffic jams during study period.

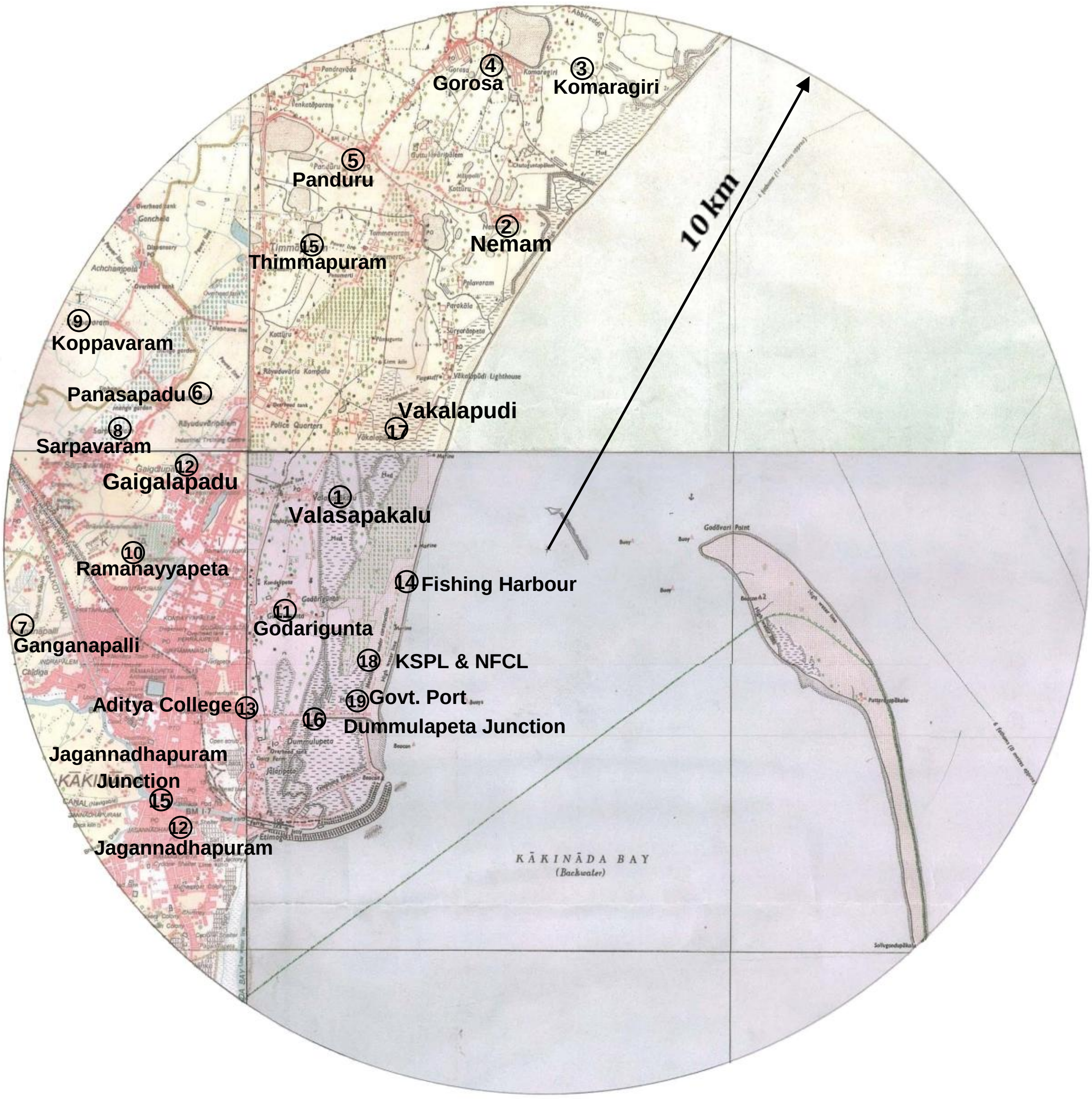


Fig. 3.7.1: Ambient Noise Monitoring Locations

Table 3.7.1: Locations for Monitoring Ambient Noise Levels

Sr. No.	Monitoring locations	Direction
1.	Valasapakalu	WNW
2.	Nemam	N
3.	Komaragiri	N
4.	Gorsa	N
5.	Panduru	NNW
6.	Panasapadu	WNW
7.	Ganganapalli	W
8.	Sarpavaram	WNW
9.	Koppavaram	WNW
10.	Ramanayyapeta	W
11.	Godarigunta	WSW
12.	Jagannada Puram	WSW
13.	Aditya College	WSW
14.	Fishing Harbour	W
15.	Jagannadapuram Junction	WSW
16.	Dummulapeta Junction	SW
17.	Vakalapudi	WNW
18.	KSPL&NFCL Centre	WSW
19.	Govt. Port	SW

Table 3.7.2: Ambient Noise Levels in Study Area – LNG Terminal Project (December 2012 – January 2013)

Sr. No.	Monitoring locations	Day time (dB(A))			Night time (dB(A))		
		Min.	Max.	Leq	Min.	Max.	Leq
Villages							
1.	Valasapakalu	36.8	57.6	46.5	41.4	48.3	42.5
2.	Nemam	43.0	64.6	51.5	38.1	44.1	42.0
3.	Komaragiri	33.2	54.1	50.9	30.4	47.8	42.1
4.	Gorsa	32.4	54.5	42.1	31.7	52.4	41.8
5.	Panduru	38.6	60.8	50.1	34.9	49.8	42.4
6.	Panasapadu	41.3	52.3	45.4	33.4	57.6	41.4
7.	Kovvada	40.1	56.5	47.1	36.7	52.7	43.0
8.	Sarpavaram	38.8	61.6	53.4	35.4	50.7	43.8
9.	Koppavaram	41.4	58.4	50.8	34.7	45.8	40.1
Kakinada Town							
10.	Ramanayyapeta	47.8	63.6	54.3	42.6	50.7	45.4
11.	Godarigunta	52.0	65.7	60.7	42.5	55.7	51.7
12.	Jagannada Puram	47.8	60.7	56.4	44.8	58.5	50.4
13.	Aditya College	54.3	70.4	62.1	40.7	52.1	45.7
Commercial Zone							
14.	Fishing Harbour	53.8	83.4	60.1	36.2	53.4	61.1
15.	Jagannadapuram Junction	69.0	79.4	67.4	40.7	51.3	44.1
16.	Dummulapeta Junction	65.4	84.7	67.8	37.4	50.4	50.4
Industrial Zone							
17.	Vakalapudi	47.6	62.7	50.8	45.0	59.8	56.7
18.	KSPL&NFCL Centre	56.8	84.6	70.8	46.2	71.9	67.5
19.	Govt. Port	53.0	81.0	71.9	43.4	65.7	63.4

3.8 Socio Economic Environment

Socio- economic Environment is an integrated part of the EIA studies as it refers to the total environment as well as to various components related to human interest. So, socio-economic impact assessment in the project vicinity of any ensuing major development project revolves around the mode of change to facilitate that it is imperative to outline the socio-economic profile of Environmental Impact Assessment Study.

3.8.1 Reconnaissance

East Godavari is one of the coastal districts of Andhra Pradesh. The district covers a vast portion of the Godavari Riverdelta area. Kakinada (Major Town) is the district HQ, situated on Bay of Bengal coast. There are three major industries, petroleum marketing terminals of HPCL, IOCL and power plants around Kakinada town. Kakinada is a port town (Anchorage port and deep water port) and also popularly known as fertilizer city in the Andhra Pradesh State. Agriculture and fisheries are predominant professions and economic activities. The coastal villager are predominantly fishermen community mostly dependant on marine fisheries, aquaculture as well as inland fresh water fisheries,

3.8.2 Baseline Status

Baseline information on the socio-economic environment was collected within 10 km radial distance around project site. The primary socio-economic data was collected through field survey in sample villages in study area as well as the observations made by the survey team. It has been substantiated with relevant secondary data from various official records, viz., primary census abstract (2001), provisional census data 2011, District statistical abstract, district health office, District industry center of A.P. state, tourism office etc.

The socioeconomic database thus compiled relevant to study area includes:

- Demographic structure
- Infrastructure base in the area
- Economic structure

- Health status
- Cultural attributes
- Socio economic status in relation to quality of life
- Public awareness and their concern about the project

The villages identified for socioeconomic survey in study area (figure 3.8.1) are listed in **Table 3.8.1.** The study area is shown in **Fig 3.8.1**.Socio-economic surveydone through group discussionwith population samples, Government officials and village representatives. The photographs taken during socioeconomic survey with local people and official representatives are presented in plates **3.8.1**to **3.8.4**

3.8.2.1 Demographic Structure

The east Godavari district has population density of 477 persons/ sq. km (as per the Provisional Census details of India information for 2011).The details concerning the demographic structure of the study area was collected from Census hand book of East Godavari district. Study area covers two Mandals (Samalkota and Kakinada). The details about demographic structure is given in **Table 3.8.2** and the summary of demographic information is given in **Table 3.8.3.**

The salient features are as follows:

- The study area (10 Km radius) consists of 18 villages / wards of Kakinada Town.
- Kakinada urban agglomeration total population is 4,42,936 (provisional data Census 2011) with the sex ratio 1044 female / 1000 male. The decadal population growth rate in this area fall in 10-20% growth category.
- Total population of the region as per 2001 census is 124884 out of which 63302 are male and 61582are female. Out of the total population Scheduled Caste 15108 (12.09%) and Scheduled Tribe population is 721 (0.57%) respectively. However, as per provisional census 2011 the scheduled cast population is 12.1% while scheduled Tribe population is 0.6%

- Sex ratio is defined as the number of Females per one thousand Males population. It is an important and useful indicator to assess relative excess or deficit of men or women in a given population at a point of time. As per the census 2001 sex ratio for the study area is 972. Thisshows that male population is higher in the region as compared with the female population. As per 2011 census details the sex ratio is 1044 female / 100 male

- Literacy rate of the population in the study area is 78310 (62.70%) Male literate are 42034 (53.67%) and Female literate are 36276(46.32%). As per census 2011, the literacy rate is study area is about 74% (2011)

- Total main worker population is 35836(28.69%), 6237(4.99%) come under marginal worker category and 82811 (66.31%) belong to non workers category (2011).

- Fisheries and agriculture are major occupations in coastal / rural areas

3.8.2.2Infrastructure Resource Base

The infrastructure resource base of the study area with reference to education, medical facility, water supply, post and telegraph, transportation and communication facility and power supply etc. is presented in **Table 3.8.4** the infrastructure resources details have been abstracted from Housing, Household Amenities and Assets CD 2001 of A.Pstate, District East Godavari, Kakinada are described below:

Education: One important indicator of development of country or state is the level of literacy attained by it.As per 2001 village directory record, all villages are having education facility in the form of primary school. It indicates that in education field the study area is having better facility. The study area is linked with Kakinada city by well-constructed road. It is a good facility for students to take various courses because they can travel adequately for education purpose.

Safe Drinking Water facility: For the survival of humanity, none occupies a higher place then water that is why a very well recognized fact that adequate protected and wholesome drinking water is a primary need of community. The water supply in the region is in good condition. Water system is available in the form of tap, well, hand pumps,and other allied sources.

Communication and Transportation: After independence, considerable progress hasbeenmade in the field of transport and communication because of implementation of 5 years plan. In respect of development of road transport especially as regards passenger services, the state has made commendable progress.

Communication facility is outstanding in this region. Every ward and villages having Transportation facility is in excellent condition. The entire region is connecting with bus and navigable waterway. Road approach is in all form like mud road, footpath, navigable waterway etc. The entire study area is well connected with, railway and roadfor Kakinada city**.**

Power Supply: Electric power is one of the basic and key infrastructures in the growing economy. It occupies a distinct role in the development of industry and agriculture. It is also a key factor in the socio-economic transformation in rural areas. All villages and wards are electrified in the region and electricity is available for all-purpose.

Medical/Primary Health Care: Health is a state of complete physical, mental and social well-being. We take health as being free from diseases but it is much more than just the absence of a disease. Good health may enable us to do well at work and in life. Good health involves proper functioning of all body organs. It also involves feeling well both in body and in mind. People enjoying good health are cheerful, free from stress, and enjoy life to the fullest. Most of the villages having Medical facility in the form of Primary Health Center, Health Center ,Registered Private Medical Practitioner.

3.8.2.3 Economic Attributes

Economic resource base of any region mainly depends upon its economically active group i.e. the working population involved in productive work. Work may be defined as participation in any economically productive activity. Such participation may be physical or mental in nature. Work involves not actual work but also effective supervision and direction of work. It also includes unpaid work on farm or in family enterprise.

The employment pattern of worker and Main worker of the study area is described below and presented in **Table 3.8.5**.

- Majority of the workers are main other worker 23429. (65.37%). and main cultivators workers are 1597 (6.56%)

- There are 9191(25.64%) workers as agricultural worker
- 1086 (3.03%) house hold workers
- Main cultivator workers are 2130(5.94%)

3.8.2.4 Health Status

Government health institution is concerning four steps District level, rural hospital, primary health centers and sub-centers.A district hospital typically is the major health care facility in its region, with large numbers of beds for intensive care and long-term care; and specialized facilities for surgery, plastic surgery, childbirth, bioassay laboratories, and so forthe make treatment facilities available to the public-at-large.

PHCs remain the first contact between village community and medical officer. Medical officer supported by 14 Paramedical and other staffs. It acts as a referral unit for 6-sub center. It has 4-6 beds for patient.

Sub-centers: The sub-center is the most peripheral health unit and first contact point between the primary health center system and the community. Each sub-center has one female health worker. One female assistant and male health assistant supervise six-sub centers.

In the study area, there is sufficient Government health institution like Sub-center, PHC etc. Health data is shown in **Tables 3.8.6 and 3.8.8**

3.8.2.5 Cultural and Aesthetic Attributes

In the study area no significant / major cultural or aesthetic places.

3.8.3 Socio-economic Survey

3.8.3.1 Sampling & Data Collection

A judgmental and purposive sampling method was used for choosing respondents of various sections of the society i.e. Sarpanch, adult males and females, teachers, medical practitioners, businesspersons, agriculture laborers, fishermen, unemployed group etc. Judgmental and purposive sampling method includes the right cases from the total population that helps to fulfill the purpose of research needs.

Data collection is a term used to describe a process of preparing check list / questioner and collecting data. Primarily, data are collected to provide information regarding a specific topic.

3.8.3.2 Field Survey and Observations

Socioeconomic data is collected through surveys and questionnaires that are made out specifically for a purpose Observations can be conducted on nearly any subject matter and the kinds of observations will do depend on survey question. Field Survey and Observations were made at 11 each locations villages (Fig. 3.8.1) and the quality of life of that region (Table 3.8.7) is studied. Visits were made at hospitals, primary health centers and sub-centers to know the health status of the region. Various government organizations such as statistical department, department of census operations are visited to collect the population details of project region.Socio-economic survey was conducted at 11 locations within the study area located in all directions with reference to the project site.

3.8.3.3 Interview Method

Interview is verbal questioning.Interviews consist of asking questions, listening to individuals and recording their responses. At times, you may find it more profitable to ask questions to a few individuals instead of carrying out a large-scale questionnaire based survey. The interview can be done very informally, e.g. as conversations with people met in the fields, co-operative stores or block offices. In these settings, one question leads to the next based on theresponses given to the previous one. At the other end of the scale, highly structured interviews often rely on questionnaires or interview schedules with mostly closed-ended questions that allow the respondents only a limited range of possible answers. Structured interview method is used to collect data regarding the awareness and opinion from the sample selected of the various socio- economic sections of the community. The questionnaire mainly highlights the parameters of primary needs.

The interview method has the advantage that almost all perfect sample of the general population can be reached and respond to the approach. Interview method helps to collect more correct and accurate information as the interviewer is present during the field survey.

The respondents wereasked for their awareness/opinion about the project and their opinion about the impacts of the project, which is an important aspect of socio-economic environment, viz. job opportunities, education, health care, transportation facility and economic status.

★ Rural Area

- Most of the villages having Gram Panchayat building. shown in **Plates3.8.5&3.8.6**

- All surveyed villages have Aanganwadi Center. The figures from survey reported that most of the villages have Primary and Middle school facility while for further education people have to travel more than 10 km. Maximum educational level of the study area is up to 10th class. The scope of higher and technical educationis available in the study area; people are getting higher education and taking benefits of these educational institutions.Jawaharlal Nehru Technological University College is situated in Kakinada city for higher education(**Plates 3.8.7 & 3.8.8)**.

- Peoples having their own agriculture land are engaged in farming. Some population is engaged in business activities such as land dealer, shops, major it's village population is working as a labour worker in nearby industries; others are engaged in fishing activity etc. in some areas which are totally active in fishing they make dry fishes and store it as well as sell in market. Shown in **Plate 3.8.9**

- Main crops of the study area are Rice, pulses, corn, coconut, mango etc.

- for the entertainment purpose villagers having beautiful small temples in their village as well as they celebrate various festival

- Staple food of the study area is Rice, Sāmbhar, Curd and sea fish.

- Communication facility is good in the study area. Every village having mobile Phone towers, Television, Newspaper facility. It indicates that the study area is developed in communication field.

- The study area is served by rail line, roadway and waterway from which the people could easily travel to major cities as well as in other states.Approach roads are either black topped cemented.
- Tap, Tank water, well and Hand pump is the main source of drinking water supply in the region.
- Some villages having bank facility and peoples are utilizing these services for their savings.
- Sanitation facilities are good,about 80% population are using toilet. It shows that peoples are aware about sanitation, but some villages which are near by the various companies there population increasing day by day because of migration of other states labour in the study area and they are living in worst condition they couldn't get sufficient facility because of less place for their daily needs, it is the cause for making unhygienic situation
- Electricity is available in almost all the villages but only for domestic purpose very few villagers using electricity for farming
- Wood,LPG, kerosene is major fuel used for cooking purpose in the region
- Quality of houses are well and mostly people have permanent cemented (pucca) constructed house
- The language preferably spoken by the inhabitants of study area is Telugu
- Health status is in good condition. Villagers are satisfied with the health centers because they are getting proper care from Govt. hospitals. As an alternative ofGovt. hospitals there are private hospitals, dispensaries.Main disease in the study area is viral fever, skin allergy etc (**Plate 3.8.10**).
- Some of the villages which are nearby industrial area like, Ruchi Gold, NFCL, Adani Gemini, SPGL, and APSP. companies are doing developmental activity in the field of health camp, distribution of books, tables in school etc

★ **Urban Area**

- Almost all wards having good education facility. Slum schools are also available for slum population.
- LPG is main fuel for cooking purpose.
- Entertainment facility is available in various types like Cinema hall, hotels playground, youth clubs etc
- most of the population is engaged in private jobs and in labour activity
- Roads are well constructed and communication facility is in better condition
- Kakinada municipal corporation supply water for drinking purpose in the study area
- Health facility is better in urban area like district hospital, community health center and private hospitals are available in 4-8 km distance
- In Kakinada port there is good facility for import export. Details of export import in Kakinada port is shown in **Table 3.8.6**
- Telugu is main language and English and little bit Hindi is spoken in the study area

3.8.3.4 Awareness and Opinion

Awareness is the state or ability to perceive, to feel, or to be conscious of events, objects or sensory patterns. In this level of consciousness, sense data can be confirmed by an observer without necessarily implying understanding. In general, an opinion is a subjective belief, and is the result of emotion or interpretation of facts. An opinion maybesupported by an argument, although people may draw opposing opinions from the same set of facts. For assessing the awareness and opinion about the project activity socio-economic survey was conducted in the sampling villages. The salient observations drawn through survey are described below:

- A good number of respondents were aware about the Port site, but they didn't know about the proposed project.

3.8.4 Quality of Life

Definition of quality of life

Daily living enhanced by wholesome food and clean air and water, enjoyment of unfettered open spaces and bodies of water, conservation of wildlife and natural resources, security from crime, and protection from radiation and toxic substances. It may also be used as a measure of the energy and power a person is endowed with that enable him or her to enjoy life and prevail over life's challenges irrespective of the handicaps he or she may have.

Quality of life (QoL) is a term, which indicates overall status of socio-economic environment in a given area. Quality of life (QoL) is defined as a function between "objective conditions" and "subjective attitudes" involving a defined "area" of concern

Quality of life index is based on a unique methodology that links the results of subjective life satisfaction surveys to the objective determinants of quality of life across countries. The "objective conditions" are defined as numerically measurable artifacts of a physical, sociological event or economic event. Objective conditions may be defined as any number, which stands for a given quantity of a variable of interest so long as it is independent of subjective opinion. Subjective attitude" is primarily concerned with affective and cognitive dimensions. It is specifically concerned with 'how aspects of cognition vary as objective conditions vary'.

Once objective measures are obtained for each factor they are transformed to a normal scale varying from 0 to 1 (value function curve) in which 0 corresponds to the lowest or least satisfactory measure, and 1 corresponds to the highest. The weights are assigned to each factor by ranked-pair wise technique (by the expert group) based on the secondary data and general observations.

For each objective measure, a corresponding subjective measure is developed for each individual of the sample population by asking him to rate his satisfaction scale (value function curve). In addition, it is used such that 0 corresponds to the lowest level of attitudinal satisfaction and 1 corresponds to the highest level of satisfaction. Weights are assigned to each factor using ranked - pair wise comparison techniques.

The Socio-economic Indicators for QoL Assessment are:

1. Income, Employment and Working Condition
2. Housing
3. Food
4. Clothing
5. Water Supply and Sanitation
6. Health
7. Energy
8. Transportation and Communication
9. Education
10. Environment and Pollution
11. Recreation
12. Social Security
13. Human Rights

$$QoLs = 1/p \sum_{i=1} \sum_{j=1} QIij \times Wi$$

Where,

QoLs = Subjective quality of life index

p = No. of respondents, j = 1, ..., p

m = No. of factors, i = 1, ..., m

QIij = Subjective quality index for ith factor assigned by jth respondent

$\sum Qiij$ = Subjective quality index for ith factor assigned by all respondents in an area

Wi = Relative weightage of the ith factor

$$QoLo = \sum_{i=1}^{i=n} QIi \times Wi$$

I. Objective quality of life

Where,

QoLo = Objective quality of life index

n = No. of QoL Factors

i = 1, ..., n

QIi = Satisfaction level (assigned by the expert group) for the ith objective indicator

Wi = Normalized weight for its factor

II. Quality of Life (Cumulative Index)

$$QoLc = \frac{QoLo + QoLs}{2}$$

The subjective and objective QoL indices prior to commissioning of the project are presented in **Table 3.8.7.**

The average QoL index values are estimated as:

$QoL_{(s)}$ = 0.68
$QoL_{(o)}$ = 0.65
$QoL_{(c)}$ = 0.66

The average QoL index value for the study area 0.56 is leaning and satisfactory level due to good economic status like income, employment, educational facilities and also availability of basic needs, viz. food, clothing, and housing.

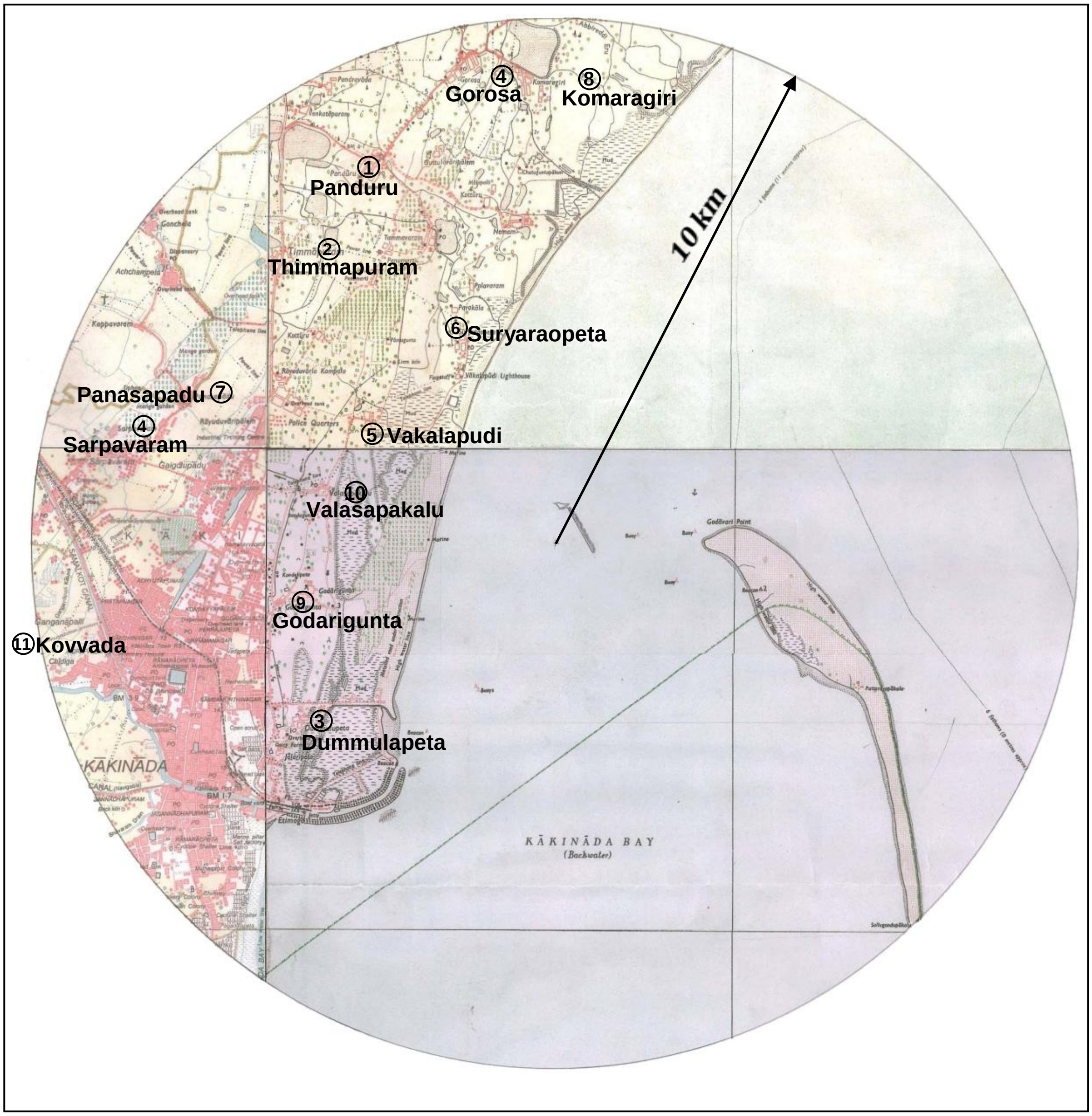


Fig.3.8.1 : Socio-economic Survey Locations

Plate 3.8.1: Socioeconomic survey at KomaragiriGrampanchayat

Plate 3.8.2: Socioeconomic survey at Kovvada village

Plate 3.8.3: Survey with local people in Suryaraopeta (CT),

Plate 3.8.4: Survey with Grampanchayat member in Sarpavaram village

Plate 3.8.5: Grampanchayat building in Komaragiri village

Plate 3.8.6: Grampanchayat building in Vakalpudi village

Plate 3.8.7: Education facility in Suryaraopeta(CT) village in the study area

Plate 3.8.8: Free education facility for slum children in the study area

Plate 3.8.9: Women drying fish at Suryaraopeta village, in the study area

Plate 3.8.10: Primary health center in Panduru village, in the study area

Table 3.8.1: Socioeconomic Surveyed Locations

Sr. No.	Villages
1.	Panduru
2.	Thimmapuram
3.	Dummulapeta
4.	Sarpavaram
5.	Vakalapudi (OG) - Ward No.71
6.	Suryaraopeta (CT)
7.	Panasapadu
8.	Komaragiri
9.	Godarigunta
10.	Valsapakalu
11.	Kovvada

Table 3.8.2: Demographic Structure

Sr. No.	Villages / Ward	Area in hector	House hold	Population			SC	ST	Literacy			Main Worker	Marginal Worker	Non Worker
				TOT_P	TOT_M	TOT_F			LIT_T	LIT_M	LIT_F			
MandalSamalkota, District East Godawari, Kakinada														
1.	Panasapadu	1677	2158	8296	4275	4021	967	50	4784	2575	2209	2383	638	5275
2.	Koppavaram	349	101	479	242	237	479	0	243	139	104	188	4	287
3.	Pandravada	91	241	955	502	453	49	7	574	312	262	76	329	550
Total		**2117**	**2500**	**9730**	**5019**	**4711**	**1495**	**57**	**5601**	**3026**	**2575**	**2647**	**971**	**6112**
MandalKothapalle, District East Godawari, Kakinada														
4.	Komaragiri	1677	1348	5504	2773	2731	1146	25	2748	1489	1259	1876	692	2936
5.	Gorsa	349	542	2346	1177	1169	324	14	1349	705	644	845	193	1308
6.	Subbampeta	91	223	1240	602	638	0	0	449	237	212	388	4	848
Total		**2117**	**2113**	**9090**	**4552**	**4538**	**1470**	**39**	**4546**	**2431**	**2115**	**3109**	**889**	**5092**
Mandal Kakinada Rural, District East Godawari, Kakinada														
7.	Panduru	687	1305	5068	2592	2476	382	8	2865	1505	1360	1237	589	3242
8.	Nemam	666	982	3765	1970	1795	528	12	1857	1038	819	1268	279	2218
9.	Thammavaram	544	1682	7413	3785	3628	195	11	2674	1493	1181	2324	340	4749
10.	Penumarthi	210	340	1391	717	674	737	0	803	444	359	460	77	854
11.	Sarpavaram	866	2319	9904	5032	4872	1359	0	5777	3112	2665	2984	629	6291
12.	Thimmapuram	955	1497	6141	3171	2970	1175	27	3896	2164	1732	1649	468	4024
13.	Ganganapalle	276	1667	6952	3461	3491	954	24	3708	1995	1713	2082	425	4445
14.	Kovvada	159	914	3816	1919	1897	649	4	2365	1270	1095	1219	74	2523
15.	Ramanayyapeta (CT)		5503	22337	11309	11028	2910	312	16665	8873	7792	6196	573	15568
16.	Suryaraopeta (CT)		4710	19225	9660	9565	1574	162	14471	7670	6801	5324	263	13638
17.	Vakalapudi (OG) - Ward No.71		3561	15003	7561	7442	1376	42	9458	5052	4406	4050	517	10436
18.	Chidiga (OG) - Ward No.72		1206	5049	2554	2495	304	23	3624	1961	1663	1287	143	3619
Total		**4363**	**25686**	**106064**	**53731**	**52333**	**12143**	**625**	**68163**	**36577**	**31586**	**30080**	**4377**	**71607**
Grand Total		**8597**	**30299**	**124884**	**63302**	**61582**	**15108**	**721**	**78310**	**42034**	**36276**	**35836**	**6237**	**82811**

Table 3.8.3: Demographic Summary

Demographic Parameters	Details
No. of District	1
No. of Mandals	2
Total Area in Hector	8597
Total No. of Households	30299
Total Population	124884
Density of Population (Persons Per sq.km)	7 persons per sq km
Sex ratio (N0. of female\ 1000 males)	972
Scheduled castes (%)	15108(12.09%)
Scheduled Tribes (%)	721(0.57%)
Literate (%)	78310(62.70%)
Main Worker	35836(28.69%)
Marginal Worker	6237(4.99%)
Non Worker	82811(66.31%)

Source: Primary Censes Abstract 2001, East Godavari district, A.P

Table 3.8.4: Infrastructure Resource Base in Study Area

Sr. No.	Villages	Education	Medical	Communi cation	Road Approaches	Drinking Water	Power	Transport
Mandal Samalkota, District East Godavari, Kakinada								
1.	PANASAPADU	P(7),M, AC(4)	DA,PHS(2),RMP(3), O(4)	PH	BS	T,W,TW, HP	EA	MR
2.	PANDRAVADA	P(2),AC	RMP,O	PH	BS	W,HP	EA	PR
3.	KOPPAVARAM	P,AC	RMP		BS	T,W,TW, HP	EA	MR
Mandal Kakinada Rural, District East Godavari, Kakinada								
4.	KOMARAGIRI	P(8),M,S,AC	D,PHS,RMP(4)	PO	BS	W	EA	PR
5.	GORSA	P(2),AC	PHS, RMP(3)	PO	BS	T,W	EA	PR
6.	SUBBAMPETA	P,PUC	RMP		BS	W	EA	PR
Mandal Kakinada Rural, District East Godavari, Kakinada								
7.	PANDURU	P(9),M,S,AC	PHC,RMP	PO,PH	BS	T,W,HP	EA	PR
8.	NEMAM	P(6),AC	PHS,RMP	PO,PH	BS	T,W,HP	EA	PR
9.	THAMMAVARAM	P(4),AC	PHS(2),RMP(2)	PO,PH	BS	T,W	EA	PR
10.	PENUMARTHI	P,AC	PHS	PO	BS	T,W	EA	PR
11.	SARPAVARAM	P(9),M(3), S(3),Tr,AC	PHS,RMP	PO,PH	BS	T,W	EA	PR
12.	THIMMAPURAM	P(2),AC,O	HC,PHS,RMP	PH	BS	W,TK,HP	EA	PR
13.	GANGANAPALLE	P(2),M,AC	PHS,RMP	PO,PH	BS	W	EA	PR
14.	KOVVADA	P(2),M,S,AC	PHS,RMP	PO,PH	BS	W	EA	PR

Source: Village Directory 2001, East Godavari district, Kakinada, State A.P

Table 3.8.5: Main Worker Employment Pattern

Sr. No.	Villages/ Wards	Main Cultivator	Main Agriculture	Main Household	Main Other Worker
Mandal Samalkota, District East Godavari, Kakinada					
1.	Panasapadu	433	972	34	944
2.	Pandravada	0	177	1	10
3.	Koppavaram	10	10	15	41
Total		**443**	**1159**	**50**	**995**
Mandal Kakinada Rural, District East Godavari, Kakinada					
4.	Komaragiri	224	1206	142	304
5.	Gorsa	183	482	17	163
6.	Subbampeta	0	0	2	386
Total		**407**	**1688**	**161**	**853**
Kakinada Rural, District East Godavari, Kakinada					
7.	Panduru	259	572	67	339
8.	Nemam	130	872	14	252
9.	Thammavaram	107	456	127	1634
10.	Penumarthi	44	241	30	145
11.	Sarpavaram	257	1315	137	1275
12.	Thimmapuram	152	599	29	869
13.	Ganganapalle	76	469	19	1518
14.	Kovvada	45	402	89	683
15.	Ramanayyapeta (CT)	82	628	178	5308
16.	Suryaraopeta (CT)	72	320	123	4809
17.	Vakalapudi (OG) - Ward No.71	42	254	47	3707
18.	Chidiga (OG) - Ward No.72	14	216	15	1042
Total		**1280**	**6344**	**875**	**21581**
Grand Total		**2130**	**9191**	**1086**	**23429**

Source: Primary Censes Abstract 2001, East Godavari district, A.P

Table 3.8.6: Exports & Imports Handled At Kakinada Port

Export/ Imports	Sr. No.	Commodity	2008- 2009		2009-2010	
			Quantity in Tonnes	Value in (Rs. Lakhs)	Quantity in Tonnes	Value in (Rs. Lakhs)
1	2	3	4	5	6	7
Export	1.	Maize	748920	73908.72	396175.4	31444.6
	2.	Sorghum	11000	1521.82	3961754	31444.6
	3.	Rice Bran Extraction	0	0	42210	2665.98
	4.	Cement	71194	0	42210	2665.98
	5.	Project Material	501	1471.22	600	2990.62
	6.	Organic Manure	0	0	91	7.2
	7.	Building Material	0	0	900	252.86
	8.	Crude Palm Oil	0	0	26201.7	8181.48
	9.	Soyabean Meal Extraction	42344	5998.59	0	0
	10.	Rice	512559	85320.91	0	0
	11.	Roofing Sheets	0	7057.68	0	0
	12.	Soyabean Oil	751	109	0	0
	Sub Total		1387269	175388	4482219	79691.3
Imports	1.	Murate of Potash	328700	55864.26	55611	32471.14
	2.	Urea	169361	23634.85	16000	2027.87
	3.	Rock Phosphate	114710	12159.33	8500	2046.54
	4.	Non cooking Coal	91760	12983	154489	13443.34
	5.	Dap	0	0	28850	1362.68
	6.	Cutter Section Dredger	0	0	187	18.71
	7.	Sunflower Oil	5095	1199.65	0	0
	8.	Crude Palmolien Oil	33954	7943.34	0	0
	9.	Industrial Salt	2839	8189.32	0	0
Sub Total			**746419**	**297362**	**263637**	**51370.3**
Total			**2133688**	**297362**	**4745856**	**131602**

Table 3.8.7: Quality of Life

Sr. No.	Villages/ CT	$QoL_{(S)}$	$QoL_{(O)}$	$QoL_{(C)}$
1.	Panduru	0.51	0.48	0.50
2.	Thimmapuram	0.49	0.43	0.46
3.	Dummualpeta	0.59	0.53	0.56
4.	Sarpavaram	0.53	0.59	0.56
5.	Vakalapudi (OG) - Ward No.71	0.69	0.67	0.68
6.	Suryaraopeta (CT)	0.67	0.62	0.65
7.	Panasapadu	0.54	0.49	0.52
8.	Komaragiri	0.47	0.42	0.44
9.	Godarigunta	0.65	0.61	0.63
10.	Valsapakalu	0.62	0.61	0.62
11.	Kovvada	0.55	0.54	0.54
Average		0.57	0.55	0.56

Chapter 4

Anticipated Environmental Impacts and Mitigation Measures

Chapter 4

Anticipated Environmental Impacts and Mitigation Measures

4.1 Identification of Impacts

The identification of significant environmental impacts due to proposed project at selected site is an imminent step in EIA study as it leads to the other elements of EIA such as quantification and evaluation of impacts. Although a number of non-project related impacts have been identified while describing the existing (baseline environmental status, it is necessary at this stage to identify the types of the potential impacts which might be caused by the proposed project activities. Whether these impacts would actually occur (and their significance and magnitude) will eventually be determined by the quality and quantity of the potential sources of environmental effects.

A number of techniques are available for identification of environmental impacts from major development projects. In case of the proposed port terminal, the “Network method” has been adapted, which involves an understanding of the cause-condition-effect relationship between an activity and environmental parameters.

The detailed list of activities and their potential environmental impacts have been taken into consideration for generation of cause-condition-effect network, i.e. chain of events. This method has been basically advantageous in recognizing the series of impacts that could follow from the proposed activities. This method has also provides a "road map" type of approach to the identification of second and third order effects.

The idea is to take into account the individual components of project along with related activities and identify the types of impacts that could initially occur, followed by identification of resultant secondary and tertiary impacts. This process is repeated until all possible types of impacts are identified. The greatest advantage of this type of approach is that it allows the identification of types of potential impacts by selecting and tracing out the events as they could occur. With this method the impact network has been identified for the proposed project. The impact network generated for proposed project w.r.t. marine environment and comprehensive network for different components of terrestrial environment are respectively shown in **Figs.4.1.1 and 4.1.2**. It has to be noted that in these illustrations the lines are to be read as "might have an effect on".

4.1.1 Project Site Specific Impacts

For setting up the LNG terminal, the present site is finalized after considering the available various alternatives. Therefore, the objective is to carefully examine the project site specific impacts and implement mitigation measures so that the adverse impacts, if any can be minimized. Various possible impacts of project location are analyzed and results are discussed below :

- The land requirement for proposed project is very limited since the major part of project (LNG storage and re-gasification process) will be in seawater (about 35.4 Ha area in KDWP harbour). The estimated land requirement is 2.64 Ha only for construction of landfall / gas metering station.
- There will be no private land procurement for the project. The identified land belongs to A.P state government, Revenue Department and has no human habitation at present. Hence, there will be no direct PAPs (Project Affected People) / PAFs (Project Affected Families) due to this project.
- Any major infrastructure or developmental project will involve change of landuse. At present project site is vacant with sparse casuarina plantation and there is no agriculture or any other activity at site and in the immediate vicinity. This land is within port area and expected to be used for port activities. Therefore, there will be no change in designated landuse due to proposed project except relatively intensification.
- Since project site is vacant land and does not have any significant natural vegetation / large trees or any specific species except few causuarina trees.

The site grading / preparation will not involve cutting of natural trees. There is No forest land at the project site or in the immediate vicinity – no encroachment impact.

Mitigation Measures

Project proponent shall have proper / good coordination with the existing KDWP operator / authority as well as the neighboring fishing harbour operator / users for necessary planning and execution of proposed project to mitigate potential adverse impacts, if any, on existing operations.

4.1.2 Prediction of Significant Impacts - Methodology

Subsequent to identification of significant impacts specific to the proposed project and site, it is very essential to predict their levels based on available project design data and also by making use the data collected during field surveys for monitoring pre-project environmental data at project site in study area.

Mathematical models are the best tools to quantitatively describe the cause-condition-effect relationship between the source of effect due to proposed project and the different components of environment. In case mathematical models are not available or it is not possible to identify/validate models for a particular situation, predictions are arrived through available scientific knowledge and judgments.

The impact predictions results are superimposed over the monitored pre-project (baseline) data to derive potential post-project environmental conditions / status. These conditions are evaluated by comparison against the respective prescribed standards for ambient environmental quality.

In the present study the mathematical models that have been used for predictions include a state Gaussian Plume Dispersion models designed for multiple point sources of air emissions (ISCST3 / AERMOD) and Hemispherical wave propagation model (DHWANI) developed for one or more noise sources (stationary) and MIKE 21 for prediction of water quality due to dredged material disposal as well as colder sea water discharge. In the case of land, biological and socio-economic components of environment, the predictions have been made based on available scientific knowledge and judgment.

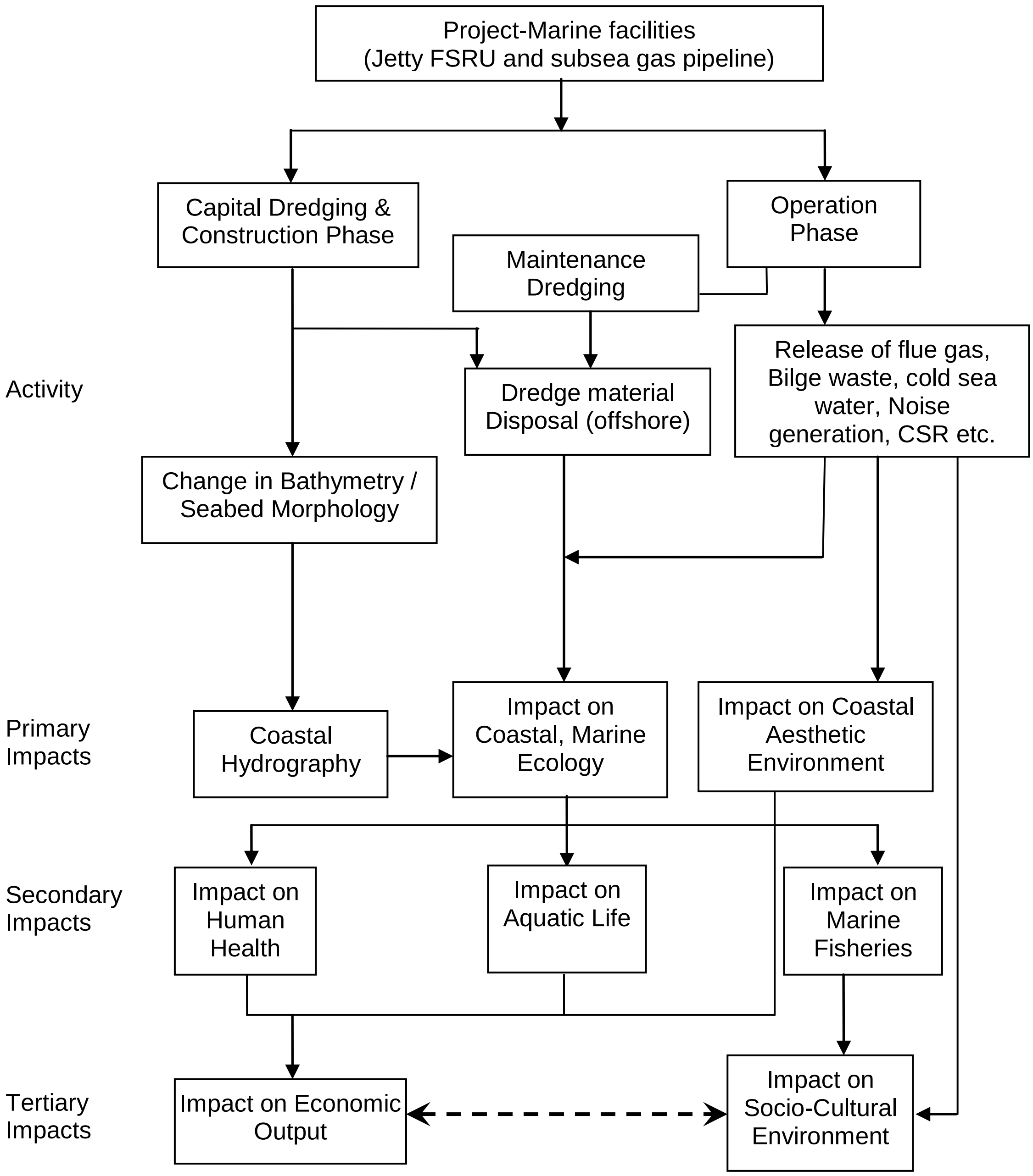


Fig. 4.1.1 : Project Impact Network for Marine Environment

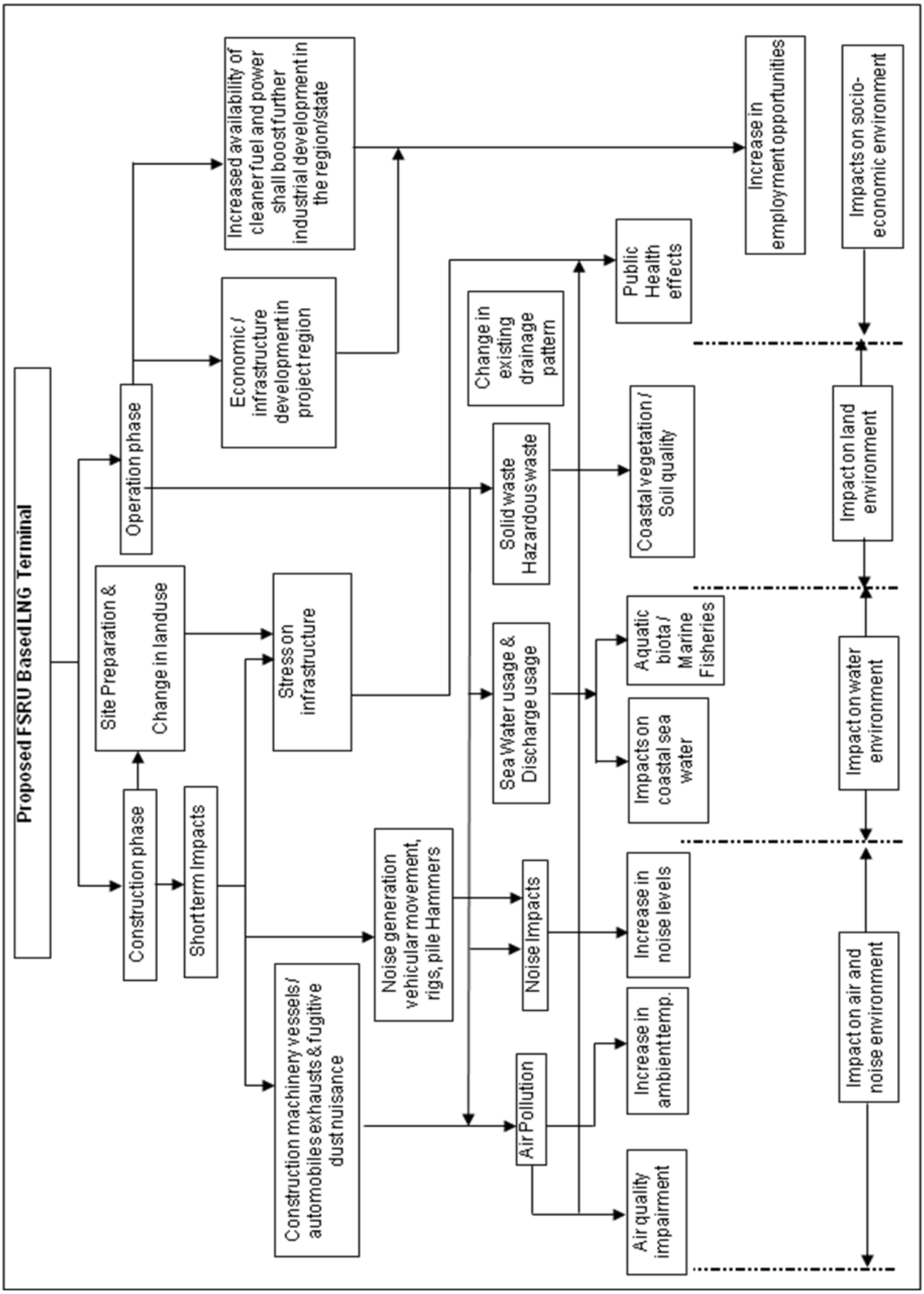


Fig. 4.1.2 : Comprehensive Impact Network for Proposed FSRU Based LNG Terminal

4.2 Impacts Prediction - Construction Phase

The total project construction duration will be about 15-18 months from the date of start including marine as well as land based facilities. Environmental impacts related to construction phase are mostly temporary in nature and last only during the period of construction. However, appropriate environmental protection measures should be planned and implemented during construction period also to minimize the potential adverse impacts. The identified potential impacts and their characteristics corresponding to various construction activities are listed in **Table 4.2.1** including environmental protection measures.

The major part of proposed project construction will be in sea water (Within Kakinada Deepwater Port (KDWP). The marine construction activities for proposed LNG terminal include, dredging for Jetty area, FSRU & LNG Carrier (ship) berthing basin, turning circle (600 m diameter) widening and deepening of entry / ship navigation channel (approx.7 km) and trenching to lay the subsea gas pipeline within KDWP harbor area. The water front area requirement for proposed marine facilities is estimated about 35.4 Ha. within KDWP harbour area, for which M/s KSPL (port authority) agreed on lee side of existing breakwater.

The following are the major construction equipment / machinery planned to be used for installation of marine facilities:

- Dredging – Trailer Suction Hopper Dredgers (TSHD), Excavators
- Jetty & Mooring Dolphins – Rigs, barges / vessels, Generator sets
- Subsea Pipeline – Crawler crane with a clam-shell type bucket mounted cargo barge equipped with anchors.

The land based construction activities will be on very limited area (2.64 Ha) for Onshore Receiving Facility (ORF) consisting control room, gas metering, pipeline pigging facility, water bath heaters and emergency backup generator set. The equipment planned to use for construction are : vehicles for material transport, dozer, crane and civil construction machinery.

Apart from impacts on marine environment, the proposed project construction activities are also expected to cause impacts on land, water, air, noise, socioeconomics components of environment.

