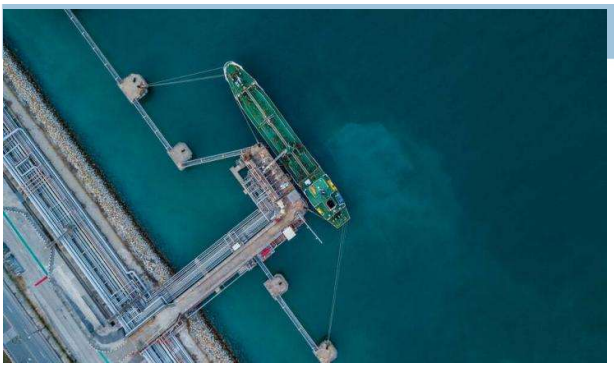
LNGFlex

Final Report
February 2025

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (EIA)

CLOSED-LOOP VIRTUAL LNG (VLNG) TERMINAL AT KARACHI PORT







EHS Services
Environmental & Analytical Solutions

Table of Contents

Abbreviations 1

Units 1

Executive Summary 2

1.0 Introduction 7

1.1 Project Need 8

1.2 Environmental & Social Impact Assessment 10

1.2.1 Need for ESIA 10

1.2.2 Objectives of ESIA 10

1.2.3 Approach to the ESIA 11

1.2.4 Methodology Adopted for ESIA 12

1.2.5 Scoping 13

1.2.6 Review of Legislation and Guidelines 14

1.2.7 Baseline Data Collection 15

1.2.8 Identification of Aspects 16

1.2.9 Impact Assessment & EMP 16

1.2.10 Documentation & Review 17

2.0 Policy, Legal & Regulatory Framework 18

2.1 The 18th Amendment in Constitution of Pakistan 18

2.2 Sindh Environmental Protection Act, 2014 19

2.3 Sindh EPA (Environmental Assessment) Regulations 2021 21

2.4 Sindh Environmental Quality Standards 21

2.5 Self-Monitoring and Reporting by Industry Rules 2014 25

2.6 The Hazardous Substances Rules 2014 26

2.7 Labor and Health and Safety Legislation 26

2.8 Sindh Wildlife Protection Ordinance 1972 27

2.9 Sindh Fisheries Ordinance 1980 28

2.10 Sindh Forest Act 1927 28

2.11 The Sindh Factories Act 2015 28

2.12 The Sindh Factories Rules 1975 29

2.13 Land Acquisition Act (LAA) 1984 29

2.14 Pakistan Penal Code 30

2.15 Sindh Antiquities Act 1974 30

2.16 Sindh Cultural Heritage (Preservation) Act 1994 30

2.17 The Biodiversity Action Plan 31
2.18 National Climate Change Policy 32
2.19 Climate Change Act 2017 32
2.20 National Forest Policy 2015 33
2.21 Disaster Management Act, 2010 33
2.22 Building Code of Pakistan, Fire Safety Provisions 2016 33
2.23 Karachi Ports Trust Act 1886 as amended in 1994 34
2.24 The Sindh Occupational Safety and Health Act, 2017 35
2.25 World Bank Guidelines on Environment 35
2.26 IFC Performance Standards 36
2.27 IFC- Environment, Health & Safety Guidelines for LNG 39
2.28 International Treaties and Conventions 40
2.29 International Convention on Biodiversity 41
2.30 Convention on Wetlands of International Importance, (RAMSAR) 1971 41
2.31 IUCN Red List 42
2.32 Liquefied Natural Gas (LNG) Policy, 2011 42
2.33 Ports Act 1908 & Pakistan Territorial Waters & Maritime Zones Act 1976 46
2.34 United Nations Convention on the Law of the Sea 47
2.35 National Maritime Policy of Pakistan 49
2.36 International Maritime Conventions 50
3.0 Description of Project 54
3.1 Overview 54
3.2 Selection of the Preferred Site 55
3.3 Estimated Throughput and Equipment Sizing 57
3.4 LNGC & FSU 59
3.5 Type of Terminal 61
3.6 Berth Design 62
3.7 Onshore Terminal Facility 65
3.7.1 ISO Tank Filling Bays 65
3.7.2 Onshore Terminal Facility (OTF) Package Systems with Suggested Capacities (Utilities): 65
3.8 Operating Scheme 67
3.8.1 General Philosophy 67
3.8.2 LNGC proposed Navigation Scheme 68
Figure 3.5: LNGC Navigation Route 68

3.8.3 LNGC and FSU Mooring Scheme 68
3.8.4 Ship to Ship Transfer Scheme (LNGC to FSU)..... 69
3.8.5 Ship to Shore Transfer Scheme (FSU to LNG ISO Tank Loading Skids)..... 69
3.8.6 ISO Tanks loading scheme 70
3.9 Proposed End User Facility 70
3.9.1 Small to Medium Enterprise (SME) Industrial Sectors & Housing Colonies 70
3.9.1 LCNG Stations..... 71
3.10 Road Congestion & Transportation Assessment.....72
4.0 Description of Existing Environment..... 73
4.1 Introduction 73
4.2 Karachi Port 73
4.2.1 Aids to Navigation.....74
4.2.2 Topography of the Macroenvironment 76
4.2.3 Topography of the Microenvironment 78
4.2.4 Geology & Landforms 79
4.2.5 Seismotectonics of the Area 80
4.2.6 Meteorological & Climatic conditions 84
4.2.7 Hydraulic Regime 88
4.2.8 Water Quality 96
4.2.9 Analysis of Sediments Samples 97
4.2.10 Sources of Pollution..... 98
4.2.11 Ambient Air & Noise Quality..... 102
4.2.12 Marine Ecosystems 111
4.2.13 Socioeconomic Status of the Macroenvironment 119
4.2.13.1 Population Distribution.....119
4.2.13.2 Education and Literacy 121
4.2.13.3 Karachi Human Development Index (HDI) 122
4.2.13.4 Health 122
4.2.13.5 Infant and Maternal Mortality.....122
4.2.13.6 Disability in Urban Sindh.....123
4.2.13.7 HIV.....123
4.2.13.8 Occupational Safety and Health Situation in Urban Sindh.....123
4.2.13.9 Housing..... 124
4.2.13.10 Economy..... 125
4.2.13.11 Employment 126

4.2.13.12 Informal Sector 127
4.2.13.13 Social Infrastructure and Services 127
4.2.13.14 Water Supply 127
4.2.13.15 Sewerage System 130
4.2.13.16 The Drainage System 132
4.2.13.17 Solid Waste 133
4.2.13.18 Power Supply 134
4.2.13.19 Public Transport 134
4.2.13.20 Roads 135
4.2.13.21 Fire Services 135
4.2.14 Socioeconomic Status of the Microenvironment 136
4.2.14.1 Cultural and Archaeological Heritage 136
4.2.14.2 Localities 137
4.2.14.3 Mother Language 137
4.2.14.4 Ethnicity / Tribes near the Project Area 137
4.2.14.5 Main Occupation Dwellers near the Project Area 137
4.2.14.6 Industry 137
4.2.14.7 Other Facilities of Life 137
4.2.14.8 Education Facility 138
5.0 Stakeholder Engagement, Impact Assessment, and Proposed Mitigation Strategies 139
5.1 Assessment and Analysis of Environmental Concerns Highlighted by Stakeholders 139
5.2 Screening of Alternatives 149
5.2.1 No Project Alternative 150
5.2.2 Evaluation of Alternative Options for Site Selection 151
5.2.3 Evaluation of Alternative Options for Terminal Selection 156
5.3 Screening of Potential Impacts 157
5.4 Evaluation of Environmental Impacts for Site Preparation 157
5.5 LNG Terminal Installations 159
5.5.1 Waste Discharges 161
5.5.2 Air Quality 162
5.5.3 Noise 165
5.5.4 Manmade Hazards 168
5.5.5 Natural Hazards 171
5.5.6 Protected Areas 171