4.2.1 Capital Dredging

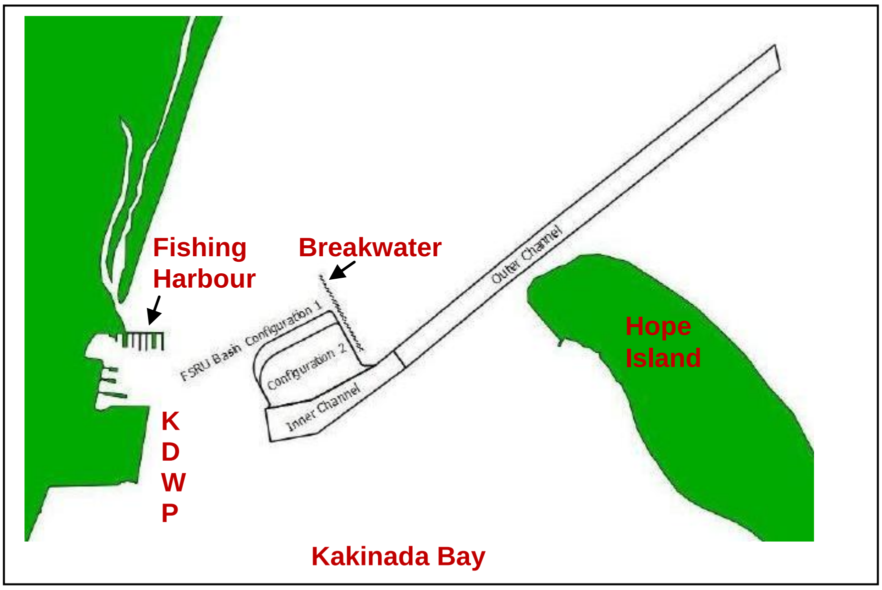
Dredging Area

Kakinada bay extends over an area of about 150 sq.km.. On the southern side of the bay significant volumes of river water and sediments are discharged into the bay through the Godavari distributaries viz. Matlapalem creek, Coringa, Gaderu and Pillarava creek where one finds extensive mud flats and thick mangroves could be observed. The bay about is enclosed on the eastern side by 15km long sand spit which protects the bay and main coast to the west and NW, from the direct wave attack. The tidal inlet between the sand spit head and the main land towards NW is narrow and strong tidal currents during flood and ebb tides move the sediment to and fro across the inlet. The hydrodynamics of the Kakinada bay driven by the tidal currents through the inlet from NW and the river currents from the south plays a crucial role in the conservation and management of Coringa mangroves.

The proposed project comprises following three components of dredging:

a) The jetty & berthing basin, comprising the turning circle (600 diameter) and the area of the FSRU & LNG carrier berth/mooring. At present seabed in this area is generally between 3m and 4m below Chart Datum (CD) and is to be dredged down to -14.5m CD with Side slopes of 1 Vertical: 6 Horizontal.

b) The shipping channel is to be widened from existing 165 m to 250 m and deepened where required to -14.5m CD. This component includes the outer and inner channels, as shown in following figure.



Areas to be dredged

c) The subsea pipeline route is to be pre-dredged (trenching) to 3m below seabed with 4m plus width. The seabed in this area is currently 4 to 6 m below CD. This is a temporary excavation so side slopes will be 1Vertical : 2 Horizontal.

The estimated volumes of capital dredging required for proposed project are given in the following Table. Two configurations are under consideration for proposed jetty: i) configuration 1- twin jetty (FSRU on one side and LNGC on other side of jetty) and ii) configuration 2- single jetty (both FSRU as well as LNGC on one side of jetty). As can be seen the FSRU basin is configuration 1 requires about 25% more dredging than the configuration 2; the dredging required in the inner and outer shipping channel remains the same for both configurations.

The dredging of the subsea pipeline and cables would be about 3200m long with cross section of about 30m^2, which results in approximately 96,000 m^3 excavation.

As per the following table, the total capital dredging volume under highest possible scenario, i.e. configuratuin-1 (Twin jetty) is estimated as 13.8 million m^3.

Location	Very Soft Clay (million m^3)	Stiff Clay (million m^3)	Total Volume (million m^3)
FSRU Basin – configuration-1	8.3	2.5	10.8
(FSRU Basin-conguration-2	6.7	2.0	8.7)
Inner Channel	1.3	0.4	1.7
Outer Channel	Insignificant	1.3	1.3
Total Volume-Configuration-1	**9.6**	**4.2**	**13.8**
(Total Volume-Configuration-2	8.0	3.7	11.7)

4.2.2 Estimated Dredging Rate

Based on the dredging experience at existing Kakinada Deep Water Port the following are taken into consideration for the proposed project:

- The dredge material is not suitable for land fill / reclamation and will be required to be dumped at designated offshore dumping area at approximately

8 km north of the site.

- The existing port vessels traffic in the shipping channel would limit the number of dredgers operating simultaneously to max. 2 nos. Accordingly the dredged volume would be between 40,000m^3 (for the shallow water) and 70,000 m^3 (for the deeper water) per day.
- Based on past experience at KDWP, the dredging of an area should be carried out in 2 phases:
  - In the first - shallow water dredgers suitable for handling soft clays should dredge down to approximately -9m.
  - In the second – deep water dredges capable of handling stiff clays should complete the dredging down to the target depth of 14.5m below CD.
  - The Trailing Suction Hopper Dredges (TSHD) with dredge capacity as high as 10,000 m^3 shall be used. The production rates of these dredgers work out to approximately 40,000 - 70,000 m^3/day. At proposed jetty and berthing basin the existing depth is only 3.0 to 4.5 m. Therefore, contractors would have to use smaller dredgers (production rates of 25,000 to 35,000 m^3/day) to start dredging. Once sufficient water depth is achieved, the bigger machines can be used.
- The dredging required for the burial of 24 inch (610mm) gas pipeline and the 2 power cables that run from the ORF to the FSRU berth will be carried out either by:
  - Using a crawler crane with a clam-shell type bucket mounted on a cargo barge equipped with anchors, and supported by an anchor handling vessel (OR)
  - Using the shallow water dredger (OR)
  - A combination of the two, with the clamshell excavating the section adjacent to the Bridge support platform, and the shallow water dredge excavating the remainder.

Because the dredged material will be placed back in the trench after the pipeline and cables are laid, the spoil will be placed beside the trench. The clamshell or similar will be used to fill in the trench using adjacent material from the seafloor, after the pipeline and cables has been laid.

4.2.3 Disposal of Dredge Material

Sediment Characteristics

Fine material derived from the various creeks occupied the southern part of Kakinada bay. The bed in the southern parts consists mainly of very fine slit with D50 ranging from 0.002 to 0.003 mm. The silt (0.002-0.02mm) and clay (<0.002mm) content is predominant (about 60%) in KDWP harbour area. The bed samples in the channel adjoining the sand spit consist of fine sand with D50 of 0.15 mm. The total organic carbon (TOC) in sediment samples in bay area (near shore line) is 1.92‰.

Previous Studies in Kakinada Port Area

Raju, Sanil Kumar et al., (2004) studied coastal processes north of Kakindada by with emphasis on Uppada erosion. After the construction of breakwater Reddy and Ranga Rao (2004) conducted model studies for the region and presented a detailed account of currents, circulation, sediment transport, diffusion and water quality etc, to determine the “No impact zone” for Coringa mangroves.

Climate

The climate of the region is characterized by an oppressive summer and a good seasonal rainfall. The summer season extends from March to May and is followed by the southwest monsoon, which lasts till September. The average annual rainfall is about 1150 mm with about 92.2% of the rainfall concentrated from June to November. Thus there is a clear demarcation between the wet season and the dry season.

Tides

The tides in Kakinada region are predominantly semidiurnal. Water level at high tide reaches its maximum (2m above MSL) during October. Tidal range is maximum (about 1.53 m) in the month of February. Mean spring tidal range is about 1.05 m and tidal ranges of 0.9 to 1.2m are more frequent.

4.2.4 MIKE-21 Model Description

The MIKE 21 system (software package) was developed by the Danish Hydraulic Institute Water & Environment, that can be applied for 2D flows in coastal areas and seas where stratification can be neglected. The hydrodynamic model (MIKE 21 HD) is the central module of the MIKE 21 system. It serves as the basis for most of the other modules within the system; for example, it provides the basis for sediment transport studies.

The MIKE 21 HD module is versatile enough to simulate water-level fluctuations and flows resulting from tides and waves. The water levels and flows are determined by solving the time-dependent nonlinear equations of continuity and conservation of momentum on a pre-defined grid covering the study area, by providing with bathymetry, bed resistance coefficients, hydrographic boundary conditions etc. The model results are in the form of water levels and velocities (currents) in the x and y directions over the predefined study area.

The MIKE 21 Mud Transport (MT) module describes, transport and deposition of mud or sand/mud mixtures under the action of currents and waves. The MT model simulations were carried out for dispersion of dredge spoil disposal at designated offshore dumping area, off Uppada coast to describe the spatial and temporal variations of suspended sediment concentration. The simulated results of HD model were used as input for the MT simulations. In MT module, since the settling velocity depends on salinity (32-36‰) an average value of 34‰ was given to the model.

Model calibration and validation

As per the extract from past studies at project site, the MIKE 21 HD model has been calibrated using bed resistance, wind friction factor and the dispersion coefficient. The model setup requires bathymetry, boundary conditions, initial conditions, meteorological data and initial values for the calibration coefficient.

The model was calibrated by varying bottom friction and eddy viscosity and a suitable constant value of eddy viscosity 0.21 m^2/s and a constant value of bottom friction 27 $m^{1/3}/s$ (in the form of Manning's coefficient) were set for the entire model area. Wind speed of 3.5 m/s and direction 210^0 was given in the model simulation to include the wind effect on resultant water levels and flow pattern. Also the water levels at the open boundaries of the ocean in the off Uppada coast were suitably adjusted to reproduce the seasonal reversals of the coastal currents. Comparisons of observed and simulated tidal elevations indicate that the predicted elevations are well correlated with the observed ones. The observed and simulated curves almost merge with each other. The validated Mike 21 HD model is used to simulate the tide levels and flow velocities in the vicinity of designated dumping area (Uppada) for different seasons and for different tidal conditions.

4.2.5 Mud Transport - Prediction Results

The estimated disposal rate of 40000 - 70000m^3/day has been taken into consideration with maximum one time dumping of 10000m^3 with 80% concentration of suspended solids. Although the dredge material disposal will be in batches, i.e. dredger after dredger at the intervals of about 2-3 hours, for the purpose of model simulation, the source is assumed to be continuous at the rate of $0.8m^3/s$ disposal at designated offshore dumping area having the depth of 12m. The predictions are carried out for wet season predominant SW winds and southerly currents as well as dry season predominant NE winds and northerly currents.

The model predicted the suspended solids (sediment parameters) concentration (SSC) in x and y directions, the net deposition and the deposited bed thickness in the dredge material dumping area.

In wet season the mud plume (turbid with silty clay loam as suspended solids) is carried away towards north with the southerly currents. The SSC is very high in the near field of dumping site, which gradually settles and also carried away along with currents. The SSC concentration distribution field is predicted using model of 0.2 kg/m^3 (equal turbidity about 28 NTU) contour spread to 1.25 km in cross current direction (y-direction) and to about 3 km in current flow direction (x-direction) north words, which shall settle over the time and result in minor bed thickness temporarily. During neap tide (falling tide) the bottom deposit will get washed away towards deeper depths of sea.

In dry season the currents are strong with 0.4 m/s along with relatively higher flow in perpendicular direction to coast line. The above indicated discharge rate will get dispersed / diluted rapidly and the SSC concentration field with 0.2 kg/m^3 will spread only 1.0 km wide and with shorter plume more spread low and away from coast. Under no circumstances the mud plume would reach to coast line and it will disperse, settle within the Kakinada port limits (no fishing zone).

4.2.6 Prediction of Impacts – Marine Environment

- The proposed capital Dredging (estimated 13.8 million m^3) will increase the depth to -14.5 m CD from the present depth of 3.0-4.5 m below CD in considerable part of the existing harbour area.
- The currents data collected during marine survey in Kakinada bay area indicates reversal in current in flood and ebb tides with speed up to 0.37 m/s. With the proposed increase in depth, there is possibility for marginal increase in currents speed while the direction pattern remains unchanged. During the slack periods of high tides and low tides, the currents are insignificant in the bay area, which indicates that tidal currents are pre-dominant in Kakinada bay / Harbour area.

- The pre-project status of macro and meo-benthos within bay area indicate no rare species. The existing benthic fauna in the bay area will be disturbed and possibility of loss locally during the jetty construction period, however it will be temporary phenomena. Moreover, the sediment benthos are expected to get re-established after completion of construction activities through natural siltation process.
- As per the coastal hydrodynamics studies carried out by CWPRS through modeling studies, there will be no adverse impact due to jetty construction activities and proposed capital dredging for the project on the coastline including the identified sensitive area of Uppada.
- The sea bed sediment will be distributed due to dredging, drilling of pile foundations and construction of jetty, mooring dolphins etc. Marine water turbidity will increase locally due to suspension of silt and clay, which will lead to reduction in penetration of sunlight dissolved oxygen concentration leading to lowering primary and secondary productivity.

Impacts on Marine Fisheries

The marine fish catch is not a permissible activity within the prescribed port limits, in which the project construction as well as dredge material disposal will take place. However, during the construction phase, temporary increase in turbidity of coastal water is envisaged. This could on the one hand result in a reduction of the primary and secondary productivity as a consequence of increased turbidity (and lower light penetration), but on the other hand positive effects can be expected from the mobilization of nutrients from the seabed into the water column (suspension).

The impact on fishes may be either due to physical impact of suspended solids or due to changes caused in the food chain. As the fishes are capable of free movement in water, they avoid areas with higher turbidity. The return to the area, once the turbidity reduces after the cessation of construction activities. They excess amount of sediments entrained as a result of placement of construction material in the water column results in fish suffocation as gill chambers become coated or clogged with material. Many researchers have concluded that extremely turbid water that is formed briefly during construction phase can be detrimental to fish, but the impacts are not very alarming. The dredge material disposal at designated dumping area at the estimated rate of 50,000 m^3/day, shall not have any significant impact due to existing high wave/tidal currents and sufficient dilution factor at designated offshore dumping area.

Mitigation measures:

- The site specific construction protocol to be developed and adhered, to mitigate environmental impacts
- A dredge management plan including controlled disposal at identified points (within dumping area) shall be prepared and followed along with necessary monitoring at dredging sites and in dumping area.
- Based on the model prediction results, the dumping shall be done at two locations alternatively within the designated dumping area by each / individual dredger in a planned pre-programme manner to allow internal dilution in relatively pristine water to minimize adverse impacts. The attentive locations are identified as (i) 644 850m E, 886 980m N and (ii) 646 900m E, 887 500m N.
- Regular monitoring of marine water quality and sediment samples
- No marine construction activities including jetty piles during disturbed sea conditions (cyclones, depressions etc.)
- All necessary precautionary measures would be taken so as not to create localised turbulences during marine construction period leading to re-suspension of bottom sediment and or apply geo-textile lining (temporarily) in the vicinity of construction area to prevent entrainment of silty sediment and to minimize turbidity related impacts.
- The dredging to be carried out using suction type dredgers to minimize the turbidity impact at dredging location. There will be no drilling or blasting required as per geotechnical details at proposed dredging area.
- Sophisticated, purely suction type dredgers with no scope for leaks of dredge material shall be used.
- Any marine pollution arising out of the jetty construction / movement of barges / vessels would affect the surrounding water, aquatic lives. In view of this, precautionary measure would be taken to avoid any pollution that could disturb the marine environment.
- Construction wastes such as waste wooden strips, packing materials, used/ empty paint containers etc. will be returned to land for proper disposal to avoid marine pollution. Oil spill contingency plan will be strictly followed to prevent any pollution of the coastal environment by oil spills during the construction phase.

- The jetty deck / platform will be supported by circular hollow steel piles with minimal interference to wave movement and the related coastal hydrodynamics in the bay. Appropriate spacing between consecutive jetty deck planks will be maintained to protect the jetty structure in case of unusual rise in sea level.

- The project proponent would ensure that the marine construction activities including dredging does not affect the daily fishing harbour / fishing trawler / boats movement in the project area. Demarcation zones for boat will be strictly observed.

4.2.7 Land Environment

- The land requirement for the landfall (metering) station/ORF is very less compared to similar capacity land based LNG terminal. At the proposed site (2.64 Ha) the envisaged land use breakup is : about 37% for RLNG facilities; 23% for internal roads; 7% for bund wall; 8% open area for vehicle parking; balance 25% will be used greenbelt development. As per the site area as well as the development area within it, the civil construction will also be very limited. The site will be only levelled and there will be no level rising expected.

- The bund wall of sufficient height and strength will be constructed around the site to protect the metering facility from surge / wave attack during cyclones / depressions and or Tsunami, in case of occurrence. The bund wall could resist the force, but it may not be useful to project the site from floods.

- The proposed widening of entry channel would be on the north side of existing channel, away from Hope Island, hence the impact on the Hope Island will be negligible. The existing sand trap would also prevent any adverse impact on the Hope Island.

- The site falls in seismic zone-III moderately active zone. Hence, the structures at ORF as well as jetty shall be designed and constructed with appropriate strength and stability.

- There will be no construction waste envisaged at the site hence no scope for waste disposal and related soil contamination, ground water impacts etc.

4.2.8 Water Environment

- There is no proposal for ground water extraction and usage.
- The construction water requirement (ORF construction and pre-fabrication yard for RCC panels for jetty / platform) is estimated about 60 KLD, which is to be provided by the KDWP operator, M.s KSPL / by third party supplier, which will have negligible impact on water resources.
- During construction, sewage of the order of 10-15 KLD is expected at construction site / fabrication yard, which shall be managed through septic tank / soak pit.

4.2.9 Biology / Ecology

- There are no rare species of flora and fauna in KDWP harbour area.
- The disturbance by the direct impacts of the jack-up rigs /steel pile driving may lead to loss of benthos (purely temporary).
- The increased turbidity could reduce light penetration at dredging / marine construction site, cause reduction in photosynthetic species
- The envisaged low littoral draft in high (flood) tide periods would have negligible impact on mangrove ecology at more than 10 km distance from project site.

4.2.10 Air Environment

The project site and surrounding study area is relatively clean and does not have any major source of air pollution as per the baseline status on air quality. Various construction activities shall contribute to air pollution in the area such as: Dust generation during site grading, foundation works, civil transportation of construction material by road/rail/sea; construction machinery viz., DG sets, Concrete mixers, etc.

The impacts on air environment during the construction phase of the proposed LNG terminal at Kakinada are described here under:

The major pollutant in the construction phase is particulate matter, PM_{10} especially at project site due to various construction activities. The vehicular movement generates pollutants such as NO_X, CO and HC. But, the vehicular pollution is not expected to lead any major impacts except near the roadside. The soil in the project area is sandy in texture, and is likely to generate substantial quantities of dust. However, the fugitive emissions generated due to vehicular movement are not expected to travel beyond a distance of 200 to 300 m. Since, there is no habitation or ecologically sensitive areas in the vicinity of the site; the impact on air environment during the construction phase is not expected to be significant. The combustion of diesel in various construction equipments could also be one of the sources of air pollution during the construction phase. However, the increase in SO_2 levels due to operation of these equipments is insignificant to cause any adverse impact on air environment. Thus the impact on air environment during the construction phase is not expected to be significant.

4.2.11 Noise Environment

The construction machinery especially impact based like drilling rig, hydraulic hammers, diesel driven machinery like dozers, generator sets, vehicle / vessels mounted cranes, barges etc. are the considerable noise sources during construction phase of proposed project (Marine facilities as well as land based facilities).

Operation of pile hammers at jetty construction site, dredger jacks etc. contribute noise in ambient air as well as submarine noise. The noise generator by pile hammer is expected to generate more than 115 dB(A), which is not acceptable to even short period noise exposure to workers. Hence necessary noise control measures are to be implemented including, personal protection equipment (ear muffs / ear plugs) to the workers engaged in the close vicinity.

Materials transported during the construction period to the site will result in an increase in noise levels of 1.5-2 dB(A) close to the road side. Regulation of traffic may however alleviate impacts due to noise.

4.2.12 Socioeconomic Environment

Social environment refers to people and their surroundings, human beings and their products, their property, groups, heritage etc. The effects of a project on people and their responses may be direct and immediate or short term and long term. Estimation of the change in the income in an area, value of structures, equipment, standard of living, statistical information on population growth etc form socio-economic studies.

Positive consequences of the project for the social aspects of the environment include direct and indirect employment opportunities, general spin-off in the region as a result of availability & cleaner fuel.

4.2.13 Mitigation Measures

- During land based construction activities, workers normally cut branches / trees for firewood, especially the causuarina plantations available in the immediate vicinity, if they are not provided with alternate domestic fuel. This could lead to loss of trees in surrounding areas during construction phase. Provision of community kitchen with fuel such as LPG to construction workers to avoid felling of trees for fuel wood should be considered as part of the implementation plan.

- Necessary measures will be implemented for pest and vector control for the construction workforce (temporary habitation) and the nearby communities.
- As part of their EMP, authorities should introduce appropriate clauses in the contract so that the entire contractor related activities – onsite and offsite, are done in environmental friendly manner.
- All the construction debris should be removed continuously and dumped at pre-designated land fill site in consultation with existing KDWP operator / APPCB
- Proper maintenance of construction equipment/machinery for controlling excessive noise levels
- Use of silencers/mufflers for high noise generating equipments
- Restricting the movement of vehicles and noise prone activities during nighttime as nighttime noise levels are more sensitive
- Ambient noise levels should be regularly monitored at critical locations in the, construction sites before start of work and during the execution of work so that increased ambient load can be estimated. If the levels are crossing the permissible values, immediate mitigation measures need to be adopted
- Any noise level arising out of the construction activity such as hammering would be of temporary nature. Operators at noise generation equipment will also be provided with personal protective equipment such as ear plugs or ear muffs.
- Most of these activities shall be undertaken through contract work. Therefore, authorities should put such clauses in the contractual agreement and ensure their implementation during construction work
- Proper maintenance of construction equipment/machinery for controlling excessive noise levels
- Use of silencers/mufflers for high noise generating equipments
- Restricting the movement of vehicles and noise prone activities during nighttime as nighttime noise levels are more sensitive
- Ambient noise levels should be regularly monitored at critical locations such as construction sites before start of work and during the execution of work so that

increased ambient load can be delineated and in case of exceeding standards, necessary measures to be implemented to control

- Adequate quantity of potable water shall be provided to the workers through contractors
- Adequate number of community toilets with arrangements of sewage disposal in septic tanks shall be provided for the use of entire migratory labour force
- Medical facilities need to be provided in association with local hospitals and health centers including immunization for children
- To ensure that all the workers are paid at least minimum wages as per government norms so that their sustenance requirements can be taken care of

Occupational Health Safety

- Provide safety helmets to protect workers from head injuries
- Barriers like a toe boards or mesh guards should be provided to prevent items from slipping or being knocked off of a structure
- Secure objects to the structure like lashing of scaffold boards
- Ensure that there are no loose objects & all tools are properly secured
- Create an exclusion zone beneath areas where work is taking place
- Danger areas should be clearly marked with suitable safety symbols & indicators that access is restricted to essential personnel wearing hard hats while the work is in progress

Table 4.2.1

Identification / Evaluation of Impact Characteristics – Construction Phase

Activity	Impacts		Impact Characteristic	Significance Level with low cost EMP
	Env. Component	Cause	Duration/ Nature / Reversibility	
Transportation of construction materials / Construction material handling	Air	Exhaust emissions, fugitive dust emission	Short term Negative Reversible	Low, by covering the trucks with tarpaulin sheets or by using water sprays
	Noise	Noise generation by handling equipment vehicles and material	Short term Negative Reversible	Medium when there are noise sensitive receptors Low when there are no noise sensitive receptors in the vicinity
Construction activities site grading, civil works, local fabrication and erection	Air	Fugitive dust generations and exhaust emissions from operation of construction machinery	Short term Negative Reversible	Low, by sprinkling water and wearing masks
	Noise	Noise generation by construction machinery, generator sets	Short term Negative Reversible	Low when following standard & lubrication / maintenance as well as use of ear plugs by workers
	Water	Water requirement for construction and wastewater from construction site	Short term Negative Reversible	Low, as groundwater shall not be tapped Impact of runoff from construction site can be minimized by arresting through small bunds
	Land	Change in landuse construction wastes	Long term Positive, Short term Negative	Medium to high as per the project requirement
Construction work force / Labour colony as applicable	Water	Exploitation of water resources for domestic usage and generation of domestic / sanitary wastewater	Short term Negative Reversible	Low, when workers are local, current usage pattern is maintained and when groundwater is not be tapped Low, when wastewater is disposed with basic treatment such as soak pits.
	Land / Aesthetics	Springing up of temporary buildings / dwellings. Generation of solid wastes,	Short term Negative Reversible	Low, when proper collection and disposal is practised Low, when hutments are within premises
	Socio-Economics	Increased employment opportunities	Short term, Positive, Reversible	Low, since employment is temporary

Contd…

Contd…Table 4.2.1

Activity	Impacts		Impact Characteristic	Significance Level with low cost EMP
	Env. Component	Cause	Duration/ Nature / Reversibility	
Capital dredging	Noise	Use of dredging equipment and power tools	Short term Negative Reversible	High w.r.t. Quantum. Relatively low in view of soft & hard silt / clay up to final depth of dredging. No drilling or blasting envisaged for entire dredging activity
	Marine Water	Sediment re-suspension	Short term Negative Reversible	Medium for turbidity when the material is clayey in texture
	Sediment	Release of toxic substances and nutrients	Short term Negative Reversible	Low for toxicity when sediment toxicity is minimal
	Benthic Ecology	Disturbance of bottom sediments and/or destruction of spawning grounds	Short term Negative Reversible	Low, when commercially / ecologically significant species/ breeding/spawning grounds are not present. Deposition of dredged material may cause short term impact and revive shortly after stopping disposal
Dredge Material Disposal	Marine Water	Suspended silt / fine material	Short term Negative Reversible	Low, when disposed at designated offshore area in a controlled manner
	Seabed marine / Benthic	Deposition layer Depleted oxygen due to high turbidity	Short term Reversible Short term Negative / Reversible	Low, when disposed at distributed locations in designated dump area in controlled manner
Construction of jetty plat form on piles	Noise	Use of pile drivers, boring equipment, power tools, drill bits etc.	Continuous for a Short period Negative Reversible	Low if standards are followed Low when ear protection devices are used
	Water	Increased suspended solids and turbidity	Short term Negative Reversible	Low, since area of impact is localised and negligible
Trenching and laying of subsea pipeline and backfilling	Marine Water	Use of dredging equipment, dredging	Short term Negative Reversible	Low, in view of proposed back filling, reinstate to normal in short duration
	Seabed / Benthic Ecology	Disturbance to bottom / sediment re-suspension , Turbidity, reduction in solar light penetration / reduction in primary productivity	Short term Negative Reversible	Low, in view of proposed back filling, reinstate to normal in short duration

Contd…

Contd…Table 4.2.1

Activity	Impacts		Impact Characteristic	Significance Level with low cost EMP
	Env. Component	Cause	Duration/ Nature / Reversibility	
Marine dredging / construction	Marine occupational hazards	Human error, accident	Short term / Long term	Low, if standard work instructions are strictly followed along with meticulous usage of PPEs

4.3 Operation Phase Impacts

Any major developmental project is expected to have interference with the surrounding environment and cause some environmental impacts which may be inevitable during its normal operation phase. The significant environmental impacts from the project could be controlled through policy / technological interventions if they are identified and assessed before the project implementation. The impacts due to operation of proposed project at the identified location are identified predicted and assessed for individual environmental components in this section.

The proposed FSRU based LNG terminal overall operations falls into relatively low polluting category, as the fuel requirement at the project site will be met from Boil Off Gases (BOG) from LNG storage at FSRU and the re-gasified LNG (RLNG) at onshore receiving facility (ORF); the major part comprising storage, LNG re-gasification process and RLNG supply i.e. FSRU, will come with built-in modular waste Management (bilge, domestic / sanitary waste, solid waste), air pollution control and noise mitigation system complying to international standards like MARPOL, ISO etc.. The FSRU will be self-sustained towards domestic / soft water requirement, estimated to be about 20 KLD, through self-generation (by de-salination).

Similar to construction phase, in the normal operation phase also, the major part of the project, i.e. LNG import, FSRU - storage and re-gasification (continuous operating process) and RLNG send out will be located in offshore (KDWP Harbour) area (Approx. 2 km distance seaward from shoreline). Hence the impacts on marine environment will have relative significance in operation phase too. The identified environmental impacts during operation phase are enlisted in **Table 4.3.1** along with relative significance and preliminary mitigation measures.

4.3.1 Marine Environment

The proposed FSRU will have the provision (option) for LNG re-gasification / vaporization through open loop vaporization process. In this process the heat available in sea water will be utilized to facilitate the heat-transfer for re-gasification of LNG. The sea cold water then discharged into the sea at a identified location. NEERI has carried out the studies for the assessment of impact of cold water discharge into the harbour / bay area using MIKE 21 dispersion model.

The volume of sea water in harbour / bay area is more than 300 Million m^3 and the maximum water depth will be 14.5 m in the turning circle, berthing basin and entry channel. The water currents within the harbour area vary between 0.02 m/s and 0.37 m/s in both conditions (spring or neap tide). The direction of water current is Northeast-Southeast during increase in tide and the direction of current will be Southwest-Northeast during reducing tide.

The discharge of cold sea water from FSRU will be at the rate of 15,500 m^3/h into the harbour area. MIKE 21 software was used to determine thermal energy dissipation by considering different thermal gradients/marine conditions. This software package has a provision to compute the heat exchange between the water and the atmosphere based on four physical processes namely (i) the long wave radiation (ii) the sensible heat flux (convection) (iii) the short wave radiation and (iv) the latent heat flux (evaporation).

4.3.2. MIKE Model Results and Discussion

The sea water temperature variation at project site is considered between 18^0C and 32^0C. The differential temperature between discharge and ambient se water temperature is taken as 7^0C and 10^0C and the predictions are carried out at two hours after the high tide and two hours after the low tide at 1m below the water surface, for the discharge of 15500 m^3/hr. The result obtained from model are summarized below:

   - At 10^0C differential temperature (less than ambient sea water) in winter season the mixing zone covers -300m radius to become the water temperature almost near to ambient sea water.
   - At 7^0C differential temperature, the mix zone extends to 220 m radial distance in the absence of currents
   - In summer season at 10^0C the mixing zone spread to about 249 m radius
   - In summer season at 7^0C the mixing zone spread to about 195 m radius

- During summer season the sea water requirement would be less compared to winter and monsoon seasons
- As the temperature difference is not significant (7^0-10^0 less than ambient seawater), the impact of cold water on chemical and biological characteristics will be insignificant. The conditions in the mixing zone are not harmful in terms of water quality standards to aquatic biota which may enter the zone.
- The quality of sea water intake for LNG vaporization and discharge are same thereby implying no discharge of pollutants except change of temperature.
- The location of mixing zones for thermal discharges is not interfering with spawning areas, and fish migration routes.

- The maintenance dredging (estimated 1 million m^3) in jetty, basin area required for the project will be carried out by KDWP operator, M.s KSPL, following the present practice and would not have any noticeable impact on the marine environment as per the past / ongoing practice / experience.

Mitigation Measures

- The DFDE / turbine engines cooling water out let and LNG vaporizer outlet should be mixed prior to discharge into sea to minimize the thermal impact on marine water.
- During the operation phase, the marine environment will be closely monitored so as to check presence of unusual aquatic mortality cases. An oil spillage contingency plan will be executed in case of accidental oil spillage.
- Littering would be strictly prohibited. Under any circumstances no scraps, food waste that could impact on the quality of the coastal water due to degradation of organic matter potentially affecting the level of nitrate, thereby contributing to algal bloom, be dumped into the seawater. As such, the management will ensure that no litter is dumped into the sea either during construction of the jetty or during the operational phase of the project.

4.3.3 Land Environment

As indicated in earlier section, the land based operations of proposed project will be limited to only gas metering station, control room, water bath heaters (to be used intermittently as and when required). There will be no manufacture process envisaged on continuous basis. The proposed land is only 2.64 Ha, owned by Govt. of Andhra Pradesh and at present vacant land in coastal belt within existing port area.

As per the CRZ study carried out by NIO, the identified project site is situated beyond the applicable CRZ limit as per MoEF CRZ notification 2011. The proposed project falls in the category of permissible activities as per the latest CRZ notification.

The site being in coastal belt, on the bank of a small backwater (creek) body, it is prone to coastal disasters like cyclones / storms, floods, Tsunami surges etc..

The operational staff at proposed landfall station / ORF will also be very limited, 8-12 nos. only and the material to be handled is regasified LNG (RLNG), the solid waste (domestic / process) generation could be insignificant on continuous basis.

The proposed greenbelt development in the 25% of ORF (2.6 Ha) area allocated / reserved for greenbelt, (even though small area) would improved the aesthetics / diversity of flora.

- The intermittent generation of solid waste in operation phase is expected to be in the categories of domestic waste, recyclable and hazardous waste categories.
- The hazardous waste comprising empty barrels, spent oils / lubricants, pipeline, pigging wastes etc. shall be managed as per Hazardous Waste Rules 2008 including latest amendments.
- The Recyclable wastes like metallic scraps, used batteries etc. shall be disposed through APPCB / CPCB authorized agencies.

4.3.4 Water Environment

- The domestic / soft water requirement for proposed project is estimated as less than 5 KLD (excluding FSRU)
- The required water will be available from KSPL supply system / third party supplier. No groundwater resource will be used for proposed project.
- The potable water requirement at FSRU, estimated as 20m^3/day (approx.) will be generated on board (desalination) by FSRU.
- Keeping in view the availability of water from existing port allocation and the ability to produce potable water onboard the FSRU, there will not be any additional burden on available water resources in the region.
- The sanitary waste at ORF (insignificant quantity for 8-12 persons only) will be managed through septic tank / soak pit.
- The wastewater generated at the FSRU will be treated and managed in accordance with International (IMO-MARPOL) regulations and also to meet Indian Standards.
- No ground water abstraction or use envisaged at proposed project, hence negligible impact on ground water.

Mitigation Measures

- Water required during construction will be supplied by the existing port operator, M/s KSPL, without affecting the domestic water supply to surrounding dwellings.
- Special care shall be taken during construction works to avoid any spillage of construction debris so as not to pollute the marine environment.

4.3.5 Biological Environment

As per coastal hydrodynamic study carried out by CWPRS, the proposed project does not cause any adverse impact on coastline dynamics upto and beyond Uppada, i.e. MoEF notified area.

The proposed project would have negligible impact on natural vegetation, species diversity, food web index due to low pollution category project and very limited number of species and natural vegetation present in the study area.

As per the prediction results through modeling studies (marine, atmospheric, noise) the proposed project does not cause any adverse impacts on Coringa Sanctuary ecological sensitive area the mangroves at about 12.5 km distance and also extended Coringa forest on Hope Island at 4.0 km distance from project site.

The land on which the project will be established is at present vacant land with sparse casuarinas plantation. Thus it can be concluded that the proposed project is unlikely to cause any adverse impact on terrestrial ecology

4.3.6 Air Environment

The FSRU berthed in offshore, area at jetty consisting storage and re-gasification facility will have the facilities / equipment such as: LNG Storage tanks; Turbine generators (2W +1S) of 11.4 MW capacity each, gas combustion boiler for close loop vaporization, flare etc. The project will be designed and operated with ‘zero’ flaring concept in normal operation phase. The flare at jetty / mooring dolphins as well as at ORF will be installed as only safety measure for emergency purpose.

The power generation by 2W + 1S gas turbine generators will be used at FSRU. Low NOx burners will be provided in order to control NOx emission. The stacks connected to continuous operating units like turbine generators, gas combustion boilers water bath heaters at ORF etc. are the major sources of air emission at proposed LNG terminal at Kakinada. The major air pollutants are NOx from captive power through gas turbine electrical generators and SO_2, NOx and PM_{10} from the DG sets during the operation which will be operated only during emergency. The stack details like height, top internal diameter, flue gas velocity, gas temperature as provide along with the respective estimated emission rates of air pollutants are given in **Table 4.3.2**.

- The impact due to exhaust emissions from FSRU will be insignificant on land as the estimated emissions are very low due to proposed cleaner fuel usage (RLNG). During normal operation the predicted maximum NOx concentrations from proposed project are 8.6 µg/m^3 in post-monsoon, 10.5 µg/m^3 in winter and 14.9

µg/m^3 (24 hrly) in summer season. The post project status, i.e. cumulative / net NOx levels will be well within the prescribed NAAQS.

- The proposed project (operation phase) will not cause any additional road traffic as the total RLNG (gas) will be transported through pipeline from terminal up to consumers.

Fugitive Emissions (HCs)

The fugitive emissions from valves, connectors, flanges, pressure relief valves, compressor valves, etc are computed following US Environmental Protection Agency (USEPA) and American Petroleum Institute (API) guidelines. The total fugitive emissions in terms of hydrocarbons will be around 0.05 TPD. The fugitive emissions may be reduced by applying effective control measures available. The HCs emissions from storage tanks may be controlled through effective vapour recovery techniques which is provided in the existing system.

The emission rates of individual air pollutants are calculated based on fuel combustion rate quality of fuel and applicable emission factors.

Air Quality Modelling

The impact on air quality due to emissions from single source or group of sources is evaluated by use of mathematical models. When air pollutants are emitted into the atmosphere, they are immediately diffused into surrounding atmosphere, transported and diluted due to winds and atmospheric turbulence. The air quality models are designed to simulate these processes mathematically and to relate emissions of primary pollutants to the resulting ground level concentrations downwind direction. The inputs include emissions, meteorology and surrounding topographic details to estimate the concentration of conservative air pollutants.

The Industrial Source Complex Version 3 (ISCST-3) model adopted from the USEPA guideline models and routinely used as a regulatory model to simulate plume dispersion and transport. ISCST–3 is the state of the art model with USEPA and extensively used for predicting the Ground Level Concentrations (GLCs) of conservative pollutants from point, area and volume sources. The impacts of primary air pollutants are predicted using this air quality model keeping in view the plain terrain at the project site. The micrometeorological data monitored at project site during study period as well as the project site relevant data (weather satellite data) procured from M/s LaGa systems, Hyderabad for one year duration (January – December, 2012) have been used in this model.

The ISCST-3 model is, an hour-by-hour steady state Gaussian plume dispersion model which takes into account the following:

- Terrain adjustments
- Stack-tip downwash
- Gradual plume rise
- Buoyancy-induced dispersion
- Complex terrain treatment and consideration of partial reflection
- Plume reflection off elevated terrain
- Building downwash
- Partial penetration of elevated inversions is accounted for
- Hourly source emission rate, exit velocity, and stack gas temperature

The ISCST-3 model thus provides estimates of pollutant concentrations at various receptor locations. NOx being relatively high emission at project site compared to other pollutants, the ground level concentrations are predicted for NOx.

Micro-Meteorology

The seasonal wind roses derived from the local meteorological data are presented in Chapter 3. The hourly wind speed, solar insulation and cloud cover during day time; wind speed and total cloudiness during night time were used to determine the hourly atmospheric stability class as given in air quality modeling guidelines by CPCB.

- For day or night: If total cloud cover (TC) = 10/10 and ceiling <7000 ft (2134 m), NR=0
- For night-time (defined as period from one hour before sunset to one hour after sunrise):
  a) If TC<4/10, use NR = -2
  b) If TC>4/10, use NR = -1
- For daytime: Determine insulation class number (IN)
  a) If TC<5/10, use NR=IN
  b) If TC>5/10, modify IN by the sum of the following applicable criteria
     i) If ceiling<7000 ft (2134m), modification = -2
     ii) If ceiling>7000 ft but <16000 ft (4877 m), modification = -1

iii) If TC=10/10 and ceiling>7000 ft, modification = -1, and let modified value of IN=NR, except for day-time NR cannot be <+1

The hourly meteorological data used for the prediction of ground level concentrations (GLCs) during post-monsoon, winter and summer seasons are given in **Tables 4.3.3 – 4.3.5** respectively. The predicted ground level impact NOx from the project are presented in **Figs.4.3.1 – 4.3.3** for different seasons. The Prediction Results are summarized as follows:

Post-monsoon Season: The 24 hrly maximum GLCs of NOx emission from all sources (**Table 4.3.2**) (under normal operation phase) are found to be 8.6 µg/m^3 occurring at 0.3 km in WSW direction from the ORF stacks (**Fig.4.3.1**).

Winter Season: The 24 hrly maximum GLC of NOx from proposed project (under normal operation) is predicted as 10.5 µg/m^3 occurring at a distance of 0.5 km in west direction from ORF stacks. The isopleths showing the incremental GLCs of NOx due to project under normal operation is shown in **Fig. 4.3.2**.

Summer Season: The 24 hrly maximum GLC of NOx during summer season is predicted as 14.9µg/m^3 at 0.5 km in north direction from ORF. The isopleths showing the incremental GLCs of NOx under normal plant operations are shown in **Fig. 4.3.3**.

From the prediction results it could be observed that the air quality impact from ORF (landfall station) would be more than from FSRU (marine facility). However, the overall air quality status with the project after super imposing even maximum GLCs over baseline status will remain well within prescribed NAAQ standards.

The proposed project (operation phase) will not cause any additional road traffic as the total RLNG (gas) will be transported through pipeline from terminal up to consumers.

4.3.7 Noise Environment

Prediction of Impacts due to the Proposed Terminal

The project proponent is committed to stipulate in the EPC contract the condition related to maximum allowable noise levels. This means that the LNG terminal will be designed such that the sound pressure level in normal operation phase shall not exceed 90 dB(A). The impulse noise level shall not exceed 120 dB(A).

The design of the terminal will be such that the sound pressure level in the operations (major) work area will not exceed 85 dB(A). The work area is defined as any position not less than 1 m from equipment surfaces accessible to personnel, or any position where a worker's ear may be exposed in the normal course of duty. Restricted areas will be those locations where it is not reasonably practicable to reduce the noise level below the work area limit. Where practicable, attempts shall be made to reduce the noise level below 80 dB(A).

All the LNG unloading regasification equipment including DFDE, GCU on FSRU shall comply to MRPOL/IMO regulations where as the Emergency DG sets, cranes etc. on jetty platform, backup generator (Dual Fuel) at ORF shall comply to prescribed Indian Standards for Noise Generation

As per the noise generation source details provided at FSRU/jetty location **Table 4.3.6** the combined noise sources derived used for prediction of impact are given **Table 4.3.7**. The hemispherical wave propagation model has been applied for prediction of noise impact from stationary sources.

The predicted noise impact in ambient air around project site is presented in **Fig.4.3.4.** As per the prediction results, the noise levels will fall to <50 dB(A) at 400 m distance from the facility of terminal, i.e. FSRU & ORF.

During normal operation of proposed project, the additional vehicular traffic will be negligible, hence no possibility of increase in noise impact from mobile sources. As per the prediction results the noise impact from proposed project at nearest habitat will be negligible and well within the prescribed ambient noise standards.

4.3.8 Socio-economic Environment

Social environment refers to people and their surroundings, human beings and their products, their property, groups, heritage etc. The effects of a project on people and their responses may be direct and immediate or short term and long term. Estimation of the change in the income in an area, value of structures, equipment, standard of living, statistical information on population growth etc form socio-economic studies.

Import of LNG introduces a cleaner fuel in the region, which could replace conventional fuels, such as fuel oil, LSHS, LDO, HSD, naphtha, coal etc. thereby reducing the of air pollution emissions.

Particularly during the construction phase the pressure on the area will be higher as the amount of traffic will increase. In addition, about 500-1000 construction workers will be brought in to Kakinada town.

It is necessary to identify the extent of these impacts for further planning of control measures leading to mitigation of the adverse impacts. The impacts due to proposed project on parameters of human interest have been assessed in term of:

The proposed marine facilities jetty & FSRU will be at more than 1.2 km distance from existing fishing harbor and will not have any interference on the ongoing marine fisheries activities

Although there is possibility of some temporary impact on marine fish population due to increased turbidity during dredging and disposal, it will be purely temporary, and will get normalized within few weeks time after stopping dredging and disposal due to existing relatively high currents in offshore dumping area

In operation phase, direct employment would be very limited hence there is no scope for additional stress on local infrastructure / amenities. The proposed project will supply cleaner fuel & total supply will be through pipeline, hence no additional road traffic is envisaged due to proposed project. The overall socioeconomic adverse impact would be insignificant

Positive Impacts

- There will be no private land acquirement for the project
- Positive consequences of the project for the social aspects of the environment include direct and indirect employment opportunities, general spin-off in the region as a result of availability & cleaner fuel.
- New jobs will be created during construction phase mostly on temporary basis and for skilled and unskilled workers
- General growth in commercial and industrial activity in the area

Negative Impacts

- Traffic flow and congestion will increase at and around the project location
- Noise effects on Health and life style due to activity during construction phase
- Pollution will be increased marginally during construction phase (temporary).

The expected change in the predicted quality of life (subjective and cumulative) after the implementation of EMP measures presented in **Table 4.5** and **Table 4.6**. With proposed project, which supplies cleaner fuel in bulk quantity will help in improvement of quality of life from existing 0.56 to 0.60 in the project region.