5.5.7 Risks 171
5.5.7.1 Release of Liquefied Natural Gas 171
5.5.7.2 Non-pressurized liquefied natural gas spill 172
5.5.7.3 Pressurized liquefied natural gas spill/leakage 173
5.5.7.4 Dispersion 173
5.5.7.5 Rapid Phase Transformation 173
5.5.7.6 Flash Fire 174
5.5.7.7 Pool Fire 174
5.5.7.8 Fireball/BLEVE 174
5.5.7.9 Vapor Cloud Explosion 175
5.5.7.10 Jet Fire 175
5.5.7.11 Risk Assessment 176
5.5.8 Socioeconomic Impacts 177
6.0 Environmental Management Plan (EMP) 179
6.1 Need for EMP 179
6.2 Scope of the EMP 179
6.3 EMP Process 181
6.4 Project Proponent's Commitment to EHS 181
6.5 Management Approach 181
6.6 Training 183
6.7 Communications 183
6.8 Operation Phase 185
6.9 Standard Operating Procedures 193
6.9.1 Wastewater/Storm water management 193
6.9.2 Noise and air emissions 197
6.9.3 Erosion protection requirements 200
6.9.4 Cleanup and revegetation 201
6.9.5 Waste management plan 203
6.9.6 Environmental Inspection by SHE department 208
6.10 Contingency planning-accidents & malfunctions 210
6.10.1 Fire Contingency Plan 210
6.10.2 Hazardous spill contingency plan 212
6.10.3 Housekeeping 215
6.10.4 Security 215
6.10.5 Training 215

6.10.6 Fire Detection and Warning 215
6.10.7 Site accommodation 216
6.10.8 Fire drills 216
6.10.9 Materials storage 217
6.10.10 Firefighting equipment 217
6.10.11 Training 218
6.11 Environmental Compliance 218
6.11.1 Audits 219
7.0 Conclusion 220

Abbreviations

Symbol	Description
LNG	Liquefied Natural Gas
KPT	Karachi Port Trust
Regas	Regassification
FSU	Floating Storage Unit
SSLNGC	Small-Scale LNG Carrier
FSRU	Floating Storage and Regasification Unit
BOG	Boil-Off Gas
CNG	Compressed Natural Gas
DG	Dangerous Good
CAPEX	Capital Expenditure
OPEX	Operational Expenditure
RLNG	Regasified LNG
IRR	Internal rate of return
SSGCL	Sui Southern Gas Company Limited
SNGPL	Sui Northern Gas Pipeline Limited
L-CNG	LNG supply solution for CNG stations

Units

Symbol	Description
mtpa	Million tons per annum
scf	Standard Cubic Feet
mmscfd	Million Standard Cubic Feet Per Day
BTU	British Thermal Unit
MMBtu	Million BTU
Cbm	Cubic meter
°C	Degree Celsius
Lbs	Pounds
Kg	kilogram

Executive Summary

LNGFlex Limited (LNGFlex), wholly owned by Bison Energy FZCO (Dubai, UAE), is strategically positioning itself to emerge as a significant contender in the gas market of Pakistan. The parent company of LNGFlex has purchased the Tabeer RLNG Terminal from Mitsubishi at Port Qasim Authority.

LNGFlex Limited (hereinafter "LNGFlex") is developing the Project Pluto as the Pakistan's first Virtual Liquefied Natural Gas (VLNG) Terminal at Karachi Port, designed to meet the country's rising energy needs.

LNGFlex is developing a closed-loop VLNG integrated end to end LNG supply chain project encompassing:

- import of Liquefied Natural Gas (LNG) through LNG Carriers (LNGC);
- storage of LNG in a permanently berthed Floating Storage Unit (FSU) at Karachi Port Trust (KPT), Pakistan;
- filling of ISO tanks using pipe manifold connected to ISO tank loading bays;
- transportation of ISO tanks to customers;
- regasification of LNG at customer premises.

LNGFlex has already obtained a comprehensive License from Oil & Gas Regulatory Authority (OGRA) and an No Objection Certificate (NOC) from KPT to proceed with the technical studies for establishing the suitability of the selected site for the intended purpose.

The PDWCP basin at KPT has been identified as a promising harbor for establishing a dedicated LNG terminal, along with its associated storage and onward transportation facilities for LNG stored in cryogenic ISO tanks to downstream industries.

Quantitative Risk Analysis (QRA) and HAZOP/HAZID have been conducted by the globally renowned classification and risk management firm RINA Consulting. EHS Services has been appointed by LNGFlex Ltd to carry out an Environmental & Social Impact Assessment (ESIA). LNGFlex Limited is in the final stages of completing all regulatory formalities to obtain regulatory approvals from relevant departments/agencies/authorities for the pioneering closed-loop virtual LNG (VLNG) Terminal project. The aim is to introduce much-needed LNG by the 3rd Quarter of 2027.

ESIA study has covered all the applicable National and Provincial legal requirements in the context of environmental protection & sustainable development, and the institutions that exist in the country that may influence the environmental management of the proposed Project PLUTO. In addition to the local laws and regulations, Pakistan is also signatory to a number of International environmental conventions which have been ratified by the

government. In carrying out this Environmental Assessment, relevant international guidelines have duly been followed.

The stakeholders during the scoping process highlighted several critical observations regarding Pakistan's gas supply and demand situation.

- Pakistan's population has surged to approximately 250 million, resulting in an escalating gas demand that currently stands around 6.6 billion cubic feet per day (bcfd). This demand is anticipated to increase to7 bcfd in the near future, even as local gas production is expected to decline below 2 bcfd. Presently, the country operates only two LNG terminals, which are insufficient for ensuring a continuous and reliable gas supply.

- As of 2022, Pakistan's total gas supply was recorded at 3.3 bcfd, encompassing 2.63 bcfd from domestic productionand630 million standard cubic feet per day (mmscfd) from imports. This troubling scenario indicates that Pakistan will need to import Liquefied Natural Gas (LNG) at a volume three times that of its local production, a situation that significantly impacts policy and regulatory frameworks and ultimately affects consumers.

- Environmental Expert from academia has observed a significant increase in aquatic pollution levels in the Karachi Port Trust (KPT) coastal area, situated along the southern coast of Pakistan, over recent decades. This alarming trend can be largely attributed to the unrestricted discharge of sanitary waste into the water.

- The Sindh Environmental Protection Agency (SEPA) has underscored the importance of involving all stakeholders during the scoping phase of the Environmental and Social Impact Assessment (ESIA). The assessment should prioritize sustainable development within the project's area of influence.

- For the proposed VLNG Terminal project, it is crucial that it complies with the safety and security standards set forth in the LNG Policy 2011, as well as adhering to pertinent local and international regulations, including those established by SIGTTO. Additionally, it is imperative that studies are conducted on the dredging spoil disposal arrangements to guarantee safe and scientific disposal methods.

- SEPA has expressed concerns regarding the lack of commitment to post-environmental monitoring against the Environmental Management Plan (EMP) and approval conditions. They recommended that LNGFlex Limited establish a dedicated Health,

Safety, and Environment (HSE) department helmed by qualified personnel to ensure the effective implementation of HSE protocols.

- Furthermore, the site preparation phase should prioritize local labor, and Corporate Social Responsibility (CSR) initiatives should be strategically designed to enhance the welfare of the local population, focusing on areas such as health, technical education, and skill development, which would yield long-term benefits.