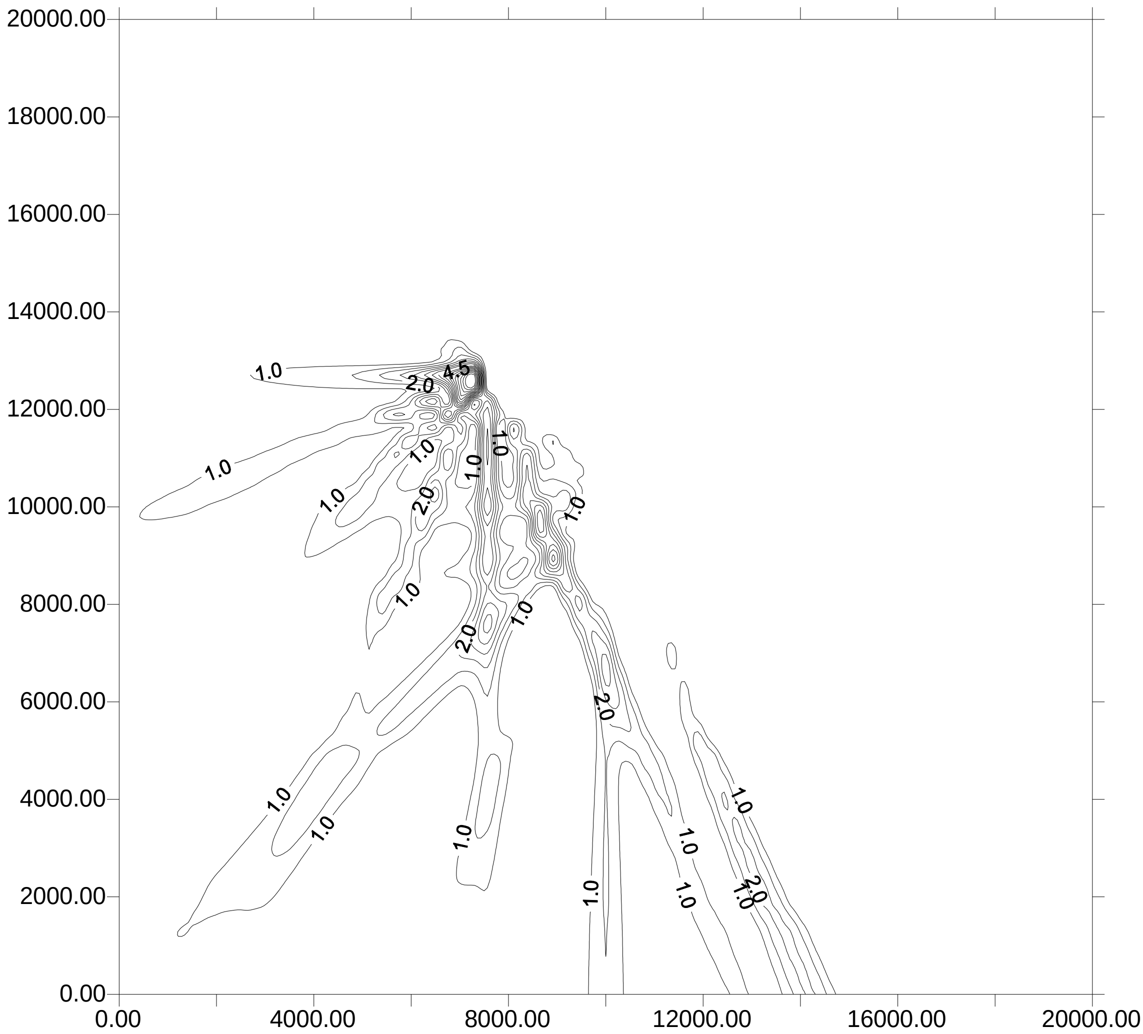


Fig.4.3.1: Predicted NOx Impact during Post-Monsoon Season

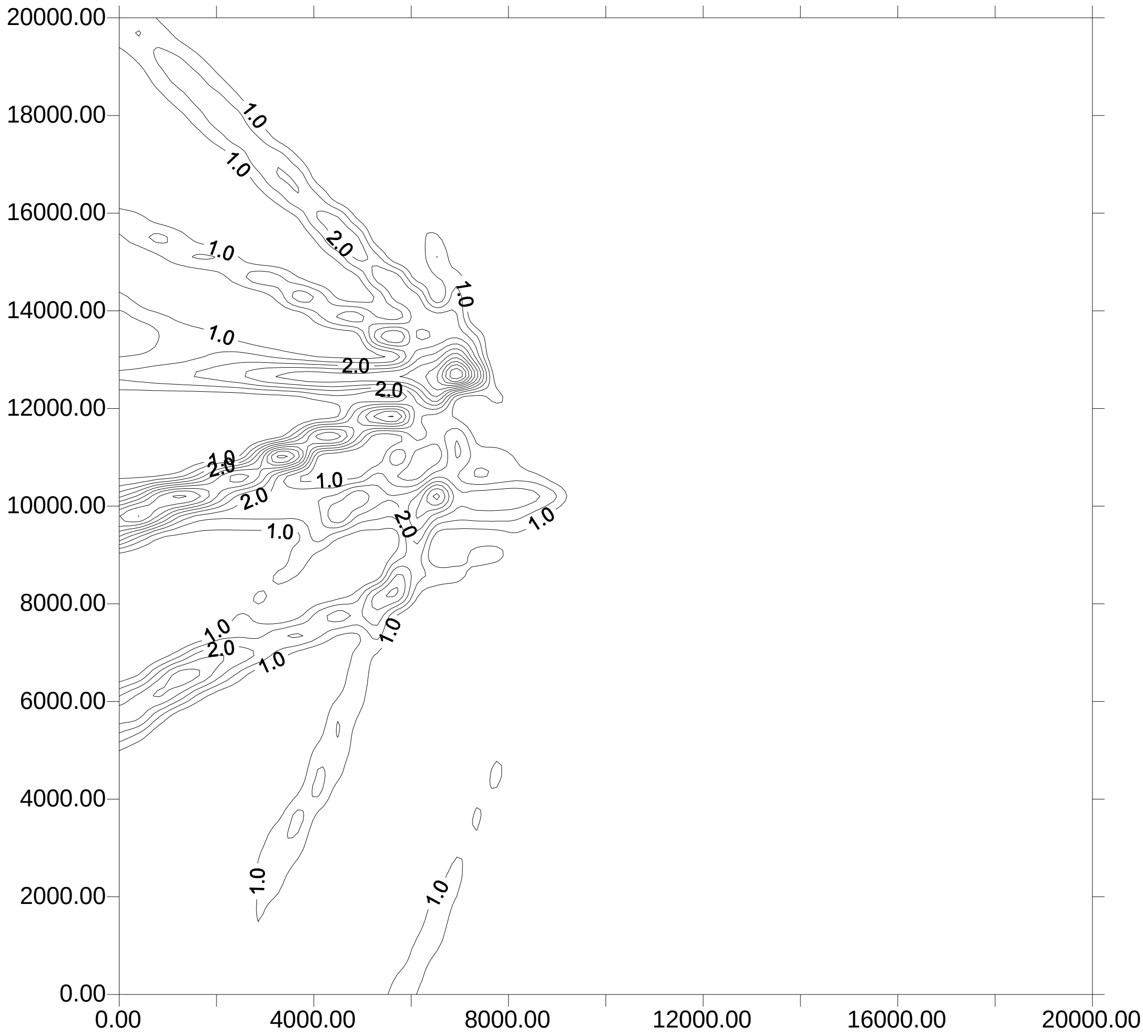


Fig.4.3.2: Predicted NOx Impact during Winter Season

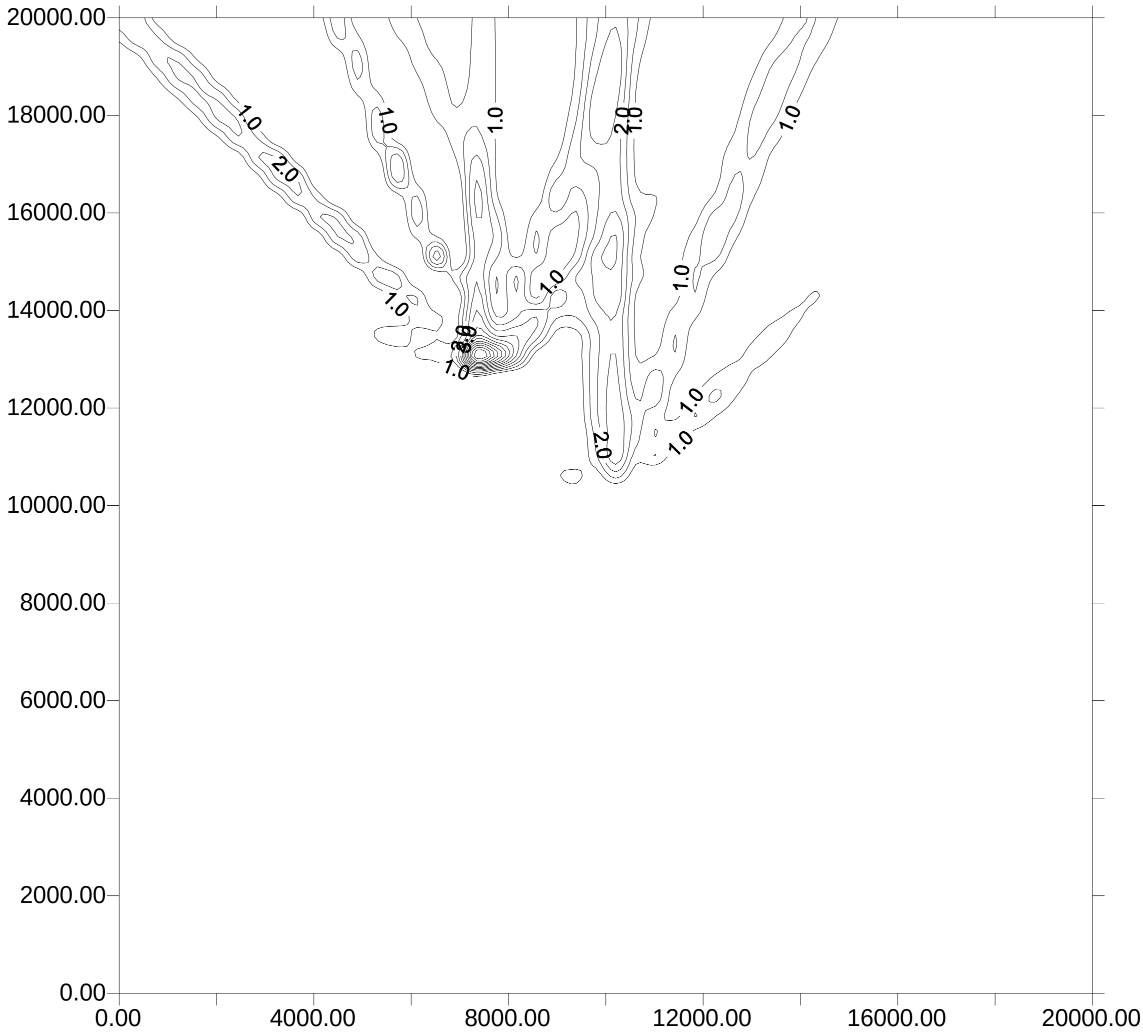


Fig.4.3.3: Predicted NOx Impact during Summer Season

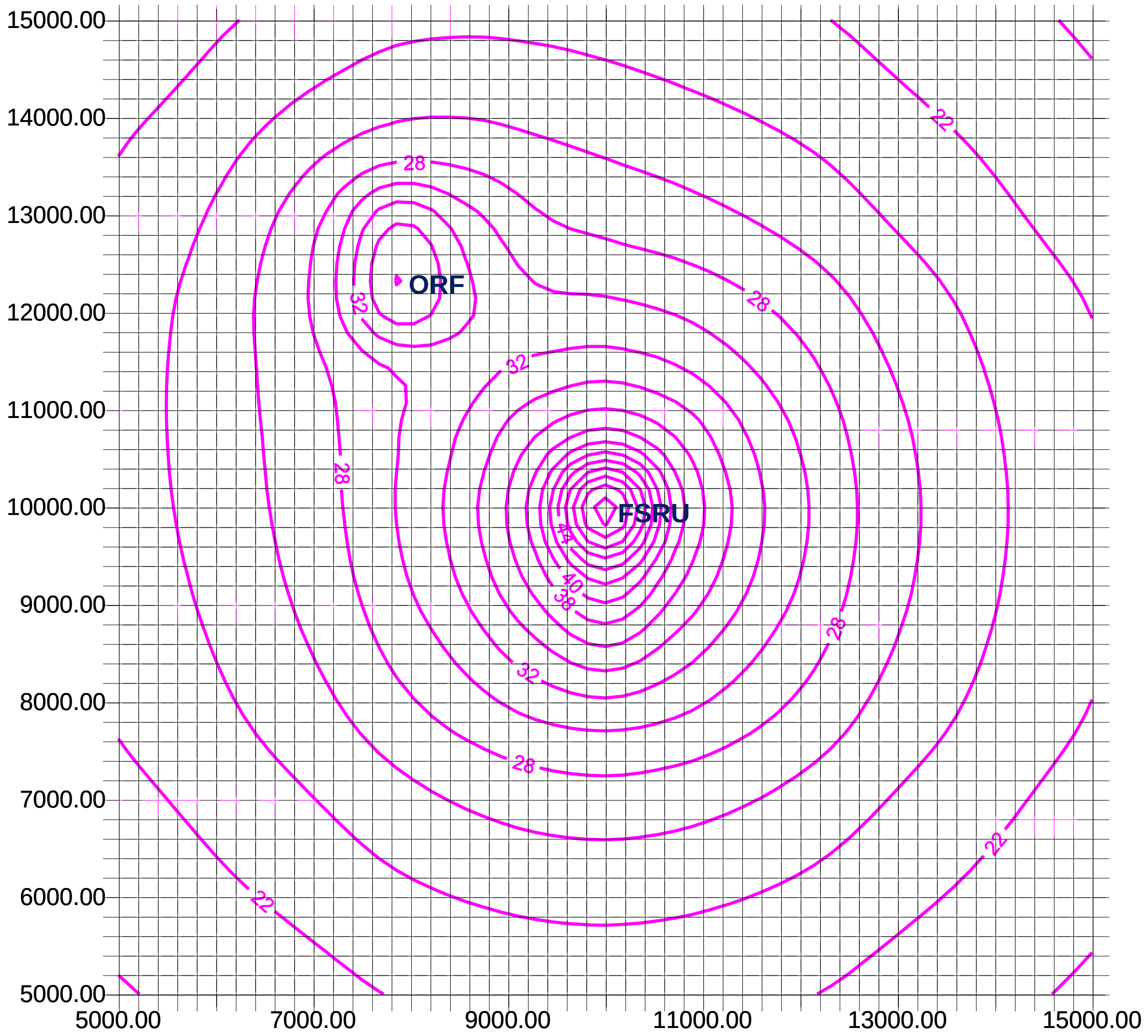


Fig.4.3.4: Predicted Noise Impact from Stationary Sources

Table 4.3.1

Identification / Evaluation of Impact Characteristics – Operation Phase

Activity	Impacts		Impact Characteristic	Significance Level with low cost EMP
	Env. Component	Cause	Duration/ Nature / Reversibility	
Handling of LNG and transportation of RLNG through pipeline	Air	Malfunction of valves, couplings minor leaks cause fugitive emissions of methane	Short-term Negative Reversible	Low, immediate measures will be in practice to rectify the leakages
	Water	Spillage into the marine environment	Short term	Low, since quantity of spill is expected to be negligible with Standard Operating Procedures
FSRU operation	Air	Funnel emissions	Long term negative possible to control	Low with potential scope for further mitigation through appropriate control measures
	Water	Bilge, deck process effluents	Long term negative possible to control	Low with potential scope for further mitigation through appropriate control measures
	Solid waste	Pantry waste / domestic waste	Long term negative possible to control	Low with potential scope for further mitigation through appropriate control measures
	Hazardous waste	Process waste, spent oils, lubricants containers etc.	Long term negative possible to control	Low with potential scope for further mitigation through appropriate control measures
	Ecology	Concentration of heavy metals from spillage on the sediments	Long term Negative Irreversible	Low, since commercially valuable species are not common
Maintenance dredging	Sediment	Accumulation in sediments Movement of dredge spoils	Short term Short term Negative Reversible	Low, part of existing port maintenance dradging Low for toxicity when sediment toxicity is minimal
	Water	Sediment resuspension, release of toxic substances and nutrients	Short term Negative Reversible	Medium for turbidity when the material is clayey
	Benthic Ecology	Disturbance of bottom sediments and/or destruction of spawning grounds	Short term Negative Irreversible	Low, when commercially valuable species/ breeding/spawning grounds are not present
Shipping Operations	Air	Exhaust emissions	Short term, Negative, Reversible	Immediate dilution effect due to breeze condition in coastal area

Contd…

Contd…Table 4.3.1

Activity	Impacts		Impact Characteristic	Significance Level with low cost EMP
	Env. Component	Cause	Duration/ Nature / Reversibility	
	Water	Discharge of bilge, cargo residues, operational wastes, waste water	Short term Negative Irreversible	Low as there shall be strict adherence to MARPOL
Spillage of gases	Air	Dispersion of volatiles from spilled cargo and/or Vapour cloud explosion	Short-term, negative	LOW probability under normal operating conditions RISK under accidental releases or abnormal conditions
	Water	Spillage and spreading of hazardous liquid cargo	Short-term, negative	LOW probability under normal operating conditions RISK under accidental releases or abnormal conditions
	Sediment / Ecology	Concentration of heavy metals from spillage on the sediments	Long term Negative Irreversible	Low, since commercially valuable species are not common
	Socio-economics	Availability of cleaner / env. Friendly fuel as well as feed stock	Long term, Positive, Irreversible	---
		Economic development along with environmental sustainability	Long term, Positive, Irreversible	---
		Direct / indirect employment / business opportunities	Long term, Positive, Irreversible	---
		Improvement in quality of life	Long term, Positive, Irreversible	---
		Social Welfare measures / CSR by project proponent	Long term, Positive, Irreversible	---

Table 4.3.2 : Details of Stack Emissions

S. No	Source	Fuel	Consumption Rate	Flue Gas Flow Rate	Stack Details				Emission rates								Stack Location	
									NO_x		SO_2	PM_{10}	CO		HC			
			kg/h	(m^3/h)	Stack Height (m)	Top I.D (m)	Flue Gas Velocity (m/s)	Flue gas Temp (°K)	g/s	mg/ Nm^3	g/s	g/s	g/s	mg/ Nm^3	g/s	mg/ Nm^3	N	E
FSRU																		
1.	DFDE-1	BOG/NG	1440	105943	37	1.485	17	606	3.8	262	-	-	3.17	219	8.23	569	10000	10000
2.	DFDE-2	BOG/NG	1440	105493	37	1.485	17	606	3.8	262	-	-	3.17	219	8.23	569	10000	10005
3.	Boiler-1#	BOG/NG	6305	264215	37	2.025	22.8	714	4.5	146	-	-	0.73	24	-		10002	10002
4.	Boiler-2#	BOG/NG	6305	264215	37	2.025	22.8	714	4.5	146	-	-	0.73	24	-		10005	10003
5	Boiler-3#	BOG/NG	6305	264215	37	2.025	22.8	714	4.5	160	-	-	0.73	24	-		10003	10005
Jetty																		
6.	290KW*[1] EGS	HSD	78.3	5757	14	0.305	22	498	0.7	771	0.61	0.024	0.28		0.105			
ORF																		
7.	600KW*[2] EGS	HSD	162	7098	15	0.305	25	498	1.5	629	1.27	0.05	0.58	-	0.217		12700	7500
8.	WBH-1	NG	2025	42816	30	1.4	7.73	360	0.73	73	-	-	0.12	12	-		12750	7500
9.	WBH-2	NG	2025	42816	30	1.4	7.73	360	0.73	73	-	-	0.12	12	-		12750	7500

Note: * Emergency Generator set on Jetty will be rarely operated during load shed and failure of 600KW EGS , hence not considered in prediction of impacts

(2W+1S) Units will be operated only in case of closed loop heating process for LNG re-gasification

Table 4.3.3

Micrometeorological Data for Prediction of Impacts-Post-Monsoon Season

S.No	Wind Direction	Wind Speed (m/s)	Temp. (K)	Atmospheric Stability	Mix.Ht. (m)
1.	360.0	2.2	295.4	6	70
2.	337.5	2.3	295.0	6	70
3.	22.5	2.6	294.6	6	70
4.	337.5	2.4	294.2	5	100
5.	45.0	3.0	294.1	5	100
6.	67.5	2.2	294.3	4	100
7.	90.0	2.8	295.9	4	100
8.	90.0	3.1	297.1	3	200
9.	45.0	2.9	298.6	3	400
10.	90.0	2.4	299.3	2	500
11.	112.5	2.6	301.7	2	700
12.	135.0	2.3	303.1	2	850
13.	112.5	1.9	304.0	1	900
14.	90.0	1.8	304.7	1	900
15.	67.5	2.5	304.5	2	700
16.	45.0	2.7	304.0	2	600
17.	45.0	2.2	303.6	3	500
18.	67.5	2.8	302.9	3	300
19.	22.5	3.2	301.8	4	300
20.	360.0	3.0	300.4	4	200
21.	337.5	2.6	298.1	5	100
22.	360.0	2.2	296.7	5	100
23.	337.5	2.1	295.1	6	70
24.	315.0	2.3	225.3	6	70

Table 4.3.4

Micrometeorological Data for Prediction of Impacts-Winter Season

S.No	Wind Direction	Wind Speed (m/s)	Temp. (K)	Atmospheric Stability	Mix.Ht. (m)
1.	45.0	1.1	294.5	6	70
2.	67.5	1.1	294.0	6	70
3.	90.0	2.2	293.4	6	70
4.	67.5	1.2	292.5	6	70
5.	22.5	1.5	292.0	5	100
6.	67.5	1.5	293.5	5	150
7.	90.0	1.8	294.5	4	200
8.	157.5	2.1	296.0	3	250
9.	135.0	2.1	297.2	3	400
10.	90.0	2.4	298.3	2	600
11.	112.5	2.2	299.5	2	750
12.	90.0	1.5	300.4	2	800
13.	90.0	2.0	301.5	2	900
14.	45.0	2.6	301.4	2	900
15.	67.5	2.5	301.1	3	900
16.	90.0	2.1	301.1	3	850
17.	112.5	2.1	299.5	3	800
18.	157.5	2.0	299.0	4	650
19.	112.5	1.5	299.0	4	500
20.	90.0	1.5	298.0	5	200
21.	135.0	1.2	297.2	5	100
22.	22.5	1.2	297.0	6	70
23.	67.5	1.1	296.0	6	70
24.	112.5	1.1	295.0	6	70

Table 4.3.5

Micrometeorological Data for Prediction of Impacts-Summer Season

S.No	Wind Direction	Wind Speed (m/s)	Temp. (K)	Atmospheric Stability	Mix.Ht. (m)
1.	157.5	2.7	300.4	6	100
2.	135.0	2.1	299.5	6	100
3.	157.5	1.9	298.8	6	100
4.	180.0	2.8	299.1	5	160
5.	202.5	2.1	298.8	5	200
6.	112.5	2.5	300.0	4	250
7.	237.5	3.1	301.5	4	300
8.	180.0	2.3	303.1	3	500
9.	225.0	2.8	305.8	3	600
10.	202.5	2.4	307.2	2	800
11.	180.0	1.8	308.5	2	900
12.	180.0	1.3	309.8	1	1000
13.	112.5	1.5	310.2	1	1100
14.	135.0	1.4	310.5	1	1100
15.	180.0	2.0	310.8	1	1100
16.	180.0	2.6	309.7	2	1000
17.	202.5	2.1	309.6	2	800
18.	225.0	3.0	307.1	3	500
19.	225.0	2.5	306.6	4	400
20.	202.5	2.8	304.1	5	300
21.	180.0	3.2	303.7	5	200
22.	180.0	2.7	302.9	6	100
23.	157.5	2.1	301.5	6	100
24.	135.0	1.8	301.0	6	100

Table 4.3.6 : Details of Individual Noise Sources at FSRU*

Equipment	Horsepower	Sound Pressure Level (dBA)	
		1 m (3 ft)	5 km (3 mi)
Fire Water Pump	300–700	96.9	23
Air Compressor	125	98.0	24
Gas Compressor	1,200	107.5	34
Boil-off Gas Compressor	720	107.5	34
LNG Tank Pump	310	96.9	23
LNG Send-out Pump	2,060	96.9	23
Mobile Crane	100–450	109.0	35
Crane	274	108.0	34
Jib Crane	550	105.0	31
Combined Noise Level		**115**	**41**

Table 4.3.7 : Major Noise Sources for Prediction of Impact

S.No	Identification of Source	No. of noise generating equipment	Relative Locations		Net source strength (dB(A))
			X	Y	
1.	FSRU / Jetty*	1	10000	10000	115
ORF					
2.	Water Bath Heater-1	1	8000	12500	90
3.	Water Bath Heater-2	1	8010	12500	90
4.	Energy Generator Set	1	8050	12400	90

Table 4.3.8 : Expected Change in Subjective Quality of Life

Sr. No.	Villages	$QoL_{(S)}$	QoL (s) After Implementation of EMP and Welfare Measures
1.	Panduru	0.51	0.53
2.	Thimmapuram	0.49	0.52
3.	Dummualpeta	0.59	0.61
4.	Sarpavaram	0.53	0.54
5.	Vakalapudi (OG) - Ward No.71	0.69	0.70
6.	Suryaraopeta (CT)	0.67	0.69
7.	Panasapadu	0.54	0.58
8.	Komaragiri	0.47	0.50
9.	Godarigunta	0.65	0.68
10.	Valsapakalu	0.62	0.66
11.	Kovvada	0.55	0.60
	Average	**0.57**	**0.60**

QoL(s) = Subjective Quality of Life

Table 4.3.9 : Expected Change Cumulative Quality of Life

Sr. No.	Villages	QoL(c)	QoL (c) After Implementation of EMP and Welfare Measures
1.	Panduru	0.50	0.54
2.	Thimmapuram	0.46	0.50
3.	Dummualpeta	0.56	0.59
4.	Sarpavaram	0.56	0.59
5.	Vakalapudi (OG) - Ward No.71	0.68	0.70
6.	Suryaraopeta (CT)	0.65	0.70
7.	Panasapadu	0.52	0.56
8.	Komaragiri	0.44	0.50
9.	Godarigunta	0.63	0.68
10.	Valsapakalu	0.62	0.64
11.	Kovvada	0.54	0.58
	Average	0.56	**0.60**

QoL(c) = Cumulative Quality of Life

Chapter 5

Environmental Management Plan

Chapter 5

Environmental Management Plan

5.1 Introduction

In the previous Chapter the Environmental Impact from the construction and operation phases of the proposed FSRU based LNG terminal project have been identified, predicted and evaluated. Where potential sources of environmental impacts could not be managed in line with Indian or international standards, (additional) mitigation measures are required to minimize the adverse impacts and such measures are delineated in this chapter. They are either of process, technological, procedural or operational nature. These measures are over and above all items already considered in feasibility study of the proposed project.

Initial proposals for mitigation measures have been considered and evaluated for technical feasibility and have been subsequently translated into commitments as described in the following sections. These commitments will be implemented as part of the Company's Health, Safety and Environmental Management System.

The Environment Management Plan exclusively for the proposed project will be implemented and maintained by project proponent. However, the overall KDWP environmental management will remain with KSPL as operator of the Kakinada Deep Water Port. Hence the project proponent shall coordinate with the port operator in all EMP aspects and it shall be ensured that the total port operations / activities including proposed project (cumulative impacts) shall comply to prescribed environmental / regulator standards.

In general, the proposed project is not expected to be de-commissioned. In case, under any unavoidable Circumstances, if de-commissioning becomes essential, First of all, Control valves will be closed, the RLNG available in the pipeline upto the next Control Valves will be evacuated (flared or compressed /stored), and the line will be purged/flushed with N_2 and then the project is de-commissioned. There will be no soil contamination envisaged, hence no remediation or reclamation would be required.

5.2 Environmental Management System

5.2.1 Health, Safety and Environmental Management System

The project proponent will have a comprehensive Environment Management System which will be in the form of a Health, Safety and Environmental Management System (HSE-MS). This HSE-MS will be set up to formulate, implement and monitor plans, policies and actions encompassing Environment, Safety, Occupational health and Corporate Social Responsibility.

GAIL (India) Limited, a “Maharatna” Public Sector Undertaking of the Govt. of India which is one of the promoter of APGDC, has a comprehensive Corporate HSE system in place and follows the same in all its activities. The Board of GAIL (India) has a Sub-committee for Sustainable Development including all HSE aspects and has the highest level of Management Commitment.

GDF SUEZ has similar Management system for the environment at corporate level.

M/s Kakinada Seaport Limited, the port Concessionaire and operator, has put in place a HSE policy and Environmental Management System, as part of its commitment towards safe and environmental friendly port operations.

There will be an HSE-MS developed for construction and later on a separate system for the operations phase. The EPC contractors will be obliged by contract, to follow HSE-MS and HSE Management Plan of the Project Proponent for construction and commissioning phases. Following shall be carried out under the System:

- Issue a HSE policy statement applicable to this project, which takes full account of social responsibilities and sustainable development. The statement should be fully in line with the APGDC HSE commitment and policy

- Prepare a HSE-MS for the construction and commissioning phases and at a later stage also a HSE-MS for the operations phase, as an integral part of the overall port and terminal management system
- Carry out as early as possible in the planning stage for the construction phase of the project a one-off assessment of the HSE risks for the planned construction activities. This should be done by APGDC and EPC contractors' Senior Managers who are familiar with the project and location, advised by HSE specialists. The objective is to identify any significant HSE risks, particular to this project which cannot be adequately managed by the normal risk management processes and construction HSE procedures. Following the one-off overall construction HSE risk assessment, a systematic assessment of all health, safety and environmental risks shall be carried out during the planning of all construction activities which will include the following :
  - List all types of work during the activity
  - List the health, safety and environmental hazards of each type of work
  - Indicate how each risk will be controlled, e.g. by referring to the relevant project procedure, by additional training, by close supervision
  - Indicate the need for specific job safety analysis, where the normal procedures and controls are expected to be inadequate

The output will be a risk which should be made readily available as a basis for supervision and monitoring.

- Provide Personal Protective Equipment (PPE) required for specific work such as ear protection, respirators and face visors, as determined through the HSE risk assessment and specified in a method statement or job safety analysis
- Develop and implement health safety for the construction/ commissioning phase
- Prepare an HSE audit and (technical safety) review scheme for the construction phase
- Set up an HSE organization within the construction team with adequate (financial and manpower) resources and responsibilities to fulfill their role in monitoring the EPC contractors

- Provide general induction training and job focused HSE training to all construction workforce
- Provide sufficiently qualified first aiders and medical staff as well as primary health care facilities for construction workforce
- Develop and implement procedures and programs for pest and vector control for the construction workforce and the nearby communities
- All injuries, illnesses, damage and environmental incidents shall be reported and investigated
- Develop an emergency response plan which addresses potential major incidents at the site, including fire, explosions, collapse of structures, serious injuries, exposure to chemicals and toxic materials. It shall also deal with possible environmental incidents on land and at sea and possible social impacts
- Set up procedures and systems for monitoring and reporting of HSE performance in line with the Indian regulatory requirements and applicable international regulations. Monitoring will include all discharges, but also environmental components such as ambient air quality, meteorological parameters, noise, ambient water quality and success of any company initiated afforestation/landscaping. This will ensure compliance with the applicable Indian environmental quality standards.

5.2.2 Environment Management Policy

APGDC is committed to conduct business with strong environment conscience ensuring sustainable development, safe workplaces and enrichment of quality of life of Employees, Customers and the Community. A good HSE performance is an integral part of efficient and profitable business management. The proposed environmental policy of the PROJECT PROPONENT will have the following doctrines:

- Establish and maintain good standards for safety of the people, the processes and the assets.
- Comply with all Rules and Regulations on Safety, Occupational Health and Environmental Protection.
- Plan, design, operate and maintain all facilities, processes and procedures to secure sustained Safety, Health and Environmental Protection.

- Remain trained, equipped and ready for effective and prompt response to accidents and emergencies.
- Welcome audit of our HSE system by external body, so that stakeholder confidence is safeguarded.
- Adopt and promote industry best practices to avert accidents and improve our HSE performance.
- Remain committed to be a leader in Safety, Occupational Health and Environmental Protection through continuing improvement.
- Make efforts to preserve ecological balance and environmental sustainability.

5.2.3 Organization

The HSE structure of the Project Proponent will have the Senior Management level person as Head (overall coordinator) and wherever required, the system will be managed through suitable outsourcing to professional environmental consultants.

5.2.4 Budgetary Provisions for HSE Management Plan

HSE Premises have been formulated, which are the minimum standards to be met by the design, construction and the operation of the project. The HSE premises ensure that the project is fully in line with Indian regulatory requirements, proposed Principles and policies of the Project Proponent and standards and applicable international standards. In that context adequate budgetary provisions will be made and spent by the project for:

- Development of general induction (including HSE awareness) training program and job focused HSE training for all workforce
- Construction, operation and maintenance of different pollution control systems required to comply with legislative requirements, such as sewage treatment facilities and low NOx-burners
- Development of HSE awareness/information programs for the nearby communities in collaboration with the local administration
- Procedures, human resources and equipment to monitor environmental performance of the operations and the associated environmental quality directly or through outsourcing

- Additional environmental studies to assess in detail the potential effects on physico-chemical and biological characteristics of the near shore environment
- Investment in nature conservation/biodiversity projects

5.3 Environment Management Plan during Construction Phase

With the objective to have minimum adverse impact during the construction phases, sources of Pollutions to the air, water and land are identified and suitable management plan shall be delineated to mitigate the adverse effects and also to review the efficiency of control measures.

Primary construction activities are Capital Dredging, Piling and structural works of Jetty and mooring facilities, laying of subsea pipeline and construction of on shore Receipt facilities.

Primary sources of pollution of air are identified as follow:

- Emissions from generator sets (NOx, SO_2 , HC, CO etc.) for operation of barges, cranes, excavators, welding sets and other construction equipment, fugitive emissions from site preparation and excavation activities for construction of Onshore Receipt facilities.
- Dust emissions from on land vehicle movements, vehicular emissions from transportation of construction materials
- Sources of disturbances to surface and marine water are due to Dredging and piling, structural works for jetty and mooring facilities and construction of Onshore Receipt Facilities. Noise pollutions will results from hammering during piling activity and other construction equipment.

Following are the specific measures of Environment Management Plan during construction phase:

- Water sprinkling in construction area to mitigate fugitive dust impacts;
- Asphalting the main approach road;
- Proper maintenance of vehicles and construction equipment; and
- Tree plantation in the area earmarked for greenbelt development.
- Provision of earplugs and earmuffs to workers.
- Tree plantation (large size species) should be undertaken at the time of preparation of site in the area identified for greenbelt, so that they

would grow to considerable size by time of commissioning of the proposed project.

- Avoid additional road traffic (construction material) during local peak hours of vehicular traffic
- Develop and implement procedures for waste segregation, collection and safe disposal, in consultation with relevant authorities. Disposal shall preferably be at government controlled waste disposal sites. On-site burning of waste shall not be allowed
- For vehicular transportation, the existing road system will be used for transport of materials to the maximum extent possible. Upgrading of existing roads, if required, will be implemented in consultation with competent authorities. New roads will be constructed only when absolutely required
- Covering Vehicles/ Barges with tarpaulin during transportation of construction materials to site.
- Regular monitoring of ambient air quality
- Usage of low sulphur diesels in Dredgers and Barges.
- All excavation in ground and in seabed will be done careful and regulated ways and quick backfilling will be done.
- Usage of Personal Protection Equipment Units (PPE s) during construction working time
- Dredging activities will be performed by specialist contractors using purpose built dredger and under active supervision of the port operator.
- The dredge material disposal shall be ensured at only designated offshore dumping area through dispersive diffuser manifold, if possible at specific time intervals of not less than 2-3 hrs to minimize impacts on local marine ecology
- No Dredging construction operations during Cyclone, Sqaulls and other natural disturbances
- Close coordination will be done with fisheries department with respect to plan and movement of Dredgers during Dredging operations.
- Monitoring of turbidity, suspended sediment concentration and dissolved oxygen levels

- During construction of onshore terminal, Ground water will not be used. Sources of water will be port operator / third party supplier for potable purposes.
- Wastewater and sewage of the construction workforce will be treated through septic tank and soak pits.

5.4 Environmental Management Plan in Operation Phase

With the objective to have minimum adverse impacts during the operation phase, sources of Pollution with respect to marine, land, water, biology, noise are identified and suitable management plans devised to mitigate the adverse effects. Primary operation activities are Maintenance Dredging, Berthing and Mooring of LNG carrier, FSRU operations and operation of ORF. Primary sources of air pollution are identified as follow:

- Emissions from generator sets (NOx, SO_2 , HC, CO etc.) for operation of Dredgers and barges
- Emissions from Tug boats for Piloting and berthing of LNGCs
- Emissions from FSRU Boilers and emergency generator sets
- Emissions from LNG Carrier engines
- Emissions from Generators sets on ORF

Water pollution in marine environment are due to increased turbidity during Maintenance Dredging, Discharge of cold water from FSRU, domestic sewage of FSRU operating personnel, ballast water etc.

Primary solid wastes from FSRU are Food waste, general solid waste, plastic wastes, spent oil and paint, spent filters, spent batteries, empty chemical containers etc.

Sources of noise are: noise generated during maintenance dredging, noise from pumps, compressors, boilers, condensers etc., vehicular movement etc.

Following are the specific measures of Environment Management Plan during Operation phase:

i. Land Environment

- The solid waste generated during operation phase of the project will be disposed as per the applicable regulations in an identified area.
- General solid waste (packaging, glass, paper, cardboard etc) will be collected and delivered onshore for disposal on a regular basis;
- Adequate number of collection bins will be provided;

- Plastic bottles, glass bottles and plastic bags will be stored in the separate bins and will be sold to recyclers;
- Cardboard sheets will be stored in separate yard and sold as a scrap; and
- All the hazardous waste generated will be handled and managed as per the Hazardous Wastes (Management, Handling & Trans- boundary Movement) Rules, 2008

ii. Water Quality Environment

- Rainwater harvesting structures can't be built in the project due to influence of salinity
- Strictly no open discharge of sewage or oily wastes in harbour waters;
- The FSRU shall be equipped with a centrifugal-type bilge oil/water separator that reduces oil in the discharge to 10 ppm;
- The FSRU to be berthed on long term basis. The intake and discharge of ballast water will be from the same source and thus no possibility of alien and /or potentially invasive marine species;
- Sewage generated on FSRU will be treated at on-board STP and will meet MARPOL/MoEF/ CPCB/ APPCB's effluent discharge standards;
- Use of sophisticated dredgers to avoid or minimize scattering of dredge sediments during dredging; and
- Controlled dredging operations during high tidal disturbances.
- Monitoring of turbidity, suspended sediment concentration and dissolved oxygen levels

iii. Biological Environment

The measures required to be undertaken to minimize the impact on the ecology are:

- Greenbelt will be developed around the metering and distribution station boundary. The total greenbelt will amount to about 33% of total project area.
- The plantation schedule will be completed within the construction period of the project. This green belt will be implemented / developed in accordance with CPCB guidelines.

- Develop in consultation with the Ministry of Environment and Forests (MoEF) programs for investment in nature conservation and/or biodiversity.

iv. Air Environment

The air pollution control measures proposed for the project are described below:

- Providing adequate stack height to all emission sources in conformance to the set norms of APPCB / MoEF;
- The combustion processes (DFDE, GCU on FSRU and water bath heaters / backup generator set at ORF) shall be maintained with optimum air fuel ratio and control NOx emissions as per MARPOL standards.
- Installation of Online Flue Gas Monitors & Emergency Stop Systems
- Regular monitoring of ambient air quality
- Compliance to the emission norms prescribed by MoEF vide No GSR 520 (E) dated 01-July 01, 2003 and GSR 448 (E) dated July 12, 2004 for the DG set capacity up to 800 KW
- Tugs and LNGC will be comply the standards of International Maritime Organization with regard to emissions

v. Noise Environment

- Equipment's should be designed to conform to noise levels prescribed by regulatory authorities;
- The major noise generating units will be acoustically enclosed to the extent possible;
- Use of rubber padding underneath high noise and vibration generating machines;
- Regular ambient noise quality monitoring at the project site and around site
- Provision of greenbelt at ORF/metering and distribution station to attenuate the noise impact
- Provision of Personal Protective Equipments (PPE) such as earplugs, earmuffs to the workers working in high noise working area

vi. Socio-economic Environment

- Fishing activity is prohibited in the navigation channel and as precautionary measure Port's Patrol boats are constantly on the vigil and guides fishing boats from straying into the channel
- Endeavor to employ local or regional workforce for skilled and unskilled jobs.
- Provide, where required, opportunities for training to workers engaged within the APGDC system
- Develop HSE awareness/information programs for the nearby communities in collaboration with the local administration. Issues to be dealt with may include the HSE aspects of project, APGDC's HSE management and performance, environmental conservation and sustainable development, personal hygiene and sanitation awareness programs etc.
- Ensure the provision of a Public Liability Insurance scheme for various activities at the terminal

CSR Activities

As a part of socio-economic development following CSR activities are proposed:

S. No	List of Activities
1	Adoption of one of the neighbor village depending upon the condition for socio-economic development
2	Drinking water provision
3	Educational facilities
4	Health and Awareness Camps
5	Environmental Initiatives (Tree plantation and tree guards in nearby villages
6	Support sports and cultural activities
7	Development of new main/approach road, and proper drainage system in nearby villages

5.5 Costs of EMP

Wherever responsibility of EMP action items lies with construction contractors, the cost could be part of the construction contract rates and prices

The cost break-up of the various items of the EMP is listed in **Table 5.6**. While the list is not exhaustive, it gives a broad idea of the various items for which funds need be allocated in the cost estimate of an EMP. The funds to be allocated for the various heads are

Personnel

- Training
- Periodic health check-up
- Protective devices like masks, helmets, earplugs etc.

Air Pollution Control

- Maintenance and pollution check for emission levels from exhausts
- Shields for restricting material being flown
- Dust control measures

Water Management

- Water procurement for construction, workforce etc.
- Construction of dykes, berms etc. if required)

Environmental Quality Planning/maintenance

- Monitoring agencies (Involvement of third party monitoring)
- Hiring experts
- The impacts from various activities of the proposed development and the specific measures that need to be implemented during the design, construction and operation phases of the project including estimated budget are illustrated in **Tables 5.1** to **5.6**. Best housekeeping practices shall be incorporated in the design, construction and operation phases of the project.

5.6 Monitoring

Environmental monitoring shall be undertaken during the construction and operation phases of the project. The responsibility of implementation shall lie with the construction contractors during the construction phase and the project proponent during the operations phase, while the overall responsibility of monitoring shall always lie with project proponent.

An appointee of project proponent may do external monitoring/auditing. It needs to be recognized that monitoring of the marine environment requires a fairly sophisticated establishment and skilled personnel.

5.7 Training

Training of responsible parties in environmental management is essential for the proper execution of any EMP. The EMP shall form the practical basis of the training program.

- Training responsibilities for the workforce could be responsibility of the contractors during the construction phase and during the operation phase and/
- The port authorities shall also train their workforce to carry out their environmental responsibilities in environmental management.

5.8 Framework

The nodal agency of APGDC, such as the Environmental Management Cell (EMC) must be empowered by all the agencies at the port to address pollution issues. The EMC must co-ordinate with the contractors for waste minimization and identify buyers for recycling of waste material. Issues such as green belt development, oil spill management; health and safety may be coordinated by this nodal agency thus being solely responsible for the environmental quality.

Environmental monitoring in the port area shall be undertaken by KSPL, the port operator. Annual monitoring of air, water and sediment quality shall be carried out routinely for the port area.

5.9 Emergency Response Plan

The company shall develop an emergency response plan which addresses potential major incidents at the site, including fire, explosions, collision of ships, collapse of structures, serious injuries, exposure to chemicals etc. It shall also deal with possible environmental incidents on land and at sea and possible social impacts. The plan shall therefore be developed in consultation and co-operation with relevant local authorities and emergency services.

The plan should also address natural disasters such as lightning, storms, tsunami and floods where relevant. If the location is prone to lightning storms a procedure shall be implemented to raise the alarm and to protect personnel from lightning strikes.

The plan shall detail the emergency organization, responsibilities of key personnel, communications and call-out, work site evacuation, rescue of injured persons and co-operation with authorities and local industry. It should include a medical emergency plan.

Although during construction the contractor has the main responsibility for implementing the emergency response plan the company will have an important input on liaison with authorities and on handling process emergencies during commissioning.

5.9.1 Emergency Preparedness & Response

Disaster is considered as a sudden, low probability incident with dire consequences for the surrounding environment (community) requiring unusual action to be taken. An incident may be considered a major environmental disaster if it causes long-term damage to rare or valuable features of the natural or man-made environment, or there is wide spread environmental damage. This chapter defines procedures to address potential incidents arising from abnormal operational conditions, accidents and emergencies.

5.9.1.1 Safety Procedures

The first step to minimize risk would be to ensure efficient and safe operations at the various stages of transfer operations. This can be achieved by adhering to strict inspection and routine maintenance schedule of the various components of the transfer system.

5.9.1.2 FSRU

FSRU has certain safety features depending on the type of material and the volume of material being stored. Generally the systems comprise of the following:

- **Fire Water System:** Firewater is provided for cooling of the shell in case of fire to the adjacent facility, thus providing against tank/membrane failure. The firewater shall be made available from the sea through Tugs equipped with fire fighting equipments.
- As a protective measure, inter distances are also provided between the tanks according to the International LNG storage guidelines.
- For all tanks emergency relief provisions and normal venting arrangements are provided as per the API guidelines.

5.9.1.3 Liquid Cargo Spill Response

In LNG receipt and unloading system, there is no possibility of cargo spillage. Since LNG ships are double hull and therefore it is not possible for LNG spill in the sea. In case of any minor LNG leakage it will vaporize very fast and therefore no special facility required for handing of spilled LNG.

Although the probability of oil spillage from LNG ship is very remote, the following measures will be considered in case of oil spill from the LNG ship:

The primary aims of an oil spill response are to protect human health and safety, minimize environmental impacts and to restore the environments, as nearly as practicable, to pre-spill conditions. The environmental impact of a spill can be minimized by good management and planning as well as through the response actions put into effect by the responsible authority. The various TIERS of response for oil spills can be utilized for emergency preparedness while handling liquid cargo.

5.9.1.4 Tiers of Response

Internationally oil spills and the responses they require is categorized into three "Tiers". The concept of a tiered response links the credible spill scenarios to attainable scales of response, and by linking joint arrangements, enables escalation from one tiered response to the next, should the need arise. It is a practical method of planning a spill response in terms of required resources.

In India, the Coast Guard is the Coastal Coordinating Authority for marine pollution. It is also responsible for implementation and enforcement of the relevant marine pollution laws and regulations. The Coast Guard has brought out a "National Oil Spill Disaster Contingency Plan-2000" (NOS-DCP) as per the Contingency Plan, the Director General-Indian Coast Guard, Coast Guard Headquarters; Delhi is the Central Coordinating Authority. The Port authorities are responsible for dealing with accidents within the port limits keeping the Coast Guard Regional Centre duly informed. The responsibility for combating oil spill contingencies on shore is with the coastal State.

As per the requirements of the NOS – DCP, all contingency plans of all handling companies and ports are to be vetted and approved by the Indian Coast Guard.

The Oil Industry Safety Directorate has also brought out their OISD Guidelines-200: "Guidelines for preparation of Oil Spill Response Contingency Plan" (First Edition August 2000).

Tier 1 – Small Local Spills

This includes spills at company owned or operated (or shared) facilities where events are largely controlled by the company's operating procedures, and personnel and equipment can be made available to respond immediately to an "on site" incident. Generally, such an incident would be associated with ship transfer or bunkering operations at a jetty, pier or mooring and around waterside storage tanks. The facility contingency plan should recognize the need for a rapid response capability aimed at quickly containing and, if possible, recovering the spill.

According to OISD: 200, the extent of this spill is 100 tonnes at each installation.

Tier II – Medium Sized Spills

This includes spills beyond local response team capability where resources from other companies, industry and government response agencies in the area can be called in on a mutual aid basis. Companies may participate in a local co-operative where each member pools their Tier 1 resources and have access to any equipment that may have been jointly purchased by the co-operative. Tier II risks would typically be associated with shipping accidents in ports or harbours, in estuaries and coastal waters, but could also be from pipelines, tank failures or near shore exploration.

According to OISD: 200, the extent of this spill is 1000 tonnes at regional level.

Tier III – Large Spills

Tier III spills are classified as major incidents, typically resulting from spillage at sea such as from tankers and offshore platforms, the scale and scope of which is beyond the capabilities of a Tier II response. Substantial further resources are required and support from a national or international cooperative stockpile may be necessary. As such incidents are often high profile and politically sensitive, the Tier III plan will most probably form part of a National Emergency Plan headed by an appropriate national agency or government department.

According to OISD: 200, the extent of a Tier III spill is more than 1000 tonnes.

5.9.1.5 Spill Response Methods

If a spill occurs, it is most effectively dealt with by tackling it speedily, whilst it is still localized. Spraying with chemical dispersant can be used to break up the oil, and wave action will help to complete the dispersion. Where wave heights are not excessive, it may also be possible to use mechanical means to contain and collect the oil with brooms. In general, oil brooms are used to deflect oil away from sensitive areas, to guide oil towards a location in which it might be recovered, or to encircle and entrap oil on the water. Different forms of skimmers, vacuum units and recovery devices may be used to remove the oil from the water surface. Dispersant chemicals may be used to disperse the oil on the surface of the water. Different types of absorbent materials and products to enhance biological degradation, etc. are available.

The most common system includes oil containment and recovery using brooms and skimmers. This system consists of a recovery vessel; tug boats, containment brooms, skimmers, transfer pumps, and temporary storage. The effectiveness of the system depends on weather and sea conditions, size of spill, type of oil, presence of debris, seamanship, vessel capability, broom configuration / performance, skimmer type, type and capacity of transfer pump, and storage capability.

When a spill occurs, the first step is to prevent it spreading and to restrict it in an area for further action. This is achieved by using brooms.

Brooms

Brooms are floating devices that may have one or more of the following functions in connection with oil spill response:

- Deflecting oil to prevent the oil slick from contaminating sensitive areas
- Containment of liquid cargo
- Containment and concentration of oil (for recovery by a skimmer)

Brooms are designed and manufactured in many sizes and materials in order to meet various requirements. However, although they may differ structurally, basically they have in common the following components:

- Freeboard to prevent or reduce splash over
- Subsurface skirt to prevent or reduce escape of oil under the broom
- Floatation by air or some buoyant material
- Longitudinal tension member (chain/wire) to withstand effects of wind, waves and currents.

Spill Oil Recovery Skimmer

The oil spill contained in the broom is recovered from the surface of the water by means of a skimmer.

The skimmer will be of the weir type suitable for harbour oil spillage cleanup operations. It will have the following accessories:

- Pump unit with three pontoon floating frame and inlet weir
- Cutting knives fitted in both the inlet and outlet units of the pump system in order to handle all types of oil.
- Diesel driven hydraulic power pack.
- Collecting tank for recovered oil.

The skimmer head assembly is fabricated out of stainless steel and fixed to a superstructure supported on buoyancy chambers. These chambers are cylindrical in shape and also constructed out of stainless steel. The design allows each buoyancy chamber to keep the skimmer head floating. The structure is designed to have reserve buoyancy of about 50% so that if one chamber is punctured, the skimmer head can still float. The chambers are polished or painted in bright colours for easy spotting.

The skimmer head is usually designed to handle all types of oils, and the weir has perforated sections to allow flow of the oil into the rear pump.

The skimmer unit has a hydraulic power pump driven by a diesel engine of about 20 HP.

The recovered oil is discharged into a container, which transported to a shore based reception facility for treatment. Oily water of less than 15 ppm is released in accordance with the MARPOL convention.

5.9.1.6 TIER I Response System Proposed at Kakinada

For the proposed FSRU project, response system for Tier 1 has been planned. It consists of containment using brooms and then recovery through skimmers. The recovered oil / slop will then be transferred to authorized agency for treatment before disposal

The various components of the system are as follows:

- Oil containment broom
- Towing and mooring accessories
- Broom reels with diesel hydraulic power packs for launch and recovery of deployment brooms

- Aluminum work boat with engine for launch and recovery of brooms, maintenance and line handling operations
- Disc skimmer with diesel hydraulic power pack with hoses
- Accessory package including storage tank, sorbets, spill response equipment and tools.

5.9.1.7 Handling Major spills

- On noting a spill transfer operations shall be suspended immediately
- The onsite personnel at the jetty locations shall indicate the position and cause of spill to onshore control room. The onsite personnel shall also indicate the probable size of the spill
- The site main controller shall assist the designated oil spill response team/ Coast Guard reach the site of spill and mobilize oil spill combating equipment to the site depending on the size of the spill
- The responsibility of the site main controller is also to inform all statutory authorities, i.e., Coast Guard, Kakinada Deep Water Ports, Superintendent of Police, Local Customs etc.

  The operational command structure can be similar to **Fig. 5.1**.
- The spills shall be contained as per the National Oil Spill Disaster Contingency plan with KSPL providing the necessary equipment and manpower assistance.
- Recovered emulsions shall be suitably treated at the treatment plant.

5.9.1.8 Minor Spills

Minor spills are those, which may occur due to pipeline leakage or snapping of hose or any minor events.

The steps involved in handling a Minor spill are

- Stop the source of the spills as soon as possible by turning off valves, pumps or affected equipment.
- Notify only the on-duty supervisors.
- Take necessary steps to confine the spill to immediate area.

5.9.1.9 Handling Fire and Explosion Emergencies

Handling the Storage Tank Fire

The general strategy that can be used to deal with a fire emergency in a storage tank for flammable materials comprises three steps, namely:

- Information gathering and accident assessment
- Decision making
- Implementation of the response actions

The types of actions to be implemented will depend on the first two steps, and can be summarized in three possible courses of action, i.e.

- Attacking the fire
- Controlling the fire without attempting to put it out, or
- Complete withdrawal

Step 1. Information gathering and accident assessment

- Determine whether casualties have occurred, and whether rescue operations would be required
- Identify the materials involved in the accident. It is possible that more than one material is involved in the accident. It is possible that more than one material is stored in the same location.
- Obtain the MSDS for the material involved. In addition, obtain additional physicochemical information that could be important in controlling the accident, such as:
  - the flash point of the material
  - reactivity of the material with water and other extinguishing media
  - explosive limits of the material
  - polymerisation reactions of the material
  - appropriate extinguishing agents for the material
- Determine the type of tank, safety features, and fire control features installed on it

- Determine the damage already suffered by the tank, and the extent to which the tank is affected by the fire
- Determine the location of the tank with respect to exposed facilities such as other storage tanks, processing units, building, or power lines
- Determine weather conditions such as wind direction and speed, temperature, humidity, and precipitation.
- Determine available resource in terms of manpower, equipment and supplies. Also determine what additional resources could be mobilized and how soon.

Step 2. Decision Making

After all this information has been collected, a decision should be made as to the type of action to take. Rescue of casualties should, of course, be the first task. However, even this task will depend on the overall accident assessment, on the resources available, and on the alternatives implementable. In general, three possibilities should be considered,

- Attack the fire
- Control the fire without attempting to put it out
- Withdrawal of emergency response personnel

The choice of one of these actions will depend on the accident assessment and the materials involved. In addition, putting out the fire could sometimes introduce even greater hazards, since the un-ignited vapours could accumulate or move to a vulnerable area where any ignition source will have dramatic consequences. Therefore, the only variable alternative can sometimes be to let the fire burn, making sure that the tank is cooled sufficiently. Cooling of vessels under these circumstances may also be carried out using uncanned water cannon positions, thus limiting the exposure of personnel.

The duties of the fire and rescue team leader include:

- Overall in-charge of the firefighting operations.
- Inform the Main Controller if external fire tender/firefighting equipment/ materials/Mutual Aid is required.
- Lias with the utilities and arrange for external water supply/diesel for hydrant pump/D.G. Sets, etc.
- Maintaining adequate supplies for firefighting equipment and facilities.

5.9.1.10 Roles and Responsibilities

Contingency plans backed up by adequate and well-maintained equipment, detailed procedures, necessary supplies of products for treatment, and personnel trained to deal with spills are essential to ensure an effective response. The following section defines the roles and responsibilities of the various agencies involved in combating oil pollution in the event of spillage in the event of a disaster.

KSPL Authorities

- Identify spills: Location, size, source and intimate site main controller at the Jetty Control Room / ORF control room
- Inform statutory bodies, Coast Guard about spillages; Coordination with Coast Guard and external agencies in the event of disaster.
- Vessel traffic management to avoid collision, grounding
- Provide standby to remove vessel location and mobilize tugs, mooring staff and/or launches whenever need arises
- Identify special equipment and product requirements and provide for their acquisition, deployment and maintenance. Equipment may include inflatable broom, dispersant spraying equipment and suitable surface craft for mounting, oil skimmers etc.
- Provide for training of personnel and periodical exercise; Organization of mock drills under the guidance of the Regional Coast Guard to keep equipment and personnel in constant readiness
- Establish crisis management group and define roles and responsibilities
- Coordination on quick and safe handling of tankers
- Identification of suitable means for treatment and disposal of debris, emulsions etc.

Regional Coast Guard Commander

- Coordination of activities of Regional Communication Centre
- Receive reports of oil pollution and mobilize Coast Guard resources to support On Scene Commander (OSC) action at spill area
- Provision of administrative and infrastructure to the Regional Communication Centre (RCC) to conduct routine and operational tasks

- Maintain a list and assess available resources including local, regional, national and international groups, and the scale of spillage at which they should be contacted
- Conduct periodical exercises of combating oil pollution at sea
- Maintain and update inventory on anti-pollution equipment and material
- Provide assistance to local groups in implementation of Local Action Plan
- Periodic reporting to the Director General, Coast Guard on antipollution activities.