- Senior Executives of WWF Pakistan, IUCN, and Sindh Forest Department have expressed serious concerns regarding the pollution in the port areas of Karachi and the imminent threats to the ecosystem posed by human activities. The Sindh Forest Department (SFD) has been making significant advancements in the conservation and management of mangrove forests in the province. They have undertaken the planting of mangroves on 55,555 hectares along the Sindh coastline, predominantly in the Indus Delta, through ambitious projects spanning from 2020 to 2024. These collaborative initiatives with WWF-Pakistan and IUCN have resulted in a noteworthy increase in Pakistan's mangrove forest cover from 1,338.16 km^2 in 2016 to 1,573.57 km^2 in 2020 [REDD+; Subnational GHG Inventory 2022].

- Despite the positive progress made by the SFD and various conservation organizations, the mangroves in Karachi are facing significant challenges. The SFD reports a loss of approximately 200 hectares of mangrove forests along the coastline between 2010 and 2022. This alarming trend is primarily driven by land encroachment, residential developments, and infrastructure projects.

- The National Forum for Environment & Health (NFEH) reaffirmed its support for sustainable development, welcoming initiatives along Karachi's coastal regions while stressing the necessity of reducing negative environmental impacts. A detailed evaluation of the existing pace of development around KPT and PQA is imperative, as the cumulative effects of multiple projects could lead to serious and lasting environmental issues. The diminishing space between residential and industrial sectors presents administrative challenges and enhances the risk of environmental harm, highlighting the need for a buffer zone to separate these areas.

- The residents of Shireen Jinnah Colony warmly embraced the Project with open arms, eagerly anticipating the promised benefits such as job opportunities and Skill Development Training outlined in the Project's Corporate Social Responsibility plans. Their optimism, however, is tempered by pressing concerns regarding environmental issues, particularly the inadequate sewerage system and improper

solid waste disposal practices prevalent in the area. The community also grapples with challenges like frequent electricity and gas shortages, as well as the lack of access to clean drinking water, which are identified as major obstacles to their quality of life.

The screening process is a crucial component of the environmental assessment for the proposed Closed-loop Virtual LNG (VLNG) Terminal Project. It involves identifying significant environmental and social aspects prior to the construction, establishment, and operation phases. The aspects recognized during stakeholder consultations and the screening were evaluated for their severity, leading to proposed mitigation measures.

The screening of possible impacts from both the construction and operational phases of the proposed LNG import terminal at Project PLUTO's location in KPT encompasses several key areas:

- Site Preparation
- Construction of Berth
- Waste Discharges
- Air Quality
- Noise Level
- Man-Made Hazards
- Natural Hazards
- Sensitivity
- Operational Risks and Hazard Management
- Socioeconomic Impacts

The Project Proponents will implement the mitigation measures to minimize, reduce, and offset any negative impacts.

The Quantitative Risk Assessment has been performed for Pluto project to estimates the process risk to operations activities associated to flammable hazards (such as jet fires, flash fires) and overpressure hazards (such as vapour cloud explosions).

The analysis has been performed through the following steps:

- Identification of Accidental Events;
- Evaluation of Frequencies of Occurrence;
- Assessment of the Consequent Scenarios;
- Risk Evaluation and Assessment.

Results have been expressed in terms of Local Specific Individual Risk (LSIR). Comparing LSIR result with risk tolerability criteria, it can be stated that the LSIR values fall within the "Low risk area" (LSIR < 1 ×10-6 ev/y) and the "Medium risk area" (1 ×10-6 ev/y ≤ LSIR < 1 ×10-4 ev/y).

It is recommended to consider the implementation of risk reduction measures to ensure the risk is managed and minimized. Some examples are reported below:

- implement an adequate Emergency Shut-Down system, to reduce the quantity of hazardous substances released in the event of an accidental leak;
- implement an adequate Fire & Gas system, to promptly detect accidental leak and hazardous scenarios and to reduce the duration of the accidental releases;
- ensure the independence between instrumentation serving safety systems and that used for basic process control systems;
- carry out the design and construction of plant/equipment in accordance with internationally recognized standards and regulations;
- select proper materials and sealing devices in relation to the circulating fluid;
- consider using highly reliable control instrumentation and, for critical variables, redundant systems;
- adopt safety valves and depressurization valves on pipelines and equipment, in accordance with internationally recognized standards and regulations;
- consider minimizing the flanged connections, to reduce the frequency of occurrence of the loss of containment events.

The overall impact on the national economy is projected to be overwhelmingly positive, with the project poised to generate significant additional resources for the nation, aligning with the government's long-term development strategy. Increased licensing income, along with other revenue sources, will bolster government revenues and foster economic growth through expanded and diversified business opportunities in Pakistan.

To mitigate risks associated with the handling of LNG/RLNG, a comprehensive set of monitoring and mitigation measures has been put in place. The Environmental Management and Monitoring Plan, alongside safety and security protocols, will ensure that the project does not lead to unmitigated adverse environmental impacts or compromises stakeholder safety.

The Environmental & Social Impact Assessment (ESIA) study indicates that the proposed VLNG Terminal, known as Project PLUTO, aligns with sustainable development objectives by providing a reliable energy source, thus aiding economic development. The study recommends approval of the ESIA report, contingent upon the implementation of suggested mitigation measures and strict adherence to the Environmental Management Plan (EMP) by LNGFlex Limited.

1.0 Introduction

LNGFlex Limited (LNGFlex), wholly owned by Bison Energy FZCO (Dubai, UAE), is strategically positioning itself to emerge as a significant contender in the gas market of Pakistan. The parent company of LNGFlex has purchased the Tabeer RLNG Terminal from Mitsubishi at Port Qasim Authority.

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The PDWCP basin at KPT has been identified as a promising harbor for establishing a dedicated LNG terminal, along with its associated storage and onward transportation facilities for LNG stored in cryogenic ISO tanks to downstream industries.

LNGFlex articulates the project objectives as a means to enhance efficiencies in the LNG supply chain by:

- Harnessing procurement efficiencies through direct negotiations with LNG suppliers.

- Establishing a virtual pipeline utilizing a permanently docked FSU at KPT, filling ISO tanks via a pipe manifold for transportation to customer sites.

- Delivering LNG to small/medium industrial customers and the transport sector.

- Optimizing the supply chain by transforming existing CNG stations into L/CNG stations.

- Leveraging the strengths of key stakeholders across multiple countries.

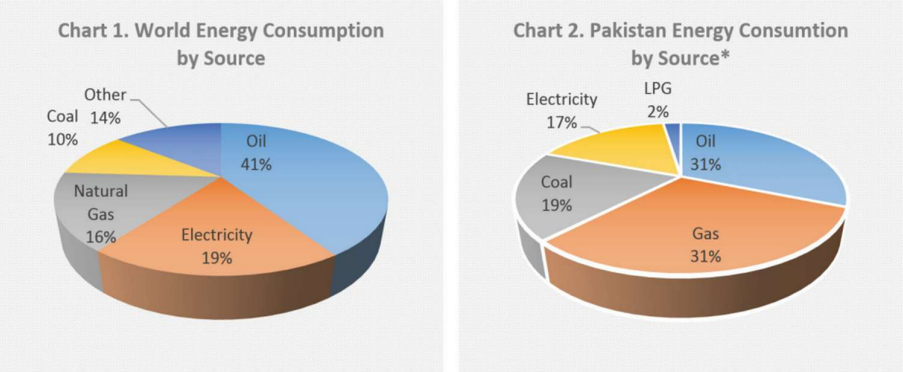
Quantitative Risk Analysis (QRA) and HAZOP/HAZID have been conducted by the globally renowned classification and risk management firm RINA Consulting. EHS Services has been appointed by LNGFlex Ltd to carry out an Environmental & Social Impact Assessment (ESIA). LNGFlex Limited is in the final stages of completing all regulatory formalities to obtain regulatory approvals from relevant departments/agencies/authorities for the pioneering closed-loop virtual LNG (VLNG) Terminal project. The aim is to introduce much-needed LNG by the 3rd Quarter of 2027.