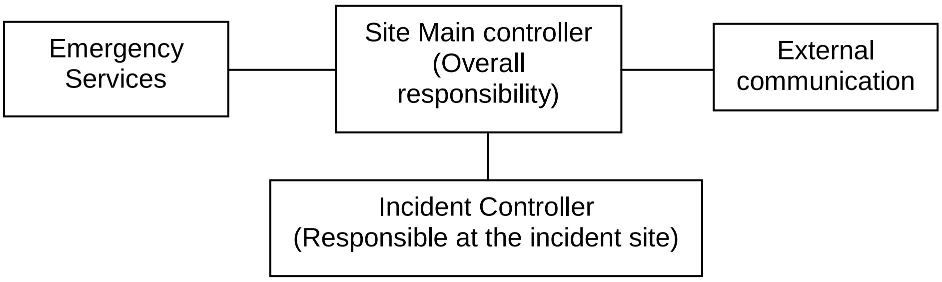


Fig. 5.1 : Typical Command Structure for Emergency Response

Table 5.1: Transportation of raw materials

Potential Impacts	Mitigation	Implemented by	Timing (Phase)
Generation of Noise	Periodic maintenance of vehicles shall be ensured	Contractor	Construction
Generation of dust	Materials shall be covered with tarpaulin sheets during transport	Contractor	Construction
Vehicular emissions	There shall be periodic emission check for vehicles	Contractor	Construction

Table 5.2: Construction activities / fabrication and welding

Potential Impacts	Mitigation	Implemented by	Timing (Phase)
Generation of Noise	Ear protection devices and helmets shall be provided for workers	Contractor	Construction
Generation of dust	Concrete mixing plants shall be located at least 500m away from dwellings/offices Masks shall be provided for workers Waste materials shall not be burnt	Contractor	Construction
Equipment emissions	Equipment/ machinery shall be periodically checked for emission levels Regular maintenance of equipment shall be done	Contractor	Construction
Exploitation of water resources	Water shall be obtained only from approved locations	Contractor	Construction
Increased turbid runoff	Stockpile of materials shall be located at least 100m away from waterfront Sediment runoff shall be intercepted by hay bales or detention trenches	Contractor	Construction

Table 5.3 : Labour Force

Potential Impacts	Mitigation	Implemented by	Timing (Phase)
Generation of wastewater	Proper sanitary facilities shall be provided Septic tanks/soak pits shall be provided for collection of toilet wastes Ensure treatment of domestic sewage and treated effluent shall comply with standards	Contractor	Construction / Operation
Exploitation of water resources	Water shall be obtained only from approved sources	Contractor	Construction
Generation of solid waste	Solid wastes shall be collected in dustbins and dispose as per the requirements	Contractor	Construction

Table 5.4: Capital/ Maintenance Dredging

Potential Impacts	Mitigation	Implemented by	Timing
Turbidity/ water quality deterioration	Confined method of dredging may be used. (a cutter suction dredger)	Contractor/ APGDC	Construction
Coastal erosion	Coastal vegetation shall be preserved/rehabilitated/regenerated	Contractor/ APGDC	Construction
Generation of noise	Workers shall be provided with ear plugs without compromising ship safety requirements	Contractor/ APGDC	Construction
Emissions from dredging equipment	Emission check on equipment shall be done before every operation	Contractor/ APGDC	Construction

Note: The above activities will be carried out by Kakinada Seaport Limited

Table 5.5: Ship Operations based on Frequency

Potential Impacts	Mitigation	Implemented by	Timing (Phase)
Discharge of Oil and oil sludge, cargo residues, operational waste from ship (domestic refuse, engine room waste) Waste water, bilge water,	Awareness, understanding and observance of MARPOL regulations among ships' crews shall be ensured All liquids containing oil shall pass into the sea only via oil separation systems, Sludge shall not be discharged. The sludge and the separated oil residues are either to be incinerated on board in special furnaces or discharged in port to the oil collection facilities Adequate facilities for discharging oily residues shall be provided and effective supervision and monitoring of adherence to the regulations shall be done Only marine diesel oil or marine gas-oil shall be used to reduce sludge formation Different types of refuse shall be collected in separate containers and temporarily stored till they are disposed to appropriate facilities on shore	Licensee/ APGDC	Pre-construction / operation
Exhaust emissions Gases from the cargo as a result of gas leakage or evaporation Gases from cargo are released during loading and unloading operations	Exhausts shall be frequently cleaned Correct adjustment and maintenance of engines and boilers shall be ensured Mechanical precautions (like safety valves) shall be included to ensure the containment of the gases which escape during loading and discharge operations	Licensee / APGDC	Operation
Discharge of domestic waste, kitchen waste, floor washing	Adequate facilities will be provided to collect and treat domestic waste on the ship itself Kitchen waste will be crushed and mixed with the cultured biomass and converted into manure and discharged into sea, it will be used as a food material for the fishes during anchoring.	Licensee / APGDC	Operation

Table 5.6: Cost for Environment Management Plan

S. No.	Details	Amount in Rs. lakh
A	Capital Cost for EMP	
1	Greenbelt Development	40
2	Equipment for Air Pollution Control, Noise Pollution Control & Water Management	50
3	Sanitary facilities for construction workers and Waste disposal	30
4	Training to personnel for EMP activities	30
5	Contingency for Misc. EMP activities and measures	50
	Total (A)	**200**
B	Recurring Cost for EMP	20
	Total (B)	**20**
	Total Cost for EMP (A+B)	**220**
C	Marine Contingency and Emergency Response Plan	**80**
D	CSR activities	**300**
	TOTAL (A+B+C+D)	**600**

Chapter 6

Environmental Monitoring Programme

Chapter 6

Environmental Monitoring Program

Post-Project environmental monitoring program (EMP) is important in terms of evaluating the performance of pollution control measures implemented at project site during construction and operation phases. The sampling and analysis of the environmental attributes will be as per the specifications of MOEF as well as Andhra Pradesh Pollution Control Board (APPCB).

The Project proponent shall developed schedule for environmental monitoring, and management will meet regularly to review the effectiveness of the EMP measures. The data collected on various EMP measures would be reviewed and if needed corrective action will be formulated for implementation. Environment Management System (EMS) will form short term & long term plans for environmental issues, which require monitoring and effective implementation.

6.1 Pollution Monitoring

It will also be responsibility of the Project proponent for implementation and maintenance of measures suggested in EMP and all relevant environmental aspects at project site. The proponent shall create full-fledged EMS, including pollution monitoring, for the proposed project either in-house or through outsourcing to duly recognized / accredited consultant. The results of the environmental monitoring shall be submitted to the terminal-in-charge.

The environmental quality-monitoring will be carried out at the project site as well as within the impact zone with suitable sampling stations and frequency for environmental parameters with respect to different environmental components. Conventional parameters will be monitored by the project proponent. For conventional pollutants, the methods prescribed in "Standard Methods for Water and Wastewater Analysis" published by APHA (American Public Health Association), AWWA (American Water Works Association) and WPCF (Water Pollution Control Federation) will be adhered to.

The following attributes will be covered during the operation phase for environmental monitoring (**Table6.1**) in and around the project site:

6.2. Marine Environment

- Temperature monitoring of the sea water discharge (colder in case of LNG regasification through open loop system) shall be done on continuous basis.
- Marine water quality monitoring with respect to physico-chemical, demand and nutrient parameters, hydrocarbons, heavy metals etc. shall be done on monthly basis.
- The seabed sediments to be monitored at the berthing pockets as well as Dredge material disposal area on quarterly basis.
- Marine biology (Primary, secondary and tertiary productivity) to be monitored on annual basis
- Marine fish landing data related to Fishing Harbour shall be compiled on regular basis

6.3 Land Environment

- Monitoring and review of the effectiveness & constant strengthening of green belt development in and around the project site will be done on regular basis.

6.4 Air Environment

Following measures would be taken up for air quality monitoring on a regular basis after terminal becomes operational:

- Monitoring of stack emissions as per stipulations of APPCB
- FSRU on board stack emissions (PM_{10}/$PM_{2.5}$, SO_2, NOx, CO and HC as applicable) shall be monitored on continuous basis. Air quality monitoring with respect to SO_2, NOx, PM_{10}/$PM_{2.5}$, CO and HCs (Methane and non-methane) at all locations identified in consultation with APPCB / KSPL (port operator), including FSRU deck.

6.5. Noise Environment Monitoring

- Noise levels in the work zone environment (FSRU, Jetty and ORF) and ambient noise levels will be monitored as per the requirements of OSHA, CPCB and APPCB guidelines.
- The noise monitoring results will be utilized to assess the efficacy of maintenance schedules of noise control measures at project sites.

6.6. Inland Water Environment

- Groundwater quality will be monitored in ORF and surrounding area.

6.7. Environmental Management Apex Review Committee

An Environmental Management Apex Review Committee (EMARC) shall be constituted to review, assess and monitor the progress of Environment Management Plan implementation. The committee will have HSE specialist along with CSR (social Manager) and Occupation health specialist. The coordinator of the committee will actively interface with the KSPL port managers for implementation of EMP. .

6.8 Budgetary Provisions

Necessary budgetary provisions towards environmental monitoring program for the proposed project will be included as part of the project budget. The details of the same are provided in the Chapter 5 – Environmental Management Plan.

6.9 Submission of Environmental Monitoring Reports to MoEF / APPCB

As per the requirements, the compliance status of the conditions stipulated in the Environmental Clearance stipulation including implementation of schedule will be submitted to MoEF in hard and soft copy by 1st December for the period from April to September and by 1st June for the period from October-March of every year. The conventional pollutants will be monitored on monthly basis and reports will be submitted to APPCB, as per the requirements.

Table 6.1 : Environmental Monitoring Details

Environment	Unit / Location	Parameter	Frequency	Remarks
Air	FSRU - at all operating DFDE stacks	Flue Gas - PM, SO_2, NOx, CO and HC	Online	
	FSRU – at deck at a horizontal distance of 4 times the stack height	Air quality - PM_{10} / $PM_{2.5}$, SO_2, NOx, CO and HC	2 times in a week	
	Combustion Boilers / Vaporizers, in case of close loop	Flue Gas - PM, SO_2, NOx, CO and HC	Online	
	Jetty	Air quality - PM_{10} / $PM_{2.5}$, SO_2, NOx, CO and HC	2 times in a week	
	ORF	Air quality - PM_{10} / $PM_{2.5}$, SO_2, NOx, CO and HC	2 times in a week	
	ORF	Flue Gas - PM, SO_2, NOx, CO and HC	Once in a month	
	ORF	Fugitive emissions, methane and non-methane hydrocarbons	Online detection	
Noise	FSRU – all major noise generating items at 1 m distance	Noise level- Decibel	During operations – once in a week	
	ORF - Emergency back – up Gen. set	Noise level at 1 m distance	Once in a month	
	ORF – Water bath heater	Noise level at 1 m distance	Once in a month	
Water	FSRU – Sea water inlet	Water flow rate	Online	
		Temperature	Online	
	FSRU- Sea water discharge	Temperature	Daily	
		Chlorine and HC content	Daily	

Contd…

Contd…Table 6.1

Environment	Unit / Location	Parameter	Frequency	Remarks
	FSRU – wastewater	-		No discharge in hazardous area
	ORF	Domestic water consumption	Daily basis	
	ORF	Ground water quality – pH, TDS heavy metals etc.	Once in a month	
Solid waste	FSRU	Quantity and characteristic of following : Sanitary waste, process waste, used scrap material, domestic solid wastes	Monthly basis	
Marine Biology / Mangrove ecosystem	Study area	Primary, Secondary, tertiary productivity	Once in a year	
Social Welfare Measures	Around project area	Effectiveness of social welfare measures to be assessed, liaison with local fisherman community, identification of significant needs in the area, accountability to be recorded	Once in year	
Seabed Sediment Quality	FSRU, Jetty, Berthing pockets	– Particle size distribution, – Total Organic Carbon, Oil & Grease, PHCs – Metals: Cd, Co, Hg, As, Cr, Ni, Pb – Macrobenthos – Meobenthos	Once in 3 months	

Chapter 7

Additional Studies

Chapter 7

Additional Studies

The proposed project is aimed to handle liquefied natural gas (LNG) as well as re-gasified LNG (RLNG) in bulk quantities. The project will be located within existing sea port area, i.e. coastal zone and expected considerable capital dredging, disposal of dredge material and erection of marine structure within harbour area as part of project construction. In accordance with the proposed draft terms of reference (ToR) for conducting EIA study as well as the additional ToR approved by MoEF, Govt. of India regulatory process for prior environmental clearance for proposed project, the following additional studies are carried out and dealt in this chapter:

- Rapid Risk Assessment & Approach to Disaster Management Plan
- CRZ Demarcation at project site and in the vicinity in accordance with Coastal Regulation Zone (CRZ) Notification 2011
- Hydrodynamic study to delineate effect on coastline changes. The coastline near Uppada village is one of vulnerable areas identified by MoEF through O.M. dated November 03, 2009 regarding high erosion area. This area is at about 10km distance in the north of project site.

7.1 Rapid Risk Assessment & Approach to Disaster Management Plan

Accidental risk involves the potential occurrence of an event or sequence of events resulting into fire, explosion or toxic hazards to human health and environment. Risk Assessment (RA) provides a numerical measure of the risk that a particular facility poses to the public. It begins with the identification of probable potential hazardous events at an industry / facility and categorization as per the pre-determined criteria.

MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and expertise in the field of risk analysis especially in accident analysis. The consequences of major credible events are calculated for different combinations of weather conditions to simulate worst possible scenario. These consequence predictions are combined to provide numerical measures of the risk for the entire facility.

A disastrous situation is the outcome of fire, explosion or toxic hazards due to human errors and or due to natural causes that eventually lead to loss of life, property and ecological imbalances.

7.1.1 Past Accidents / Analysis - LNG Marine Transport and Handling

In general LNG has been very safely handled for many years. However, the industry is not without its incidents and accidents, but it maintains an enviable “modern-day ” safety record. The process of natural gas liquefaction, storage and vaporization is not a new technology. In 1939, the first commercial LNG peak-shaving plant was built in West Virginia. There are over 120 peaks shaving and LNG storage facilities worldwide, some operating since the mid- 1960s. In addition, there are 18 base-load liquefaction (LNG export) facilities in various countries including Abu Dhabi, Algeria, Australia, Brunei, Egypt, Indonesia, Libya, Malaysia, Om an, Nigeria, Qatar, Trinidad and U.S. (Alaska). LNG is transported by a fleet of LNG tankers of varying sizes from 18,500 m^3 to 265,000 m^3. This fleet of LNG ships delivers to receiving terminals in the Belgium, Dominican Republic, France, Greece, Italy, Japan, Korea, Spain, Taiwan, Turkey, U.K., India, U.S.A and other countries.

The LNG storage tanks at these facilities are constructed of an interior cryogenic wall, usually made of 9% nickel steel, aluminium or other cryogenic alloy. The outside wall is usually made of carbon steel or reinforced concrete. A thick layer of an insulating material such as Perlite separates the two walls.

With a few exceptions, LNG handling facilities have revealed an exceptionally superior safety record when compared to refineries and other petrochemical plants. With the exception of the 1944 “Cleveland Disaster,” all LNG-related injuries and/or fatalities, however devastating, have been limited to plant or contractor personnel. There have been no LNG shipboard deaths. There has not been a member of the public injured by an incident involving LNG since the failure of the improperly constructed Cleveland facility. Small LNG vapour releases and minor fires have also been reported, but impact was limited to the plant and the hazard was promptly handled by plant personnel. Other accidents have occurred during the construction and repair of LNG facilities. Some of these accidents have been used to tarnish the exceptional safety record of LNG, but as no LNG was directly involved in the incident these accidents can only truly be called “construction” accidents. Damage has always been limited to the plant property.

7.1.1.1 Safety Record of LNG Ships

The first transportation of LNG by ship took place early in 1959 when the Methane Pioneer (an ex-Liberty ship that had been extensively modified) carried 5,000 M^3 (cubic meters) of LNG from Lake Charles, Louisiana, to Canvey Island, near London, England. Commercial transportation of LNG by ship began in 1964 when LNG was transported from Arzew, Algeria to Canvey Island in two purpose-built ships the Methane Princess and the Methane Progress .

The overall safety record compiled by LNG ships during the thirty -nine year period 1964 - 2002 has been remarkably good. During this period, the LNG tank ship fleet has delivered m o re than 30,000 shiploads of LNG, and travelled more than 100 m million kilometres while loaded (and a similar distance on ballast voyages).

In all of these voyages and associated cargo transfer operations (loading/unloading), no fatality has ever been recorded for a member of any LNG ship’s crew or member of the general public as a result of hazardous incidents in which the LNG was involved. In fact, there is no record of any fire occurring on the deck or in the cargo hold or cargo tanks of any operating LNG ship.

Among LNG import and export terminal personnel, only one death can be even remotely linked to the loading or unloading of LNG ships. (In 1977, a worker in the LNG Export Facility at Arzew was killed during a ship-loading operation when a large-diameter valve ruptured and the worker was sprayed with LNG. His death was the result of contact with the very cold LNG liquid; the spilled LNG did not ignite.

Appendix summarizes the historical record of LNG ship incidents. Although a major effort was made to ensure the record presented is complete, it is possible that some incidents have been missed. However, it is very unlikely that a major incident has been omitted. Firstly, nearly every shipping incident that results in an insurance claim will be published in "Lloyd's List." Secondly , even if the ship owners are self- insured, news of major incidents travels quickly through the LNG industry because it is composed of a relatively small number of ship and terminal operators that often share experiences through industry associations such as SIGTTO (Society of International Gas Tanker. & Terminal Operators)

LNG is cryogenic; it is a liquid; and its vapours are flammable. It is not without its safety concerns – it, however, can be produced, transported and re-vaporized as safely , and in most cases, more safely , than other liquid energies. Chronological summary of incidents involving LNG ships are summarized in **Table 7.1.**

7.1.2 Hazard Identification (HAZID)

Identification of hazards is an important step in risk assessment as it leads to the generation of probable accidental scenarios. The merits of the hazards for further investigation are subsequently determined by its significance, normally using a cut-off or threshold quantity.

A comprehensive Hazards Identification study for individual facilities at proposed project has been carried out by a team of expert, the members of which were drawn from different departments viz., Design, Engineering, Projects, Environment, Operations, safety etc. with consultant, i.e. M/s WorleyParsons and from different organizations namely GDF SUEZ, APGDC, GAIL, and the port operator M/s KSPL.

7.1.2.1 Objective of HAZID

- Identify hazards at a system level, including external factors that pose a hazard to the facilities and to examine and identify mitigation measure, taking into consideration the consequences and likelihood of such hazards and existing safeguards considered for the project; and
- Evaluate the marine exclusion/safety zones

7.1.2.2 Approach & Methodology

The HAZID was performed based on a structured brain storming session using an appropriate list of guidewords. The facilities were split into small sub systems ("Nodes") to facilitate brainstorming. The hazards associated with each element were reviewed by the HAZID participants. Following were the major nodes for discussion:

- LNGC
- FSRU
- Jetty
- ORF
- Subsea Pipelines

The workshop participants brainstormed all potential hazards and identified the associated consequences. Existing controls were analyzed for their adequacy and recommendations as control measures were established as necessary. Action Party was appointed for effective close-out of each action item. The workshop discussion have been summarized and recorded on HAZID Study Worksheets. An outline of the basic HAZID process is provided in the following **Fig.7. 1**.

7.1.2.3 Risk Matrix

The risk level was assessed taking into account the existing controls/ design intent that are in place or has been put in plan. For the purpose of this HAZID study, the agreed Risk Matrix (RM) is used to categorize the hazards as shown in **Table 7. 2**.

The RM shown is a 5 by 5 matrix that categorize hazards and their threats into:

- Health & Safety
- Natural Environment
- Social/Cultural Heritage
- Community/ Government / Reputation/ Media
- Legal
- Financial

The horizontal axis of the matrix represents Consequence (the effect / result in the event that the failure mode occurs) and the vertical axis represents increasing Probability/Likelihood (the probability / frequency of occurrence). The boxes inside the matrix represent levels of risk, increasing from bottom left to top right corners.

The risk levels are categorized into four levels, which are:

- Low
- Medium

- High Risk
- Very High Risk

7.1.2.4 Results of HAZID

A total of 58 action items were identified during the HAZID session, where 8 were identified for High Risk, 37 for Medium Risk, 1 for Low Risk and 12 action items not ranked as there are no sufficient details at this stage. The actions items are listed in **Table 7.3**.

Once a hazard has been identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences should be considered, but there are occasions wherein it either the probability or the consequence can be shown to be sufficiently low or sufficiently high and decisions can be made on just one factor.

7.1.3 Fire and Explosion Index (FEI)

Fire and Explosion Index (FEI) is useful in identification of areas in which the potential risk reaches a certain level. It estimates the global risk associated with a process unit and classifies the units according to their general level of risk. FEI covers aspects related to the intrinsic hazard of materials, the quantities handled and operating conditions. This factor gives index value for the area which could be affected by an accident, the damage to property within the area and the working days lost due to accidents. The method for evaluation of FEI involves following stages.

- Selection of pertinent process unit which can have serious impact on plant safety
- Determination of Material Factor (MF): This factor for a given substance in the process unit gives intrinsic potential to release energy in case of fire or an explosion. Material Factor can be directly obtained from Dow's Fire and Explosion Index Hazard classification Guide of American Institute of Chemical Engineers, New York. The factor can also be evaluated from NFPA indices of danger, health, flammability and reactivity
- Determination of Unit Hazard Factor: The Unit Hazard Factor is obtained by multiplication of General Process Hazard (GPH) factor and Special Process Hazard (SPH) factor. GPH factor is computed according to presence of exothermic reactions and loading and unloading operations. The penalties due to each of these reactions / operations are summed up to compute GPH factor. Similarly, SPH factor can be evaluated for the operations close to flammable range or pressures different from

atmospheric. Penalties of these operations for both factors can be obtained from Dow's EFI index form

Fire and explosion index is then calculated as the product of Material Factor (MF) and Unit Hazard Factor. Degree of hazards based on FEI is given **Table 7.4.**

Preventive and protective control measures are recommended based on degree of hazard. Therefore, FEI indicates the efforts to be taken to reduce risks for a particular unit. FEI computed for various process equipment is presented in **Table 7.5.**

7.1.4 Maximum Credible Accident (MCA) Analysis

MCA analysis encompasses defined techniques to identify the hazards and compute the consequent effects in terms of damage distances due to heat radiation for fire scenarios and pressure waves for explosion scenarios. A list of probable or potential accidents of the major units in the installation arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed. Hazardous substance, on release can cause damage on a large scale. The extent of the damage is dependent upon the nature of the release and the physical state of the material. In the present report the consequences for LNG storage, pumps and pipelines are considered and the damages caused due to such releases are assessed with recourse to MCA analysis.

Flammable substances on release may cause Jet fire and less likely unconfined vapour cloud explosion causing possible damage to the surrounding area. The extent of damage depends upon the nature of the release. The release of flammable materials and subsequent ignition result in heat radiation wave or vapour cloud depending upon the flammability and its physical state. Damage distances due to release of hazardous materials depend on atmospheric stability and wind speed. It is important to visualize the consequence of the release of such substances and the damage caused to the surrounding areas. Computation of damage distances are carried out at various atmospheric stability conditions for various wind velocities and the result is tabulated. Pasquill-Giffard atmospheric stability classes with corresponding weather conditions are listed in **Table 7.6**

7.1.5 Fire and Explosion Scenarios

Combustible materials within their flammable limits may ignite and burn if exposed to an ignition source of sufficient energy. On process plants, this normally occurs as a result of a leakage or spillage. Depending on the physical properties of the material and the operating parameters, the combustion of material in a plant may take on a number of forms like jet fire, flash fire and pool fire.

7.1.5.1 Jet Fire

Jet fire occurs when flammable material of a high exit velocity ignites. In process industries this may be due to equipment failure or an accident. Ejection of flammable material from a vessel, pipe or pipe flange may give rise to a jet fire and in some instances the jet flame could have substantial “reach”. Depending on wind speed, the flame may tilt and impinge on pipeline, equipment or structures. The thermal radiation from these fires may cause injury to people or damage equipment some distance from the source of the flames.

7.1.5.2 Flash Fire

A flash fire is the non-explosive combustion of a vapour cloud resulting from a release of flammable material into the open air, which after mixing with air, ignites. A flash fire results from the ignition of a released flammable cloud in which there is essentially no increase in combustion rate. The ignition source could be electric spark, a hot surface, and friction between moving parts of a machine or an open fire.

Upon initial release very cold vapourised LNG is denser than the surrounding air and will disperse at ground level. As it warms up the vapour’s’ density changes and it will begin to rise from the ground. If no ignition occurs it will eventually continue to heat and disperse into the atmosphere. If after the release and dispersion of the flammable fuel the resulting vapour cloud is ignited it will burn with a “slow” flame through the cloud rather than explode. When the fuel vapour is not mixed with sufficient air prior to ignition, it results in diffusion fire burning. Therefore the rate at which the fuel vapour and air are mixed together during combustion determines the rate of burning in the flash fire.

The main dangers of flash fire are radiation and direct flame contact. The size of the flammable cloud determines the area of possible direct flame contact effects. Radiation effects on a target depend on several factors including its distance from the flames, flame height, flame emissive power, local atmospheric transitivity, sheltering of subject (clothes, windows etc.), time of exposure. Most of the time, flash combustion lasts for no more than a few seconds.

A flash fire may also occur after a delayed ignition of a pool of LNG when the pool is producing vapour for a short time before ignition of the cloud occurs. In such cases the cloud will burn back to the pool and a pool fire will form

7.1.5.3 Pool Fire

The FSRU will have storage for Diesel oil and Fuel oil whereas ORF will have storage for diesel only. Releases of fuel oil / diesel oil in the absence of immediate ignition would form an unconfined pool, which on ignition would result in a pool fire. Radius of pool depends upon mass flow rate, ambient temperature; heat of vaporization of material released and discharge duration. Emissive power generated from the pool surface depends upon pool burning rate, heat of combustion of release material, atmospheric transitivity and area of pool. Flames can tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of thermal radiation generated.

During combustion heat will be released in the form of thermal radiation. Temperatures close to the flame surface will be high but will reduce rapidly to tolerable temperatures over a relatively short distance. Any plant building or persons close to the fire or within the intolerable zone are at risk of experiencing burn damage with the severity depending on the distance from the fire and the time exposed to the heat of the fire.

7.1.5.4 Unconfined Vapour Cloud Explosion

The Unconfined Vapour Cloud Explosion (VCE) begins with a release of a large quantity of flammable vaporizing liquid or gas from a storage tank, transport vessel or pipeline producing a dangerous overpressure. These explosions follow a well-determined pattern. There are basically four features, which must be present for an effective vapour cloud explosion to occur with an effective blast. These are:

- First, the release material must be flammable and at a suitable condition of temperature and pressure which depends on the chemical. The materials which come under this category, range from liquefied gases under pressure (e.g. butane, propane); ordinary flammable liquids (e.g. Cyclohexane, naphtha) to non-liquefied flammable gases (e.g. ethylene, acetylene)
- Second, before the ignition, a cloud of sufficient size must have been formed. Normally ignition delays of few minutes are considered the most probable for generating the vapour cloud explosions
- Third, a sufficient amount of the cloud must be within the flammable range of the material to cause extensive overpressure
- Fourth, the flame speed determines the blast effects of the vapour cloud explosions, which can vary greatly

- The flammable content of a gas cloud is calculated by three-dimensional integration of the concentration profiles, which fall within the flammable limits. If the gas cloud ignites, two situations can occur, namely non-explosive combustion (flash fire) and explosive combustion (flash fire + explosion)

7.1.6 Models for Calculation of Heat load and Pressure Waves

If a flammable gas or liquid is released, damage resulting from heat radiation or explosion may occur on ignition. Models used in this study for the effects in the event of the ignition of a gas cloud will be discussed in succession. These models calculate the heat radiation or peak overpressure as a function of the distance from the torch, the ignited pool or gas cloud. The physical significance of the various heat loads is depicted in **Table 7.7.**

A pressure wave can be caused by gas cloud explosion. The following damage criteria are assumed as a result of the peak overpressure of a pressure wave:

- 0.03 bar over pressure wave is taken as the limit for the occurrence of wounds as a result of flying fragments of glass
- Following assumptions are used to translate an explosion in terms of damage to the surrounding area:
  - Within the contour area of the exploding gas cloud, Casualties are due to burns or asphyxiation. Houses and buildings in this zone will be severely damaged
  - In houses with serious damage, it is assumed that one out of eight persons present will be killed as a result of the building collapse. Within the zone of a peak over pressure of 0.3 bar the risk of death in houses is 0.9 x 1/8 = 0.1125, and in the zone with a peak over pressure of 0.1 bar the probability of death is 0.1 x 1/8 = 0.0125, i.e. one out of eighty people will be killed

The significance of the peak over pressures 0.3 bar, 0.1 bar, 0.03 bar and 0.01 bar are depicted in **Table 7.8**.

7.1.7 Computation of Damage Distances

Damage distances for the accidental release of LNG due to various leak sizes for the terminal have been computed at 2F (wind speed: 2 m/s), 3D (wind speed: 3 m/s) and 5D (Wind speed: 5 m/s) weather conditions according to NFPA 59 A code. These weather conditions have been selected to accommodate worst case scenarios to get maximum effective distances.

DNV based **PHAST 6.51** software has been used to carry out consequence analysis. Damage distances computed for various credible scenarios for LNG carrier, FSRU LNG unloading arm, LNG pumps and ORF are described below:

7.1.7.1 Jet Fire

This scenario was visualized by considering leak sizes of 25 mm and 50 mm in LNG Vaporizer at various heat radiation levels under the different atmospheric stability classes and wind velocities. The damage distance due to 50 mm leak for stability class 5D is 110.64 m at heat load of 4.0 KW/m^2, 86.30 m at heat load of 12.5 KW/m^2 and 67.86 m at heat load of 37.5KW/m^2 condition. The damage distances for LNG carrier and FSRU vessel are given for 300 mm and 1000 mm leak sizes. The computed damage distances for other process units for 25 mm and 50 mm leak sizes at heat loads of 37.5 KW/m^2, 12.5 KW/m^2 and 4.0 KW/m^2 are given in **Table 7.9**.

7.1.7.2 Flash fire

For the visualisation of this scenario, leak size of 50 mm is considered. Consequences are analysed under the atmospheric stability class 5D. Vapour dispersion scenario is analysed at LFL & LFL fraction (50% LFL) distance. Damage distance due to 50 mm leak in LNG Unloading arm at 5D condition is 88.58 m at LFL concentration. The damage distances for LNG carrier and FSRU vessel are given for 300 mm and 1000 mm leak sizes. The computed damage distances for other equipment of the terminal are given in **Table 7.10**.

7.1.7.3 Late Pool Fire

For the visualisation of this scenario, leak size of 50 mm as worst case has been considered. Consequences are analysed at various heat radiation levels under the atmospheric stability class 5D. The damage distances due to 50 mm leak in Diesel oil storage tank at stability class 5D are 25.57 m and 52.52 m for heat loads of 12.5 kW/m^2 and 4 kW/m^2, respectively. The computed damage distances for fuel oil and Diesel oil equipment of the terminal are given in **Table 7.11**.

7.1.7.4 Vapour Cloud Explosion

This scenario was visualized by considering leak sizes of 25 mm, 50 mm for LNG Vapourizer at various overpressure waves under the different atmospheric stability classes and wind velocities. The damage distances due catastrophic rupture at stability class 2F are 138.7 m, 110.8 m and 100.37 m for overpressure waves of 0.03 bar, 0.1 bar and 0.3 bar, respectively. The damage distances for LNG carrier and FSRU vessel are given for 300 mm and 1000 mm leak sizes. The computed damage distances for other process units are given in **Table 7.12.**

7.1.8 Quantification of Individual and Societal Risk

Risk is quantified in terms of probability of occurrence of hazardous event and magnitude of its consequences. The consequence modelling was carried out in order to assess the extent of damage by visualizing accidental release scenarios for various process equipments. The risk to the human due to accidental release scenarios is represented in two ways viz. individual risk and societal risk. Individual risk associated with the various equipment of LNG terminal has been evaluated by analysing various scenarios which are described in subsequent sections.

7.1.8.1 Individual Risk

The Individual Risk (IR) level is more specifically defined as the Individual Risk Per Annum (IRPA), which is the calculated annual risk loading to a specific individual. Clearly this depends on the amount of time in a year that the individual spends in different risk areas. The individual risk calculation takes account of the fact that people move from one place to another.

When calculating individual risk from major accident scenarios, it is normal to take account of protection by buildings. Individual risk is typically depicted as contour plots on overall plot plan of a facility, the risk level falls rapidly as one moves away from the source of the leak / epicentre of potential explosions. The Risk Acceptable Criteria based on annual individual risk is shown in **Fig 7.3**

7.1.8.2 Societal Risk

Societal risk is used in quantified risk assessment (QRA) studies and is depicted on a cumulative graph called an F/N curve. The horizontal axis is the number of potential fatalities, N. The vertical axis is the frequency per year that N or more potential fatalities could occur, F. This risk indicator is used by authorities as a measure for the social disruption in case of large accidents.

It is normal to take account of protection by buildings, and people's response. For large toxic release models, alarm and evacuation can be included. Because it is a cumulative curve, the curve always drops away with increasing N. Normally the F/N curve has a lower frequency cut-off at one in a billion (1×10^{-9} /yr). Regulators often split the graph into different regions, so that different actions have to be undertaken depending on where the F/N curve falls. Sometimes a maximum limit is placed on N (number of fatalities) possible for any event.

This type of curve is normal for plant type hazardous installations where a large group of people could be affected and their location is well established (housing estates, schools etc.) relative to the event location (the plant). For pipelines however, because there is no single location for an event and the population affected varies along the pipeline route, this curve is not normally generated unless a large group of people can be affected over a reasonable distance.

7.1.9 Failure Frequencies

The frequency of releases from equipment has been determined by application of generic frequency data available from various sources. The **Table 7.13** states the frequency data for the LNG terminal process equipment**.**

7.1.10 Risk Acceptance Criteria

The level of risk in this study is quantified with an express purpose of comparing against typical acceptable risks. The acceptable risk levels can change with time and place. Although there are differences between the legislation adopted in the various countries, there appears to be broad consensus on the tolerability of risk. The majority of the countries would accept risk levels for the public around 10^{-5}/yr whilst the more stringent countries would set the tolerability level at 10^{-6}/yr. Detailed guidelines available from various countries have been presented below.

i. United Kingdom

In the UK the "Control of Major Accident Hazards" (COMAH) regulations are in line with the latest EU "Seveso-2" Directive. The regulations do not formally require a quantitative risk assessment, but the guidance notes make clear that in some circumstances quantification will help or could be asked for by the UK regulator - the Health and Safety Executive (HSE) - and this is often done in practice.

To advise planning authorities on developments around industrial installations, the UK HSE has been developing risk acceptance criteria over the years. A comprehensive treatment of the subject of tolerability of risk was given in a report titled "Reducing Risks Protecting People". The report repeated the concept and criteria as argued by the Royal Society in 1987. It accepted the concept of tolerable Individual Risk as being the dividing line between what is just tolerable and intolerable and set the upper tolerable limit for workforce fatalities at 10^{-3}/yr (1 in a thousand) for workers and 10^{-4}/yr (1 in 10 thousand) for members of the public. A level at which risks might be broadly acceptable but not altogether negligible was set at 10^{-6}/yr (1 in a million). The region in between would be controlled by the ALARP concept.

ALARP can be demonstrated in a variety of ways, depending on the severity of the worst case scenario. These are expressed in HSE guidance to Inspectors Consultation Draft September 2002. When a QRA is carried out, then the F/N regions are defined as in the **Fig. 7.2**.

Unlike the Netherlands (see below), the potential workforce fatalities are included in the F/N curve.

ii. Canada: Major Industrial Accidents Council of Canada (MIACC)

The MIACC recommend individual risk levels for use in respect to hazardous substances risk from all sources, i.e. there is no need to distinguish between risk from a fixed facility at which hazardous substances may be found, or a pipeline or a transportation corridor. The acceptability levels are equally applicable.

iii. Malaysia

The criteria used by the Department of Environment (DOE) for existing facilities are outlined below for residential and industrial areas:

- Residential 1 x 10^{-6} fatalities / person / year
- Industrial 1 x 10^{-5} fatalities / person / year

In words, the acceptability criteria are as follows: the risk of death to persons in a residential area must not exceed 1 chance in a million per person per year and the risk of death to persons in a nearby industrial area must not exceed 1 chance in 100,000 per person per year.

If the quantified individual risk compares favourably with the acceptability criteria, then it is deemed acceptable. If not, the components of the overall risk are re-examined to determine where risk mitigation measures can be implemented cost effectively. Risk evaluation must also be conducted taking into account the fact that hazard analysis and consequence assessment only gives an estimation of risks from a facility.

iv. Australia

The Western Australia (WA) Department of Planning has adopted risk criteria for hazardous installations. They are based on risk contours and can be summarised as follows:

- A risk level in residential zones of one in a million per year (1 x 10^{-6}/yr) or less, is so small as to be acceptable to the WA EPA (Environmental Protection Agency);
- A risk level in "sensitive developments", such as hospitals, schools, child care facilities and aged care housing developments, of between one half and one in a million per year (5 x 10^{-7} and 1 x 10^{-6}/yr) is so small as to be acceptable to the WAEPA;
- Risk levels from industrial facilities should not exceed a target of fifty in a million per year (1 in 20,000) at the site boundary for each individual industry, and the cumulative risk level imposed upon an industry should not exceed a target of one hundred in a million per year (1 in 10,000);
- A risk for any non-industrial activity, located in buffer zones between industrial and residential zones, often in a million per year or lower is so small as to be acceptable to the WA EPA;
- A risk level for commercial developments, including offices, retail centres and showrooms located in buffer zones between industrial facilities and residential zones, of five in a million per year or less, is so small as to be acceptable to the WA EPA.

v. The Netherlands

The policy statement approved by the Dutch Parliament states the following criteria for existing facilities. The risk is unacceptable if the 10^{-6}/yr risk contours affect residential areas or the F/N curve is above 10 fatalities with a frequency of 10^{-5}/yr with a slope of -2. This is illustrated in **Fig. 7.4**.

Below the criteria, the ALARP, "As Low As Reasonably Practicable", principle should be used.

AH Dutch installations should meet the criteria for new facilities by the year 2005. For the Societal Risk it should be emphasised that the exposure or "presence" factor of population used for calculating the F/N curve during the day is 0.7 and 1 during night. Also the assumption is made that being indoors gives protection where the fraction of people being indoors is 0.93 during daytime and 0.99 during night time.

vi. Hong Kong Government Criteria

The Hong Kong government has published "Interim Risk Guidelines for Potential Hazardous Installations". The guideline covers new installations and expansion of existing installations and also controls the development of land around installations. It should be pointed out that although these are described as "guidelines" they are very strictly applied in practice. They are seen as necessary because of the special circumstances of Hong Kong, where there is a dense population in close proximity to industrial facilities, and are mainly used for land-use planning decisions. Societal risk guidelines are shown in **Fig. 7.5** and set forth two criteria;

- A risk contour of 10^{-5}/yr for fatality as an upper limit of tolerability.

The maximum F/N curve exceeds the line through the point of 10 fatalities at a frequency of 10^{-4}/yr with a slope of -1. No event at any frequency should take place which causes more than 1000 deaths.

The Hong Kong regulators scrutinise each risk assessment closely and insist on the use of consistent methodology from case to case.

7.1.11 Risk Evaluation

Individual risk and societal risk are computed using software SAFETI MICRO 6.51 for various process equipments. Risk has been presented in terms of Individual Risk (IR) contours and F/ N curves in the subsequent sections. For the comparison of evaluated risk with the acceptable risk criteria, risk criteria given by Health and Safety Executive (HSE), UK has been used.

i. LNG Carrier/ Shuttle

IR contours, risk transect and F/N curves for LNG Carrier/ Shuttle have been presented in **Figs. 7.6, 7.7 and 7.8,** for loss of containment events in case of all possible fire and explosion scenarios.

ii. FSRU (Vessel)

IR contours, risk transect and F/N curves for FSRU (Vessel) have been presented in **Figs. 7.9 - 7.11** for loss of containment events in case of all possible fire and explosion scenarios.

iii. LNG Unloading arms

IR contours, risk transect and F/N curves for LNG Unloading arms have been presented in **Figs. 7.12 - 7.14** for loss of containment events in case of all possible fire and explosion scenarios.

iv. LNG Pump

IR contours, risk transect and F/N curves for LNG PUMP have been presented in **Figs. 7.15 - 7.17** for loss of containment events in case of all possible fire and explosion scenarios.

v. LNG Vaporiser

IR contours, risk transect and F/N curves for LNG Vaporizer have been presented in **Figs. 7.18 - 7.20** for loss of containment events in case of all possible fire and explosion scenarios.

vi. HP gas Send out arm

IR contours, risk transect and F/N curves for HP gas Send out arm have been presented in **Figs. 7.21 - 7.23** for loss of containment events in case of all possible fire and explosion scenarios.

vii. Onshore Receipt Facility / IR contour

The damage distances / IR contours predicted during jet fire and flash fire scenario due to major leak in gas pipeline at ORF are shown in **Figs.7.24** and **7.25.** The damage distances are contained with ORF premises.

7.1.12 Conclusion

The societal risk has been given as F/N curve where F is the failure probability and N is the number of fatalities. The curve has been presented by considering the population, population density and ignition sources around the plant. The F/N curve for LNG facility is in the "As Low As Reasonably Practicable" (ALARP) region where risk can be further reduced with the precautionary measures. The necessary risk mitigation measures for LNG facility have been recommended in following sections.

7.1.13 Risk Mitigation Measures

The scope of the study covers mitigation measures based on Maximum Credible Accident (MCA) Analysis. The Fire and Explosion Indices were computed for the identification and screening of vulnerable sections and consequence analysis was carried out for the accidental release scenarios of hazardous chemicals at various atmospheric conditions. The following are general and specific mitigation measures.

7.1.13.1 General Recommendations

Fire prevention and code enforcement is one of the major areas of responsibility for the fire service. Following are the general recommendations for the proposed facility

- Facility should be equipped at strategic locations with the following fire fighting systems
    - Water supply
    - Fire hydrant and monitor nozzle installation
    - Foam system
    - Water fog and sprinkler system
    - Mobile Fire fighting equipment
- Surrounding population (includes all strata of society) should be made aware of the safety precautions to be taken in the event of any mishap within the facility. This can effectively be done by conducting the safety training programs
- Safety escape routes should be provided at strategic locations and should be easily accessible
- Grating and vent panels should be provided to minimize Domino Effects
- Critical switches and alarm should be always kept in line
- A wind direction pointer should also be installed at the site, so that in an emergency the wind direction can be directly seen and downwind population cautioned
- Shut off and isolation valves should be easily approachable in emergencies
- Hydrocarbon detectors to be installed at strategic locations of the facility to assess any leak
- Periodical mock drills should be conducted so as to check the alertness and efficiency of the DMP and ERP and records should be maintained
- Signboard including phone numbers, no smoking signs and type of emergencies should be installed at the site

i. Control Room

- Multiple entry / exit shall be provided for control room for safe exit
- Dry chemical fire extinguishers should be used in control rooms and computer rooms

- Smoke detectors system shall be provided for control rooms at suitable locations
- To resist fire spread through ducts, dampers shall be installed in ducts as applicable

ii. Electricity Hazard

- All electrical equipments shall be provided with proper earthing. Earthed electrode shall periodically tested and continuity should be maintained
- Emergency lighting shall be available at all critical locations including the operator's room to carry out safe shutdown and ready identification of fire fighting facilities such as fire water pumps and fire alarm stations
- All electrical equipments shall be free from moisture, carbon dust, oil deposits and grease
- Approved insulated tools, rubber mats, shockproof gloves and boots, tester, fuse tongs, discharge rod, safety belt, hand lamp, wooden or insulated ladder should be used while carrying out the maintenance of electrical parts
- Flame and shock detectors and central fire annunciation system for fire safety should be provided
- Temperature sensitive alarm and protective relay should be in place to make alert and disconnect equipment before overheating
- Danger from excess current due to overload or short circuit should be prevented by providing fuses, circuit breakers, thermal protection
- Carbon dioxide or dry chemical fire extinguishers are to be used for electrical fires

iii. Fire Protection System

The typical fire fighting system for the various facilities described is outlined in this section. The exact details of the fire fighting systems and capabilities to be installed and developed will be finalised after the completion of detailed engineering in consultation with the concerned process and equipment vendors and fire. It is also to be understood that not all facilities described below will be applicable for every installation. The outline of the fire system proposed is described below:

Fire protection system shall be designed in accordance with the requirements of OISD, Tariff Advisory Committee (TAC) of India, NFPA standards, design requirements and safe engineering practices and will have full capability for early detection and suppression of fire. The system will primarily consist of:

- Hydrant system
- Foam protection system
- Portable fire extinguisher
- Fire detection and alarm system

a. Hydrant System

The system will essentially consists of firewater storage, pumping, system pressurisation and all inter connected pipe work and auxiliary fire fighting appliances. The water storage and pumping capacity and other features of this system will be finalised considering TAC recommendations.

Adequate number of engine driven / electric motor driven fire water pumps will be provided. The pumps will be started automatically in the event of drop in header pressure. The actuation will be through pressure switches, the setting of which will be staggered to achieve sequential starting of the pumps to meet the system demand. When power supply is available, the electric motor driven pump will start first and in case of further pressure drop the engine driven pump will start. However when electric power is not available, the engine driven pump will cut-in depending on the system demand. The pumping capacity should also meet the guidelines of Tariff Advisory Committee (TAC) for this size of plant, considering ordinary hazard occupancy.

The outdoor hydrant system will be provided all over the ORF for exterior protection. The hydrant mains will be laid underground. Hose houses, complete with all accessories, will be provided at suitable intervals. The pressurised main will also be connected to Sprinkler/ emulsifier System for protection of transformers etc. Foam Protection System

Oil storage tanks and the surrounding dyke areas will be protected with low expansion foam system. The foam protection system will be designed as per the requirements of NFPA, OISD and TAC. Sprinkler System

b. Portable Fire Extinguishers

Besides, fire hydrant arrangement, portable fire extinguishers of suitable categories will be placed at control rooms, electrical switchgear room and various utility buildings for immediate use in the event of fire. Three different kinds of extinguishers i.e. foam, CO_2 and multipurpose dry chemical (MPDC) will be provided. Each type of extinguisher has its own characteristic to fight a particular class of fire. The size and type of extinguishers will be decided as per recommendations of NFPA and relevant Indian Standard and will be placed in convenient accessible locations.

iv. Fire Fighting System

The fire protection equipment shall be kept in good operating condition at all times and fire fighting system should be periodically tested for proper functioning and logged for record and corrective actions.

v. Pipeline Testing

All welds should be Radiographic, Dye Penetrant Test and Hydrostatic testing of the pipeline should be performed at a pressure up to 1.15 times the design pressure of the pipeline system based on the design code requirements. The test pressure should be held for a minimum period of 24 hours.

vi. Leak Detection System

Leak detection software module, precision instrument and dedicated communication system should be installed at ORF. The leak detection system should alert the ORF operator about the potential leaks.

7.1.13.2 Specific Recommendations

Specific recommendation is suggested for the hazardous or flammable chemical / material, equipment which is to be transported or handled from FSRU to Jetty.

i. LNG Jetty

- There should be no source of ignition source at all within the restricted area of the site at all times
- General cargo, other than ship's stores for the LNG tanker, should not be handled within 30 metres of the point of transfer connection while LNG is being transferred through piping systems
- Ship bunkering at the LNG jetty should not be permitted during LNG unloading operation
- Warning signs or barricades should be used to indicate that transfer operation is in progress
- Gas leak detectors should be provided for flanges as well as where there is cluster of flanges and at the unloading point

- Any potential static electric charge will be mitigated by an appropriate earthing.

ii. FSRU and LNG Carrier

- Electrical classification of areas for electrical installation in LNG terminal should be as per OISD Standard 113 (as applicable)
- Electrical equipment must be of flame proof type and certified for Zone II, Gas group II 'A' and temperature class T3 requirements classification as per NFPA classification
- All high current (capacity) electrical cables should be armoured and fire resistant type
- Cathodic protection system for the pipe work should be installed, to deal with static charge build-up

iii. Training

On job training to the engineers on various facets of risk analysis would go a long way in improving their horizon which in turn is expected to reflect in the operation of plant, especially from the safety stand point. In order to combat with emergency situations arising out of accident release of hazardous chemicals, it is necessary for industries to prepare an exhaustive offsite and onsite emergency preparedness plan.

The training should also be conducted to ensure adequate understanding of the nature of potential hazards and the facilities and the equipment and procedures to be used to handle any emergency. Following trainings to various groups should be conducted.

- Pre-incident Planning
- Emergency Response Training
- Basic Fire Fighting Training
- First Aid Training
- Permit To Work Training

iv. Environmental Safety

In general, the frequency of leaks is low. Ensuring proper safety can still lower this frequency. Risk reducing measures include proper training for personnel, presence of well-trained engineers and strict adherence to safety management procedures to be incorporated in the plan.

v. Personnel Safety

Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk. Safety practices are needed to carry out jobs safely and without causing any injury to self, colleagues and system.

For total safety of any operation, each team member must religiously follow the safety practices / procedures pertaining to respective operational area. If every team member starts working with this attitude, zero accident rate is not a distant dream.

Any operation is a team effort and its success depends upon the sincerity, efficiency and motivation of all team members. Safety in such operations is not a duty of a single person, but it is everyone's job.

Use of protective fireproof clothing and escape respirators will reduce the risk of being seriously burnt. In addition, adequate fire fighting facilities and first aid facilities should be provided, in case of any emergency.

vi. Personal Protective Equipment

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems.

PPE is considered to be a last resort that is above and beyond the other facility controls and provides the worker with an extra level of personal protection. **Table 7.14** presents general examples of occupational hazards and types of PPE available for different purposes. Recommended measures for use of PPE in the workplace include:

- Active use of PPE if alternative technologies, work plans or procedures cannot eliminate, or sufficiently reduce, a hazard or exposure
- Identification and provision of appropriate PPE that offers adequate protection to the worker, co-workers, and occasional visitors, without incurring unnecessary inconvenience to the individual
- Proper maintenance of PPE, including cleaning when dirty and replacement when damaged or worn-out. Proper use of PPE should be part of the recurrent training programs for Employees

Selection of PPE should be based on the hazard and risk ranking described earlier in this section, and selected according to criteria on performance and testing established

7.1.14 Types of Emergencies at Port

There can be various types of emergencies that can occur on port as defined below and requires to be tackled as per emergency plan

- Fire in the port and / or in the neighbouring installations
- Toxic effects due to release of chemicals
- Spillage of any chemical followed by fire or toxic effects
- Spillage of any oil followed by fire or toxic effects.
- Spillage of oil from pipeline snaps and leaks
- Collision of ships in the vicinity of port and within Harbour area

7.1.15 Approach to Disaster Management Plan

In recent years, there has been a rapid increase in the number, variety and complexity of the chemicals being used in the industry and in our daily life. Many of these chemicals are toxic, highly reactive, explosive or inflammable or have a combination of these characteristics and all these are classed as hazardous chemicals. Such chemicals are potential hazardous not only to the human beings, flora and fauna but also to all forms of property and our environment as a whole.

Several agencies of the Government, both at the Central and State levels, such as the Directorate of Explosives, the Inspectorate of Factories, Ports and Transport Authorities are entrusted with the responsibility of ensuring safe handling and management of hazardous chemicals under acts and rules made for the purpose. In spite of these measures, the possibility of accidents cannot be ruled out. Human errors and mechanical, electrical, instrumental or system failures have, on occasions, led to severe disasters. Accidents occurred at Bhopal, Mexico and other parts of the world have made people concerned with the dangers of chemical accidents. Occurrence of such accidents makes it essential that the Central and State Governments as well as the local authorities are fully prepared to mitigate the sufferings and meet the eventualities resulting from any unfortunate occurrence of accidents in our country.

7.1.15.1 Objectives of Disaster Management Plan

The purpose of DMP is to give an approach to detail organizational responsibilities, actions, reporting requirements and support resources available to ensure effective and timely management of emergencies associated to production and operations in the site. The overall objectives of DMP are to:

- To protect persons and property of processing equipments in case of all kinds of accidents, emergencies and disasters
- To inform people and surroundings about emergency if it is likely to adversely affect them
- To inform authorities including helping agencies (doctors, hospitals, fire, police transport etc.) in advance, and also at the time of actual happening
- To identify, assess, foresee and work out various kinds of possible hazards, their places, potential and damaging capacity and area in case of above happenings. Review, revise, redesign, replace or reconstruct the process, plant, vessels and control measures if so assessed.
- Minimize the impact of the event on the installation and the environment, by:
  - Minimizing the hazard as far as possible
  - Minimizing the potential for escalation
  - Containing any release
- To provide guidance to help stack holders take appropriate action to prevent accidents involving hazardous substances and to mitigate adverse effects of accidents that do nevertheless occur. Following figure shows effect of loss of containment from the process

7.1.15.2 Phases of Disaster

Warning Phase

Many disasters are preceded by some sort of warning. For example, with the aid of satellites and network of weather stations, many meteorological disasters like cyclones and hurricanes can be predicted and actions can be taken to eliminate/reduce their effect to counteract them.

Impact Phase

This is the period when the disaster actually strikes and very little can be done to lessen the effects of disaster. The period of impact may last for a few seconds (like fire, explosion, gas leak etc.) or may prolong for days (fire, gas leak, etc.). This is the time to bring the action plan in force.

The coordinators in organization structure will perform the responsibilities assigned to them. Needless to emphasize that prompt and well organized rescue operations can save valuable lives.

Rescue Phase

The rescue phase starts immediately after the impact and continues until necessary measures are taken to rush help and combat with the situation.

Relief Phase

In this phase, apart from organization and relief measures internally, depending on severity of the disaster, external help should also be summoned to provide relief measures (like evacuations to a safe place and providing medical help, food clothing etc.). This phase will continue till normalcy is restored.

Rehabilitation Phase

This is the final and longest phase. It includes rebuilding damaged property, estimating the damages, payment of compensation, etc. Help from revenue/insurance authorities need to be obtained to assess the damage, quantum of compensation to be paid etc.

7.1.15.3 Key Elements of DMP

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident/emergency response planning procedures
- Obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment
- Ensure safety of people, protect the environment and safeguard commercial considerations
- Immediate response to emergency scene with effective communication network and organized procedures
- On-site Disaster Management Plan
- Off-site Disaster Management Plan

- In order to handle disaster / emergency situations, an organizational chart entrusting responsibility to various personnel of the facility showing their specific roles should be available as shown in following **Fig. 7.26**.

7.1.15.4 Emergency Planning and Response Procedures

Emergency rarely occurs, therefore activities during emergencies require coordination of higher order than for planned activities carried out according to fixed time schedule or on a routine day-to-day basis. To effectively coordinate emergency response activities, an organizational approach to planning is required. The important areas of emergency planning are Organization and Responsibilities, Procedures, Communication, Transport, Resource requirements and Control Center. Offsite emergency requires additional planning over and above those considered under onsite plans, which should be properly integrated to ensure better coordination.

The emergency planning includes anticipatory action for emergency, maintenance and streamlining of emergency preparedness and ability for sudden mobilization of all forces to meet any calamity.

7.1.15.5 On-site Disaster Management Plan

Before Crisis

Prepare a plan of the storage, handling and pumping stations premises and surroundings showing therein the areas of various hazards like fire, explosion, toxic releases and also location of assembly points, fire station or equipments room, telephone room, first aid or ambulance room, emergency control room, main gate, emergency gates, normal wind direction, outside fire station, hospital and other services. Mention their distances from proposed activities.

- The fire protection equipment shall be kept in good operating condition at all time and fire fighting system should be periodically tested for people functioning logged for record and corrective action.
- The fire fighting training shall be provided to all officers, truck drivers and other employees who are likely to be present in installation
- There should be regular mock fire drills once a month record of such drills shall be maintained

- Every employee or authorized person working in the production shall be familiarized with the fire alarm signal and shall know the location of fire alarm point nearest to place of work
- Assign key personnel and alternate responsible for site safety
- Describe risk associated with each operation conducted.

During Crisis

- Monitor the behaviour of entrant for any effects that suggests they should be evacuated
- Evacuate the space if any hazard that could danger the entrant is detected
- Perform no other duties that may interfere with their primary responsibilities
- Notify the attendant if they experience any warning signs or symptoms of exposures or detect a dangerous condition
- Exit the permit space when instructed by attendant
- Reporting Procedure

In the event of fire from accidental release of flammable chemical, a person seeing the incident will follow the laid down procedure in the plant and report as follows:

- Will dial the nearest telephone
- Will state his name and exact location of emergency
- Will contact affected officers on duty
- People reporting the accident will remain near the location to guide emergency crew arriving at the scene

In case fire emergency person should activate the nearest available push button type instrument which will automatically sound an alarm in fire control room indicating the location of fire.

After Crisis

- Report injuries or blood or body fluid exposures to the appropriate supervisor immediately
- Assembly points:

- Assembly points shall be set up farthest from the location of likely hazardous events, where pre-designed persons from the works, contractors and visitors would assemble in case of emergency. Up-to-date list of pre-designed employees shift wise must be available at these points so that roll call could be taken. Pre-designated persons would take charge of these points and mark presence as the people come into it.

- Wash wounds and skin sites that have been affected with soap and water.
- Workers should be seen as soon as possible by a health professional.
- Provide information to the relevant public authority and community including other closely located facilities regarding the nature of hazard and emergency procedure in event of major accident.
- Record and discuss the lessons learned and the analysis of major accidents and misses with employees and employee representative.

Duties of the Management Team

The duties that will be performed by the key personnel during emergency are as follows:

Incident Controller

- Direct all operations to stop within the affected area taking into consideration priorities for safety of personnel, minimize damage to the plant, property and environment and minimize loss of material
- Provide advice and information to the Fire and Security Officers, the local fire service and the Personnel/Administrative Manager
- Ensure that all non-essential workers/staff of the areas affected are evacuated to the appropriate assembly points and the areas are searched for causalities
- Set up communication points and establish contact with Emergency Control Center (ECC) in the event of failure of electric supply, Public Address System (PAS) and internal telephones
- Report on all significant developments to the Communication Officer
- Have regard to the need to preserve the evidence so as to facilitate any enquiry into the cause and circumstances, which caused or escalated the emergency

- The police and fire brigade incident control vehicles should be located at pre-designated place at side. It is necessary to keep one lane clear for access / egress and spaces for vehicle passing.
- Assessments of the situation and any associated risks should be carried out by the emergency services before entering the hazard area.

Site Controller

- Assess the magnitude of the situation and decide if staff needs to be evacuated from their assembly points to identified safer places
- Exercise direct operational control over areas other than those affected
- Undertake a continuous review of possible developments and assess in consultation with key personnel as to whether shutting down of the plant or any section of the plant and evacuation of personnel are required
- Liase with senior officials of Police, Fire Brigade, Medical and Factories Inspectorate and provide advice on possible effects on areas outside the factory premises
- Look after rehabilitation of affected persons on discontinuation of emergency
- Issue authorized statements to news media and ensure that evidence is preserved for inquiries to be conducted by the statutory authorities

Personnel / Administrative Manager

- To ensure that causalities receive adequate attention arrange additional help if required and inform relatives
- To control traffic movements into the plant and ensure that alternative is available when need arises
- When emergency is prolonged, arrange for the relief of personnel and organize refreshments/catering facility.

Communication Officer

- Advise the Site Controller of the situation, recommending (if necessary) evacuation of staff from assembly points.
- Recruit suitable staff to act as runners between the Accident Controller and himself if the telephone and other system of communication fail.
- Maintain prior agreed inventory in Control Room

- Maintain a log of the incident on tape
- In case of a prolonged emergency involving risk to outside areas by windblown materials - contact local meteorological office to receive early notification of changes in weather conditions

Fire and Safety Officer

- To instruct all the security personnel to help in maintaining law and order
- To ensure that systematic and proper efforts are launched to avoid chaos or panic at site
- To ensure smooth evacuation, if necessary
- To close all gates except main gate, control traffic and allow only authorized persons to enter the plant
- To arrange additional fire fighting aids from nearby factories and district authorities and take care of rescue operation
- To cordon off the accident area and direct external help to respective coordinators
- Visit by media men to be arranged only through public Relations Coordinator, circumstances responsible for emergency and convey these findings confidentially to the Safety Coordinator
- To keep Chief Coordinator informed regarding status of fire, casualties, loss of property, methods adopted to combat fire, etc.
- To arrange for additional fire fighting crew / equipment, if required
- To inform Medical Coordinator regarding casualties, loss of life

Transport Coordinator

- To keep ambulances (own and others) along with drivers in readiness as per instructions of Medical Coordinator
- To keep all the vehicles and drivers in readiness and send vehicles as per requirement of various coordinators
- To requisition vehicles from outside agencies, if required

Medical Coordinator

- To inform hospitals regarding emergency at site and make them, ready in advance, to handle casualties
- To take charge of ambulances
- To requisition additional ambulances through Transport Coordinator, if required
- To arrange for first aid for the injured and send them for hospitalization

Media Representatives

- To assist in plant evacuation in co-ordination with transport coordinator
- To arrange for evacuation of neighbouring people, if warranted
- To inform latest situation to Chief Coordinator and Communications Coordinator
- To receive media, government officials, and consultants and impart information keeping the following in mind:
    - Communicate directly to avoid distortion by others
    - Impart factual information
    - Only official spokesman imparts information
    - Necessary facilities are made available to the media. Reasons for restriction on media-men be duly explained to them
    - Do not cover up facts as correct picture will finally emerge
    - Provide full information on safety measures to media for balanced reporting
- To inform insurance agency to assess damage
- To provide relief and rehabilitation to affected personnel

Communication Coordinators

- To keep all communication equipment viz. telephone radio-telephone, telex, fax, etc., in working condition
- To report to emergency site and take charge of communication equipment
- To inform local authorities from whom the help be required viz. fire brigade, hospitals, transporters, police station etc.

- To act as liaison between different coordinators
- To keep all communication lines free for use during emergency

Assembling Points

Assembly points shall be set up farthest from the location of likely hazardous events, where pre-designated persons from the works, contractors and visitors would assemble in case of emergency. Up-to-date list of pre-designated employees of various departments (shift-wise) must be available at these points so that roll call could be taken Pre-designated persons would take charge of these points and mark presence as the people come into it.

7.1.15.6 Disaster Management / Emergency Preparedness Program: Off-site

Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving Off-site Emergency Plan to combat any such eventuality. In Offsite disaster management plan, many agencies like Revenue, Public Health, Fire Services, Police, Civil Defence, Home Guards, Medical Services and other Voluntary organization are involved. Thus, handling of such emergencies requires an organized multidisciplinary approach.

Evacuation of people, if required, can be done in orderly way. The different agencies involved in evacuation of people are Civil Administration (both state and central), non Govt. organizations, factory Inspectorate and Police authorities.

Fire

Effects of fire on population will be mainly due to thermal radiation. In such cases, houses situated to the proximity of disaster need to be evacuated, although a severe smoke hazard due to fire is to be reviewed periodically.

Explosion

An explosion will give a very little time to warn population and areas affected may be much longer than that in case of fire. The effects of explosion on population will be mainly due to shock waves, flying splinters, collapse of structures and exposure to thermal radiation.

Purpose

- To save lives and injuries and to prevent or reduce property losses
- To provide for quick resumption of normal situation or operation

- To make explicit the inter related be suggested if necessary
- To make explicit inter related set of actions to be undertaken in the event of an industrial accident posing hazards to the community
- To inform people and surrounding about emergency and disaster if it is likely to adversely affect machinery will be established for this purpose to guide the people in proper way
- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest time

Before Crisis

This will include the safety procedure to be followed during an emergency through posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts before and during emergency should be circulated to educate the people in vicinity

- People in vicinity of hazardous installation, and others who are potentially affected in the event of an accident, should be aware of the risks of accidents, know where to obtain information concerning the installation, and understand what to do in the event of an accident
- Non-governmental Organizations (NGO's) (Such as environmental, humanitarian and consumer group) should motivate their constituents and others, to be involved in risk reduction and accident prevention efforts. They should help to identify specific concerns and priorities regarding risk reduction and prevention, preparedness and response activities
- NGO's should facilitate efforts to inform the public and should provide technical assistance to help the public analyze and understand information that is made available
- Public authorities (at all levels) and management of hazardous installation should established emergency planning activities/ program's for accidents involving the hazardous substance

- All parties who will be involved in emergency planning process. In this respect public health authorities, including experts from information centers should be involved in relevant aspects of offsite emergency planning
- Emergency warning alert system should be in place to warn the potentially affected public, or there is an imminent threat of an accident
- The system chosen should be effective and provide timely warning. Suitable warning system could include or a combination of sirens, automatic telephone message, and mobile public address system

During Crisis

- Central Control Committee: As the off-site plan is to be prepared by the government a central control committee shall be formed under the chairmanship of area head. Other officers from police, fire, factory, medical, engineering, social welfare, publicity, railway, transport and requisite departments shall be incorporated as members. Some experts will also be included for guidance. The functions of committee should be:
  - To work as main co-coordinating body constituted of necessary district heads and other authorities with overall command, coordination, guidance, supervision, policy and doing all necessary things to control disaster in shortest times
  - To prepare, review, alter or cancel this plan and to keep it a complete document with all details
  - To take advice and assistance from experts in fields to make plan more successful
  - To set in motion all machineries to this plan in event of disaster causing or likely to cause severe damage to public, property or environment
  - The incident control committee, traffic control committee and press publicity committee will first be informed, as they are needed first
- Medical Help, Ambulance and Hospital Committee: This committee consisted of doctors for medical help to the injured persons because of disaster. Injuries may be of many types. As such doctors are rarely available we have to mobilize and utilize all available doctors in the area. Functions and duties of the committee include:
  - To give medical help to all injured as early as possible
  - Civil surgeon is the secretary who will organize his team

- On receiving information to rush to spot he will immediately inform his team and will proceed with all necessary equipments
- First aid and possible treatment shall be provided at the spot or at some convenient place and patients may be requested to shift to hospitals for further treatment
- All efforts shall be made on war basis to save maximum lives and to treat maximum injuries
- Continuity of the treatment shall be maintained till the disaster is controlled

- Traffic Control, Law and Order: The committee is headed by District Superintendent of Police. Functions and duties of this committee should be:
  - To control traffic towards and near disaster , to maintain law and order
  - To evacuate the places badly affected or likely to be affected
  - To shift the evacuated people to safe assembly points
  - To rehabilitate them after disaster is over.
  - Necessary vehicles, wireless sets and instruments for quick communications shall be maintained and used as per need

After Crisis

- At the time of disaster, many people may badly be affected. Injured people shall be treated by medical help, ambulance and hospital committee, but those not injured but displaced kept at assembly points, whose relative or property is lost, houses collapsed and in need of any kind of help shall be treated by this welfare and restoration committee. Functions and duties of this committee are:

- To find out persons in need of human help owing to disastrous effect. They may give first aid if medical team is not available
- They will serve the evacuated people kept at assembly points. They will arrange for their food, water, shelter, clothing, sanitation, and guidelines to reach any needful places
- They will look for removal and disposal of dead bodies, for help of sick, weak, children and needy persons for their essential requirements
- The team will also work for restoration of detached people, lost articles, essential commodities etc.

- The team will also look after the restoration of government articles
- The team will also ensure that the original activities, services and systems are resumed again as they were functioning before the disaster

- Police Department
  - The police should assist in controlling of the accident site, organizing evacuation and removing of any seriously injured people to hospitals.
  - Co-ordination with the transport authorities, civil defence and home guards
  - Co-ordination with army, navy, air force and state fire services
  - Arrange for post mortem of dead bodies
  - Establish communication center
- Fire Brigade
  - The fire brigade shall organize to put out fires and provide assistance as required.
- Hospitals and Doctors
  - Hospitals and doctors must be ready to treat any injuries.
  - Co-ordinate the activities of Primary Health Centers and Municipal Dispensaries to ensure required quantities of drugs and equipments
  - Securing assistance of medical and paramedical personnel from nearby hospitals/institutions
  - Temporary mortuary and identification of dead bodies
- Media
  - The media should have ready and continuous access to designated officials with relevant information, as well as to other sources in order to provide essential and accurate information to public throughout the emergency and to help avoid confusion
  - Efforts should be made to check the clarity and reliability of information as it becomes available, and before it is communicated to public
  - Public health authorities should be consulted when issuing statements to the media concerning health aspects of chemical accidents

- Members of the media should facilitate response efforts by providing means for informing the public with credible information about accidents involving hazardous substances

- Non-governmental organizations (NGO)

- NGO's could provide a valuable source of expertise and information to support emergency response efforts. Members of NGOs could assist response personnel by performing specified tasks, as planned during the emergency planning process. Such tasks could include providing humanitarian, psychological & social assistance to members of community and response personnel.

Duties of NGO are listed below:

- Evacuation of personnel from the affected area
- Arrangements at rallying posts and parking yards
- Rehabilitation of evacuated persons
- Co-ordination with other agencies such as police, medical, animal husbandry, agriculture, electricity board, fire services, home guards and civil defence.
- Establishing shelters for rescue, medical, fire fighting personnel.

Various organizations involved during emergencies are shown in **Fig. 7.27**.

7.1.16 Oil Spill Contingency Plan

An Oil Spill Contingency Plan is an important working document that identifies the oil spill risks, the appropriate response strategies, the resources required to submit a response and the training and exercises necessary to ensure practicality and effectiveness of the plan. The purpose of this document is to provide guidance for the Disaster Management groups at project site.

Levels of Oil Spill

Level I:

Minor spillage, which do not affect the surrounding area limited within port premises and can be managed by the available resources. It calls for activation of On-Site Emergency Plan, as the danger is limited within port premises.

Level II:

Major spillage, where surrounding area get affected and extensive District, State and other Neighbouring Industries' assistance / Coast Guard assistance is required. In this case Off-Site Emergency Plan is to be activated.

Objectives of Oil Spill Contingency Plan

- Pollution control team response within 15 minutes
- To prepare an organisational chart identifying personnel to coordinate during oil spill and assign responsibilities on specific functions to be carried out
- To ensure efficient communication process as the communication plays an important role in the efficient management of an oil spill response
- To identify mutual aid programmes with nearby industries
- To ensure adequacy and efficiency of pollution response equipment such as booms, skimmer etc., personnel protective appliances, medical services & safety and pollution response training of staff
- To prepare a map for showing linkage with other areas and display them at vantage locations
- To maintain weather conditions of each season of local areas (temperature, wind speed and wind direction) for the instant identification of evacuation procedure
- To maintain the surrounding area map showing location of villages, industries, hospitals, police stations, rehabilitation centres and evacuation routes

7.1.17 Management Plan for Natural disasters

7.1.17.1 Flood

The objectives in case of flood at the terminal are to provide timely rescue, immediate medical attention / evacuation and normalize the operations after the emergency is over. Following is the emergency alert process in case of flood at the LNG Terminal shown in **Fig. 7.28**.

Following are the actions to be taken by various key persons and plant teams to tackle the floods effectively shown in **Table 7.15**:

7.1.17.2 Earthquake

The objectives in case of earthquake at the terminal are to minimize the damage to terminal, protect environment and expedite the rescue operations. The emergency alert process in case of earthquake at the LNG Terminal is shown in **Fig 7.29.** The actions to be taken by various key persons and plant teams to tackle the earthquake effectively are shown in **Table 7.16.**

7.1.17.3 Cyclone

The objectives in case of cyclone at the terminal are to prevent the loss to assets, prevent injury or casualties to the extent possible. The emergency alert process in case of cyclone at the LNG Terminal is shown in **Fig. 7.30.** The actions to be taken by various key persons and plant teams to tackle the cyclones effectively are shown in **Table 7.17.**

7.1.17.4 Tsunami

Tsunamis are a series of enormous waves created by an underwater disturbance such as an earthquake, landslide, volcanic eruption, or meteorite. A tsunami can move about 500 miles per hour in the open ocean. Once the wave approaches the shore, it builds in height. The topography of the coastline and the ocean floor will influence the size of the wave. There may be more than one wave and the succeeding one may be larger than the one before. Drowning is the most common cause of death associated with a tsunami. Tsunami waves and the receding water are very destructive to structures. Warning or confirmation should be taken by meteorological stations, coast guards and from TV/Radio news. Following measures may be considered in terminal disaster management with respect to tsunami

- The terminal authorities should make arrangements with the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad for linking up with their Early Warning System (EWS) for mitigation of Tsunami disaster. The system has the following features:
    - Seismic net-worth near real time monitoring of the potential tsunamigenic earthquakes.
    - Interconnected broadband seismic station for real time communication.
    - Bottom pressure recorder deployed in the deep ocean near Andaman and Nicobar islands.

- Tide gauges located in the coasts with key sensors to provide early warning of tsunami.

- Suitable steps on war footing basis may be adopted to restore all the essential services like, electricity, water and food supply, telecommunication, transportation, etc. Proper steps should also ensure the protection and safeguard of properties.
- Tsunami monitoring and warning systems can allow sufficient lead time for preventive measures to be taken to reduce exposure or vulnerability of equipment. Emergency shutdown of processes that depend on pumps, motors or materials located in areas close to the shoreline would reduce the vulnerability that might be triggered by the tsunami.
- Warning would also provide some time, if adequate emergency procedures are established beforehand, to move materials and portable equipment out of harms way to avoid water damage or water intrusion, or to secure any objects, equipment, etc. that could become water borne and inflict debris damage on other equipment
- A series of public awareness campaign can be launched around the terminal area by various means including AIR, Doordarshan and other Media.
- A network of local knowledge centers (rural/urban) should be developed to provide necessary training and emergency communication during crisis time
- Information on tsunami hazards, evacuation routes and the actions to be taken in case of emergency should be provided to surrounding population by distributing pamphlets, organizing the awareness program etc.

7.1.17.5 War Attack / Terrorist Attack

- The site may receive unidentified call / information from intelligence sources about plantation of bombs in ships, jetty, terminal, offices, vehicles and expats residence. Safe evacuation of <u>all</u> staff would be ensured at the site in small groups but away from normal assembly points. 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 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

7.1.18 Rehearsal / Drills

Drills will provide practical training on specific emergency equipment, means of escape and the procedures that personnel should follow in an emergency. Drills will also establish a routine so that personnel are more likely to follow the established procedures in the stress of a real emergency. The frequency of the drills is given **Table 7.18**.

7.1.19 Exercises

Exercises are required to demonstrate that personnel are able to respond effectively to an emergency, to identify the strengths and weaknesses in the emergency procedures and any training needs not yet fulfilled. Types of exercise should include:

- Individual plant emergencies based upon pre-planned scenarios which will test the shift teams and day workers ability to deal with local emergencies.
- Major in-house exercises which will test the overall state of readiness of the port and terminal to deal with a site emergency.

HSE department should co-ordinate the site emergency exercises on a quarterly basis and a crisis response (desktop exercise) at least annually. Shift Superintendents (incident controllers) will co-ordinate the local emergency exercise. Time taken by ambulance and emergency response team reaching to the site should be monitored.

7.1.20 Records and Updating the Plan

Recording Events

During an emergency an accurate log of events should be maintained. For a site emergency and crisis response, this should be the task of Duty Manager in the Emergency Control Center and the Panel operator in the Process control room. A board should also be maintained detailing the current status of the incident and the facilities involved. Any one of the Emergency response team members should carry out this task.

Updating Plan

The Plan should be reviewed and updated by HSE Manager in consultation with Port and Terminal Management team from time to time based on experience gathered from drills, exercises, incidents and emergencies.

Emergency Introduction Booklets

Emergency introduction booklets should be distributed to all staff and Contractors.

References

1) Dow fire and explosion index hazard classification guide, seventh edition 1994 Published by AIChE

2) Techniques for assessing industrial hazards by World Bank

3) Marshall, V.C. (1977)' How lethal are explosives and toxic escapes'

4) Failure Rate and Event Data for use within Risk Assessments (28/06/2012) by HSE UK, from RAS/06/05 by Keeley.

5) OGP Risk Assessment Data Directory, Report No. 434 – 1 March 2010

7.2 Hydrodynamic Study – Coastline Changes

In order to examine the technical feasibility of the proposed FSRU based LNG Terminal, APGDC engaged M/s CW&PRS to conduct detailed hydrodynamic studies, as per point no (viii) and (x) of the Terms of Reference issued by MoEF vide their letter no 11-70/2012-IA-III, to investigate effect of proposed dredging, on leeside of breakwater and widening and deepening of the approach channel and turning circle on the surrounding wave hydrodynamics and its subsequent effect on the adjacent coastline near the project site including Uppada if any, in line with the MoEF OM dated 3.11.2009.

7. 2.1 Methodology

Mathematical model studies for wave propagation were carried out to investigate the wave conditions along the approach channel and near the coastline adjacent to the project site and Uppada in particular. As part of the study, the following were carried out:

- Analysis of UK Meteorological Office (UKMO) wave data to obtain offshore wave climate.
- Wave transformation studies to obtain wave heights and wave direction along the approach channel and surrounding area.
- Analysis of nearshore wave conditions after the proposed deepening and widening of the channel and to examine its effect on the shoreline at Uppada.

An area of 72km by 35 km with an unstructured mesh was considered for studies with MIKE –21 SW model which extends up to 100 m in deep sea and high water line near the shore. The model was run for incident waves from NE, ENE, East, ESE, SE, SSE and South which are the predominant wave directions in deep sea (Table 1D) with incident wave height of 4m. The model was run for the highest high water level at 1.5m for conditions: Pre-existing conditions, prior to construction of channel and breakwater, existing conditions and post project developments.

7.2.2 Results and Findings

Wave propagation studies indicate that waves approach predominantly from East, ESE, SE, and SSE directions with percentages 2%, 7%, 74% and 9% respectively. It is observed that there is marginal change in wave heights along the channel as well as near the Uppada coast due to proposed deepening and widening of the channel and dredging of port area in the lee side of the breakwater. It is seen that the wave heights along the coast are seen to reduce or increase by 0.1m to 0.2m with the proposed dredging conditions. The

Uppada coast is at a distance of about 10km from the proposed site of development. There is no significant change in the wave heights, frequency distribution of wave height and wave direction near the Uppada coast due to deepening and widening of the channel.

Changes in the shoreline are mainly due to movement of the sediments in the surf zone, caused by currents generated by the breaking of obliquely incident wind waves. From the results of mathematical model studies of wave transformation, it is seen that there is no significant change in wave conditions near the coast due to deepening and widening of the channel. Therefore the proposed development of FSRU at Kakinada will not have any significant effect on the adjacent coastline. The erosion of the coastline is mainly due to starvation of the beach and the severe wave attack during the monsoon.

7.2.3 : Conclusions

The conclusions of the study are as follow:

- Wave propagation studies carried out for transformation of deep water wave conditions to near shore showed that the directions of wave approach are from East, ESE, SE, and SSE. with percentages 2%, 7%, 74% and 9% respectively.
- There is no significant change in the wave climate in the vicinity of Port area due to deepening and widening of the channel.
- The proposed development of FSRU project is within the KDWP Harbour (Protected) area at Kakinada will not have any significant effect on the adjacent coastline at Uppada.
- The present erosion at Uppada coastline is mainly due to starvation of the beach and the severe wave attack during the monsoon.

7.3 CRZ Demarcation Study

As per terms of the TOR issued by MOEF vide their letter dated 06.11.2012 , point no., (v) a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA, is to be submitted. Accordingly M/s National Institute of Oceanography (NIO), who is one of the authorized agencies of MoEF for carrying out the CRZ demarcation, has been engaged to take up the CRZ surveys along the coastal front of the project region in the north of Kakinada Fishing harbour . Keeping in view the requirement of coastal regulation zone legislation, National Institute of Oceanography has undertaken the project with the following scope of work.

- To delineate the relevant HTL and LTL as per the prescribed policy, practice and procedure of MoEF.
- To measure the set back lines of 200 m and 500 m for open coast and 100 m for the back waters from the HTL Line.

7.3.1 Methodology

M/s NIO has carried out the study in following manner :

1. Conduct the primary field inventory on large scale base map.
2. Gather information on status of eco-system. (such as mangroves, tidal flats, saltpans etc) prevalent.
3. Compile the CRZ map delineating the HTL, LTL and the CRZ.
4. To interpret and demarcate CRZ with optimum level of CAD support.

Delineation of HTL was carried out by using the Differential Global Positioning System techniques (Hemisphere) and the data were collected by following the established principles in survey of this nature. For demarcation of Low Tide Line (LTL), surf zone bathymetry was carried out along the study area. From the surf zone bathymetry, LTL position, was demarcated corresponding to Chart datum (0.000 m) which lies (-) 0.87 m below the MSL for the project area was identified and recorded. WGS-84 Datum and Transverse Mercator Projection have been used for presenting the HTL, LTL on the map and also for preparing the CRZ classification map. Finally the positions of HTL, LTL and CRZ boundary lines were marked on the local CZMP maps in 1: 4000 scale.

7.3.2 Details of Proposed Facilities

Details of proposed facilities attracting the CRZ Notification 2011 are as follows.

Facilities	CRZ/Non-CRZ	Permissible/non permissible	Clause
Proposed LNG Facility comprising of FSRU and satellite jetty with unloading arms, fire pump house, bridge support platform, vent stack, boat landing etc.,	It is in the CRZ IV area	Permissible activity	3 (ii) (b)
3795m length of proposed sub-sea pipeline and cabling from jetty to ORF.	It is in the CRZ IV area	Permissible activity	4 (ii) (d)
93m length of proposed sub-sea pipeline and cabling from jetty to ORF.	It is in the CRZ I area	Permissible activity	4 (ii) (d) and 8 (I) (i) (b)
198m length of proposed sub-sea pipeline and cabling from jetty to ORF.	It is in the CRZ III area	Permissible activity	4 (ii) (d)
74m length of proposed sub-sea pipeline and cabling from jetty to ORF crossing creek I.	It is in the CRZ I area	Permissible activity	4 (ii) (d) and 8 (I) (i) (b)
Proposed ORF consisting control room, gas metering, pipeline pigging facility, Powerback D.G. Set, protective Bound wall etc.,	It is in the CRZ III area	Permissible activity	3 (ii) (b)
Proposed pipeline connectivity to existing gas grid.	It is in the CRZ I & III areas	Permissible activity	4 (ii) (d) and 8 (I) (i) (b)

7.3.3 Conclusions

Based on the guidelines and procedure of MOEF, the following conclusions have been drawn.

- HTL, LTL and CRZ mapping was done for the Proposed setup of FSRU based LNG handling facilities within Kakinada Deep Water Port limits on leeside of the existing Breakwater, Subsea pipeline, Onshore Receive Facility location and connectivity pipeline to existing gas grid for Andhra Pradesh Gas Distribution Corporation Limited, Hyderabad.

- The position of HTL, LTL and CRZ boundaries are demarcated in the scale of 1:25000 (Fig.2) and 1:4000(Figs. 3 & 4). The project layout was superimposed on Google map (Fig.5).
- The whole stretches of the relevant High Tide Line along the coast/river are demarcated by taking into consideration the geomorphic signatures that was discernible in the field.
- Most of the area between HTL and creek I is comprises of vegetation such as Ipomea and Spinifex Squarrous.
- The area between creek II and beach road comprises of terrestrial vegetation.
- The area in between creek I, Creek II and Beach road comprising of casuarinas plantation, grass vegetation and Spinifex Squarrous vegetation.
- The proposed FSRU based LNG terminal, on the Leeside of existing breakwater within Kakinada Deep Water Port limits, is in the off shore area and ORF location is in between the 500m setback liner from HTL of Open sea and Creek-I which is existing in the eastern side.
- The proposed area for ORF location comprises of Spinifex Squarrous vegetation etc.
- . The proposed FSRU based LNG terminal near existing break water is falling in CRZ IV area (Figs.2&3).
- Pipeline from LNG terminal at existing break water to ORF location is passing through the CRZ IV, CRZ I and CRZ III areas (Figs. 2, 3 & 4).
- The proposed development site does not fall or contain the following environmentally sensitive area: National Park and sanctuaries, mangroves, Coral or coral reefs, Area rich genetic diversity, presence of sand dunes.

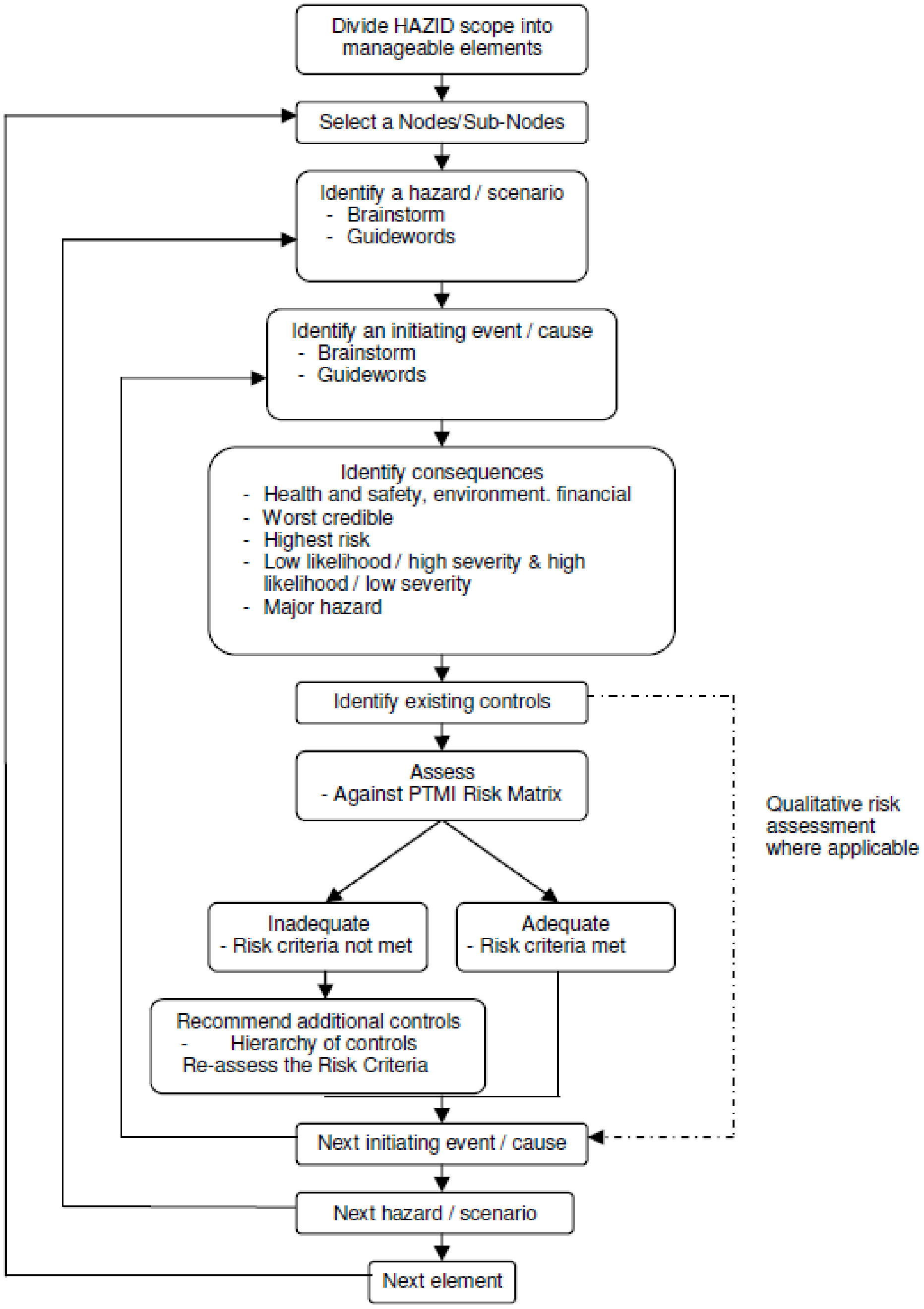


Fig. 7.1: HAZID Process

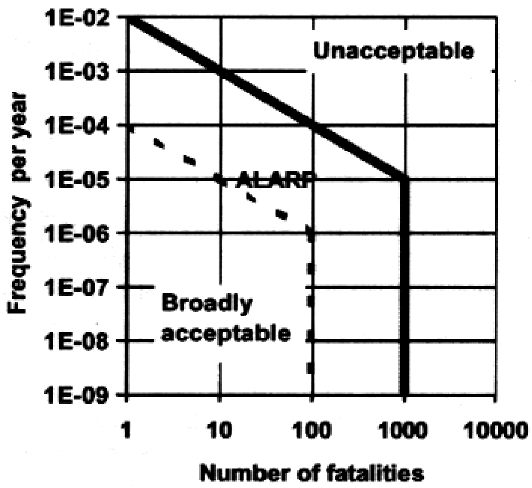


Fig. 7.2: United Kingdom Societal Risk Guidelines (risk to workforce and public)

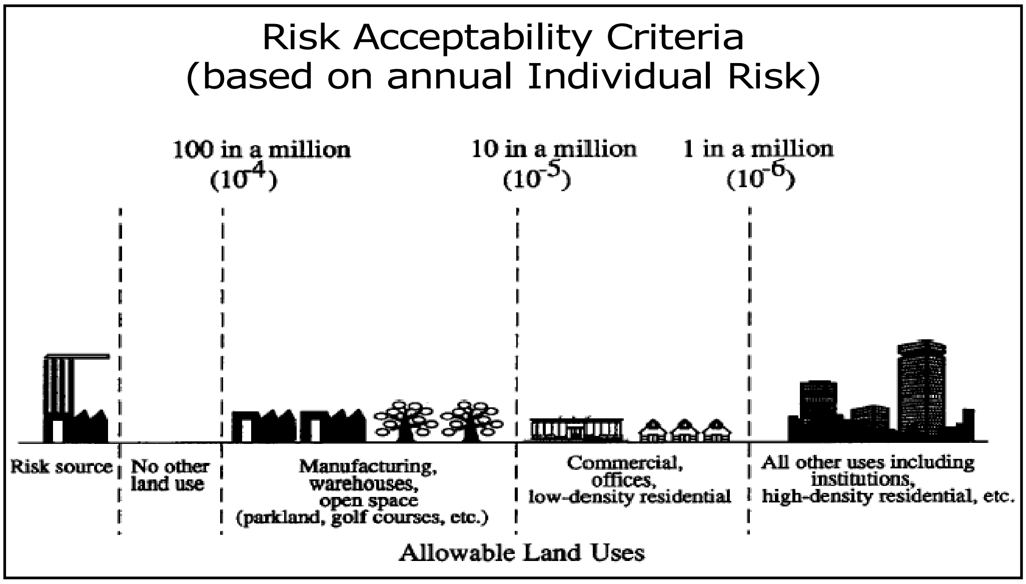


Fig. 7.3: Commonly Acceptable Individual Risks in Different Designated Land Zones

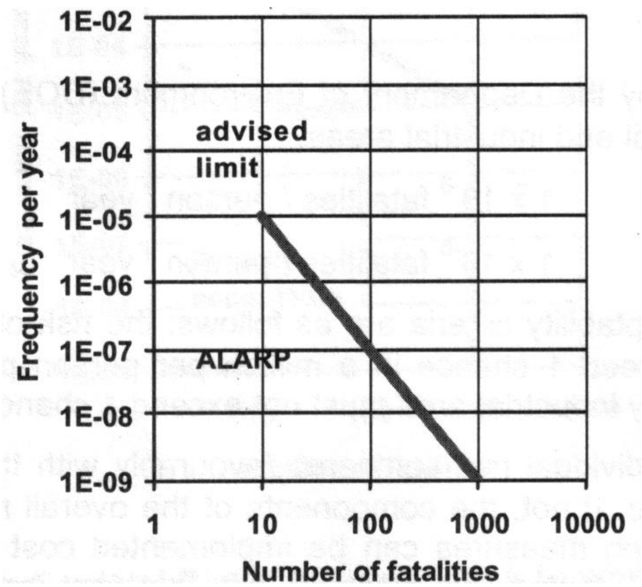


Fig. 7.4: Netherlands Societal Risk Guidelines (risk to public only)

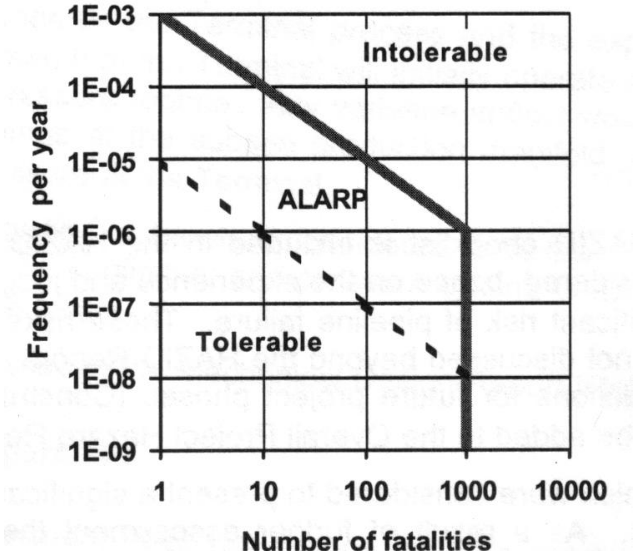


Fig. 7.5: Hong Kong Societal Risk Guidelines (risk to public only)

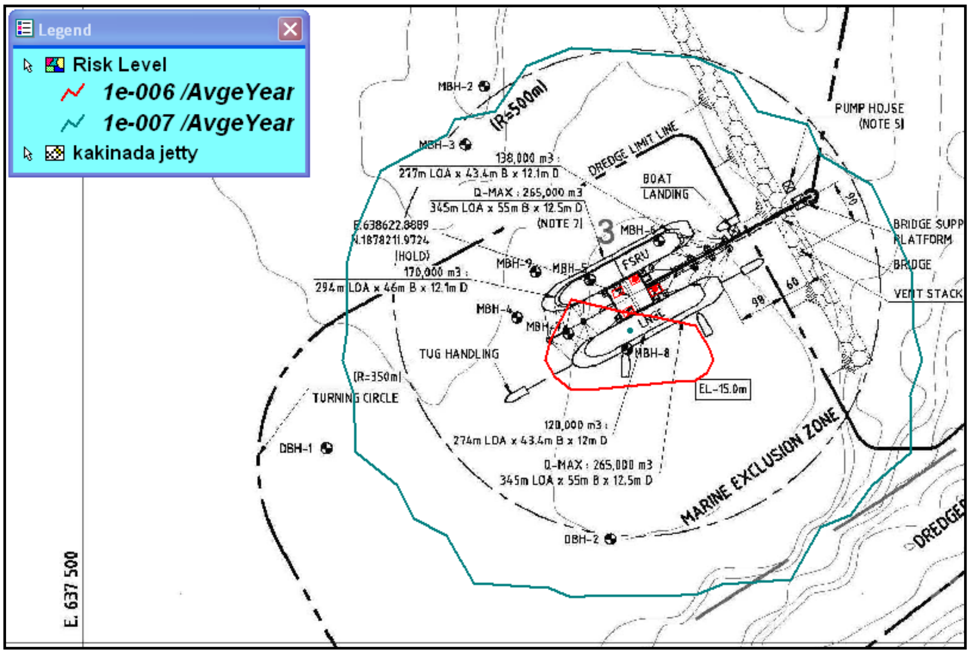


Fig. 7.6: IR contour for LNG Carrier/ Shuttle

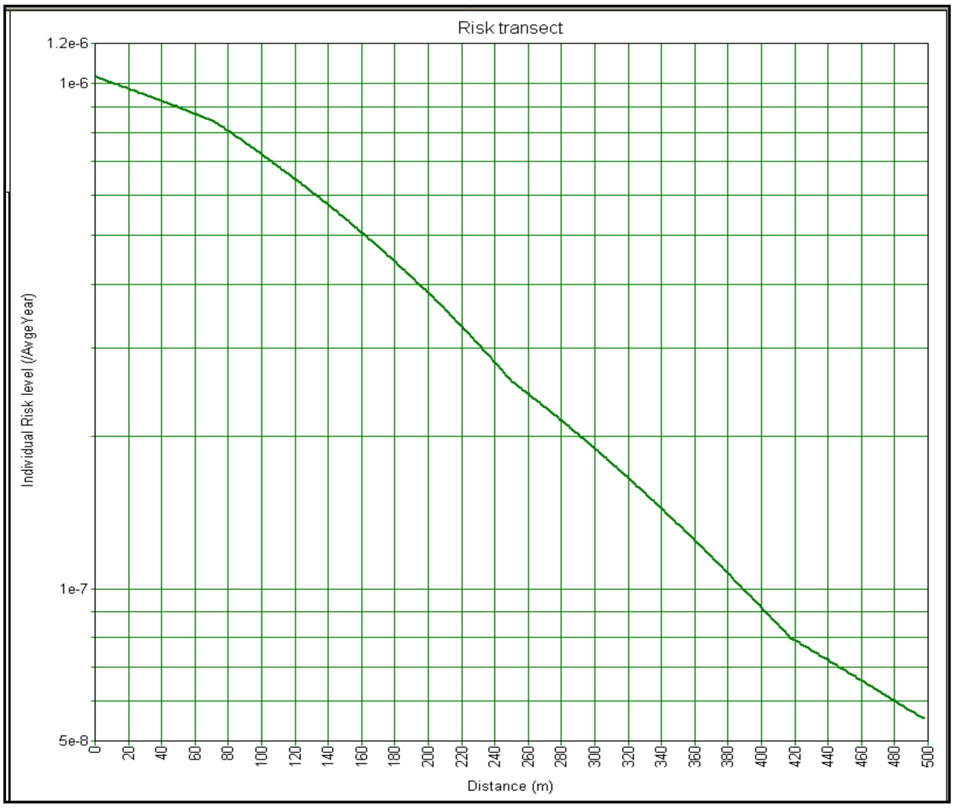


Fig. 7.7: Risk transect for LNG Carrier/ Shuttle

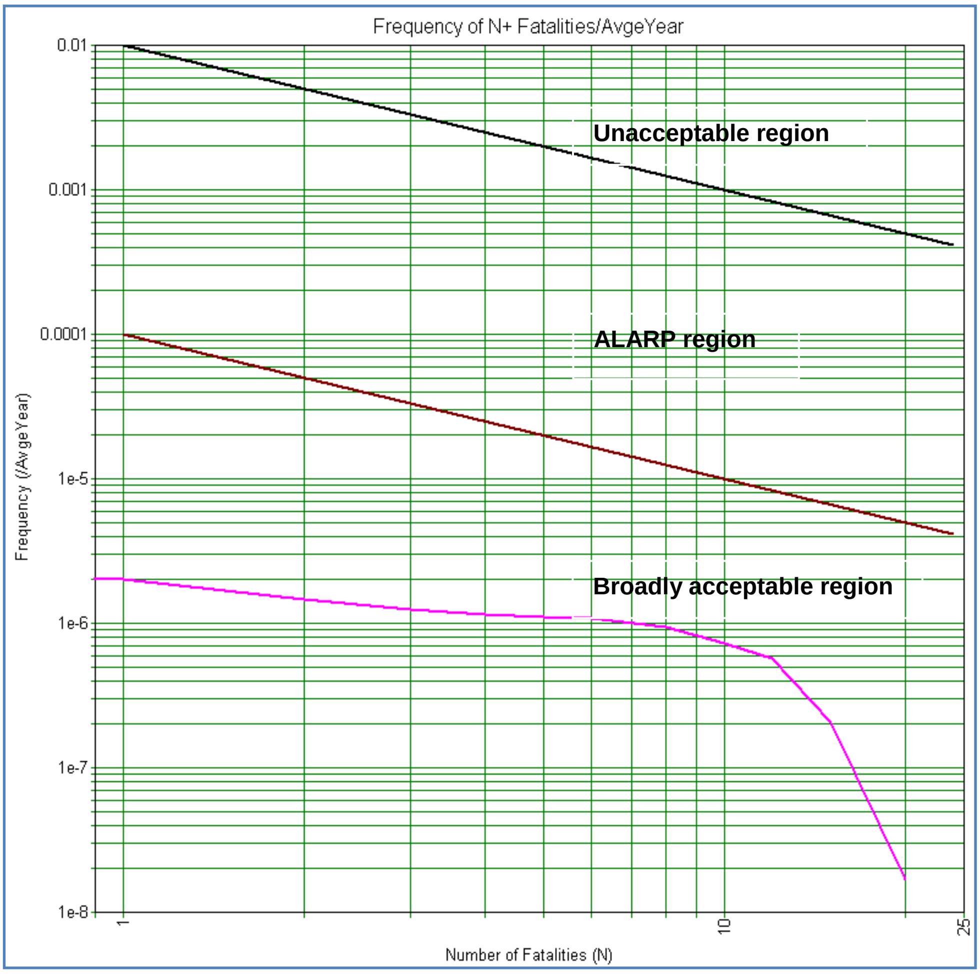


Fig. 7.8: F/N curve for LNG Carrier/ Shuttle

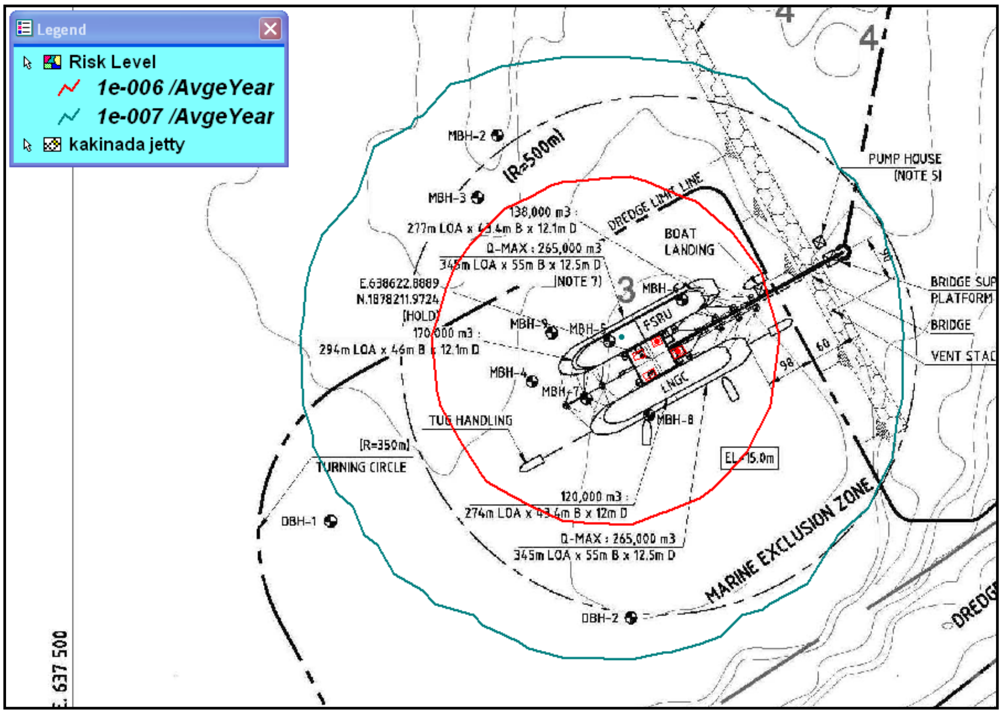


Fig. 7.9: IR contour for FSRU (Vessel)