1.1 Project Need

Natural gas accounts for 38% of the nation's total primary energy supply. The domestic gas production remains at around 4 billion cubic feet per day (bcfd), while the demand ranges between 6-8 bcfd, resulting in a significant supply-demand gap. Pakistan experienced its peak natural gas production in 2012, after which production from existing fields began to decline. Despite some recent minor discoveries, they have not been able to compensate for the decline. The Energy Information Administration reports substantial shale gas reserves in Pakistan, with the government offering investment incentives for their development. However, challenges such as complex geography, environmental constraints, water resource limitations, security issues, and low natural gas prices hinder the development of shale resources.

To address the depleting natural gas reserves in existing fields, Pakistan started importing LNG in FY 2015 to meet the rising domestic demand. The country inaugurated its first regasification terminal, the Engro Elengy floating storage and regasification unit (FSRU), at Port Qasim Karachi in 2015. The second LNG terminal commenced operations in December 2017. With a growing demand for gas from private sectors like power, cement, and textile industries, the Government has opened up the LNG sector for private firms to import LNG for their respective industries. A third LNG terminal is currently in the works, undergoing bureaucratic approvals.

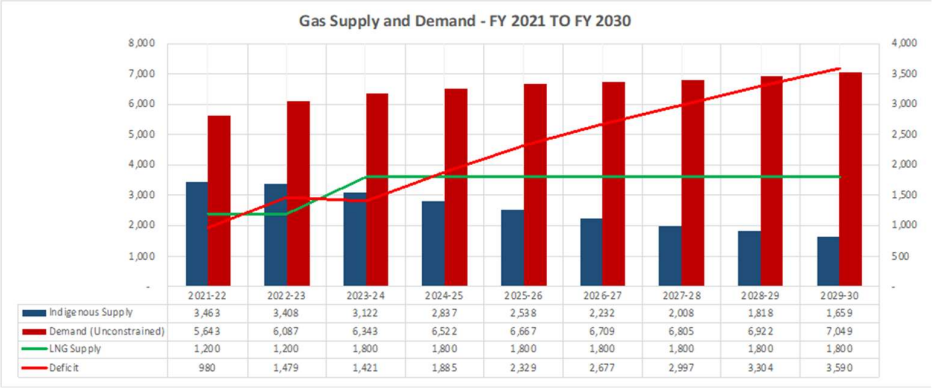
Currently, natural gas and imported LNG contribute over 40% to the country's energy mix, including gas resources used in electricity generation. The demand for gas in Pakistan has surged in recent years, while exploration and production have declined. The weak operational and regulatory framework for LNG has led to a nationwide shortage and increased supply costs. The comparison of the share of different sources of electricity generation is provided below.



Source: IEA and Pakistan Energy Yearbook.
* Gas, Oil, & Coal share does not include these fuel shares used in electricity generation.

Figure 1.1: Energy consumption by source

Pakistan's energy sector is facing significant challenges, with gas holding nearly half of the overall energy mix. The graph illustrating the supply-demand deficit in Pakistan's gas sector is presented below. The country's population, now at 241 million, has led to a gas demand of approximately 6.6 billion cubic feet per day (BCFD). As of 2022, the total gas supply in Pakistan stood at 3.3 BCFD, sourced from 2.63 BCFD domestically and around 750 MMSCFD from imports. Projections indicate that gas demand is expected to rise to 7 BCFD in the coming years, while indigenous production is anticipated to drop to less than 2 BCFD. This scenario implies that Pakistan will need to import LNG three times the volume of its locally produced gas. Given the mature geology and increased well density, significant indigenous hydrocarbon finds are unlikely. Additionally, cross-border pipeline projects for gas imports (TAPI, IRI) have made no progress over many years and are unlikely to materialize in the foreseeable future.



	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
Indigenous Supply	3,463	3,408	3,122	2,837	2,538	2,232	2,008	1,818	1,659
Demand (Unconstrained)	5,643	6,087	6,343	6,522	6,667	6,709	6,805	6,922	7,049
LNG Supply	1,200	1,200	1,800	1,800	1,800	1,800	1,800	1,800	1,800
Deficit	980	1,479	1,421	1,885	2,329	2,677	2,997	3,304	3,590

Figure 1.2: Gas supply and demand gap

The Government of Pakistan introduced an LNG Policy to attract potential investors and facilitate the successful implementation of LNG import projects. The policy allows for integrated project structures, where the terminal developer organizes LNG imports and secures buyers, or unbundled structures, where the terminal developer, LNG importer, and buyers are separate entities. In line with the LNG Policy, the Oil and Gas Regulatory Authority (OGRA) notified LNG Rules in 2007 to regulate anticipated LNG activities. The policy encourages project developers to enter the LNG market after fulfilling the necessary formalities as per the LNG Rules.

LNGFlex Limited, based at Karachi Port, is planning to establish a Closed-loop Virtual LNG (VLNG) Terminal for gas supply through cryogenic bowsers. The company aims to import LNG cargoes, fill, transport, market, and distribute the fuel under the 'Integrated LNG Project Structure' outlined in the LNG Policy 2011.

The analysis indicates a sufficient demand to support the establishment of a Closed-loop Virtual LNG (VLNG) Terminal at Karachi Port. Pakistan's extensive highway system developed over the last six years provides a solid foundation for a virtual pipeline. Moreover, Pakistan boasts the world's most extensive network of CNG-filling stations established over two decades ago.

1.2 Environmental & Social Impact Assessment

1.2.1 Need for ESIA

The ESIA study of proposed Project responds to:

- Section 17 of Sindh Environmental Protection Act 2014 which requires that every new development project in Sindh has to be preceded by an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) depending on the nature and severity of impacts anticipated on commissioning of the project;
- Procedures set out in Sindh Environmental Protection Agency (Review of IEE/EIA) Regulations 2014 which categorizes projects requiring IEE and EIA in Schedules I & II respectively.
- LPG and LNG Terminal Projects are covered by Schedule-III, list of projects requiring EIA.
- Accordingly, an ESIA study has been conducted and the report will be submitted to Sindh EPA for review & approval.

1.2.2 Objectives of ESIA

The main purpose of this ESIA Study is to respond to provisions of Sindh Environmental Protection Act 2014 and the rules & regulations framed

thereunder, and to provide information on the nature and extent of environmental impacts arising from developing Pakistan's first Closed-loop Virtual LNG (VLNG) Terminal for supply of Small-Scale LNG in ISO Cryogenic Tanks mostly to OFF-GRID clients nationwide. that would take place concurrently or subsequently. The ESIA study has been conducted for the purpose of:

- Describing the environmental baseline of the project area.
- Describing the activities pertaining to the Project.
- Ascertaining applicability of relevant rules and regulations to the site and operations.
- Identifying the environmental consequences of siting the project and inception of associated activities; QRA has assessed the risks due to the LNG handling and associated operations at proposed site at KPT.
- Undertaking the environmental assessment from the perspective of environmental & social aspects in the project area & suggesting mitigation measures for sustained development.
- Ensuring the adequacy of proposed mitigation measures to deal with residual impacts after implementation of the Project.