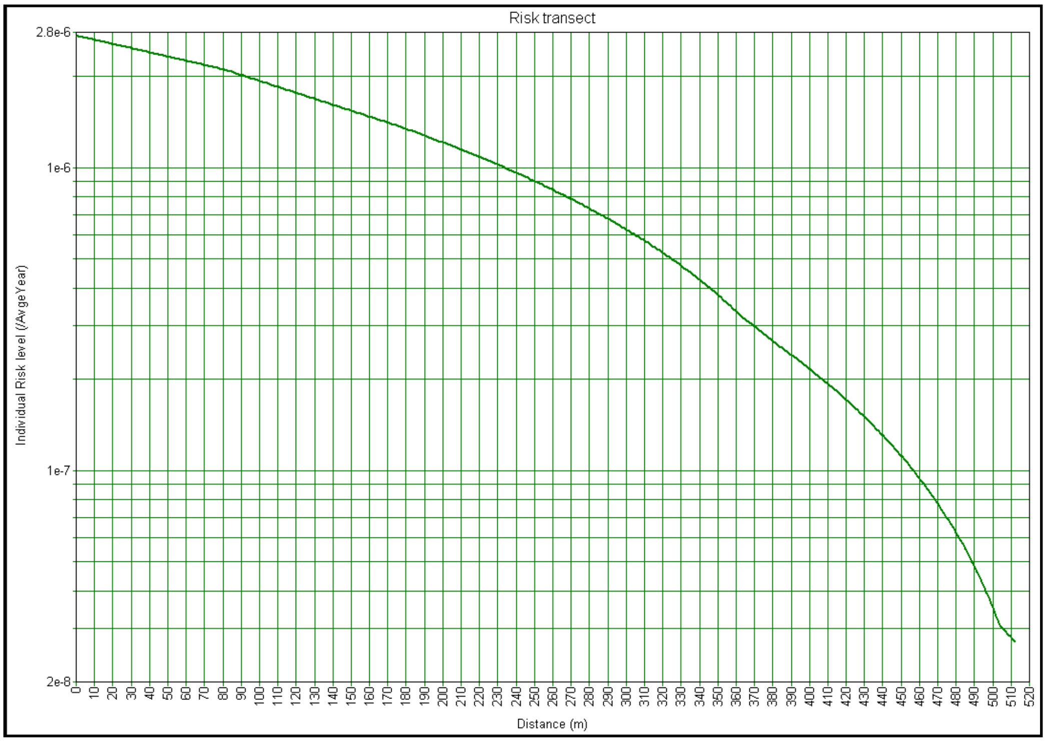


Fig. 7.10: Risk transect for FSRU (Vessel)

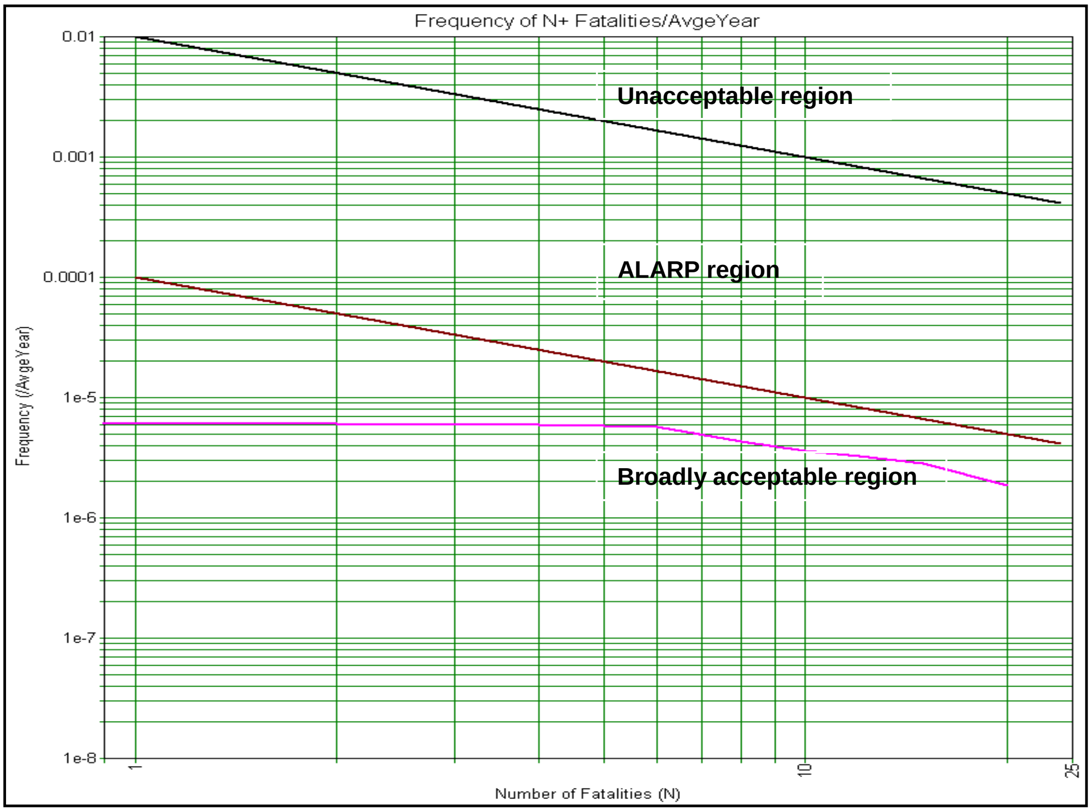


Fig. 7.11: F/N curve for FSRU (Vessel)

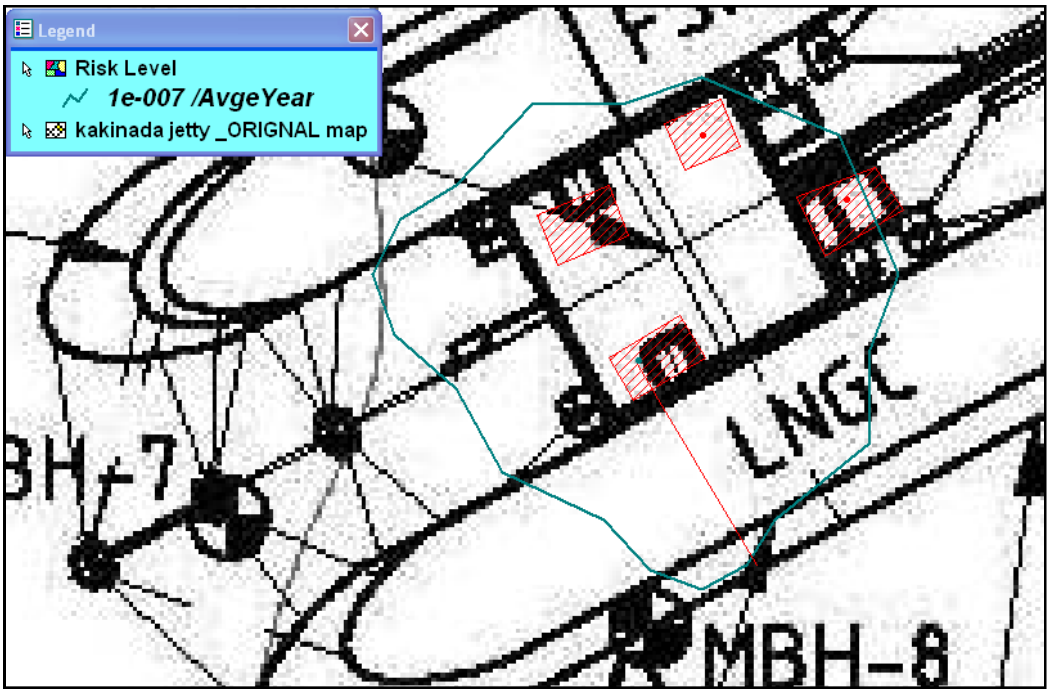


Fig. 7.12: IR contour for LNG Unloading arms

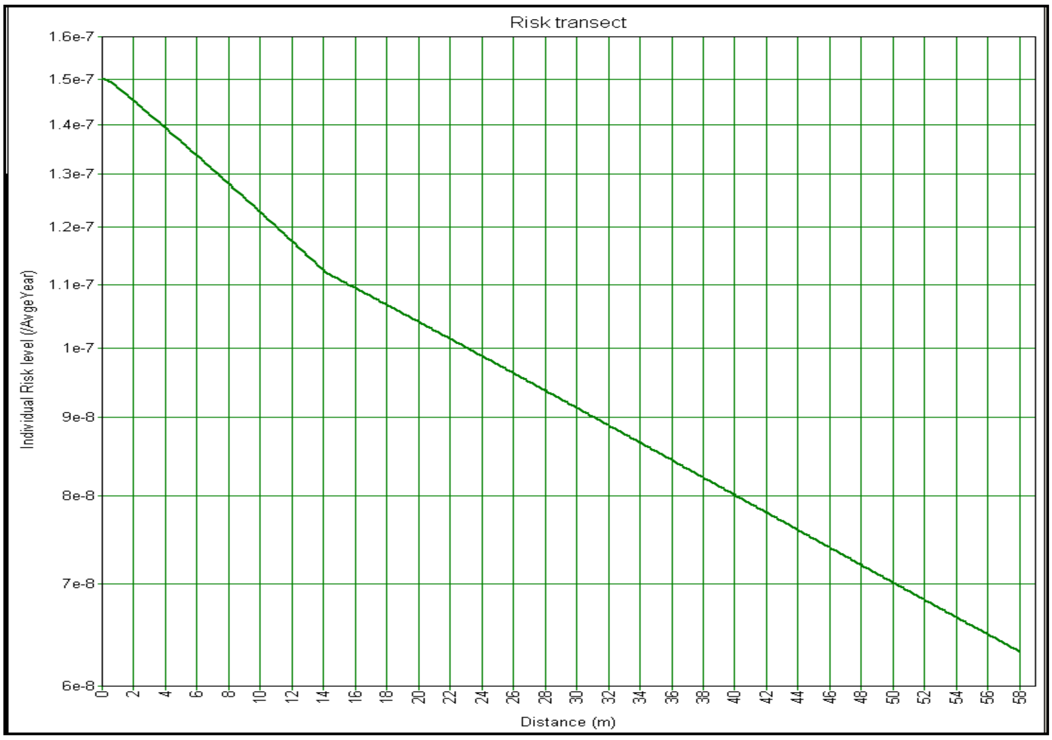


Fig. 7.13: Risk transect for LNG Unloading arms

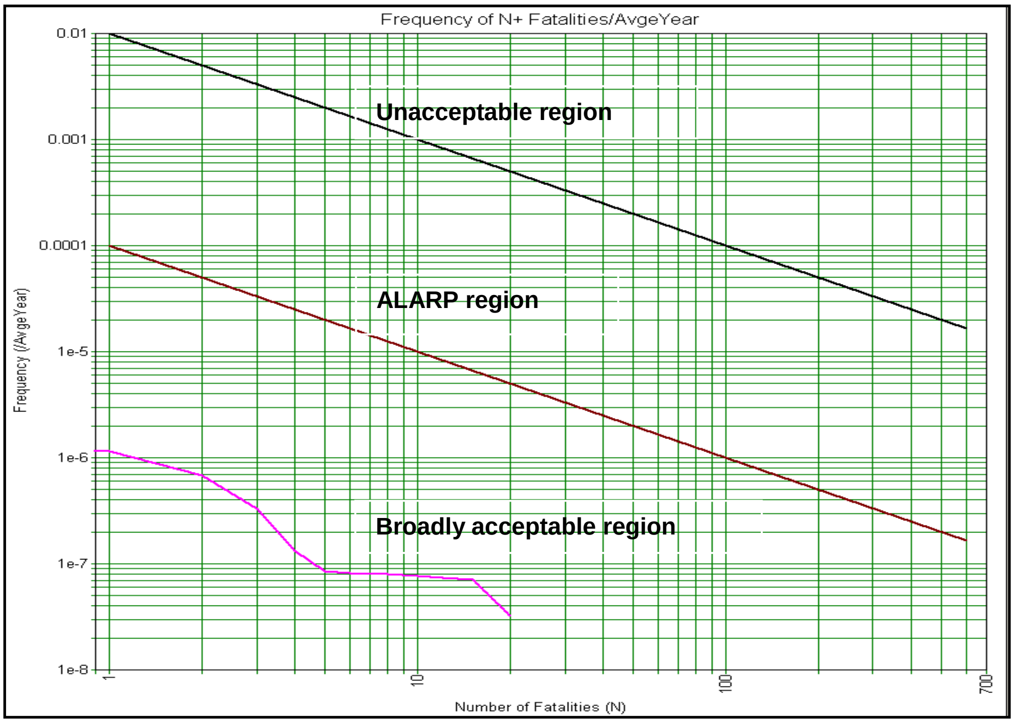


Fig. 7.14: F/N curve for LNG Unloading arms

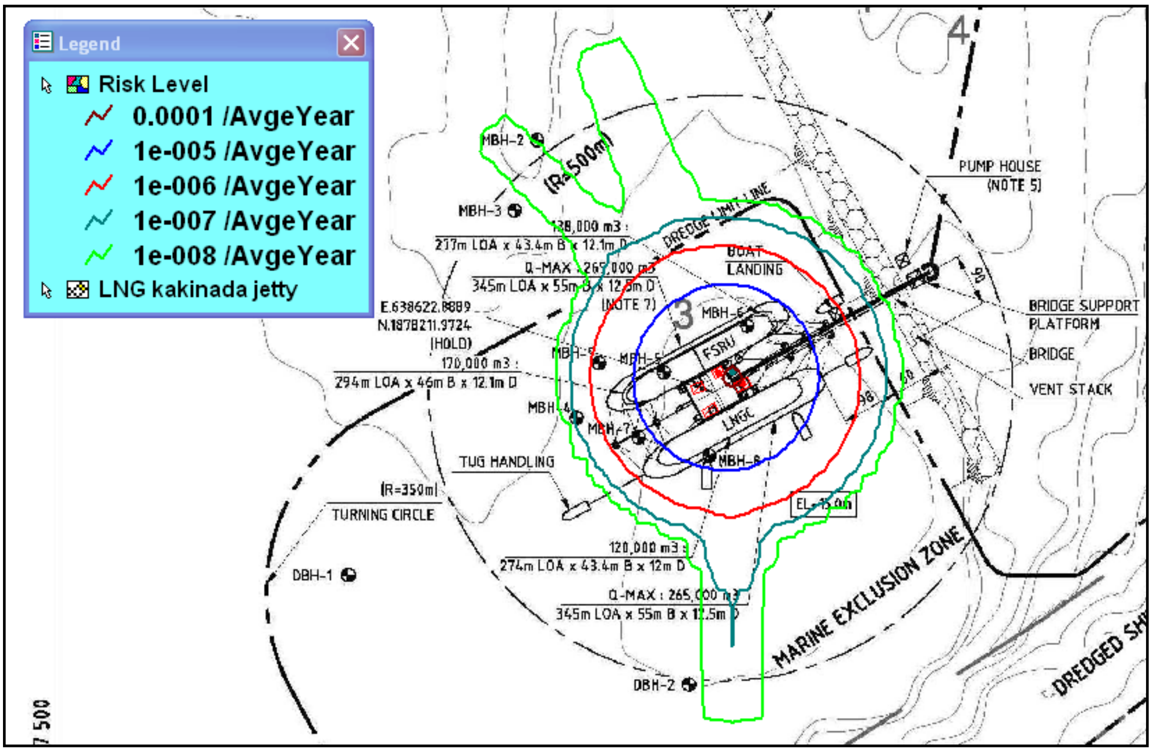


Fig. 7.15: IR Contour for LNG Pump

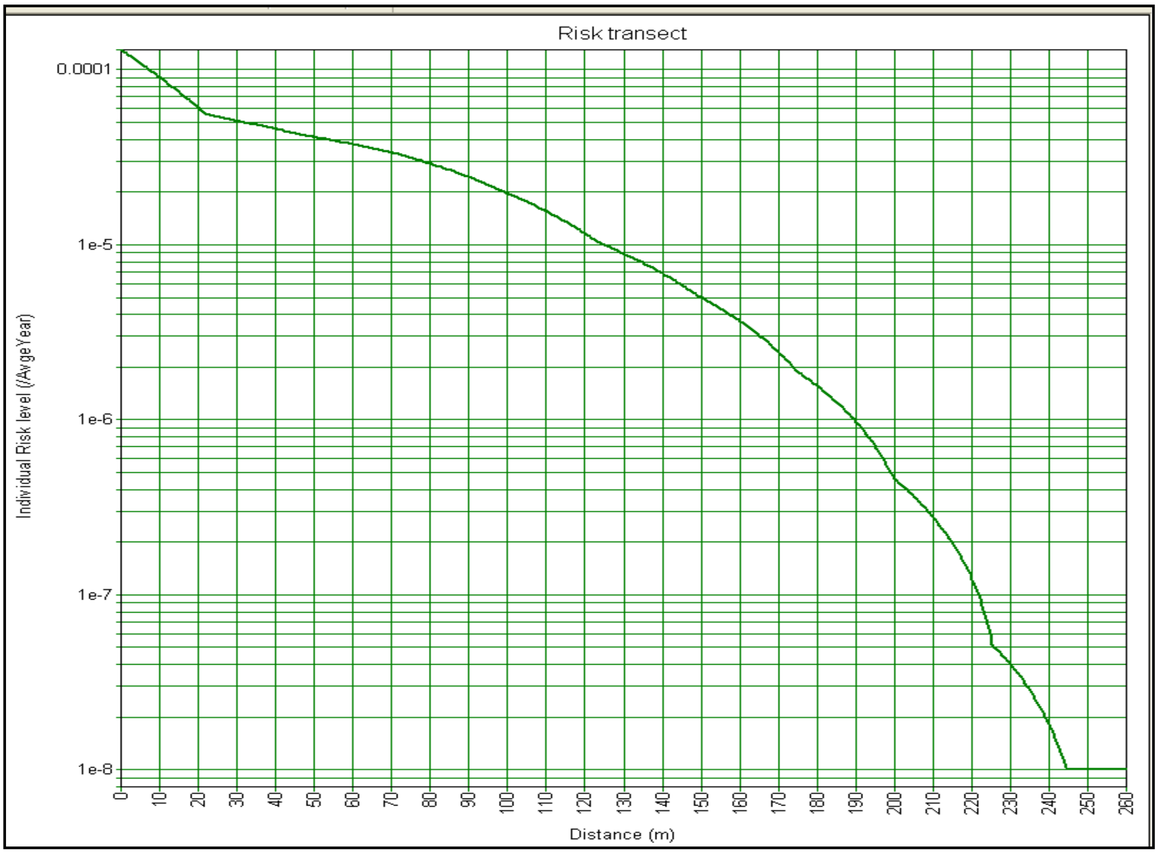


Fig. 7.16: Risk transect for LNG PUMP

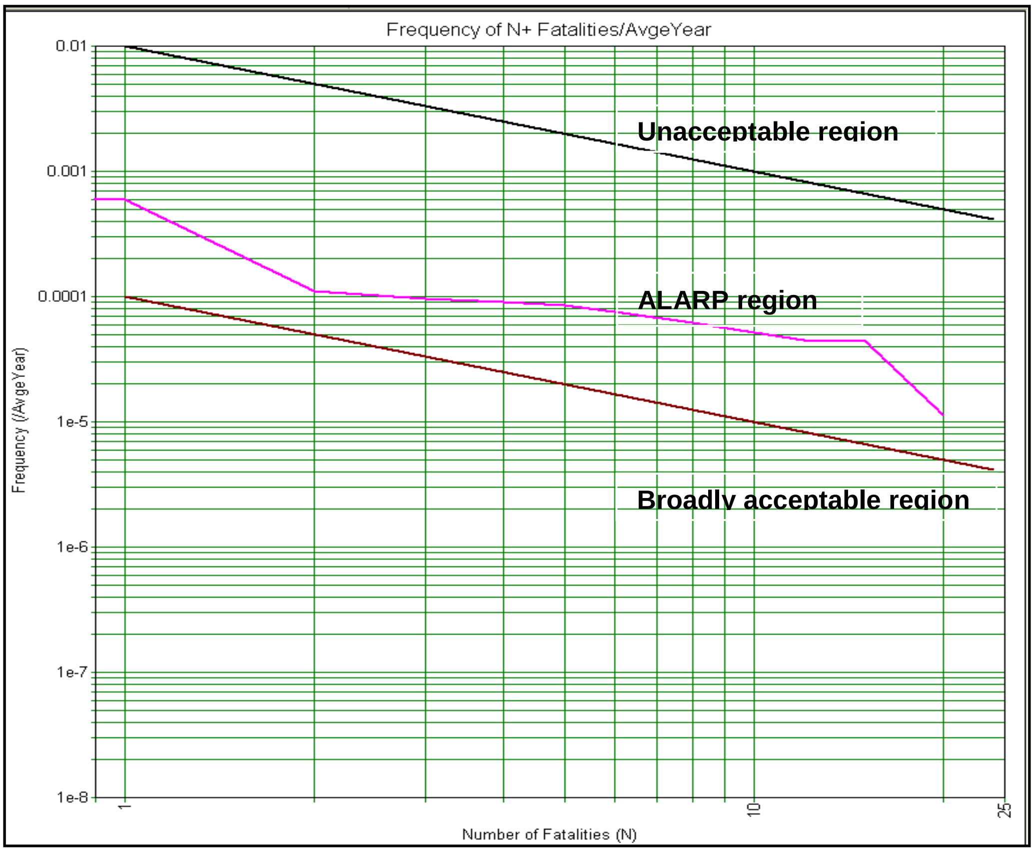


Fig. 7.17: F/N curve for LNG PUMP

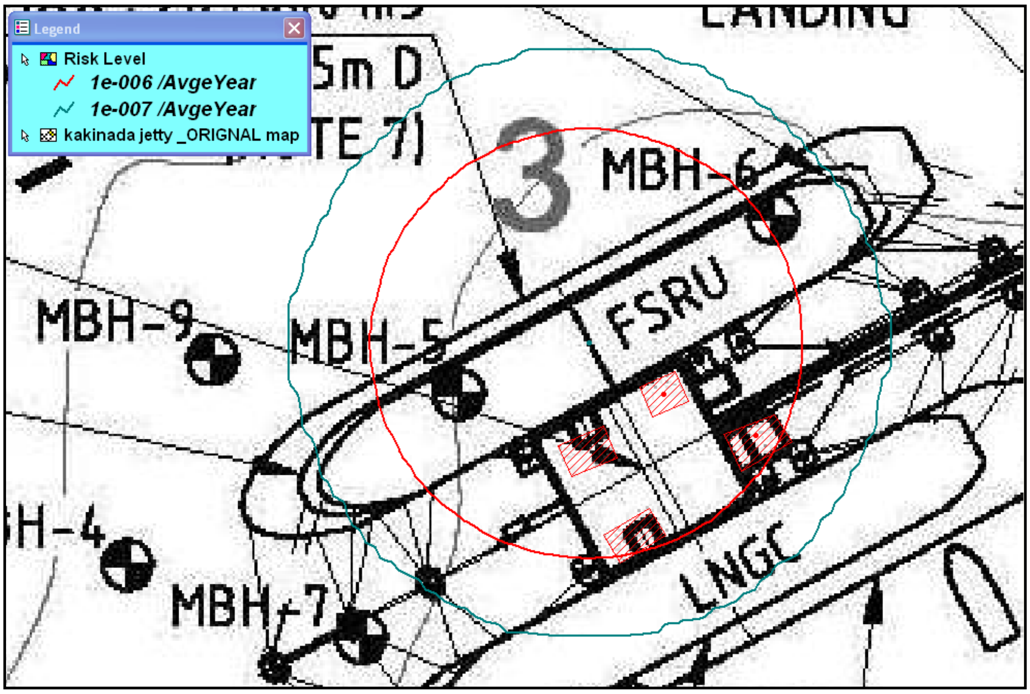


Fig. 7.18: IR contour for LNG Vaporizer

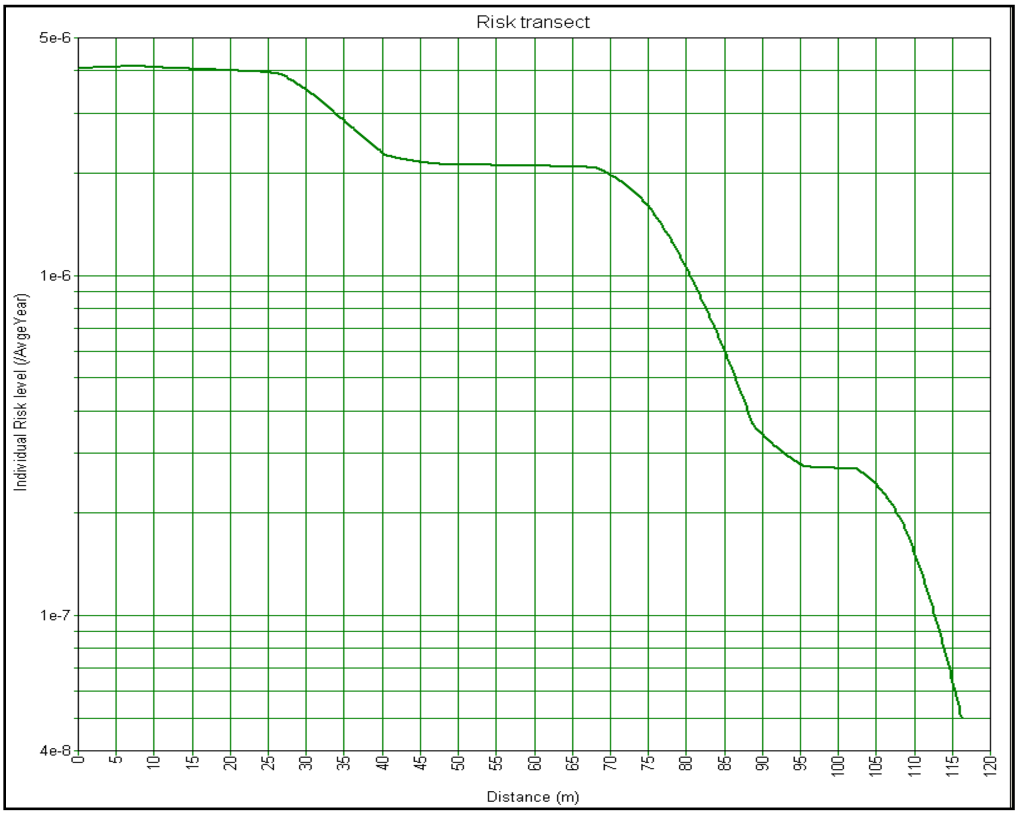


Fig. 7.19: Risk transect for LNG Vaporizer

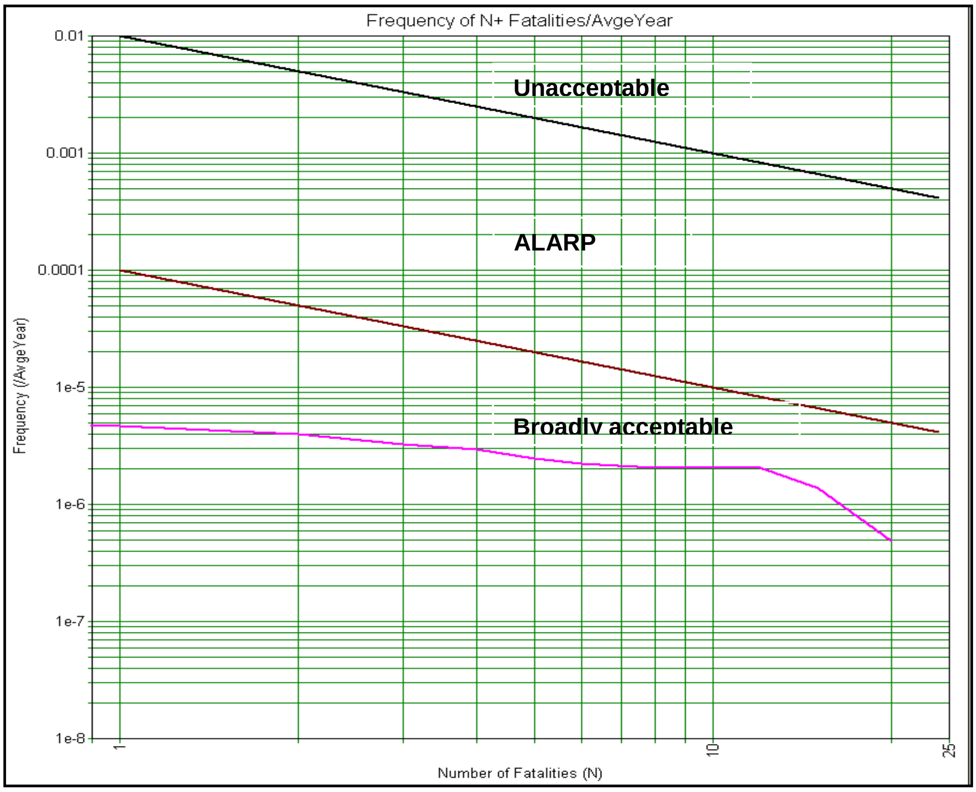


Fig. 7.20: F/N curve for LNG Vaporizer

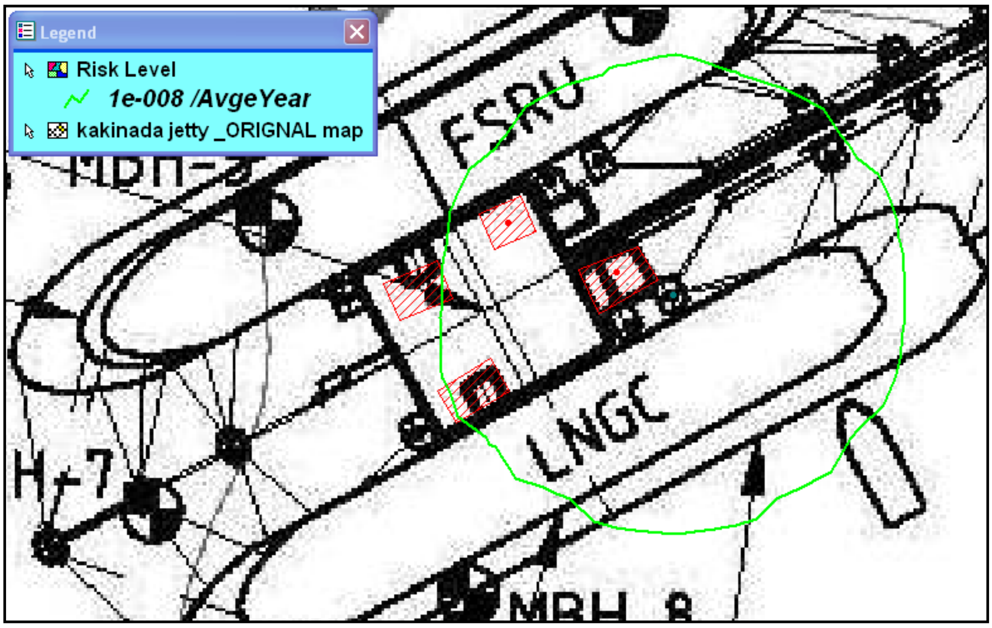


Fig. 7.21: IR contour for HP gas Send out arm

Fig. 7.22: Risk transect for HP gas Send out arm

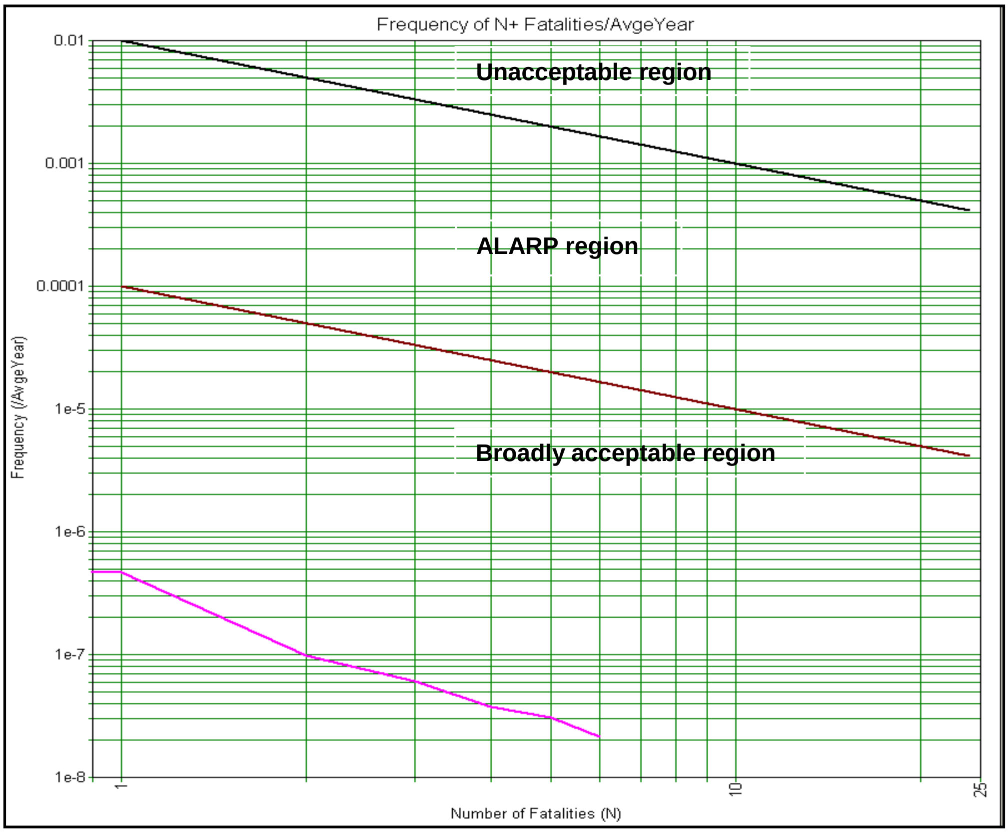


Fig. 7.23: F/N curve for HP gas Send out arm

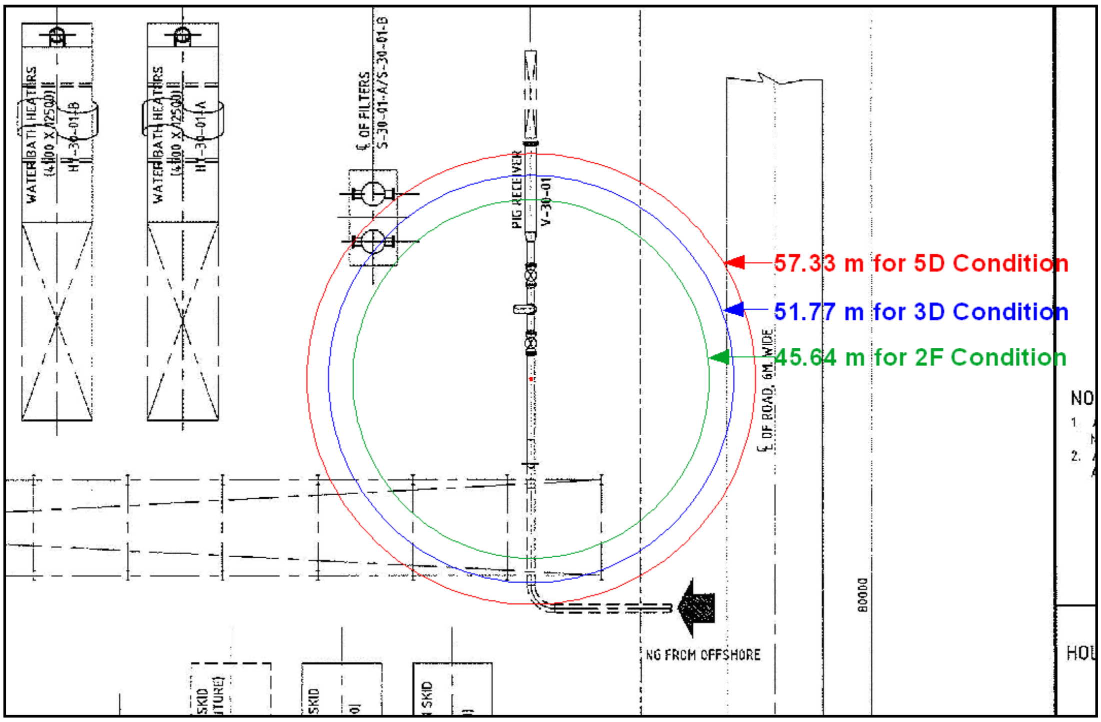


Fig. 7.24 : Damage Contours for Jet Fire due to 50mm Leak in RLNG Pipeline at Onshore Receiving Facility (ORF) at Heat Load 4.0 kW/m²

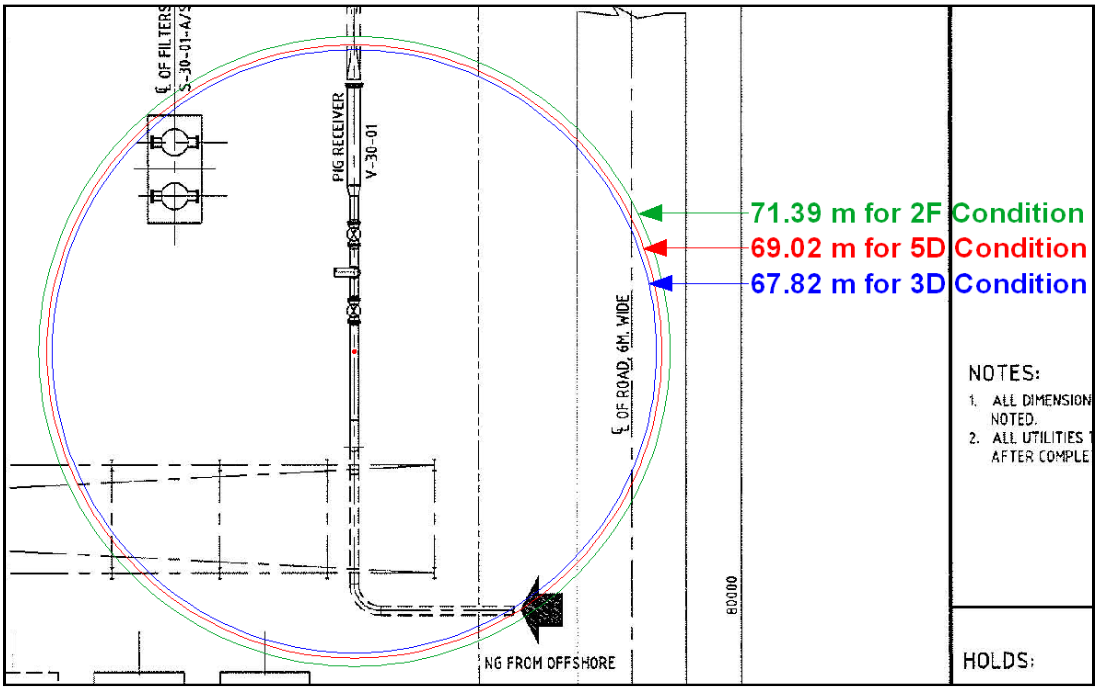


Fig. 7.25: Damage Contours for Flash Fire due to 50mm Leak in RLNG Pipeline at Onshore Receiving Facility (ORF)

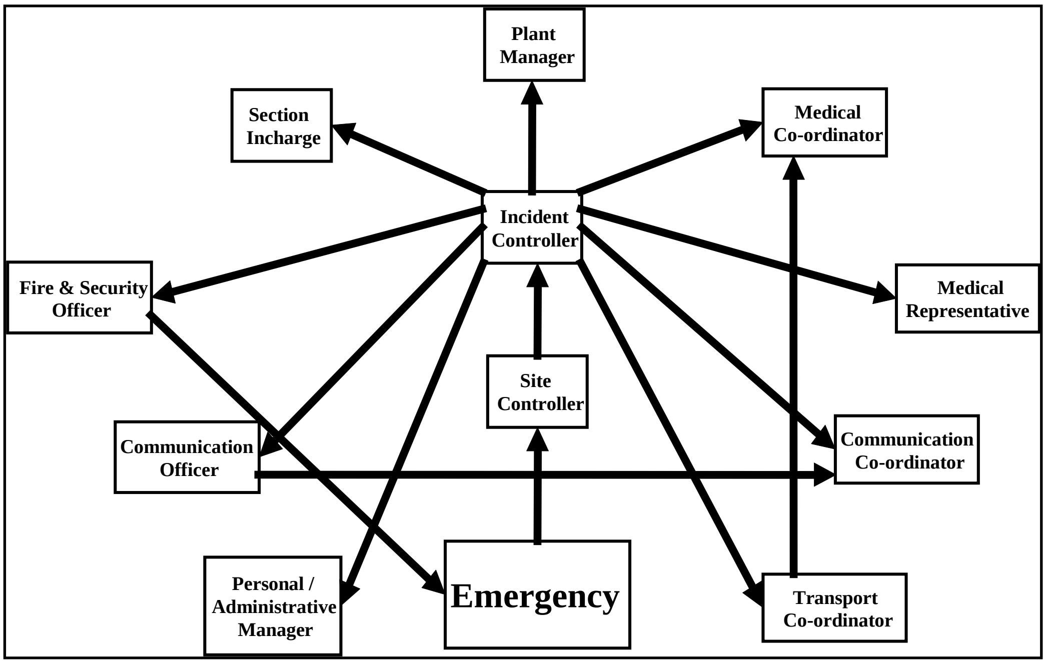


Fig. 7.26: Onsite DMP - Disaster Control / Management System

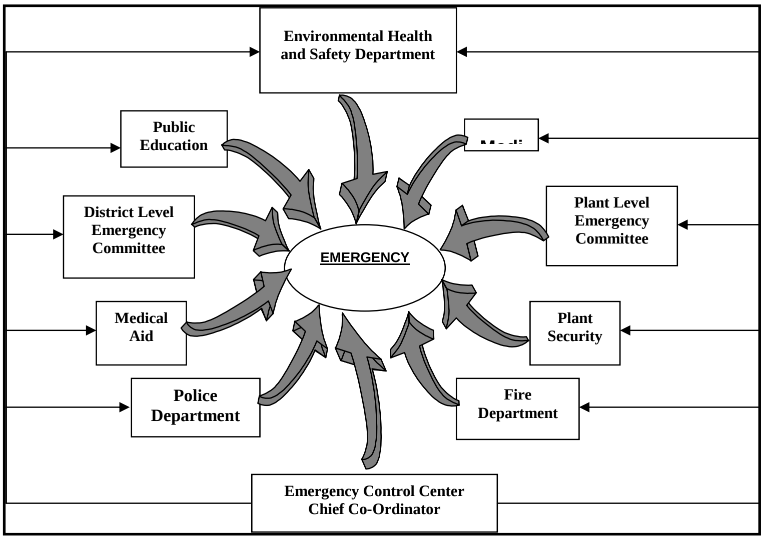


Fig. 7.27: Various Organizations Involved During Emergency

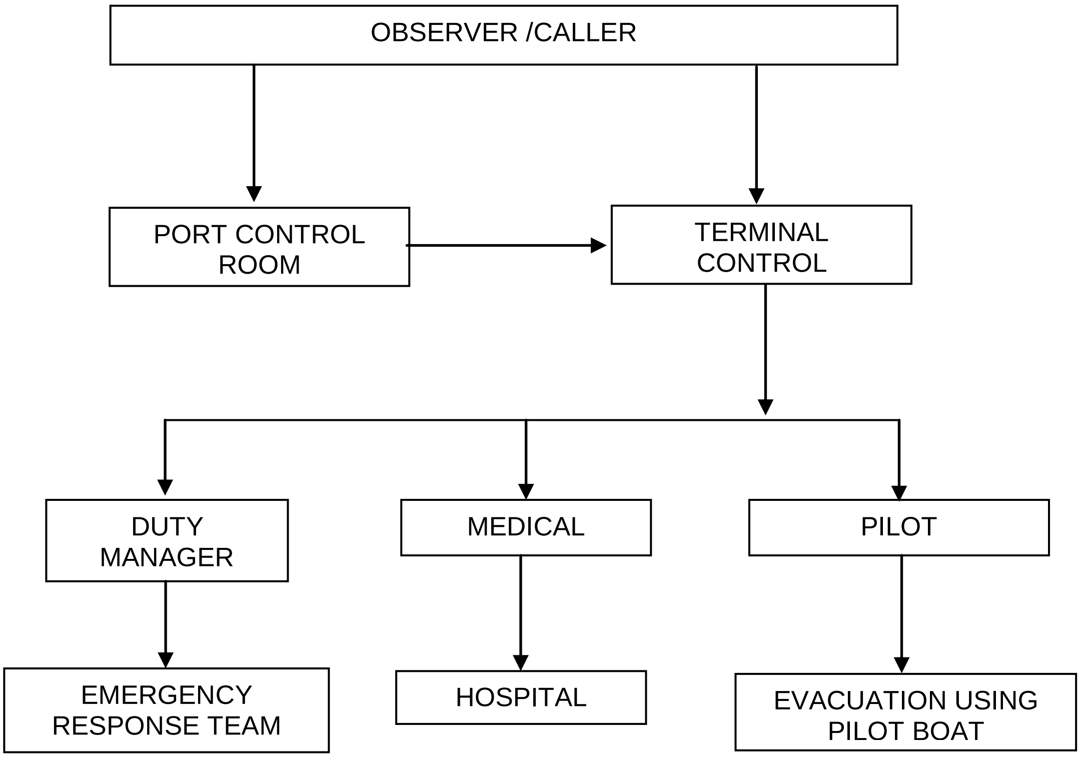


Fig. 7.28: Emergency alert process in case of flood at the LNG Terminal

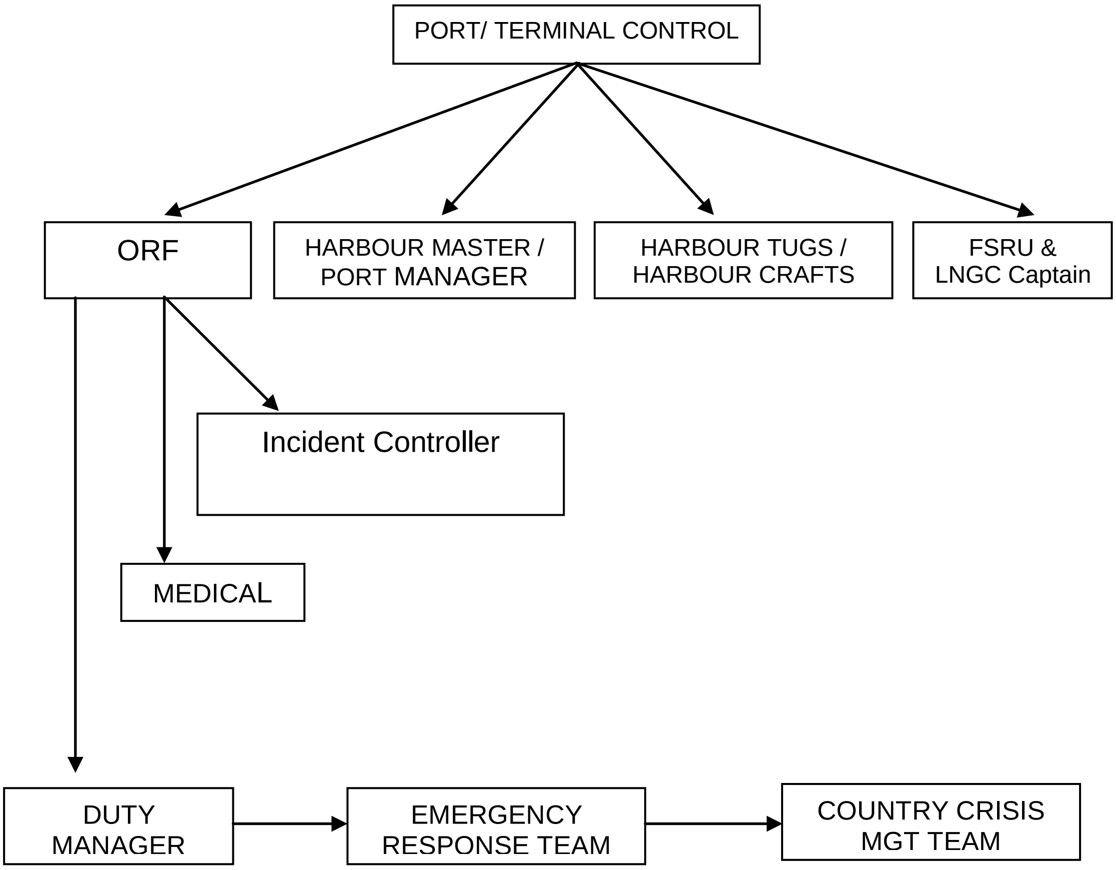


Fig. 7.29: Emergency alert process in case of earthquake at the LNG Terminal

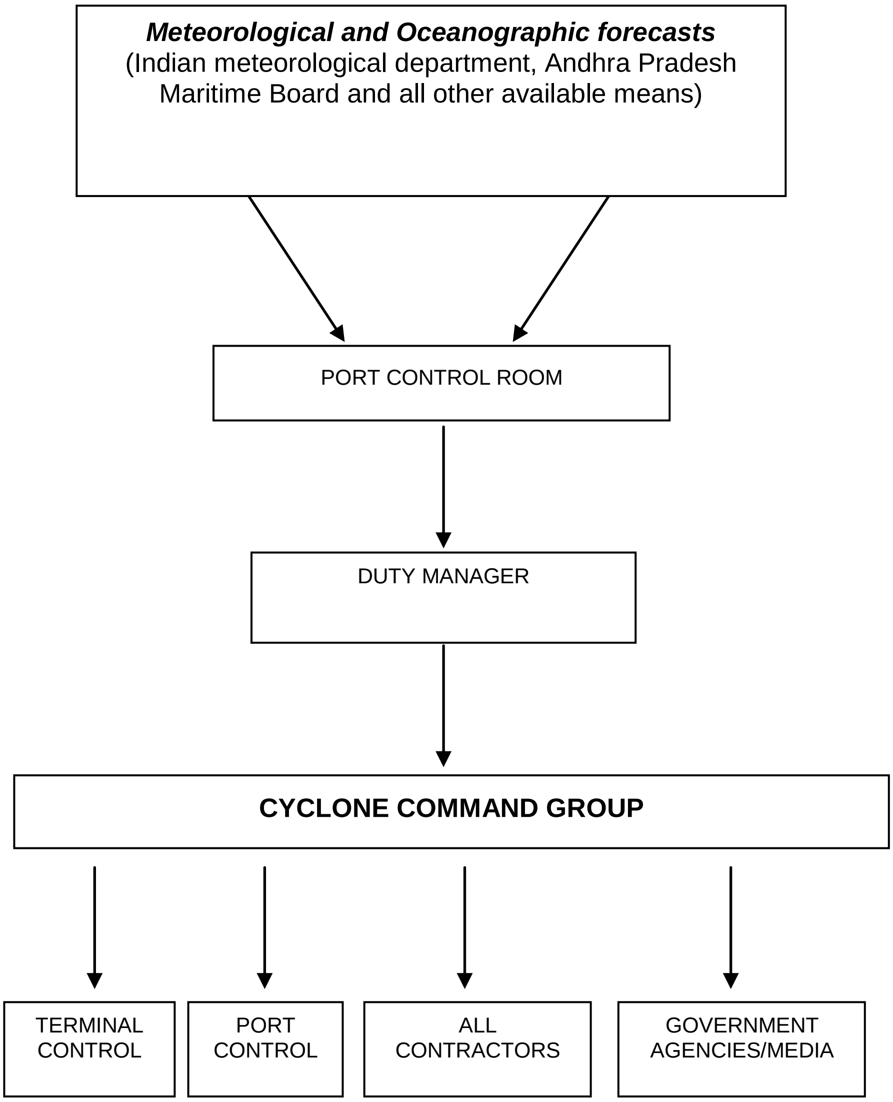


Fig. 7.30: Emergency alert process in case of cyclone at the LNG Terminal

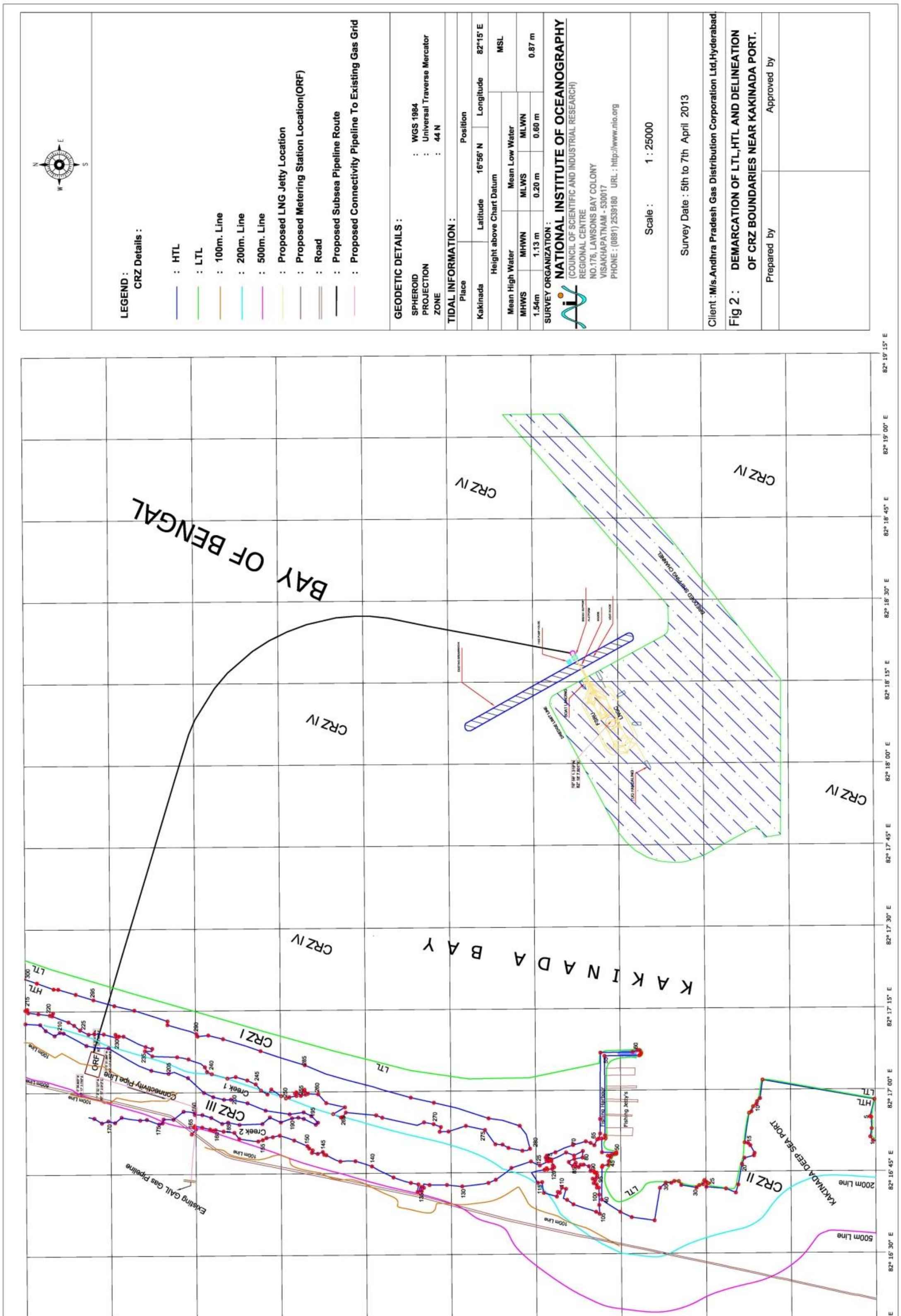


Fig.7.31 : CRZ Demarcation along with HTL, LTL at Project Site

Table 7.1 : Chronological summary of incidents involving LNG ships

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
1	1964/1965	Jules Verne 25,500 M3	While loading LNG in Arzew, Algeria, lightning struck the forward vent riser of the ship and ignited vapour, which was being routinely vented through the ship venting system . Loading had been stopped when a thunderstorm broke out near the terminal but the vapour generated by the loading process was being released to the atmosphere. The shore return piping had not yet been in operation. The flam e was quickly extinguished by purging with nitrogen through a connection to the riser. A similar event happened early in 1965 while the vessel was at sea shortly after leaving Arzew. The fire was again extinguished using the nitrogen purge connection. In this case, vapour was being vented into the atmosphere during ship transit, as was the normal practice at that time.
2	May, 1965	Methane Princess, 27,400 M^3	The LNG loading arms were disconnected before the liquid lines had been completely drained, causing LNG to pass through a leaking closed valve and into a stainless steel drip pan placed underneath the arm s . Seawater was applied to the area. Eventually , a star-shaped fracture appeared in the deck plating in spite of the application of the seawater.
3	May, 1965	Jules Verne, 25,500 M^3	On the fourth loading of Jules Verne at Arzew in May 1965 an LNG spill, caused by overflowing of Cargo Tank No.1, resulted in the fracture of the cover plating of the tank and of the adjacent deck plating. The cause of the overfill has never been adequately explained, but it was associated with the failure of liquid level instrumentation and unfamiliarity with equipment on the part of the cargo handling watch officer.
4	April 11, 1966	Methane Progress 27,400 M^3	Cargo leakage reported.