1.2.3 Approach to the ESIA

A brief overview of the conceptual components of an EIA Process that meets both Sindh, Pakistan and international standards is given below:

Table 1.4 - Conceptual Components of an ESIA process

Components	Main Purpose	Activities related to Stakeholder Consultation
Scoping	▪ Identify the issues on which the ESIA should focus ▪ Identify the project alternatives that should be evaluated during the course of the ESIA.	▪ Identify institutional and community stakeholders ▪ Engage stakeholders and record issues raised ▪ Provide feedback to the ESIA team to incorporate stakeholders concern in baseline investigations and impact assessment
Baseline investigations	▪ Collect background information on the environmental and social setting of the project	▪ Incorporate additional issues raised during the baseline survey
Impacts assessment studies	▪ Define the potential impacts of the project ▪ Undertake specialist investigations to predict changes to the environment due to the project	▪ Assess issues raised by stakeholders

Table 1.4 - Conceptual Components of an ESIA process		
	▪ Determine the significance of the potential impacts ▪ Identify measures for the management of the impacts ▪ Determine the residual impacts of the project after incorporation of the management measures ▪ Evaluate the overall acceptability of the project (from environmental and social perspectives).	
Mitigation Measures and management plan	▪ Environmental mitigation and monitoring plan will describe the measures proposed to ensure implementation of the mitigation measures identified during the impact assessment. It will include, for example, specific designs and plans, training requirements, resources requirement, monitoring details (sampling locations, methodology and frequency). Review and reporting requirements and budget.	▪ Assess the acceptability and practicability of the proposed mitigation measures
ESIA Report Preparation	▪ After the studies, the ESIA team will put together the detailed assessment of impacts and mitigation measures. This may involve liaison with various specialists to ensure correct interpretation of information and compile ESIA report.	▪ Provide stakeholders with a feedback on the ESIA specifically communicate how the project proposes to address the issues raised by the stakeholders
ESIA submittal to regulatory authorities and decision making	▪ Submittal and review of the ESIA report by regulatory authorities and other interested stakeholders. The reviewers will inform about the decision on the acceptability of the project from environmental and social perspectives and the condition of approval for the development	▪ Attend the public hearings and respond to the issues raised during the public hearings.

1.2.4 Methodology Adopted for ESIA

This study has covered all major areas of concern as per regulatory requirements. Scope of the ESIA study included collection of data from

different sources, development of baseline of the current physical, ecological and social baseline of the area through surveys. In general, the study has been conducted in accordance with the Sindh Environmental Protection Agency (Environmental Assessment) Regulations, 2021 & guidelines provided therein.

Following screening of potential environmental impacts, the requirement for mitigation measures to address the adverse impacts is presented. The Report includes the Environmental Management and Monitoring Program that will be implemented during the different phases of the project. This environmental impact assessment was conducted in the following manner:

1.2.5 Scoping

A scoping exercise was undertaken to identify the potential issues that are to be considered in the environmental impact assessment.

The scoping exercise included the following tasks:

Data Compilation: A generic description of the proposed activities relevant to this environmental assessment was compiled with the help of the Project proponent.

Review of Published literature: All available published and unpublished information pertaining to the micro and macro environment of the study area was obtained and reviewed. It included the earlier studies conducted in the study area, environmental and social baseline and impact assessment studies conducted by different consultants in past. Secondary data was very helpful in understanding the issues that were identified by other consultants.

Review of applicable Legislation: Information on relevant legislation, regulations, guidelines, and standards was reviewed and compiled.

Identification of potential impacts: The information collected in the above procedures was reviewed and potential environmental issues identified.

Initial site visit: An initial site visit was conducted to get an overview of site conditions and the surrounding areas.

Stakeholder consultation: Stakeholder consultation was undertaken to document the concerns of the stakeholders, and to identify issues that may require additional assessment in order to address these concerns. Stakeholder consultation was conducted during the survey with following objectives:

- To inform the stakeholders about the project and gather feedback

- To identify relevant potential environmental & social issues of the project, and corresponding mitigation measures.



Figure 1.3: Scoping Session

1.2.6 Review of Legislation and Guidelines

National & Provincial legislations, international agreements, environmental guidelines, and best industry practices were reviewed to set environmental standards that Project Proponents will be required to follow during different stages of the project. Review of legislations included but not limited to the following:

- Policies and Legislation relevant to LNG.
- Complementary legislation applicable to project for sustainable management of the environment covering land, water resources & water quality, solid waste management, atmospheric emissions.
- Administration: identification of relevant organization with its role and responsibility and make clear the approval process with its average time schedule though visit to relevant organization and reviewing documents.

The Sindh Environmental Protection Act 2014 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range of issues and extends to air, water, soil, marine, and noise pollution, as well as to the handling of hazardous wastes.

The LNG Terminals are classified as hazardous due to potential of fire, explosion and exposure (due to cryogenic temperatures) risks. The history of accidents/incidents, that caused fatalities or severe damage to the installations or nearby property, are rare and most have been reported either at the LNG

liquefaction facilities or at the LNG transfer points, most attributed to human error during operations or maintenance activities.

In order to ensure that safety is inherently incorporated in the design, construction and operation of an LNG Terminal, a set of Codes & Standards have been introduced which is specific to these terminals.

While there are international Codes & Standards available, the governments of many countries have introduced their own selection of the Codes & Standards, Guidelines and Procedures, compliance of which is mandatory for issuance of Licenses and Approvals for design, construction and operations of the LNG Terminal projects.

In Pakistan, Ministry of Petroleum & Natural Resources, prepared and issued an LNG Policy (2011), which also provides the list of Codes & Standards, Guidelines & Procedures that is applicable to LNG Projects in the country.

There is a long list of legislation that falls in the category of or is relevant to environmental law. Some of the more important ones are:

- LNG Policy 2011
- International maritime treaties and environmental conventions
- London convention on the prevention of marine pollution by dumping of wastes and other matter 1972
- MARPOL 1973 (modified in 1978)
- The convention on biological diversity
- IFC Environment, Health and Safety guidelines on LNG
- Sindh wildlife protection ordinance, 1972
- The Antiquities Act, 1975
- Sindh Cultural Heritage (Preservation) Act, 1994

1.2.7 Baseline Data Collection

Detailed environmental baseline surveys were conducted to collect primary data on the Project Area to help identify sensitive receptors. The primary data were examined and compared with secondary data available from earlier environmental studies in the region. The scope of survey included collection of information on following key aspects:

(1) To confirm baseline data including Biophysical of the Project Area including the following items with their seasonal variability:

- Climate and Rainfall
- Air Quality
- Noise Quality
- Geology
- Geomorphology
- Hydrology

- Topography
- Soil
- Flora & Fauna
- Marine Ecology

(2) To confirm baseline data including Socio Economic Environment of the Project Area including the following items with their seasonal variability

- Administrative Division
- Demography and Settlement
- Socio-Economic Activities
- Land use and National Resources Management in the Project area
- Existing Infrastructure and Social Services
- Current socioeconomic issues

1.2.8 Identification of Aspects

Identification of environmental aspects and their significance is fundamentally important for determination of severity of incidence of impacts at different stages of the project. This step is aimed at obtaining an inventory of the aspects. The aspects identified during this step cover all activities in order to determine those which, have or can have significant impact on the environment.