Contd....Table 7.1

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
5	September, 1968	Aristotle,5,000 M^3	Ran aground off the coast of Mexico. Bottom damaged. Believed to be in LPG service when this occurred. No LNG released.
6	November 17, 1969	Polar Alaska , 71,500 M^3	Sloshing of the LNG heel in No. 1 tank caused part of the supports for the cargo pump electric cable tray to break loose, resulting in several perforations Of the primary barrier. LNG leaked into the inter-barrier space. No LNG released.
7	September 2, 1970	Arctic Tokyo 71,500 M^3	Sloshing of the LNG heel in No. 1 tank during bad weather caused local deformation of the primary barrier and supporting insulation boxes. LNG leaked into the inter-barrier space at one location. No LNG released.
8	Late 1971	Descartes 50,000M^3	A minor fault in the connection between the primary barrier and the tank dome allowed gas into the inter-barrier space. No LNG released.
9	June, 1974	Methane Princess 27,400 M^3	the Methane Princess was rammed by the freighter Tower Princess while moored at Canvey Island LNG Terminal. Created a 3- foot gash in the outer hull. No LNG released.
10	July, 1974	Barge Massachusetts 5,000 M^3	LNG was being loaded on the barge on July 16, 1974. After a power failure and the automatic closure of the main liquid line valves, a small amount of LNG leaked from a 1-inch nitrogen-purge globe valve on the vessel' s liquid header. The subsequent investigation by the US. Coast Guard found that a pressure surge caused by the valve closure induced the leakage of LNG through the bonnet and gland of the 1-inch valve. The valve had not leaked during the previous seven or more hours of loading. Several fractures occurred in the deck plates. They extended over an area that measured about one by two meters. The amount of LNG involved in the leakage was reported to be about 40 gallons. As a result of this incident, The U.S. Coast Guard banned the Barge Massachusetts from LNG service within the U.S. It is believed that the Barge Massachusetts is now working in liquid ethylene service.

Contd....

Contd....Table 7.1

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
11	August, 1974	Euclides 4,000 M^3	Minor damage due to contact with another vessel.No LNG released.
12	November, 1974	Euclides 4,000 M^3	Ran aground at La Havre, France. Damaged bottom and propeller. No LNG released.
13	1974	Methane Progress 27,400 M^3	Ran aground at Arzew, Algeria. Damaged. No LNG released.
14	September, 1977	LNG Aquarius 125,000 M^3	During the filling of Cargo Tank No. 1 atBontang on September 16, 1977, LNG overflowed through the vent mast serving that tank. The incident m a y have been caused by difficulties in the liquid level gauge system . The high- level alarm had been placed in the override m ode to eliminate nuisance alarm s . Surprisingly , the mild steel plate of which the cargo tank cover was m a de did not fracture as a result of this spill.
15	August 14, 1978	Khannur 124,890 M^3	Collision with cargo ship Hong Hwa in the Strait of Singapore. Minor damage. No LNG released
16	April, 1979	Mostefa Ben Boulaid 125,000 M^3	While discharging cargo at Cove Point, Mary land on April 8, 1979, a check valve in the piping system of the vessel failed releasing a small quantity of LNG. This resulted in minor fractures of the deck plating. This spill was caused by the escape of LNG from a swing- check valve in the liquid line. In this valve, the hinge pin is retained by a head bolt, which penetrates the wall of the valve body. In the course of operating the ship and cargo pumping system , it appears that the vibration caused the bolt to back out, releasing a shower of LNG onto the deck. The vessel was taken out of service after the incident and the structural work renewed. All of the check valves in the ship' s liquid system were modified to prevent a recurrence of the failure. A light stainless

Contd....

Contd....Table 7.1

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
			steel keeper was fashioned and installed at each bolt head. Shortly after the ship returned to service, LNG was noticed leaking from around one bolt head, the keeper for which had been stripped, again probably because of vibration. More substantial keepers were installed and the valves have been free from trouble since that time.
17	April, 1979	Pollenger 87,600 M^3	While the Pollenger was discharging LNG at the Distrigas terminal at Everett, Massachusetts on April 25, 1979, LNG leaking from a valve gland apparently fractured the tank cover plating at Cargo Tank No. 1. The quantity of LNG that spilled was probably only a few litres, but the fractures in the cover plating covered an area of about two square meters.
18	June 29, 1979	El Paso Paul Kayser 125,000 M^3	Ran aground at 14 knots while manoeuvring to avoid another vessel in the Strait of Gibraltar. Bottom damaged extensively. Vessel re-floated and cargo transferred to sister ship, the El Paso Sonatrach. No LNG released.
19	December 12, 1980	LNG Taurus 125,000 M^3	Ran aground in heavy weather at Mature Anchorage off Tobata, Japan. Bottom damaged extensively. Vessel re-floated, proceeded under its own power to the Kita Kyushu LNG Terminal, and cargo discharged. No LNG released.
20	Early 1980s	El Paso Consolidated, 125,000 M^3	Minor release of LNG from a flange. Deck plating fractured due to low temperature embrittlement.
21	Early 1980s	Larbi Ben M'Hidi 129,500 M^3	Vaporreleased during transfer arm disconnection. No LNG released.

Contd....

Contd....Table 7.1

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
22	December, 1983	Norman Lady 87,600 M^3	During cool down of the cargo transfer arms , prior to unloading at Sodegaura, Japan, the ship suddenly moved astern under its own power. All cargo transfer arms sheared and LNG spilled. No ignition.
23	1985	Isabella 35,500 M^3	LNG released as a result of overfilling a tank. Deck fractured due to low temperature embrittlement.
24	1985	Annabella 35,500 M^3	Reported as "pressurized cargo tank." Presumably, some LNG released from the tank or piping. No other details are available.
25	1985	Ramadan Abane 126,000M^3	Collision while loaded. Port bow affected. No LNG released.
26	February, 1989	Tellier 40,000 M^3	Wind blew ship from its berth at Skikda, Algeria. Cargo transfer arm s sheared. Piping on ship heavily damaged. Cargo transfer had been stopped. According to some verbal accounts of this incident, LNG was released from the cargo transfer arm s .
27	Early 1990	BachirChihani 125,000 M^3	A fracture occurred at a part of the ship structure, which is prone to the high stresses that m a y accompany the complex deflections that the hull encounters on the high seas. Fracture of the inner hull plating led to the ingress of seawater into the space behind the cargo hold insulation while the vessel was in ballast.No LNG released.
28	May 21, 1997	Northwest Swift 125,000 M^3	Collided with a fishing vessel about 400 km from Japan. Some damage to hull, but no ingress of water.No LNG released.
29	October 31, 1997	Capricorn 126,300 M^3 LNG	Struck a mooring dolphin at a pier near the Steenbok LNG Terminal in Japan. Some damage to hull, but no ingress of water. No LNG released.

Contd....

Contd....Table 7.1

S no.	Year of Incident	Name and Size of the Vessel	Brief description of the Incident
30	September 6, 1999	Methane Polar 71,500 M^3	Engine failure during approach to Atlantic LNG jetty (Trinidad and Tobago). Struck and damaged Petrotrin pier. No injuries, No LNG released.
31	December 2002	Norman Lady 87,000 M^3	A U.S. nuclear submarine, the U.S.S. Oklahom a City , raised its periscope into the ship necessitating her withdrawal briefly from service for repairs due to penetration of outer hull allowing leakage of seawater. No LNG released

Table 7.2: Risk Matrix and Definition

				Consequence				
				Insignificant	Minor	Moderate	Major	Catastrophic
				1	2	3	4	5
		Health & Safety (H&S)		No medical treatment required	Objective but reversible disability requiring hospitalization	Moderate irreversible disability or impairment(<30%) to one or more persons	Single fatality and/or severe irreversible disability (>30%) to one or more persons	Multiple fatalities, or significant irriversible effects to >50 persons
		Natural Environment (ENV)		Minor effects on biological of physical environment but not effecting ecosystem functions	Moderate, short-term effects	Serious medium term environmental effects	Very serious, long-term environmental impairment of ecosystem functions	
		Social / Cultural Heritage		Minor medium-Term social impacts on local population. Mostly repairable	On-going social issues. Permanent damage to items of cultural significance	On-going serious social issues. Significant damage to structures/items of cultural significance		
		Community/ Govt/ Reputation/ Media		Minor adverse local public or medical attention or complaints	Attention from media and/or heightened concern by local community. Criticism by NGOs	Significant adverse national media/public/NGO attention	Serious public or media outcry (International coverage)	
		Legal		Minor legal issues, non-compliances and breaches or regulation		Serious breach of regulation with investigation or report to authority with prosecution and/or moderate fine possible	Major breach of regulation Major Litigation	Significant prosecution and fines. Very serious litigation including class action
		Profit reduction		<US$10K	US$10K-US$100K	US$100K-US$1M	US$1M-US$10M	US$10M+
Likelihood	A	Almost certain	Once a year or more frequently	Medium	High	High	Very High	Very High
	B	Likely	Once every ten years	Medium	Medium	High	High	Very High
	C	Possible	Once every thirty years	Low	Medium	Medium	High	High
	D	Unlikely	Once every 100 years	Low	Low	Medium	Medium	High
	E	Rare	Once every 10,000 years	Low	Low	Medium	Medium	Medium

Table 7.3: HAZID analysis actions details

S.No	Hazard Ref. No.	Recommendation	Risk Ranking
1	1.1.1 B	Elevation of ORF to consider the data from Met ocean Study.	Medium
2	1.1.1 H	Select properly the type of trees to be planted in the green	Medium
3	1.1.2 A	Define appropriate standards for underground electrical	High
4	1.1.4 A	Light protection to be provided by FEED contractor	Medium
5	1.1.4 A	SOP for personnel to take shelter in main control room during lighting storms to be developed	Medium
6	1.1.5 A	Design of ORF shall account for seismic data during FEED	High
7	1.1.5 A	Seismic sensor shall be provided at strategic location in the ORF	High
8	1.1.6 A	Mitigation measures shall be implemented based on recommendations of environmental impact assessment and environmental management plan.	Medium
9	1.1.7 A	Geotechnical Survey to be conducted in FEED and FEED contractor to confirm if piling is required.	Medium
10	1.2.1 A	Water Bath Heater/Diesel Generator specifications to include requirement to comply with local environment regulations	Medium
11	1.2.3 A	Certified vendor to be engaged to collect, treat and dispose water from Water Bath Heater.	Medium
12	1.3.3 A	Check that the ORF location is not within the exclusion Zone	Not Ranked
13	1.4.3 A	Review the possibility of locating the filling station outside the ORF	Medium
14	1.4.11 A	Review the possibility of the pig receiver in consideration of jet fire releases and consider providing fire walls against the release direction	Medium
15	1.4.12 A	Fire protection shall consider the result from QRA study in FEED	Medium
16	1.4.13 A	Provide FM200 for control rooms. Provide fire extinguishers	Medium
17	1.4.14 C	Overpressure design criteria for control room to be defined in FEED.	Medium
18	1.5.1 A	Pipeline design shall consider vacuum drying of subsea pipeline.	Medium
19	1.5.2 A	Confirm the piping design pressure is able to take thermal expansion of gas at 40 deg C ambient temperature.	Medium
20	1.5.3 A	Sizing of diesel tank to be confirmed during FEED	Low
21	1.5.11 A	Consider to provide insulation on water Bath Heater (for energy conservation).	Medium
22	1.6.1 A	Evaluate if aboveground or underground firewater ring main shall be used within ORF in FEED.	Not Ranked
23	1.7.1 A	Material Handling Study to be conducted in FEED.	Not Ranked

Contd....

Contd....Table 7.3

S.No	Hazard Ref. No.	Recommendation	Risk Ranking
24	1.7.2 A	Requirement for override provisions to be identified in FEED.	Medium
25	1.7.3 A	Requirement for bypass provisions to be identified in FEED.	Medium
26	1.8.5 A	Design of Natural Gas header /metering shall consider future Expansions	Not Ranked
27	1.10.1 A	Assess the adequacy for main, backup and emergency power supply during normal operations.	Not Ranked
28	2.1.6 A	FEED design to consider the scenario and design according to code requirement.	Medium
29	2.1.7 A	FEED design to consider scouring and design according to code requirement.	Medium
30	2.3.4 A	Consider providing riser protection in FEED	Medium
31	2.5.1 A	Bypass values (2'') are required around 24'' ESDV.	Not Ranked
32	2.5.6 A	FSRU pump shutoff pressure shall be lower than pipeline design pressure or HIPPS system to be provided.	Medium
33	2.6.2 A	Provide tie-in point in ORF for N2 connection for subsea pipeline purging.	Medium
34	2.8.1 A	FEED contractor to design pipeline to ensure pipeline is pig gable and ensure quality of pipeline (as PMC).	Medium
35	3.1.1 K	Distance for moving safety Zone around LNGC to be defined in pre-FEED.	High
36	4.1.1 K	Distance for moving safety Zone around FSRU to be defined in pre-FEED	High
37	4.5.20 B	Time required to depressurize has to be considered in the design of the HP arm (drift study)	High
38	5.1.3 A	Distance for moving safety zone around LNGC to be defined in pre-FEED.	Medium
39	5.1.7 A	Design of topsides of jetty shall local extreme weather conditions	Not Ranked
40	5.1.7 A	Cryogenic arm design shall be suitable for marine conditions at sea during emergency departure.	Not Ranked
41	5.1.9 B	To confirm if emergency venting (cold venting) is allowed by local/international regulations for permanent installations	Medium
42	5.1.9 C	To confirm FSRU is considered as temporary or permanent installation by Indian regulations.	Medium
43	5.2.4 A	Protective shelter to be provided for diesel/hydraulic containment systems	Medium
44	5.2.4 B	Provide pump in impoundment basin to drain rainwater	Medium
45	5.4.13 A	Firefighting system to be designated as per code requirements and results from site-specific fire safety study.	Medium
46	5.4.13 A	All mooring lines shall be equipped with nylon/ polyesters grommet and ensure that all mooring lines are insulated.	Medium
47	5.5.2 A	Possible liquid carryover to cold vent leading to	Medium

Contd....

Contd....Table 7.3

S.No	Hazard Ref. No.	Recommendation	Risk Ranking
		potential brittleness of cold vent and design to consider this scenario.	
48	5.5.2 B	Indicate nitrogen snuffing system at cold vent on UFDs.	Medium
49	5.5.5 A	Layout to be optimized to reduce the inventory in piping system.	Medium
50	5.5.8 A	Vendor shall confirm if the release of HP regasified LNG trapped between the PERCs of both loading arms can be safely disposed of locally, or a vent connection to a safe location is needed.	Medium
51	5.5.10 B	Activation of disconnection shall be studied based on drifting scenarios, ball valve characteristics and arm envelope.	Medium
52	5.5.14 A	Surge analysis to be conducted in FEED.	Medium
53	5.8.1 A	Provide ladders at forward dolphin side of jetty	High
54	5.8.4 A	Material handling study to be conducted in FEED and mobile crane to be sized according to heaviest equipment.	High
55	6.1.2 A	Access to main road shall be provided upstream of inner creek.	Not Raked
56	6.1.2 A	Outer creek to be delivered towards sea, upstream of inner creek.	Not Raked
57	6.1.3 A	Location of ORF to be checked against relevant OISD based on exclusion zone of ORF results; if no specific requirements, NFPA 59A shall be considered.	Not Raked
58	6.1.3 A	If ORF impacts the public road, location of ORF shall be optimized without compromising the shipping area in the sea.	Not Raked

Table 7.4: Degree of Hazards Based on FEI

FEIRange	Degree of Hazard
0 – 60	Light
61-96	Moderate
97 - 127	Intermediate
128 - 158	Heavy
159 and Above	Severe

Table 7.5: Fire and Explosion Index for Process Units

Sr. No.	Unit Name	FEI	Category
Fire and Explosion Index			
1	**LNG carrier**	112.66	Intermediate
2	**FSRU (Vessel)**	112.66	Intermediate
3	**LNG unloading and Loading arms**	37.80	Light
4	**LNG pump**	40.95	Light
5	**LNG vaporizer**	116.55	Intermediate
6	**HP Gas Send out Arm**	37.8	Light
7	**RLNG pipeline (ORF)**	37.8	Light
8	**Diesel oil**	22.4	Light

Table 7.6: Pasquill – Giffard Atmospheric Stability

Sr. No.	Stability Class	Weather Conditions
1.	A	Very unstable – sunny, light wind
2.	A/B	Unstable - as with A only less sunny or more windy
3.	B	Unstable - as with A/B only less sunny or more windy
4.	B/C	Moderately unstable – moderate sunny and moderate wind
5.	C	Moderately unstable – very windy / sunny or overcast / light wind
6.	C/D	Moderate unstable – moderate sun and high wind
7.	D	Neutral – little sun and high wind or overcast / windy night
8.	E	Moderately stable – less overcast and less windy night
9.	F	Stable – night with moderate clouds and light / moderate wind
10.	G	Very stable – possibly fog

Table 7.7: List of Damages Envisaged at Various Heat Loads[2]

Sr. No.	Heat loads (kW/m^2)	Type of Damage Intensity	
		Damage to Equipment	Human Injury
1	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec
2	25.0	Minimum energy required to ignite wood	50% Lethality in 1 min. Significant injury in 10 sec
3	19.0	Maximum thermal radiation intensity allowed on thermally unprotected equipment	--
4	12.5	Minimum energy required to melt plastic tubing	1% lethality in 1 min
5	7.0	--	First degree burns, causes pain for exposure longer than 10 sec
6	1.6	--	Causes no discomfort on long exposures
Source: NFPA 59 A / EN1473 / OISD 194			

Table 7.8: Damage Criteria for Pressure Waves[3]

Human Injury		Structural Damage	
Peak Over Pressure (bar)	**Type of Damage**	**Peak Over Pressure (bar)**	**Type of Damage**
5-8	100% lethality	0.3	Heavy (90% damage)
7.5-5	50% lethality	0.1	Repairable (10% damage)
2-3	Threshold lethality	0.03	Damage of Glass
1.33-2	Severe lung damage	0.01	Crack of windows
1-1.33	50% Eardrum rupture	-	-
Source: Marshall, V.C. (1977)' How lethal are explosives and toxic escapes'.			

Table 7.9: Consequence Analysis for Jet Fire Scenario

Scenario Considered	Leak Size (mm)	Source Strength (kg/sec)	Weather	Damage Distance (m) for Various Heat Loads		
				37.5 kW/m²	12.5 kW/m²	4.0 kW/m²
LNG Carrier / Shuttle	300	195.11	2F	112.91	118.65	128.36
			3D	121.50	127.86	138.63
			5D	128.78	135.67	147.35
	1000	216.79	2F	247.50	261.04	290.68
			3D	265.73	287.87	317.47
			5D	251.63	268.52	297.02
FSRU Vessel	300	326.49	2F	152.33	167.69	187.34
			3D	176.42	187.65	206.63
			5D	187.56	195.39	215.39
	1000	3627.68	2F	318.80	351.07	411.55
			3D	357.41	387.19	437.13
			5D	370.38	399.99	449.58
LNG unloading arms	25	2.70	2F	37.86	36.26	38.28
			3D	36.54	37.92	39.90
			5D	36.54	37.92	39.90
	50	10.84	2F	61.42	67.52	69.75
			3D	67.16	70.13	75.09
			5D	67.16	70.14	75.10
LNG pump	25	29.63	2F	52.53	71.06	99.37
			3D	20.19	77.15	97.91
			5D	62.67	77.31	90.31
	50	118.55	2F	96.91	131.96	187.44
			3D	101.00	137.24	182.63
			5D	59.88	72.21	127.67
LNG Vaporizer	25	10.58	2F	35.42	47.96	57.82
			3D	36.24	45.60	57.95
			5D	37.90	46.83	58.15
	50	42.33	2F	67.73	82.96	110.71
			3D	65.04	87.14	110.64
			5D	67.86	86.30	110.64
HP gas send out arm	25	9.80	2F	37.23	47.38	55.70
			3D	35.02	47.99	55.82

Contd....

Contd....Table 7.9

Scenario Considered	Leak Size (mm)	Source Strength (kg/sec)	Weather	Damage Distance (m) for Various Heat Loads		
				37.5 kW/m²	**12.5 kW/m²**	**4.0 kW/m²**
			5D	36.61	45.18	56.01
	50	39.23	2F	61.79	80.34	106.96
			3D	67.08	81.48	107.22
			5D	65.84	87.59	106.94
RLNG pipeline (ORF)	25	7.28	2F	-	-	22.15
			3D	-	-	26.07
			5D	-	8.60	29.61
	50	29.15	2F	-	-	45.64
			3D	-	-	51.77
			5D	-	21.13	57.33

Table 7.10: Consequence Analysis for flash fire

Scenario Considered	LFL Concentration (ppm)	Leak Size (mm)	Source Strength (kg/sec)	Weather	LFL Distance (m)
LNG Carrier / Shuttle	44000	300	195.11	2F	670.81
				3D	288.29
				5D	220.28
		1000	2167.95	2F	1905.47
				3D	588.75
				5D	528.71
FSRU Vessel	44000	300	326.49	2F	476.93
				3D	322.97
				5D	346.76
		1000	3627.7	2F	1347.35
				3D	1152.05
				5D	972.89
LNG unloading arms	44000	25	2.71	2F	65.44
				3D	56.22
				5D	47.23
		50	10.84	2F	145.52
				3D	107.13
				5D	88.58
		Line Rupture	-	2F	1099.8
				3D	576.1
				5D	469.1
LNG pump	44000	25	29.64	2F	127.19
				3D	120.99
				5D	127.55
		50	118.55	2F	260.99
				3D	267.32
				5D	297.23
LNG Vaporizer	44000	25	10.58	2F	37.33
				3D	35.23
				5D	37.78
		50	42.33	2F	91.55
				3D	85.04
				5D	87.53
HP gas send out	44000	25	9.81	2F	35.99

Contd....

Contd....Table 7.10

Scenario Considered	LFL Concentration (ppm)	Leak Size (mm)	Source Strength (kg/sec)	Weather	LFL Distance (m)
arm				3D	37.25
				5D	32.68
		50	39.24	2F	86.72
				3D	80.20
				5D	82.58
		Line Rupture	-	2F	522.37
				3D	519.76
				5D	527.18
RLNG pipeline (ORF)	44000	25	7.29	2F	29.40
				3D	27.39
				5D	26.41
		50	29.15	2F	71.39
				3D	67.82
				5D	69.02
		Line Rupture	-	2F	783.81
				3D	777.12
				5D	780.48

Table 7.11: Consequence Analysis for Late Pool Fire Scenario

Scenario Considered	Leak Size (mm)	Source Strength (kg/sec)	Pool Radius (m)	Weather	Damage Distance (m) for Various Heat Loads		
					37.5 kW/m²	12.5 kW/m²	4.0 kW/m²
Fuel oil	25	7.52	8.29	2F	15.81	27.82	41.99
				3D	15.90	26.92	47.32
				5D	16.11	29.83	47.61
	50	16.08	15.62	2F	-	27.73	45.52
				3D	-	26.13	47.24
				5D	-	28.31	48.99
	Catastrophic Rupture	-	237.27	2F	-	245.51	396.99
				3D	-	247.95	417.57
				5D	-	250.59	445.32
Diesel oil	25	7.57	7.36	2F	17.92	27.11	39.50
				3D	17.93	26.14	40.49
				5D	17.91	28.59	41.59
	50	11.59	17.26	2F	-	27.19	47.73
				3D	-	27.39	50.33
				5D	-	25.57	52.52
	Catastrophic Rupture	-	142.62	2F	-	148.19	259.73
				3D	-	148.09	277.11
				5D	-	151.20	297.80

Table 7.12: Consequence Analysis for UVCE Scenario

Scenario Considered	Leak Size (mm)	Source Strength (kg/sec)	Weather	Damage Distance (m)		
				0.03bar	0.1bar	0.3bar
LNG Carrier / Shuttle	300	195.1	2F	1151.0	1081.3	1067.2
			3D	938.1	676.8	598.3
			5D	772.5	558.8	479.3
	1000	2167.9	2F	2715.6	2419.9	2309.8
			3D	1748.1	1246.1	1152.9
			5D	1827.9	1265.3	1115.9
FSRU Vessel	300	326.49	2F	1017.5	857.54	836.16
			3D	1087.1	771.61	700.9
			5D	1112.9	817.0	701.3
	1000	3627.7	2F	2057.9	1781.8	1752.9
			3D	2340.9	1749.8	1639.8
			5D	2307.6	1725.7	1627.7
LNG unloading arms	25	2.71	2F	221.45	157.53	137.73
			3D	140.91	100.24	85.10
			5D	118.76	85.06	72.51
	50	10.84	2F	397.14	315.87	298.73
			3D	289.73	209.59	179.76
			5D	228.67	166.35	147.14
LNG pump	25	29.64	2F	406.74	328.32	299.12
			3D	388.63	320.60	295.26
			5D	356.84	289.83	267.88
	50	118.55	2F	798.73	638.87	579.36
			3D	808.65	666.04	612.95
			5D	739.13	596.25	547.05
LNG Vaporizer	25	10.58	2F	138.7	110.77	100.37
			3D	137.37	108.93	99.45
			5D	137.38	108.5	99.24
	50	42.33	2F	329.15	266.55	247.24
			3D	307.32	251.50	230.72

Contd....

Contd....Table 7.12

Scenario Considered	Leak Size (mm)	Source Strength (kg/sec)	Weather	Damage Distance (m)		
				0.03bar	0.1bar	0.3bar
			5D	326.46	271.14	250.54
HP gas send out arm	25	9.81	2F	137.61	110.3	100.14
			3D	132.4	108.08	99.03
			5D	131.47	107.69	98.83
	50	39.24	2F	315.76	255.11	232.52
			3D	297.2	239.75	219.85
			5D	302.88	249.61	229.78
RLNG pipeline (ORF)	25	9.98	2F	-	-	-
			3D	-	-	-
			5D	-	-	-
	50	39.92	2F	-	-	-
			3D	-	-	-
			5D	-	-	-

Table 7.13: Failure Frequencies for various Equipments[4]

Equipments	Events Frequency	
	Leak	Catastrophic
LNGC & FSRU	3×10^{-6}	5×10^{-8}
LNG unloading arm	2.4×10^{-6}	1.7×10^{-7}
Pump[5]	5.9×10^{-4}	4.8×10^{-5}
LNG VAPOURIZER	5×10^{-6}	4×10^{-6}
HP GAS SEND OUT ARM	2.4×10^{-6}	1.7×10^{-7}

Table 7.14: Land use and Industrial Risk According to MIACC

Location (based on risk level)	Possible land uses
From risk source to 1 in 10,000 (10^{-4}) risk contour:	No other land uses except the source facility, pipeline or corridor
1 in 10,000 to 1 in 100,000 (10^{-4} to 10^{-5}) risk contours:	uses involving continuous access and the presence of limited numbers of people bút easy evacuation, e.g. open space (parks, golf courses, conservation areas, trails, excluding recreation facilities such ás arenas), warehouses, manufacturing plants
1 in100,000 to 1 in 1,000,000 (10^{-5} to 10^{-6}) risk contours	Uses involving continuous access but easy evacuation, e.g., commercial uses, low-densily residential areas, offices
Beyond the 1 in 1,000,000 (10^{-6}) risk contour	All other land uses without restriction including institutional uses, high-density residential areas, etc.

Table 7.14:Summary of Recommended Personal Protective Equipment According to Hazard

Objective	**Workplace Hazards**	**Suggested PPE**
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapours, light radiation	Safety glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords	Plastic helmets with top and side impact protection
Hearing protection	Noise, ultra-sound	Hearing protectors (ear plugs or ear muffs)
Foot protection	Failing or rolling objects, points objects. Corrosive or hot liquids	Safety shoes and boots for protection against moving and failing objects, liquids and chemicals
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures	Gloves made of rubber or synthetic material (Neoprene), leather, steel, insulation materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapours	Facemasks with appropriate filters for dust removal and air purification (chemical, mists, vapours and gases). Single or multi-gas personal monitors, if available
	Oxygen deficiency	Portable or supplied air (fixed lines). Onsite rescue equipment
Body / leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration	Insulating clothing, body suits, aprons etc. of appropriate materials

Table 7.15 : Responsibilities during Flood

Observation	Action
Observer/Caller	• Inform Terminal Control room • Exact location of water flooding • Render first aid
Terminal Control Room	• Inform Port control room • Inform Duty Manager • Maintain safe operation of the plant, if not, then shut down
Duty Manager	• Ensure Communication with the site • Convey non-essential staff to stay at home • Evacuate trapped personnel • Utilize Port Pilot Boat to evacuate by river, if safe • Arrange Food/water for on-duty personnel • Arrange Shift Manpower changeover / Rest • Follow alternate road routes • Press water pumps in service
Medical	• Render Medical Assistance • Seek help of other neighboring companies • Consult company doctor • Evacuation to Hospital

Table 7.16 : Responsibilities during Eathquake

Observation	**Action**
Port Control Room	• Inform Terminal Control • Inform LNG Carrier / Pilot • Inform Harbour tugs/ crafts
Terminal Control	• Inform Duty Manager • Stop discharge from LNG Cargo • Inform customers • Stop Terminal & Pipeline operations, if it is unsafe to continue
Terminal Superintendent	• Stop LNG Cargo discharging • Head Count / safe Rescue of personnel • Isolate / water curtains • Stop Terminal Operations
LNG Cargo	• Inform Pilot • Stop Discharge of LNG, Isolate / ESD • Master Pilot to bridge • Vessels engines to immediate readiness • Prepare for vacating the berth
Pilot	• Tugs/mooring boats standby for use • Consider vacating the berth
Port Manager / Harbour	• To be in VHF contact with Pilot
Master	• Inform Emergency Response Team • Assess situation
Medical	• Medical assistance

Table 7.17 : Responsibilities during cyclone

Observation	Action
Port Control Room	• Collect / Receive cyclone warning information from available sources • Inform Harbor Master/ Port Manager • Inform Pilot / LNG C Ship • Inform Terminal Control • Inform Harbor tugs / crafts • Monitor communications
Duty Manager	• Constitute Cyclone Command Group • Assess situation • Vacate port (Ships and tugs/crafts to proceed to sea) • Secure Port • Hoist Storm signal and issue storm warnings • Liaise with Harbour tugs/crafts contractors • Maintain contact with Port Control
Cyclone Command Group	• Delegate duties/responsibilities • Execute Pre-cyclone activities • Transfer essential records to safe locations • Secure Port and Terminal • Free-standing scaffolds and planks from tied scaffolds taken down • Loose cladding on buildings and process equipment should not exist • Drainage and storm water channels checked for clearance • Oil drums removed to safe location or safely lashed • Rubbish bins secured to structure or safety lashed • Service hoses lashed to the nearby structures or removed to some room • Fire point cabinets closed. • Fire extinguishers stowed and lashed • Satellite phones and wireless sets working • Inform/instructions to contractors • Non-essential staff to be off site • Stock fuel, water and food • Staff on site to location of safety • Formulate evacuation/rescue team • Medical help on site • Maintain contact with Port Control and Terminal Control • Formulate and implement post cyclone start up plan
Post Cyclone	• Report of current plant status

	• Review downgrading of the plant status depending upon damage • On return to work, all areas to demobilize cyclone tie down measures • Meet for de-brief session

Table 7.18 : Frequency of drills

Mock drills and first aid drill	Every Six Months
Breathing apparatus drills	Once inthree Months
Casualty handling drills	once in a year
Marine incident drills	once in a year

Chapter 8

Project Benefits

Chapter 8

Project Benefits

The proposed FSRU based LNG Terminal (LNG import, storage, regasification and supply of RLNG), is primarily a material handling project, falling in the category of infrastructure development, and will become a long term resource of cleaner fuel for power generation (energy in industry, transport and domestic sectors) and cleaner feed stock for fertilizer, petrochemicals etc. sectors.

A.P. state government as one of the project proponents set an objective to implement this project at the earliest possible fast track mode to overcome the existing acute electric power shortage in the state. Hence, the first and foremost benefit would be meeting the essential need of the state.

The proposed project, during its normal operation, will be self sustenance with cleaner fuel/energy (boil off gas) resource, insignificant / negligible demand for domestic / potable water; very limited land requirement (2.64 Ha, a govt. land); insignificant pollution discharge in a controlled manner with negligible environmental impacts which may facilitate the project to be considered in low pollution category.

The proposed terminal although a material, LNG, handling infrastructure project, will not cause / lead to any material new road or rail traffic volumes as the total RLNG (5.25 mtpa) is proposed to be transported to consumers by existing gas pipeline network.

In addition to the above, the proposed FSRU based LNG terminal at Kakinada is expected to bring in a host of social and economic benefits in the region in the form of making available cleaner fuel (energy & feed stock resource). Apart from meeting the objectives set out for the project by A.P. State Govt., the project is envisaged to trigger a chain of systematic positive changes in the society, agriculture, industry and the economy. Following are some of the specific benefits from proposed project:

8.1 Energy Security

Energy security is a prime concern for a developing country like India, which is deficient according to present status of indigenous energy resources. In order to meet the growing demand – supply gap of gas, import of LNG is the one of the most viable options. Setting up an LNG import, storage, regasification and supply terminal enables supply of cleaner fuel, i.e. RLNG to industry and domestic consumers and not only supplements energy security but also helps in reducing environmental pollution impacts on a long term basis. India has already established a few LNG import and regas terminals which are operating successfully. FSRUs are also planned both on both the east coast and west coast. The share of natural gas in the overall energy sector in the country will continue to increase.

8.2 Food Security

Apart from fulfilling the immediate need of cleaner fuel (supplement) for power generation, the RLNG supply will also contribute indirectly to food security of the region, state /nation through enhancing fertilizer manufacture with a cleaner feed stock.

8.3 Environment Friendly Fuel / Feed Supply

The comparison of RLNG based power plants with that of other fossil fuel (coal and LSHS / Naphtha) based thermal power plants with respect to fuel efficiency and emissions of conventional pollutants indicate that the RLNG based plants do not generate conventional pollutants except NOx.

Various strategies are being planned & implemented at national and international levels to reduce the greenhouse gas emissions, which are the unavoidable byproducts from the combustion of other fossil fuels. RLNG and renewable sources contribute very little to atmospheric carbon dioxide (one of the GHG) or sulphur and nitrogen oxide levels.

Many of the industries using different fossil fuels (solid and liquid) in developed as well as in developing countries fail to comply with the stringent international control measures for emissions of greenhouse gases. Any measures for implementing these standards would increase the investments exponentially as well as costs of the products, making RLNG based plants clear favorite.

As per the process / technological details provided in Chapter 2, the LNG / RLNG, available from proposed project, will be a cleaner fuel than generic natural gas as explored and used directly for fuel applications, as all the natural impurities like H_2S, CO_2 etc. (expected to cause air pollution) are totally separated and removed in the NG liquefaction process (in making LNG). Hence, RLNG would be cleaner than clean (NG) fuel.

8.4 Economical Benefits of FSRU based LNG Terminal at Kakinada

The LNG terminal will provide safe, sustainable and economic means of import, re-gasification and further distribution of natural gas in the state. The major stakeholders who would benefit from the project are the gas consumers such as power, fertilizers, other industries (glass, ceramics etc.), transport and domestic sectors, gas transporters, gas importers, Govt. of Andhra Pradesh, Govt. of India, apart from a host of suppliers of materials and service providers. One of the major economic benefits would be the industrial development of the state in general and the East Godavari district in particular.

The project will result into development of power and other industrial activities. Both the proposed project and the resultant industrial development will substantially add to the revenue to both Government of Andhra Pradesh and Government of India in the form of various taxes and duties.

8.5 Social Benefits

The establishment of FSRU based terminal at Kakinada would provide RLNG at a fairly competitive price and result in a benefit to the industries and consumers. Development of industries, overall development of the area and consequent indirect and direct job opportunities would finally result in improvement in the quality of life of people in the area around Kakinada.

The proposed CSR activities by M/s APGDC, M/s GAIL Gas Ltd., aim at strengthening the bond between the project / station authorities and the local population in the vicinity of LNG terminal. In line with Government of India policy on CSR activities, GAIL (India) Limited (one of the parent company of APGDC) has been carrying out number of community welfare activities in the area through their existing station at Kakinada in the following areas:

- Education
- Health
- Community Welfare

In similar lines, APGDC plans to implement CSR measures in the area around the project site with the following action plan.

- APGDC would contribute in implementing social welfare activities in collaboration with local Gram Panchayat, Mandal Office etc. for better development of area around LNG port terminal.
- To minimize strain on existing infrastructure, adequate provision of basic amenities, viz. education, health, transport etc. would be made.

8.6 Other Tangible Benefits

- The proposed project would generate limited direct employment and more indirect employment opportunities during construction / operation, transportation activities, supply of raw materials, auxiliary and ancillary works etc.
- Development of the basic amenities, viz. roads, transportation, electricity, drinking water, proper sanitation, educational institutions, medical facilities, entertainment etc.
- Due to the project, there would be an overall development of the area and job opportunities, which may improve the quality of life in the region.

8.7 Corporate Social Responsibility (CSR)

Under Corporate Social Responsibility, the APGDC (and the SPV operating the FSRU) is committed to work towards improvement in the living conditions of local population near the project, particularly in the areas of health & hygiene, civic amenities, infrastructure, education & training, water supply etc. For this purpose, APGDC shall incur expenditure on CSR activities in line with the policies of Govt. Of India

Some of the proposed CSR activities are as follows:

S.No	List of Activities
1	Adoption of one of the neighbor village depending upon the condition for socio-economic development
2	Drinking water provision
3	Educational facilities
4	Health and awareness camps
5	Environmental initiatives (tree plantation and tree guards in nearby villages
6	Support sports and cultural activities
7	Development of new main/approach road, and proper drainage system in nearby villages

8.8 No Project Scenario

In the absence of proposed project, the electricity / power shortage may adversely impact economic development of the state and this may continue until identification & implementation of other alternatives. The requirement of fuel or feedstock for power, fertilizer and other industries would wither remain un-fulfilled or to be met through other alternatives. In case of unfulfilled demand, the society will be deprived. In case the power requirement is met through other fossil fuels, viz. coal, diesel etc., would cause adverse impacts on the environment, including global scale impacts. The proposed project would be proven to be more cost effective in long run with better environmental sustainable overall value proposition to the society than "No Project Scenario".

Chapter 9

Disclosure of Consultants Engaged

Chapter 9

Disclosure of Consultants Engaged

9.1 NEERI Profile

NEERI (National Environmental Engineering Research Institute) is a Constituent Laboratory of CSIR (Council of Scientific & Industrial Research), India (Website: www.neeri.res.in) was established in 1958.

9.1.1 NEERI Mission and Vision

- **NEERI Mission**

The Institute dedicates itself in the service of mankind by providing innovative and effective solutions to environmental and natural resource problems. It strives to enable individuals and organizations to achieve productive and sustainable use of natural resources on which all life and human activity depend. Highly skilled and motivated, the Institute strives for excellence in environmental science, technology and management by working hand in hand with its partners.

- **NEERI Vision**

NEERI envisions a world in which

- All individuals and Institutions have capacity to act in a manner that ensures achievement of sustainable environmental and economic goals.

- The natural balance is no longer threatened and all share the benefit of a healthy environment.

NEERI would continue to strive for

- Leadership in environmental science, technology and management domestically and worldwide.
- Strong and effective working relationship with its partners in ensuring ecological health of all regions in India.

9.1.2 Mandate of NEERI

- To conduct R&D studies in environmental science and engineering.
- To render assistance to the industries of the region, local bodies etc. in solving the problems of environmental pollution.
- To interact and collaborate with academic and research institutions on environmental science and engineering for mutual benefit.
- To participate in CSIR thrust area and mission projects.

9.1.3 NEERI Activities

- **R&D Thrust Areas**
  - Environmental Monitoring
  - Environmental Modeling
  - Environmental Impact & Risk Assessment
  - Environmental System Design
  - Environmental Biotechnology
  - Environmental Genomics
  - Environmental Policy Analysis
- **Advisory**
  - Central Govt. Ministries
  - State Govt. Ministries
  - Industries
  - Judiciary

9.1.4 NEERI Services & Goods

- **Research intensive areas**

- Air, Water, Wastewater, Soil (Land), Solid & Hazardous Waste

- Environmental Biotechnology & Genomics
- Environmental Materials

➢ **Public and strategic areas**

  - Environmental Monitoring
  - Environmental Policy Analysis

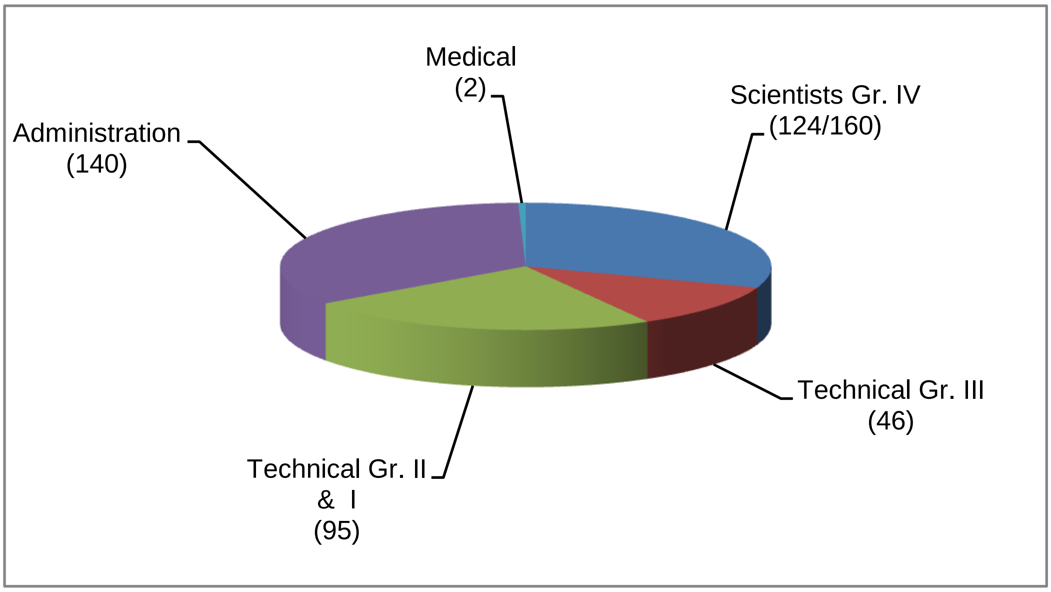
➢ **Socio-economic areas (urban & rural)**

  - Drinking water
  - Clean Air
  - Environment & Health
  - Advice to Central & State Government Agencies
  - Judiciary

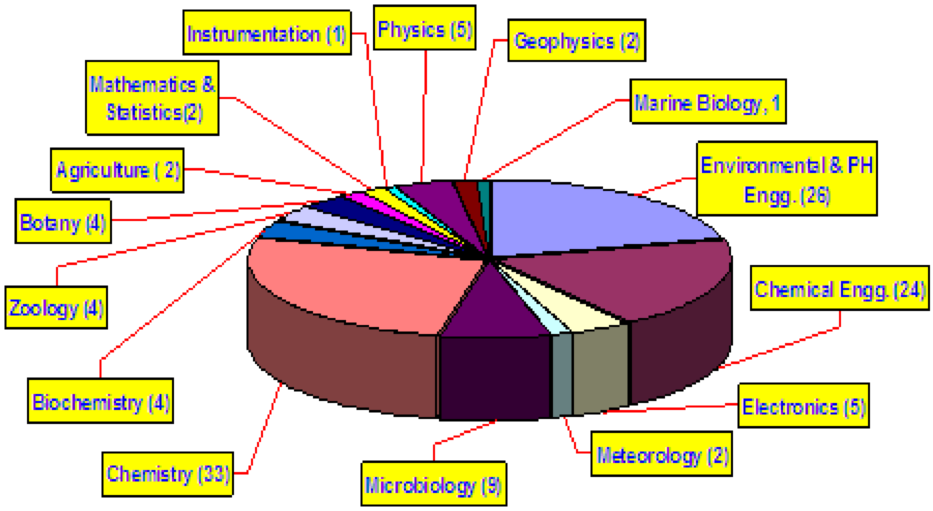
➢ **Industry focus**

  - Environmental Monitoring, Management and Audit
  - Environmental Technology Assessment
  - Environmental Impact & Risk Assessment

9.1.5 NEERI Human Resources

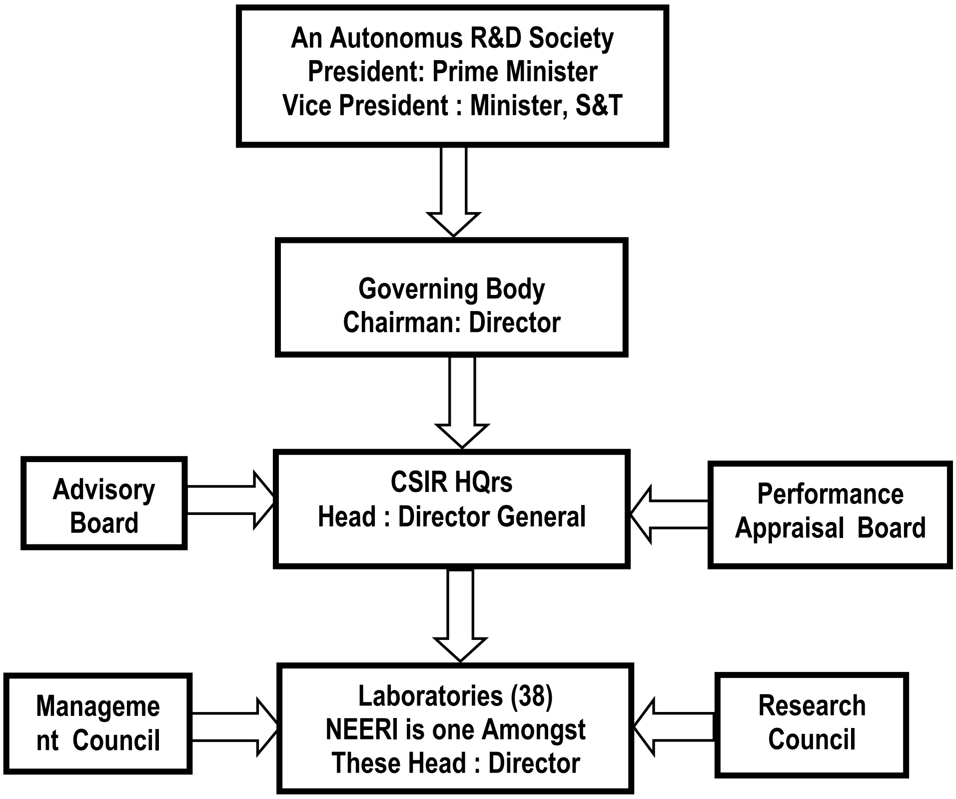


NEERI : Human Resources
Total : 407 (As on February, 2008)

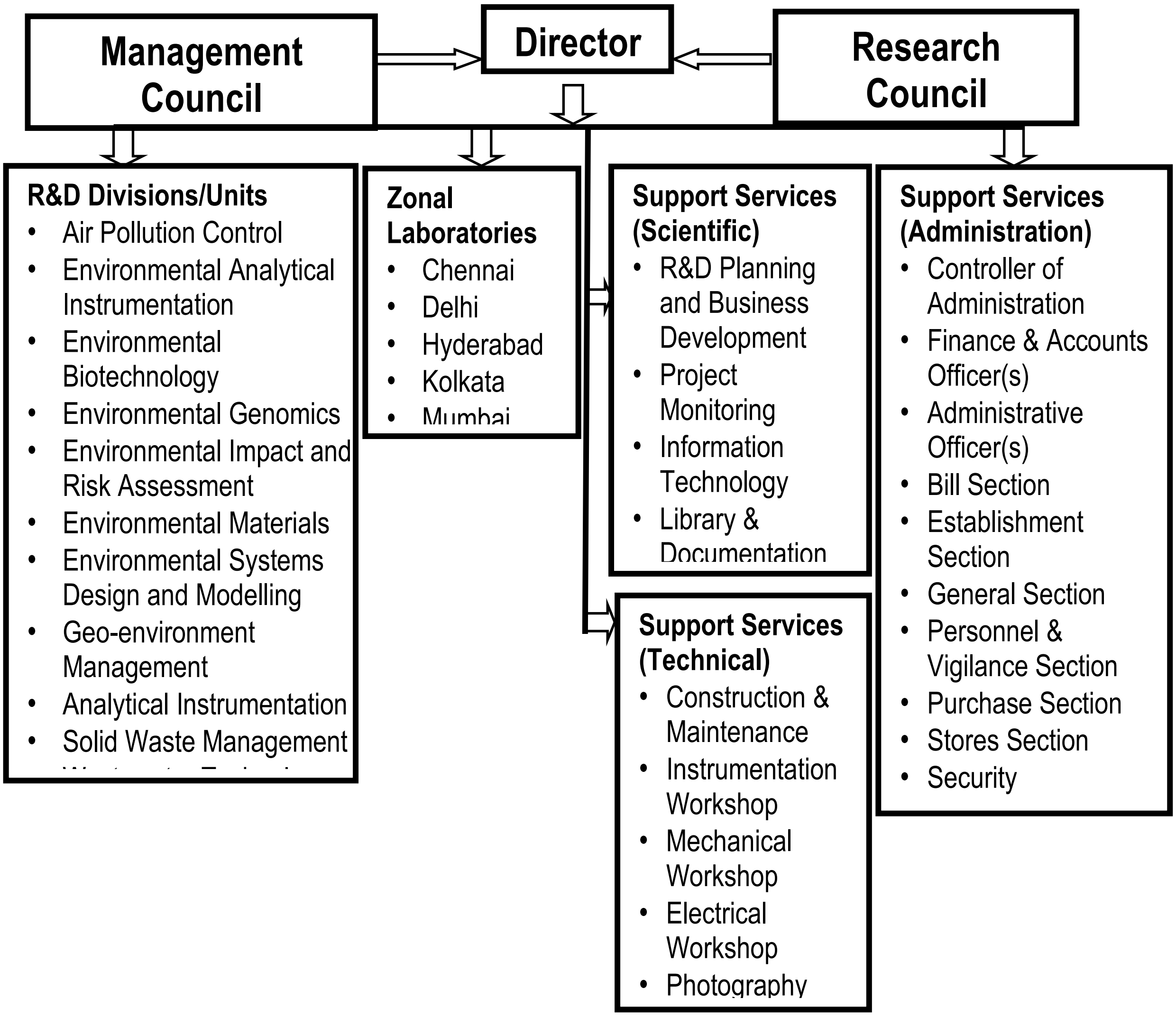


NEERI : Human Resource (Scientific) (As on March 1, 2008)

9.1.6 Organisational Chart of CSIR and NEERI

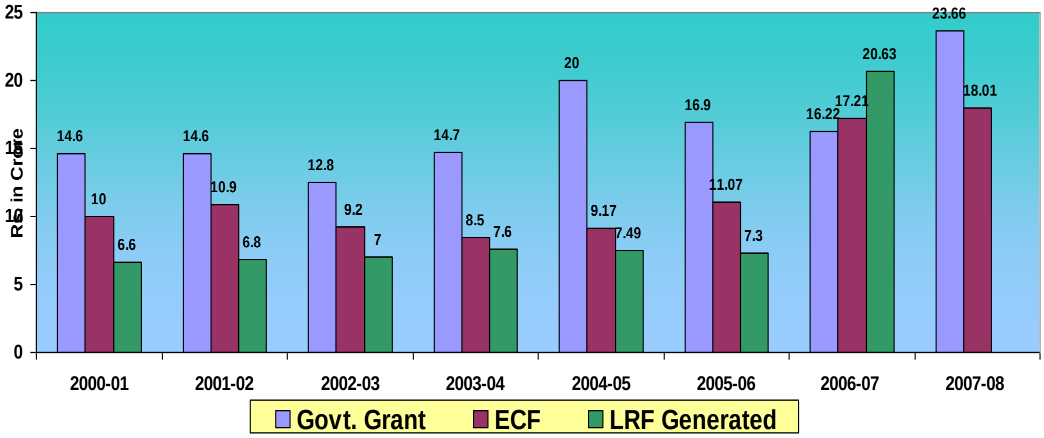


CSIR, India (Organisational Chart)



NEERI: Organisation Chart

9.1.7 Financial Resources of NEERI



Financial Resources (1999-2008) (Rs. in Crore)
(ECF- Environmental Consultancy Fund, LRF- Laboratory Reserve Fund)

9.1.8 Analytical Instruments, Computer Systems and Software at NEERI

9.1.8.1 Analytical Instrumentation Resource

- UV-VIS-NIR Spectrophotometer : Hitachi 330
- Atomic Absorption Spectrophotometer : GBC 904 A
- Fluorescence Spectrophotometers : Hitachi F-4000 & Hitachi F-4500
- Mercury Analyzers : Perkin Elmer MAS-50 A and MAS-50 B
- Gas Chromatographs : Perkin Elmer Autosystem – 5 nos.
- High Performance Liquid Chromatographs : Waters 204 and 501; Shimadzu – LC10
- Gas Chromatograph-Mass Spectrometer : Varian Saturn III
- Liquid Chromatograph-Mass Spectrometer-Mas Spectrometer : Quattro Ultima
- Ocean related studies : ADCP, CODAR, GPS, Ekmen Dredge, Reversible sampler, (Nishkin type) DRDF, Reversible thermometer, Tide Gauges
- Doppler SODAR
- Mini Sonde
- Microscopes
- Biolistic particle delivery system with accessories
- Gene Pulser II System with accessories & consumables
- Membrane Bioreactor Assembly
- Wet air Oxidation High pressure reactor
- Ground Penetrating Radar
- Multi Electrode resistivity Imaging system
- Ambient Ozone Analysers
- Eight Stage Cascade Impactor
- Microwave Furnace
- CHNS Analyser Vario ELIII
- Porosimeter Quanta Chrome PM33-7
- Mercury Analyser – Milestoen DMA80
- FTIR Spectrometer – Bruker Vertex 70

- Catalyst Evaluation assembly with GC
- Simultaneous Inductively Coupled Plasma Atomic Emission Spectrometer (for Heavy Metals) : Perkin Elmer Optima 4100 DV
- Atomic Absorption Spectrometer (for Heavy Metals) : Perkin Elmer Analyst 800 with Auto Sampler and HGA Furnace
- Total Organic Carbon (TOC) Analyser: Thermo Euroglass TC 1200
- VOC Analyser : Photovac 2020 and Photovac Voyager for Analysis of VOCs in Ambient Air
- Carbon Analyser : Behr Labor Technis C-30-IRF

9.1.8.2 Computer Hardwares & Prepherials

Computer Hardware

- High performance computer systems configures around RISC workstations
- Sun Ultra Sparc Computer Station: Sun Ultra 1 Model 170
- Silicon Graphics 02 Workstations
- Silicon Graphics 2000 Workstations
- HP APOLLO 90001730 Workstations
- Personal Computers
- Laptop Computers
- Local Area Network

9.1.8.3 Supporting Software

- Geographic Information Systems – ARC INFO, MAP INFO
- Knowledge Based System – Prokappa
- Digital Image Processing – ERDAS, EASIPACE, PCI WORKS
- INGRES
- CADCORE
- SPSS
- IMSL
- COMPLIERS
- GRAPHICS
- MATLAB
- DIVAST

Softwares for Mathematical Modeling (Available at NEERI)

Air Environment

Model	Used for Predicting Impacts due to
PAL-DS	Point (stacks), area (quarry) and line (vehicular) sources in short range
ISCST-3	Point and area sources in short range
CALINE 4	Vehicular sources close to road
RTDM3.2	Point and area sources existing at rough terrain in short range
VALLEY	Point and area sources existing in valley in short range
MESOPUFF	Point and area sources in long range
CDM	Point and area sources in short range
RAM	Point and area sources in short range
BLP	Point and line sources in short range
SDM	Point and area sources existing in coastal region in short range
CAL3QHC	Vehicular sources close to road for Hydrocarbon Levels
ADAM	Point and area sources in long range
ADMS-3	Point and area sources in long range
PANACHE	Meteorological data and point, area & line sources in any range
MTDDIS	Point and area sources in long range
TAPM	Meteorological data and impacts due to point, area and line sources in short and long range

Noise Environment

Model	Used for Predicting Impacts due to
FHWA	Vehicular sources
Wave Divergence	Stationary sources

Aquatic Environment – Ground Water

Model	Used for Predicting Impacts due to
GMS	Flow, direction, contaminant transport in saturated and unsaturated zones, subsurface solute transport with aerobic and sequential anaerobic biodegeneration, remediation
FEMWATER/ LEWASTE	Stable contaminant transport & pollution, groundwater pollution and remediation
PATRIOT	Hydrology, stable contaminant transport & pollution and landuse management
PRZM3	Stable contaminant transport & pollution and landuse management, consequence of surface water pollution on groundwater
WhAEM2000	Risk of groundwater contamination, hydrology, stable contaminant transport & pollution

Aquatic Environment – Surface Water

Model	Used for Predicting Impacts due to
MIKE 11	One dimensional model for dam break analysis, sediment transport, ecological and water quality assessments in rivers and wetlands
MIKE 21	Two dimensional model for Environmental Impact Assessment of marine infrastructure, sediment and mud transport, spill analysis
MIKE 3	Three dimensional model for various applications in different water bodies for water pollutions studies
MIKE SHE	Integrated surface and groundwater modeling
ECO LAB	For ecological modeling in rivers wetlands, lakes, reservoirs, estuaries, coastal waters and sea
CORMIX	Software for simulation for fluid-flow mixing in different water bodies
EXAMS	Aquatic Chemistry & Biology in streams and sea
GCSOLAR	Photolysis, half life
HSCTM2D	Hydrology, sediment & contaminant transport in river and estuary
HSPF	Aquatic chemistry and biology sediment transport and deposition in rivers
OXYREF	Dissolved oxygen, respiration, ventilation
PLUMES	Available dilution, design of marine outfall
PRZM3	Hydrology, metals and pesticides prediction in surface water
QUAL2EU	Water quality in stream, planning, non-point sources
SED3D	Hydrodynamics, sediment transport, 3-D, lakes, estuary, harbour, coastal
SMPTOX3	Toxic-chemicals in streams, aquatic biology, combined sewers
SWMM	Aquatic biology, combine sewers, community discharge, rivers, streams
TMDL USLE	Soil and sediment loss, watershed management
Visual Plumes	Surface water, contaminant transport
WASP	Hydrodynamics, aquatic biology, toxicant dispersal, hydrology

Surface Water Runoff

Model	Used for Predicting Impacts due to
HEC-5	Flood hydrography, runoff estimation, catchment area treatment
HSPF	Hydrologic simulation in reservoir, nutrient growth
STORM	Urban watershed, storage/reservoir routing, sedimentation, erosion, reservoir chemistry

Ecology

Model	Used for Predicting Impacts due to
ECOMOD	Estuary linked reservoirs, tidal action, saltwater intrusion, in-stream and in-reservoir dissolved oxygen primary and secondary productivity estimation
LAKE-I	Thermal stratification primary and secondary productivity

Food Chain

Model	Used for Predicting Impacts due to
EGETS	Exposure levels and effects of contaminants on organisms which make food chain
LC50	Lethal concentration, LC50 toxicity levels

Multimedia

Model	Useful for Predicting Impacts due to
3MRA	Multimedia pathway, receptor exposure, risk assessment
MINTEQA2	Aquatic biology, multimedia pathway
MMSOILS	Multimedia pathway, exposure assessment
MULTIMED (1.01)	Environmental effects of waste disposal in one media to another surface & ground water

Dam Break Analysis

Model	Useful for Predicting Impacts due to
DAMBRK	Downstream flow simulation consequent to dam break

Risk Assessment

Model	Useful for Predicting Impacts due to
SAFETI 6.21 & 6.42V	Complete package for consequence analysis and risk analysis in onshore process engineering
PHAST 6.21 V & 6.42V	Complete package for consequence analysis in onshore process engineering

9.1.9 Clients of NEERI

9.1.9.1 Clients: International

- The World Bank
- Asian Development Bank
- United Nations Development Programme
- United Nations Environment Programme
- World Health Organization
- International Union of Conservation for Nature
- Danish International Development Agency
- Global Scan Technologies, Dubai
- Global Tech Safety & Environmental Consultancy, Dubai
- Dept. of Public Works and Highways (DPWH) / Environment and Social Services Office (ESSO), Philippines

9.1.9.2 Clients: Central Government

- Atomic Energy Regulatory Board
- Bharat Oman Refineries Limited
- Bharat Petroleum Corporation Limited
- Gas Authority of India Limited
- Hindustan Organic Chemicals Limited
- Hindustan Petroleum Corporation Limited
- Indian Oil Corporation Limited
- Indian Petrochemicals Corporation Limited

- Jawaharlal Nehru Port Trust
- Madras Refineries Limited
- Mangalore Refinery and Petrochemicals Limited
- Mumbai Port Trust
- National Aluminium Corporation Limited
- National Hydroelectric Power Corporation
- National Thermal Power Corporation Limited
- Nuclear Power Corporation India Limited
- Numaligarh Refineries Limited
- Oil India Limited
- Oil and Natural Gas Corporation Limited
- Rashtriya Chemicals & Fertilizers Limited
- Tuticorin Port Trust

9.1.9.3 Clients: State Government

- Gujarat Industrial Development Corporation Limited
- Gujarat Narmada Valley Fertilizers Company Limited
- Gujarat State Petroleum Corporation Limited
- Gujarat State Petronet Limited
- Kudremukh Iron Ore Company Limited
- Maharashtra State Electricity Board
- Tamilnadu Industrial Development Corporation
- Chattisgarh State Electricity Board
- Narmada Water Resources, Water Supply & Kalpasar Deptt.
- Karnataka State Industrial Infrastructure Development Corporation Ltd.
- Steel Authority of India

9.1.9.4 Clients : Private Industries (National)

- Alembic Pharmaceuticals Ltd.
- Asian Paints India Ltd.
- Andhra Sugars
- Ballarpur Industries Ltd.
- Dighi Port Pvt. Ltd.
- Dony Polo Petrochemicals Ltd.
- Electrosteel Castings Ltd.

- ESSAR Oil Ltd.
- Grasim Industries Ltd.
- Gujarat Pipavav Port Ltd.
- Gujarat Positra Port Infrastructure Ltd.
- Hazira Port Pvt. Ltd.
- Hindustan Oil Exploration Company Ltd.
- Jindal Vijaynagar Steel Pvt. Ltd.
- Paradeep Phosphates Ltd.
- Pipavav Ship Dismantling & Engineering Ltd.
- Reliance Petrochemical Ltd.
- Reliance Industries Ltd.
- Sahara India Pvt. Ltd.
- Saurashtra Chemicals Ltd.
- Search Chem Industries Ltd.
- Tata Petrodyne
- United Phosphorus Ltd.
- Zuari Industries Ltd.
- ABG Cement
- NCTL Pvt. Ltd.
- Amanora Park Town
- Lavasa Corporation Ltd.
- Nagarjuna Fertilizer and Chemicals

9.1.9.5 Clients : Private Industries (Multi-National)

- British Gas International (India)
- Cairn Energy India Pty. Limited
- Command Petroleum, Australia
- Enron Oil & Gas India Limited
- Hindustan Oil Exploration Company Limited
- Hindustan Oman Petroleum Company Limited
- Niko Resources Limited
- Petro Energy Products Company India Limited

- Rio Tinto Orissa Mining Limited
- Shell India Private Limited
- South Asia LPG Company Limited (a JV of M/s Total Gas & Power India)
- Mitsui & Company, Japan
- OAO Gazprom, Russia
- Mosbacher India L.L.C

9.1.10 Studies with International Funding

- Construction of Middle Vaitarna Dam for Augmentation of Water Resources and Irrigation near Mumbai (WB) (1990-1993)
- Augmentation of Chennai Water Supply – a Project at New Veeranam, Tamilnadu (WB) (1994-1995)
- Construction of Aerated Lagoons and Selection of Marine Outfall Location (Worli) off Mumbai Coast (WB) (1994-1995)
- Water Quality Studies for Hyderabad Water Supply and Sanitation Project (WB) (1995-1990)
- Oceanographic Modeling Studies for Sewage Outfall Location (Bandra) off Mumbai Coast (WB) (1995-1998)
- Strengthening EIA capacity and environmental legislation in India (ADP) (1998-2000)
- Implementation off Master Tourism Plan in Andaman Islands (UNDP) (1999-2000)
- Design & Implementation of Information Network for Indian Centre for Cleaner Technologies (WB) (1999-2002)
- Planning for Coastal and Marine Environment under Gujarat State Environmental Action Programme (WB) (1999-2000)
- Development of National Guidance Manual & Support Manual on EIA Practices for Enhancing the Quality & Effectiveness of Indian EIA's (WB) (2002-2004)

- Water needs of Brahmani & Sabrmati river basins (ICID) (2002-2004)
- Technical Assistance to ESSO to Enhance the Management of Social and Environmental Safeguards for DPWH Projects, Manila, Philippines (WB) (2005-2007)

9.1.11 US-AEP AWARD TO NEERI

9.1.12 Conformity to ISO 9001:2008


DNV

DET NORSKE VERITAS

MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 30987-2008-AQ-IND-RvA Rev. 01

This is to certify that

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE (NEERI)

at

H.O.: Nehru Marg, Nagpur - 440 020, Maharashtra, INDIA
Chennai Zonal Laboratory: CSIR Complex, T.T.T.I. Taramani P.O., Chennai - 600 113, Tamil Nadu, INDIA
Delhi Zonal Laboratory: CSIR R&D Centre (1st Floor) A-93/94, Phase - I, Naraina Industrial Area, New Delhi - 110 028, INDIA
Hyderabad Zonal Laboratory: IICT Campus, Uppal Road, Hyderabad - 500 007, A.P. INDIA
Kolkata Zonal Laboratory: 1-8, Sector - C, East Kolkata Area Dev. Project, P.O. East Kolkata Township, Kolkata - 700 107, WB, INDIA
Mumbai Zonal Laboratory: 89/B, Dr. Annie Besant Road, Worli, Mumbai - 400 018, Maharashtra, INDIA

has been found to conform to the Quality Management System Standard:

ISO 9001:2008

This certificate is valid for the following scope:

FORMULATING EFFECTIVE R&D PROGRAMMES ON ENVIRONMENTAL SCIENCE AND ENGINEERING TO PROVIDE SUSTAINABLE TECHNOLOGICAL SOLUTIONS TO ENVIRONMENTAL PROBLEMS OF GOVERNMENT, INDUSTRY AND SOCIETY

Initial Certification date:
11 January 2005

This Certificate is valid until:
11 January 2014

The audit has been performed under the supervision of:
Pravin Morey
Lead Auditor

MGMT. SYS.
RvA C024

Place and date of issue:
Chennai, 01 December 2010

for the Accredited Unit:
DET NORSKE VERITAS CERTIFICATION B.V., THE NETHERLANDS

Bhupalam Ajit
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement & the annexure to this certificate may render this Certificate invalid.

DET NORSKE VERITAS CERTIFICATION B.V. Zwolseweg 1, 2994 LB Barendrecht, The Netherlands, TEL: +31 10 2922 688 - www.dnv.com / www.dnv.nl
ISSUED BY: DET NORSKE VERITAS AS, EMGEEN CHAMBERS, 10, C.S.T. ROAD, SANTACRUZ (E), MUMBAI - 400 098, INDIA - www.dnv.com / www.dnvindia.com

9.1.13 Contact Persons

DIRECTOR : Dr. S.R. Wate

Phone : +91 712 2249999
Fax : +91 712 2249900
GSM : +91 98232 79961

Email : director@neeri.res.in

CHIEF SCIENTIST & HEAD : Shaik Petnu Saheb

NEERI Zonal Laboratory, Hyderabad

Phone : +91 040 27160639, 27160122

Fax : +91 040 27160639

GSM : +91 9490712833

Email : sp_saheb@neeri.res.in

Chapter 10

Summary & Conclusions

Chapter 10

Summary & Conclusions

10.1 The project

The proposed FSRU based LNG terminal at KDWP, Kakinada would create facilities to import LNG, storage and re-gasification of LNG and supply re-gasified LNG (RLNG). The proposed LNG terminal consists of marine LNG import facilities (Jetty Platform), an FSRU for storage and re-gasification within harbour area, a high pressure subsea pipeline for transporting RLNG to coast and an onshore receiving facility / landfall station for metering and supply RLNG to consumers through existing gas pipeline grids.

The immediate objective of proposed project is to fulfill the fuel shortage for existing and upcoming gas based power plants in the project region, which shall improve the electricity / power scenario in the state.

10.2 Baseline Environmental Quality

The existing environmental quality (pre-project) status with respect to land, water, marine, biology, air quality, noise levels and socio-economic components are studied within

10 km radial area around the project site. The baseline data has been collected during October-December 2012 (post-monsoon). The winter season data has been compiled from the recent past EIA study reports in the project area.

The marine survey including hydrography (bathymetry, currents and Tides) and marine water column as well as seabed sediment sampling, has been carried out through M/s Coastal Marine Construction & Engineering (COMACOE) ltd., Mumbai, under the coordination of NEERI.

In the land environment, existing land use and soil quality has been studied in the study area. Onshore surface water and ground water samples were analyzed. In marine environment, marine water quality and sediment characteristics were studied. In Biological environment, coastal ecology and inland ecology have been studied through field surveys including socio-economic status / quality in study area.

The pre-project environmental status w.r.t. various parameters under individual environmental components during study period, in general complied with the environmental standards prescribed by MoEF / APPCB.

10.3 Anticipated Impacts and Mitigation Measures

The significant environmental impacts from proposed project have been identified for individual components, viz. marine, terrestrial - land, water, air, biology, noise and socioeconomics during construction as well as operation phases. The predictions of significant impacts have been carried out using appropriate mathematical models for relevant components of environment.

The appropriate pollution mitigation measures have been duly considered in the study, which shall be included in the design stage and implemented during construction and operation phases (deliberated in chapters 4 and 5).

10.4 Environmental Management Plan

The Environment Management Plan delineated for the proposed project (chapter 5) will be implemented and maintained by project proponent. The EMP of proposed project shall supplement to the overall Environment Management Plan of KDWP being pursued by the port operator, i.e. M/s KSPL. The present project proponent will coordinate with KSPL for implementation of EMP.

10.4.1 Construction Phase

Few of the mitigation / environmental management measures for the project are:

- Necessary integrative coordination with the KDWP operator, i.e. M/s KSPL, especially for dredging operations, movement of vessels / barges etc. (navigation)
- Marine construction safety standards to be followed and provision of appropriate PPEs to (marine) construction workers as well as marine safety and rescue facilities at construction site.
- The transport vehicles / vessels / barges and construction machinery shall comply with Bharat III / IV and or 'MARPOL 73/78 **Annexure-VI'** emission standards as applicable.
- During site grading and ORF construction, mitigation of fugitive dust impacts through dust suppression / water sprinkling
- Proper maintenance of vehicles and construction equipment
- Tree plantation (large size species) should be undertaken along the boundary of ORF site at the time of preparation of site (excluding proposed bund wall area), so that they would grow to considerable size by the time of commissioning of proposed project.
- No blasting would be envisaged for construction either on seabed or on land for the construction of project. The suction type dredgers shall be employed to minimize the impacts w.r.t. turbidity, D.O. and marine biology
- The dredge material disposal shall be ensured at only designated offshore dumping area through dispersive diffuser manifold, if possible at specific time intervals of not less than 3 hrs. to allow dredge material settling / dispersal and minimize impacts on local marine ecology

10.4.2 Operation Phase

During operation phase, the FSRU (for LNG storage & regasification) will utilize RLNG gas fuel and the related flue gas emissions from FSRU will be in marine area. At landfall station / ORF there will be no atmospheric emissions on continuous basis. The impacts from intermittent sources are used in prediction to represent worst possible scenario. Further to this, necessary EMP measures have been delineated, which will be implemented and maintained by project proponent. Specific measures with respect to handling and disposal of solid wastes, waste water discharges, maintenance dredge material disposal, control of emissions, Noise generation etc. have been (chapter 5) delineated for proposed project.

10.5 Post-Project Environmental Monitoring Program

The required (post-project) Environmental Monitoring Program to check efficiency of mitigation / EMP measures has been drawn including sampling stations and frequency for monitoring with respect to different environmental components. The project proponent will take necessary action in consultation with APPCB and KSPL in this regard to follow it up. The sampling / monitoring locations and frequency of monitoring however shall be in accordance with APPCB requirements. The project proponent may decide regarding environmental monitoring either to carry out in-house or through out-sourcing, accordingly necessary infrastructure / facilities are to be developed.

The data collected on various EMP measures would be reviewed by Apex committee and if needed corrective action will be taken. In any case there shall be HSE/Environmental Management group with the proponent, which shall be responsible for EMS, Environmental Monitoring / compliances etc.

10.6 Project Benefits

The proposed LNG Terminal will result in improvement in the industrial, economic and social infrastructure in following manner:

- The proposed project is to meet the immediate objective of making available the natural gas (cleaner fuel) for existing power plants.

- Help in meeting the growing energy requirements of major consumers of natural gas, particularly power plants and other industries such as fertilizer and petrochemicals units etc.
- Generation of employment for unskilled people during construction phase and skilled people during operation phase of the LNG terminal.
- Generation of revenue for the state as well as central Governments.
- The project will enhance the availability of cleaner / environment friendly fuel for power plants and or feed stock for industries, especially fertilizer industry.
- Proposed project will help towards achieving energy security and food security
- Enhancement of basic amenities, viz. Roads, transportation, electricity, drinking water, proper sanitation, educational institutions, medical facilities, sports and cultural activities in project surrounding areas.

10.7 Conclusions

The project details along with analysis of alternatives are studied to identify the relevant marine and terrestrial environmental concerns (project specific & site specific). The baseline environmental (pre-project) status within study area comply the environmental regulations / standards

During construction phase, the proposed project will cause marine environment degradation to some extent at construction site and at dumping area, which will be localized and temporary in nature. The local environmental quality shall become normal after commissioning of the project. Moreover the identified impacts will be mitigated to the extent possible though technology interventions.

In operation phase of proposed project, as per the emissions, discharges data provided by project proponent and the prediction of impacts results obtained from modeling studies indicate insignificant / negligible environmental impacts from proposed project. The post-project scenario derived through superimposing prediction results over baseline status, will remain within prescribed environmental regulatory standards during normal operation of proposed project.

Further, to ensure effectiveness of pollution mitigation measures and further improvements of environmental quality, the required EMP measures have been delineated including Oil spill Management contingency Plan (Chapter-5).

The safety norms as well the standards / codes relevant to the proposed project – marine and land based facilities have been comprehensively dealt (chapter-2). Moreover, the Rapid Risk Assessment along with delineation of approach to the Disaster Management Plan including Emergency preparedness as well as Emergency Response Plan have been comprehensively covered (chapter-7) to make the proposed project safe to the acceptable level during construction as well as operation phases.

The additional study as specified in the approved additional Terms of Reference, i.e. the Coastal Hydrodynamic Study, with special reference to coastline changes has been carried out through Central Water and Power Research Station (CWPRS), Pune. The results indicate that there will not be any adverse impact due to proposed project at the high erosion area (identified by MOEF) near Uppada village.

CRZ demarcation along with HTL and LTL has been carried out through CSIR-National Institute of Oceanography (NIO)-Regional centre, Visakhapatnam. The results indicate that the proposed project falls in the permissible activities in different CRZ classifications and the proposed onshore receiving facility (ORF) will be located outside CRZ demarcation in CRZ- III category.

In view of the above it could concluded that proposed project covering construction as well as operation phases, would remain environmentally sustainable with insignificant / negligible adverse impacts, with adoption of the recommended mitigation measures as well as Environmental Management Plan measures, along with follow up of the delineated post project Environmental Monitoring Program.

The project would generate a host of benefits to the stakeholders namely energy security, industrial benefits, and social economic benefits including improvement in the quality of life of the people around the project site.

The project is therefore considered to be acceptable as the project would add value to the society.

Annexures

Annexure - I

National Ambient Air Quality Standards - 2009

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1.	Sulphur Dioxide (SO_2), µg/m^3	Annual *	50	20	-Improved west and Gaeke
		24 Hours **	80	80	-Ultraviolet fluorescence
2.	Nitrogen Dioxide (NO_X), µg/m^3	Annual *	40	30	-Modified Jacob & Hochheiser (Na-Arsenite)
		24 Hours **	80	80	-Chemiluminescence
3.	Particulate Matter (Size less than 10 µm) or PM_{10} µg/m^3	Annual *	60	60	-Gravimetric -TOEM
		24 Hours **	100	100	-Beta attenuation
4.	Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$ µg/m^3	Annual *	40	40	-Gravimetric -TOEM
		24 Hours **	60	60	-Beta attenuation
5.	Ozone (O_3) µg/m^3	8 hours **	100	100	-UV photometric
		1 hour**	180	180	-Chemiluminescence - Chemical method
6.	Lead (Pb) µg/m^3	Annual *	0.50	0.50	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
		24 Hours **	1.00	1.00	-ED-XRF using Teflon filter
7.	Carbon Monoxide (CO) mg/m^3	8 hours **	02	02	-Non Dispersive Infrared Spectroscopy
		1 hour *	04	04	
8.	Ammonia (NH_3) µg/m^3	Annual *	100	100	-Chemiluminescence
		24 Hours **	400	400	-Indophenol blue method
9.	Benzene (C_4H_4) µg/m^3	Annual *	05	05	-Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10.	Benzo Pyrene (BaP) - particulate phase only ng/m^3	Annual *	01	01	-Solvent extraction followed by HPLC/GC analysis
11.	Arsenic(As) ng/m^3	Annual *	06	06	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12.	Nickel(Ni) ng/m^3	Annual *	20	20	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform intervals

** 24 hourly or 8 hourly or 01 hourly monitored values as applicable shall be compiled with 98% of the time in a year. 2% of the time they may exceed the limits but not on two consecutive days of monitoring

Annexure-II

The Noise Pollution (Regulation and Control) Rules, 2000

Schedule

[See Rule 3(1) and 4(1)]

Ambient Air Quality Standards in respect of Noise

Area Code	Category of Area/Zone	Limits in dB(A) Leq*	
		Day Time	Night time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Note:- 1. Day time shall mean from 6.00 am to 10.00 pm.

2. Night time shall mean from 10.00 pm to 6.00 am.

3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.

4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

*dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relateable to human hearing.

A "decibel" is a unit in which noise is measured.

"A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq : It is an energy mean of the noise level over a specified period.

[The Gazette of Indian Extraordinary
MoEF Notification, 14 February, 2000]

Annexure-III

International : IMO Marine Engine Regulations

Background

International Maritime Organization (IMO) is an agency of the United Nations which has been formed to promote maritime safety. It was formally established by an international conference in Geneva in 1948, and became active in 1958 when the IMO Convention entered into force (the original name was the Inter-Governmental Maritime Consultative Organization, or IMCO, but the name was changed in 1982 to IMO). IMO currently groups 167 Member States and 3 Associate Members.

IMO ship pollution rules are contained in the "International Convention on the Prevention of Pollution from Ships", known as MARPOL 73/78. On 27 September 1997, the MARPOL Convention has been amended by the "1997 Protocol";, which includes Annex VI titled "Regulations for the Prevention of Air Pollution from Ships". MARPOL Annex VI sets limits on NOx and SOx emissions from ship exhausts, and prohibits deliberate emissions of ozone depleting substances.

The IMO emission standards are commonly referred to as Tier I...III standards. The Tier I standards were defined in the 1997 version of Annex VI, while the Tier II/III standards were introduced by Annex VI amendments adopted in 2008, as follows:

- 1997 Protocol (Tier I)—The "1997 Protocol" to MARPOL, which includes Annex VI, becomes effective 12 months after being accepted by 15 States with not less than 50% of world merchant shipping tonnage. On 18 May 2004, Samoa deposited its ratification as the 15th State (joining Bahamas, Bangladesh, Barbados, Denmark, Germany, Greece, Liberia, Marshal Islands, Norway, Panama, Singapore, Spain, Sweden, and Vanuatu). At that date, Annex VI was ratified by States with 54.57% of world merchant shipping tonnage.

  Accordingly, Annex VI entered into force on 19 May 2005. It applies retroactively to new engines greater than 130 kW*installed on vessels constructed on or after January 1, 2000*, or which undergo a major conversion after that date. The regulation also applies to fixed and floating rigs and to drilling platforms (except for emissions associated directly with exploration and/or handling of sea-bed minerals). In anticipation of the Annex VI ratification, most marine engine manufacturers have been building engines compliant with the above standards since 2000.

- 2008 Amendments (Tier II/III)—Annex VI amendments adopted in October 2008 introduced (1) new fuel quality requirements beginning from July 2010, (2) Tier II and III NOx emission standards for new engines, and (3) Tier I NOx requirements for existing pre-2000 engines.

  The revised Annex VI enters into force on 1 July 2010. By October 2008, Annex VI was ratified by 53 countries (including the Unites States), representing 81.88% of tonnage.

Emission Control Areas. Two sets of emission and fuel quality requirements are defined by Annex VI: (1) global requirements, and (2) more stringent requirements applicable to ships in Emission Control Areas (ECA). An Emission Control Area can be designated for SOx and PM, or NOx, or all three types of emissions from ships, subject to a proposal from a Party to Annex VI.

Existing Emission Control Areas include:

- Baltic Sea (SOx, adopted: 1997 / entered into force: 2005)
- North Sea (SOx, 2005/2006)
- North American ECA, including most of US and Canadian coast (NOx & SOx, 2010/2012).
- US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NOx & SOx, 2011/2014).

Greenhouse Gas Emissions. 2011 Amendments to MARPOL Annex VI introduced mandatory measures to reduce emissions of greenhouse gases (GHG). The Amendments added a new Chapter 4 to Annex VI on "Regulations on energy efficiency for ships".

NOx Emission Standards

NOx emission limits are set for diesel engines depending on the engine maximum operating speed (n, rpm), as shown in Table 1 and presented graphically in Figure 1. Tier I and Tier II limits are global, while the Tier III standards apply only in NOx Emission Control Areas.

Table 1. MARPOL Annex VI NOx Emission Limits

Tier	Date	NOx Limit, g/kWh		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier I	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
Tier III	2016†	3.4	$9 \cdot n^{-0.2}$	1.96

† In NOx Emission Control Areas (Tier II standards apply outside ECAs).

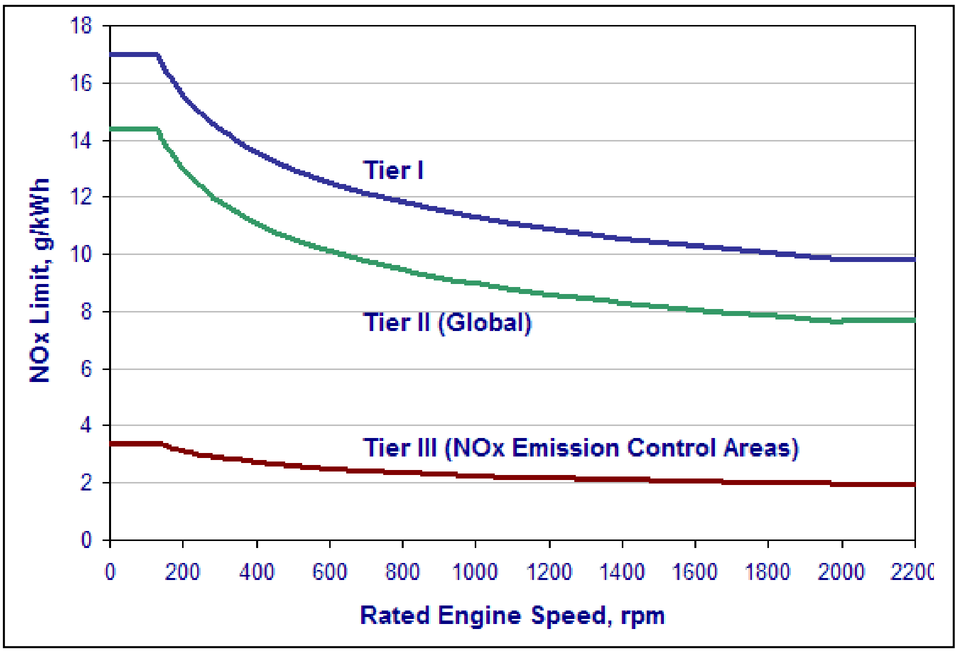


Figure 1. MARPOL Annex VI NOx Emission Limits

Tier II standards are expected to be met by combustion process optimization. The parameters examined by engine manufacturers include fuel injection timing, pressure, and rate (rate shaping), fuel nozzle flow area, exhaust valve timing, and cylinder compression volume.

Tier III standards are expected to require dedicated NOx emission control technologies such as various forms of water induction into the combustion process (with fuel, scavenging air, or in-cylinder), exhaust gas recirculation, or selective catalytic reduction.

Pre-2000 Engines. Under the 2008 Annex VI amendments, Tier I standards become applicable to existing engines installed on ships built between 1st January 1990 to 31st December 1999, with a displacement ≥ 90 liters per cylinder and rated output ≥ 5000 kW, subject to availability of approved engine upgrade kit.

Testing. Engine emissions are tested on various ISO 8178 cycles (E2, E3 cycles for various types of propulsion engines, D2 for constant speed auxiliary engines, C1 for variable speed and load auxiliary engines).

Addition of *not-to-exceed (NTE)* testing requirements to the Tier III standards is being debated. NTE limits with a multiplier of 1.5 would be applicable to NOx emissions at any individual load point in the E2/E3 cycle.

Engines are tested using distillate diesel fuels, even though residual fuels are usually used in real life operation.

Further technical details pertaining to NOx emissions, such as emission control methods, are included in the mandatory “NOx Technical Code”, which has been adopted under the cover of “Resolution 2”.

Sulfur Content of Fuel

Annex VI regulations include caps on sulfur content of fuel oil as a measure to control SOx emissions and, indirectly, PM emissions (there are no explicit PM emission limits). Special fuel quality provisions exist for SOx Emission Control Areas (SOx ECA or SECA). The sulfur limits and implementation dates are listed in Table 2 and illustrated in Figure 2.

Table 2. MARPOL Annex VI Fuel Sulfur Limits

Date	Sulfur Limit in Fuel (% m/m)	
	SOx ECA	Global
2000	1.5%	4.5%
2010.07	1.0%	
2012		3.5%
2015	0.1%	
2020[a]		0.5%

a - alternative date is 2025, to be decided by a review in 2018

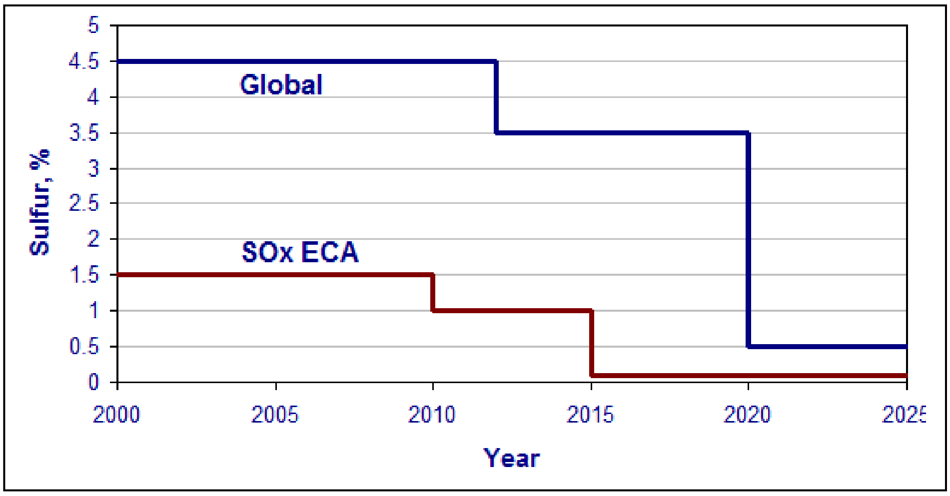


Figure 2. MARPOL Annex VI Fuel Sulfur Limits

Heavy fuel oil (HFO) is allowed provided it meets the applicable sulfur limit (i.e., there is no mandate to use distillate fuels).

Alternative measures are also allowed (in the SOx ECAs and globally) to reduce sulfur emissions, such as through the use of scrubbers. For example, in lieu of using the 1.5% S fuel in SOx ECAs, ships can fit an exhaust gas cleaning system or use any other technological method to limit SOx emissions to ≤ 6 g/kWh (as SO_2).

Greenhouse Gas Emissions

MARPOL Annex VI, Chapter 4 introduces two mandatory mechanisms intended to ensure an energy efficiency standard for ships: (1) the Energy Efficiency Design Index (EEDI), for new ships, and (2) the Ship Energy Efficiency Management Plan (SEEMP) for all ships.

- The EEDI is a performance-based mechanism that requires a certain minimum energy efficiency in new ships. Ship designers and builders are free to choose the technologies to satisfy the EEDI requirements in a specific ship design.
- The SEEMP establishes a mechanism for operators to improve the energy efficiency of ships.

The regulations apply to all ships of and above 400 gross tonnage and enter into force from 1 January 2013. Flexibilities exist in the initial period of up to six and a half years after the entry into force, when the IMO may waive the requirement to comply with the EEDI for certain new ships, such as those that are already under construction.

Other Provisions

Ozone Depleting Substances. Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs). New installations containing ozone-depleting substances are prohibited on all ships. But new installations containing hydro-chlorofluorocarbons (HCFCs) are permitted until 1 January 2020.

Annex VI also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

Compliance. Compliance with the provisions of Annex VI is determined by periodic inspections and surveys. Upon passing the surveys, the ship is issued an “International Air Pollution Prevention Certificate”, which is valid for up to 5 years. Under the “NOx Technical Code”, the ship operator (not the engine manufacturer) is responsible for in-use compliance.

सत्यमेव जयते

भारत सर ार / GOVERNMENT OF INDIA
पोत परिवहन मंत्रालय / MINISTRY OF SHIPPING
नौवहन महानिदेशालय / DIRECTORATE GENERAL OF SHIPPING
"जहाज भवन" / "JAHAZ BHAVAN"
वालचंद हीराचंद मा ी / W.H. MARG
मुंबई / MUMBAI – 400 001

टेलीफोन: 91-22-22613651-54
फैक्स: 91-22-22613655
ई-मेल: dgship@dgshipping.com
वेब: www.dgshipping.com

Tele: 91-22-22613651-54
Fax: 91-22-22613655
E-mail: dgship@dgshipping.com
Web: www.dgshipping.com

Engineering Circular No. 1 of 2012.

No: ENGG/OPP/MARPOL-38(5)/2004-Annex VI 30th January, 2012

Sub.: Ratification and enforcement of Annex VI of MARPOL 73/78, Regulations for the Prevention of Air Pollution from Ships – reg.

All concerned stake-holders may take note that the Government of India has acceded to Annex-VI (Regulations for the Prevention of Air Pollution from Ships) to the International Convention for the Prevention of Pollution from Ships 73/78 (MARPOL 73/78) on 23rd November, 2011 and this will come into force with effect from 23rd February, 2012.

.2 In view of the above mentioned accession, the existing International Air Pollution Prevention (IAPP) and Engine International Air Pollution Prevention (EIAPP) Statements / Certificates of Compliance are required to be replaced with Convention Certificates at the first of the following occasions occurring after 23rd February 2012 but no later than 23rd February 2013:

.2.1 IAPP Certificate renewal survey;

.2.2 Change of flag survey;

.2.3 Re-issue of certification for Annex VI due to possible changes to technical requirements, certification details/entries, etc.;

.2.4 At owner's request.

.3 All Recognized Organizations are advised to be governed by the above requirement in respect of issuance of Convention Certificates relating to Annex VI to MARPOL 73/78, in keeping with the extant practice as followed for other statutory certificates as dully harmonized.

.4 All Owners / Managers of vessels which are already registered with the Indian maritime administration are also advised to approach the respective Registrars with which their vessels are registered if the vessels' renewal survey do not fall due between the period, from 23rd February 2012 to 23rd February 2013, so as to ensure that the existing IAPP and EIAPP Statements / Certificates of Compliance are replaced with the Convention Certificates prior to 23rd February, 2013.

.5 This issues with the approval of the competent authority.

D. Mehrotra

(D. Mehrotra)

Dy. Chief Surveyor cum Sr. DDG(Tech)

To,

1. The Principal Officer, Mercantile Marine Department, Mumbai / Kolkata / Chennai / Kochi / Kandla.
2. The Surveyor-in-charge, Mercantile Marine Department, Jamnagar, Momugao / Port Blair / Tuticorin/ Visakhapatnam / Noida / New Mangalore / Haldia / Paradip.
3. Indian National Ship- owners Association (INSA), Mumbai
4. Indian Coastal Conference (ICC), Mumbai
5. All Recognised Organisations.
6. NA/ CS/ CSS.
7. All Branches of the Directorate.
8. Hindi Cell.
9. Computer Cell.
10. Sr. PS to DG.
11. Sr. PS to Jt. DG.

EMISSION STANDARDS FOR DIESEL ENGINES (ENGINE RATING MORE THAN 0.8 MW (800 KW) FOR POWER PLANT, GENERATOR SET APPLICATIONS AND OTHER REQUIREMENTS

(Emission Standards for Diesel Engines (Engine Rating more than 0.8 MW (800 KW) were notified by the Environment (Protection) Third Amendment Rules 2002, vide G.S.R. 489 (E), dated 9th July, 2002 at serial no. 96, under the Environment (Protection) Act, 1986.)

EMISSION STANDARDS FOR DIESEL ENGINES (ENGINE RATING MORE THAN 0.8 MW (800 KW)) FOR POWER PLANT, GENERATOR SET APPLICATIONS AND OTHER REQUIREMENTS

TABLE

<table>
<tr><th colspan="2" rowspan="2">Parameter</th><th rowspan="2">Area Category</th><th rowspan="2">Total engine rating of the plant (includes existing as well as new generator sets)</th><th colspan="3">Generator sets commissioning date</th></tr>
<tr><th>Before 1.7.2003</th><th>Between 1.7.2003 and 1.7.2005</th><th>On or after 1. 7. 2005</th></tr>
<tr><td colspan="2" rowspan="4">NOx (as NO_2) (AT 15% O_2), dry basis, in ppmv</td><td>A</td><td>Upto 75 MW</td><td rowspan="2">1100</td><td rowspan="2">970</td><td rowspan="2">710</td></tr>
<tr><td>B</td><td>Upto 150 MW</td></tr>
<tr><td>A</td><td>More then 75 MW</td><td rowspan="2">1100</td><td rowspan="2">710</td><td rowspan="2">360</td></tr>
<tr><td>B</td><td>More then 150 MW</td></tr>
<tr><td colspan="2">NMHC (as C)(at 15% O_2), mg/Nm^3</td><td>Both A and B</td><td></td><td>150</td><td colspan="2">100</td></tr>
<tr><td rowspan="2">PM (at 15% O_2), mg/Nm^3</td><td>Diesel Fuels- HSD & LDO</td><td>Both A and B</td><td></td><td>75</td><td colspan="2">75</td></tr>
<tr><td>Furnace Oils- LSHS & FO</td><td>Both A and B</td><td></td><td>150</td><td colspan="2">100</td></tr>
<tr><td colspan="2">CO (at 15% O_2), mg/Nm^3</td><td>Both A and B</td><td></td><td>150</td><td colspan="2">150</td></tr>
<tr><td colspan="2" rowspan="2">Sulphur Content in fuel</td><td>A</td><td></td><td colspan="3">< 2%</td></tr>
<tr><td>B</td><td></td><td colspan="3">< 4%</td></tr>
<tr><td colspan="2">Fuel specification</td><td>For A only</td><td>Up to 5MW</td><td colspan="3">Only Diesel fuels (HSD, LDO) shall be used.</td></tr>
<tr><td colspan="2">Stack height (for generator sets commissioned after 1.7.2003)</td><td colspan="5">Stack height shall be maximum of the following, in meter:
(i) 14 $Q^{0.3}$, Q= Total SO_2 emission from the plant in kg/hr.
(ii) Minimum 6 m. above the building where generator set is installed.
(iii) 30 m.</td></tr>
</table>

Note:

1. Acronyms used :

MW	:	Mega(10^6) Watt	FO	:	Furnace Oil
NO_x	:	Oxides of Nitrogen	HSD	:	High Speed Diesel
NO_2	:	Nitrogen Dioxide	LDO	:	Light Diesel Oil
O_2	:	Oxygen	LSHS	:	Low Sulphur Heavy Stock
NMHC	:	Non-Methane Hydrocarbon	kPa	:	Kilo Pascal
C	:	Carbon	mm	:	Milli (10^{-3}) metre
PM	:	Particulate Matter	kg/ hr	:	Kilo (10^3) gram per hour
CO	:	Carbon Monoxide	mg/Nm^3	:	milli (10^{-3}) gram per Normal meter cubic
SO_2	:	Sulphur Dioxide			
ppmv	:	parts per million (10^6) by volume			

2. Area categories A and B are defined as follows:

Category A: Areas within the municipal limits of towns/cities having population more than 10 lakhs and also upto 5 km beyond the municipal limits of such towns/cities.

Category B: Areas not covered by category A.

3. The standards shall be regulated by the State Pollution Control Boards or Pollution Control Committees, as the case may be.

4. Individual units with engine ratings less than or equal to 800 KW are not covered by this notification.

5. Only following liquid fuels viz. High Speed Diesel, Light Diesel Oil, Low Sulphur Heavy Stock and Furnace Oil or liquid fuels with equivalent specifications shall be used in these power plants and generator sets.

6. For expansion project, stack height of new generator sets shall be as per total Sulphur Dioxide emission (including existing as well as additional load).

7. For multi engine plants, flues shall be grouped in cluster to get better plume rise and dispersion. Provision for any future expansion should be made in planning stage itself.

8. Particulate matter, Non- Methane Hydrocarbon and Carbon Monoxide results are to be normalized to 25° C, 1.01 kilo Pascal (760 mm of mercury) pressure and zero percent moisture (dry basis).

9. Measurement shall be performed at steady load conditions of more than 85% of the rated load.

10. Continuous monitoring of Oxides of Nitrogen shall be done by the plants whose total engine capacity is more than 50 Mega Watt. However, minimum once in six month monitoring for other parameters shall be adopted by the plants.

11. Following methods may be adopted for the measurement of emission parameters:-

Sl. No.	**Emission Parameters**	**Measurement Methods**
1.	Particulates	Gravimetric
2.	SO_2	Barium Perchlorate - Thorin indicator method
3.	NO_x	Chemiluminescence, Non Dispersive infra Red, Non Dispersive Ultra-violet (for continuous measurement), Phenol disulphonic method
4.	CO	Non Dispersive Infra Red
5.	O_2	Paramagnetic, Electrochemical sensor
6.	NMHC	Gas Chromatograph – Flame Ionisation Detector