1.2.9 Impact Assessment & EMP

Environmental experts at EHSS analyzed and assessed the anticipated impacts that are likely to arise due to the identified aspects. Each of the potential impacts identified during the scoping session was evaluated using the environmental, socioeconomic, and project information collected. In general, the impact assessment discussion covers the following aspects:

- Present baseline conditions
- Potential change in environmental parameters likely to be affected by Project- related activities
- Prediction of potential impacts
- Evaluation of the likelihood and significance of potential impacts
- Defining of mitigation measures to reduce impacts to as low as practicable
- Prediction of any residual impacts, including all long- and short-term, direct and indirect, and beneficial and adverse impacts.
- The Quantitative Risk Assessment has been performed for Pluto project to estimates the process risk to operations activities associated to flammable hazards (such as jet fires, flash fires) and overpressure hazards (such as vapour cloud explosions). The analysis has been performed through the following steps:
  - Identification of Accidental Events;
  - Evaluation of Frequencies of Occurrence;

  - Assessment of the Consequent Scenarios;
  - Risk Evaluation and Assessment.
- Monitoring of residual impacts

An environmental management plan (EMP) was developed to oversee the environmental performance of the project and adoption of proposed mitigation measures. A monitoring plan has also been incorporated in the EMP to monitor impact of all activities and performance of mitigation measures and to identify the residual impact if any, and also the positive/negative changes in the physical, and socioeconomic environment.

1.2.10 Documentation & Review

This is the final step of the ESIA study. The data generated during and for the study are compiled and examined by experts of the respective field. Sections of this report were prepared as the study progressed, by EHSS office staff in consultation with experts. The report was finally reviewed by Team Leader, who analysed the information, assessed the potential environmental impacts in the light of national and international guidelines, examined the alternatives in the light of observations on the field as well as meetings with the stakeholders, before organizing the Report in the present form.

2.0 Policy, Legal & Regulatory Framework

This section of the ESIA study covers all the applicable National and Provincial legal requirements in the context of environmental protection & sustainable development, and the institutions that exist in the country that may influence the environmental management of the proposed Project PLUTO. In addition to the local laws and regulations, Pakistan is also signatory to a number of International environmental conventions which have been ratified by the government. In carrying out this Environmental Assessment, relevant international guidelines have duly been followed.

2.1 The 18th Amendment in Constitution of Pakistan

Prior to the 18th Amendment to the Constitution of Pakistan in 2010, the legislative powers were distributed between the federal and provincial governments through two 'lists' attached to the Constitution as Schedules. The Federal list covered the subjects over which the federal government had exclusive legislative power, while the 'Concurrent List' contained subjects regarding which both the federal and provincial governments could enact laws. The subject of 'environmental pollution and ecology' was included in the Concurrent List and hence allowed both the national and provincial governments to enact laws on the subject. However, as a result of the 18th Amendment this subject is now in the exclusive domain of the provincial government.

As a result, the Ministry of Environment at the federal level has been abolished. Its functions related to the national environmental management have been transferred to the provinces. The international obligations in the context of environment will be managed by the Ministry of Climate Change. Administration on environment has been divided into federal and provincial government. International issues such as the environmental policy and regulation has been managed by Ministry of Climate Change. On the other hand, national environmental matter has been managed by provincial government. In Sindh province, Sindh EPA has been responsible for the provincial matters. All of the environmental technical issues such as EIA, monitoring, enforcement of law/environmental quality standards are headed by Director General of Sindh EPA.

SEPA is a regulatory agency with the following main functions:

- Enforcement of Sindh Act 2014
- Prepare environmental policies for approval of the GoS
- Implement environmental policies
- Publish annual state of the environment report for Sindh
- Prepare or revise SEQS
- Ensure implementation of SEQS

- Establish systems and procedures for environmental management
- Promote research and studies on environmental issues
- Issue license for handling of hazardous substance
- Certify environmental laboratories
- Initiate legislation for environmental protection
- Provide assistance to government agencies in case of environmental accidents
- Providing advice to the government on issues related to environment
- Assist governments agencies in implementation of waste management schemes
- Provide guidance to public on environmental matters
- Assist education institutions in prescribing environmental curricula
- Undertake measures to enhance awareness on environment among general public
- Disseminate knowledge on environment
- Specify safeguards for the prevention of accidents which may cause pollution
- Review and approve mitigation plans and give guidance for clean-up operations
- Encourage the formation and working of nongovernmental organizations, community organizations and village organizations for environmental protection
- Carry out any other task related to environment assigned by the government.
- SEPA has the authority to review and issue approval of the EIA of the proposed Project.

2.2 Sindh Environmental Protection Act, 2014

The Sindh Environmental Protection Act 2014 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range of issues and extends to air, water, soil, marine, and noise pollution, as well as to the handling of hazardous wastes. This act is applicable to a broad range of issues that extends to air, water, industrial liquid effluent, marine, and noise pollution as well as to the handling of hazardous wastes. The applicable sections of the act to this project are:

- *Section 11(1): Subject to the provisions of this Act and the rules and regulations, no person shall discharge or emit or allow the discharge or emission of any effluent, waste, pollutant, noise or any other matter that may cause or likely to cause pollution or adverse environmental effects, as defined in section 2 of this Act, in an amount, concentration or level which is in excess to that specified in Sindh Environmental Quality Standards; or, where applicable, the standards established under Section 6(1)(g)(i); or direction*

issued under Section 17, 19, 20 and 21 of this Act; or any other direction issued, in general or particular, by the Agency.

- *Section 11(2): All persons, in industrial or commercial or other operations, shall ensure compliance with the Environmental Quality Standards for ambient air, drinking water, noise or any other Standards established under section 6(1)(g)(i); shall maintain monitoring records for such compliances; shall make available these records to the authorized person for inspection; and shall report or communicate the record to the Agency as required under any directions issued, notified or required under any rules and regulations.*

- *Section 11(3): Monitoring and analysis under sub-section (1) and (2), shall be acceptable only when carried out by the Environmental Laboratory certified by the Agency as prescribed in the rules.*

- *Section 12: No person shall import hazardous waste into Sindh province or its coastal, internal, territorial or historical waters, except acquiring prior approval of the Agency.*

- *Section 13: Subject to the provisions of this Act, no person shall import, generate, collect, consign, transport, treat, dispose of, store, handle or otherwise use or deal with any hazardous substance except- Handling of hazardous substances. (a) under a license issued by the Agency; or (b) in accordance with the provisions of any other law, rule, regulation or notification for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement or other instrument to which Government is a party.*

- *Section 17(1): No proponent of a project shall commence construction or operation unless he has filed with the Agency an initial environmental examination or environmental impact assessment and has obtained from the Agency approval in respect thereof.*

- *Section 17(3): Every review of an environment impact assessment shall be carried out with public participation and, subject to the provisions of this Act, after full disclosure of the particulars of the project.*

- *Section 31(1): The Agency shall cause relevant details of any proposed project regarding which an Environmental Impact Assessment has been received to be published, along with an invitation to the public to furnish their comments thereon within a specified period. (2) In accordance with such procedure as may be prescribed, the Agency shall hold public hearings to receive additional comments and hear oral submissions. (3) All comments received under sub-sections (1) and (2) shall be duly considered by the Agency while reviewing the environmental impact assessment or strategic impact assessment, and*

decision or action taken thereon shall be communicated to the persons who have furnished the said comments.

- A *number* of rules and regulations have been promulgated under the SEPA 2014. These are:
  - Environmental Samples Rules, 2014
  - Pollution Charge for Industry (Calculation and Collection) Rules, 2014
  - Provincial Sustainable Development Fund Board (Procedure) Rules, 2001
  - The Sindh Environmental Quality Standard (Self-Monitoring and Reporting by Industry) Rule, 2014
  - Sindh Environmental Protection Agency (Environmental Assessment), Regulations 2021
  - Sindh Environmental Quality Standards.
  - Hazardous Substances Rules 2014

2.3 Sindh EPA (Environmental Assessment) Regulations 2021

The Sindh Environmental Protection Agency (Environmental Assessment) Regulations 2021 outline the classifications of projects outlined in Schedules I, II, and III, dictating whether an Environmental Checklist, Initial Environmental Examination (IEE), or Environmental Impact Assessment (EIA) is required. Projects classified under Schedule III are identified by their potential to generate significant adverse environmental impacts, necessitating a comprehensive management plan. This classification also includes projects located in environmentally sensitive areas, such as those designated as National Parks, Sanctuaries, or Game Reserves, areas of international significance like protected wetlands under the RAMSAR Convention, or sites recognized by UNESCO as cultural heritage.

Pursuant to these regulations, any project categorized in Schedule III must submit an EIA to the Sindh Environmental Protection Agency due to their potential widespread impacts on communities. Consequently, the proposed project PLUTO necessitates an EIA, prompting the conduct of an Environmental and Social Impact Assessment (ESIA) study, with the findings set to be submitted to the Sindh EPA for evaluation and approval.

2.4 Sindh Environmental Quality Standards

The proposed project is mandated to comply with the Sindh Environmental Quality Standards (SEQS). In addition, the project's environmental performance will also be assessed in relation to applicable international guidelines on emissions and effluent discharge.

Article 11(1) of the Sindh Act 2014 states that: 'Subject to the provisions of this Act and the rules and regulations, no person shall discharge or emit or allow the discharge or emission of any effluent, waste, pollutant, noise or any other matter that may cause or likely to cause pollution or adverse environmental effects, as defined in Section 2 of this Act, in an amount, concentration or level which is in excess to that specified in Sindh Environmental Quality Standards…'

The Sindh EPA has promulgated several standards, the SEQS, which were applicable to the entire province of Sindh. These include:

- Ambient air quality (9 parameters)
- Drinking water (32 parameters)
- Ambient noise
- Industrial effluents (32 parameters)
- Industrial gaseous emissions (16 parameters).

Table 2.1: Sindh Environmental Quality Standard for Ambient Air

Pollutant	Time-weighted average	Concentration in Ambient Air	Method of measurement
Sulfur Dioxide (SO_2)	Annual Average*	80µg/m³	Ultraviolet Fluorescence Method
	24 hours**	120µg/m³	
Oxides of Nitrogen as (NO)	Annual Average*	40µg/m³	Gas Phase Chemiluminescence
	24 hours**	40µg/m³	
Oxides of Nitrogen as (NO_2)	Annual Average*	40µg/m³	Gas Phase Chemiluminescence
	24 hours**	80µg/m³	
O_3	1 hour	130µg/m³	Non dispersive UV absorption method
Suspended Particulate Matter (SPM)	Annual Average*	360µg/m³	High volume Sampling, (Average flow rate not less than 1.1m³/minute)
	24 hours**	500µg/m³	
Respirable Particulate Matter (PM_{10})	Annual Average*	120µg/m³	B Ray absorption method
	24 hours**	150µgm³	
Respirable Particulate Matter ($PM_{2.5}$)	Annual Average*	40µgm³	B Ray absorption method
	24 hours**	75µg/m³	
	1 hour	15µg/m³	
Lead (Pb)	Annual Average*	1µg/m³	ASS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5µg/m³	
Carbon Monoxide (CO)	8hours**	5mg/m³	Non Dispersive Infra Red (NDIR) method
	1hours	10mg/m³	

*Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.
**24 hourly / 8 hourly values should be met 98% of the in a year. 2% of the time, it may exceed but not on two consecutive days.

Table 2.2: Sindh Environmental Quality Standard for Noise

S. No.	Category of Area / Zone	Limit it in dB(A) Leq*	
		Day Time	Night Time
1	Residential area (A)	55	45
2	Commercial area (B)	65	55
3	Industrial area (C)	75	65
4	Silence Zone (D)	50	45
Note: 1	Day time hours: 6.00 a. m to 10.00 p. m		
2	Night time hours: 10.00 p. m to 6.00p. m		
3	Silence zone; Zone which are declared as such by competent authority. An area comprising not less than 100 meters around hospitals, educational institutions and courts.		
4	Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority.		
*dB(A)Leq	Time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.		

Table 2.3: Sindh Environmental Quality Standard for Municipal & Liquid Industrial Effluents

S. #	Parameter	Into Inland Waters	Into Sewage Treatment	Into Sea	unit
1	Temperature or Temp. increase	<3	<3	<3	°C
2	pH value (H^+)	6-9	6-9	6-9	
3	Biological Oxygen Demand $(BOD)_5$ at 20°C	80	250	80	mg/l
4	Chemical Oxygen Demand (COD)	150	400	400	mg/l
5	Total Suspended Solids (TSS)	200	400	200	mg/l
6	Total Dissolved Solids (TDS)	3500	3500	3500	mg/l
7	Oil and Grease	10	10	10	mg/l
8	Phenolic Compounds (as Phenol)	0.1	0.3	0.3	mg/l
9	Chloride (as Cl^-)	1000	1000	SC	mg/l
10	Fluoride (as F^-)	10	10	10	mg/l
11	Cyanide (as CN^-)total	1.0	1.0	1.0	mg/l

12	An-ionic detergents (as MBAS)	20	20	20	mg/l
13	Sulphate(SO_4^{2-})	600	1000	SC	mg/l
14	Sulphide (S^{2-})	1.0	1.0	1.0	mg/l
15	Ammonia (NH_3)	40	40	40	mg/l
16	Pesticides	0.15	0.15	0.15	mg/l
17	Cadmium	0.1	0.1	0.1	mg/l
18	Chromium (trivalent and hexavalent)	1.0	1.0	1.0	mg/l
19	Copper	1.0	1.0	1.0	mg/l
20	Lead	0.5	0.5	0.5	mg/l
21	Mercury	0.01	0.01	0.01	mg/l
22	Selenium	0.5	0.5	0.5	mg/l
23	Nickel	1.0	1.0	1.0	mg/l
24	Silver	1.0	1.0	1.0	mg/l
25	Total toxic metals	2.0	2.0	2.0	mg/l
26	Zinc	5.0	5.0	5.0	mg/l
27	Arsenic	1.0	1.0	1.0	mg/l
28	Barium	1.5	1.5	1.5	mg/l
29	Iron	8.0	8.0	8.0	mg/l
30	Manganese	1.5	1.5	1.5	mg/l
31	Boron	6.0	6.0	6.0	mg/l
32	Chlorine	1.0	1.0	1.0	mg/l

Table 2.4 - Sindh Environmental Quality Standards for Drinking Waters (mg/l)

S.#	Properties/ Parameters	Standard Values for Pakistan	S.#	Properties / Parameters	Standard Values for Pakistan
Bacterial			**Chemical**		
1	All water intended for drinking (E.Coli or Thermo tolerant Coliform bacteria)	Must not be detectable in any 100 ml sample	Essential Inorganics (mg/liter)		
			13	Aluminum (Al) mg/l	≤ 0.2
			14	Antimony (Sb)	≤ 0.005
2	Treated water entering the distribution system (E.Coli or thermo tolerant coliform and total coliform bacteria)	Must not be detectable in any 100 ml sample	15	Arsenic (As)	≤ 0.05
			16	Barium (Ba)	0.7
			17	Boron (B)	0.3

Table 2.4 - Sindh Environmental Quality Standards for Drinking Waters (mg/l)					
3	Treated water in the distribution system (E.coli or thermo tolerant coliform and total coliform bacteria)	Must not be Detectable in any 100 ml sample. In case of large supplies, where sufficient samples are examined, must not be resent in 95% of the samples taken throughout any 12-month period.	18	Cadmium (Cd)	0.01
			19	Chloride (Cl-)	< 250
			20	Chromium (Cr)	≤ 0.05
			21	Copper (Cu)	2
			Organic (mg/L)		
			22	Phenolic compounds	<0.0002
			Toxic Inorganics (mg/liter)		
			23	Cyanide (CN)-	≤ 0.05
			24	Fluoride (F)	≤ 1.5
			25	Lead (Pb)	≤ 0.05
			26	Manganese (Mn)	≤ 0.5
Physical			27	Mercury (Hg)	≤ 0.001
4	Color	< 15 TCU	28	Nickel (Ni)	≤ 0.02
5	Taste	Non-objectionable/ Acceptable	29	Nitrate $(NO_3)^-$	≤ 50
6	Odor	Non-objectionable/ Acceptable	30	Nitrite $(NO_2)^-$	≤ 3
7	Turbidity	< 5 NTU	31	Selenium (Se)	≤ 0.01
8	Total Hardness as $CaCO_3$	< 500 mg/l	32	Residual Chlorine	0.2-0.5 At consumer end 0.5-1.5 at source
9	TDS	<1000			
10	pH	6.5-8.5			
Radioactive					
11	Alpha Emitters bq/L	0.1	33	Zinc (Zn)	5.0
12	Beta emitters	1			

2.5 Self-Monitoring and Reporting by Industry Rules 2014

The self-monitoring and reporting system (SMRS) establishes priority parameters for industries under the schedules of liquid and gaseous emissions, considering the interests of both the EPA and the industry.

Schedule I is designed for industries generating effluents, categorizing them into three groups:(A),(B), and(C), with category (A)being the most polluting.

Industries in category (A) must report their effluents and emission levels monthly, while those in category (B) report quarterly, and category (C) industries report biannually.

Schedule II addresses industries producing gaseous emissions, further dividing them into categories (A)and(B), where again, category (A) includes industries that emit higher levels of pollutants compared to category (B).

Effluents must be tested by a SEPA certified or accredited laboratory, with results documented in electronic and hard-copy forms provided in a specific software package. The data should be submitted to the corresponding provincial EPA via email or floppy disk. The requirements for sampling, analysis, and associated costs have been developed through collaboration among industry, government, environmental NGOs, and academic researchers, leading to meaningful progress in operational implementation.

LNGFlex Limited is mandated to regularly submit environmental performance monitoring reports to SEPA in accordance with the conditions outlined in the ESIA approval.

2.6 The Hazardous Substances Rules 2014

The Hazardous Substances Rules 2014 clearly define the hazardous substances listed in Schedule 1 and mandate that any proponent submitting an Environmental Impact Assessment (EIA) must obtain a license for transporting any hazardous substance proposed in their plans. Furthermore, these rules require that a waste management plan be established for facilities that hold hazardous materials. Additionally, the SEP Act 2014 necessitates that the proponent submit an EIA for projects or industrial activities that involve the generation, collection, consignment, transport, treatment, disposal, storage, handling, or import of hazardous substances.

LNG terminals are categorized as hazardous due to the risks associated with fire, explosion, and exposure to cryogenic temperatures. Although accidents resulting in fatalities or significant damage have been rare, most incidents have occurred at LNG liquefaction facilities or transfer points, often attributed to human error during operational or maintenance activities. LNGFlex Limited is committed to adhering to the provisions of the hazardous substances rules thoroughly.

2.7 Labor and Health and Safety Legislation

The Constitution of Pakistan contains a range of provisions concerning labor rights, in particular:

- Article 11 of the Constitution prohibits all forms of slavery, forced labor and child labor;
- Article 17 provides for a fundamental right to exercise the freedom of association and the right to form unions;
- Article 25 lays down the right to equality before the law and prohibition of discrimination on the grounds of sex alone; and
- Article 37(e) makes provision for securing just and humane conditions of work, to ensure that children and women are not employed in vocations unsuited to their age or sex, and to provide maternity benefits for women in employment.

The Labor law regulates at both provincial and national levels with compulsory employment agreements containing the terms set out by the labor laws. There are various laws containing health and safety requirements including: Mines Act 1923; Factories Act 1934; Factories Rules; Hazardous Occupations Rules 1963; Provincial Employees Social Security Ordinance 1965; and Workmen's Compensation Act 1923.

Recently the Sindh Government has approved Sindh Occupational Safety and Health Act, 2017 to make provisions for occupational safety and health conditions at all workplaces in the province for the protection of workers during work.

2.8 Sindh Wildlife Protection Ordinance 1972

The Sindh Wildlife Protection Ordinance of 1972 empowers the government to identify areas of ecological significance as protected zones. This legislation defines three types of protected areas: national parks, wildlife sanctuaries, and game reserves, with the Sindh Forest & Wildlife Department acting as the overseeing authority for each classification. In accordance with the 1997 guidelines for sensitive and critical areas, there are thirty wildlife sanctuaries encompassing 532,582 hectares, one national park covering 308,733 hectares, and eleven game reserves amounting to 127,020 hectares.

The proposed location for project PLUTO falls under the jurisdiction of the Karachi Port Trust and lies outside any wildlife protected zones, ensuring that the project aligns with the stipulations of this act.

Table 2.5: Classification of Protected area in Sindh Province

Classification	Responsible Authority	Contents

Wildlife sanctuary	Sindh Forest & Wildlife Department	○ undisturbed breeding ground ○ prohibited or regulated public areas ○ non-exploitation of forest
National park		○ protection and preservation of scenery, flora and fauna in its natural state ○ an area of outstanding scenic merit and natural interest
Game reserves		Hunting and shooting of wild animals is not be allowed, except under a specific permit, which may specify the maximum number of animals or birds that may be killed or captured and the area and duration for which such permits shall be valid.

Source: Guidelines for sensitive and critical areas, 1997

2.9 Sindh Fisheries Ordinance 1980

This ordinance primarily governs fishing activities in all public waters for diverse purposes, spanning coastal regions and rivers. Section 8 of the ordinance explicitly prohibits the discharge of untreated industrial or domestic sewage waste into any water body in Sindh, unless the waste undergoes treatment to mitigate harm to fish and other aquatic organisms.

The proposed project must comply with these provisions and will be denied permission to release any harmful or untreated effluent into any water body, thereby meeting the specified requirement.

2.10 Sindh Forest Act 1927

The act grants provincial forest departments authority to designate any forest area as reserved or protected. It also empowers these departments to prohibit the clearing of forests for purposes such as cultivation, grazing, hunting, removing forest produce, quarrying, felling, and lopping.

The Sindh Forestry Department oversees official forestry reserves, including mangroves, and has raised concerns regarding the levels of woodcutting and camel breeding occurring in port areas. The proposed PLUTO project does not entail any tree cutting, including mangroves, thereby ensuring compliance with the provisions set out in the Sindh Forest Act.

2.11 The Sindh Factories Act 2015

The Sindh Factories Act, 2015governs all premises classified as factories, defined as locations engaged in manufacturing activities with the employment

of ten or more individuals. Under this legislation, inspectors are authorized to enforce its provisions.

Section 11(1) addressing Registration and Deregistration of Factories mandates that registration documents must include No Objection Certificates from the Industries Department, approval from the Sindh Environmental Protection Agency (SEPA), and any additional required documentation presented in the prescribed formats.

Chapter III, titled Health & Safety, outlines essential occupational health and safety regulations spanning Sections 15 to 53. This chapter emphasizes the need for a clean working environment, systematic waste disposal, proper ventilation, prevention of dust and fume accumulation, avoidance of overcrowding, and sufficient lighting. It also stipulates the availability of amenities, including drinking water, canteen facilities, fire hazard protection, the appointment of a welfare officer, and measures to prevent workplace diseases. The Act further establishes penalties for any breaches of its regulations.

LNGFlex Limited commits to complying with all relevant provisions of this act.

2.12 The Sindh Factories Rules 1975

These rules allow inspectors authorized under them to inspect factory premises at any time. Sections 13 and 14 outline the health and safety requirements. Sections 15, 16, and 17 stipulate that work areas must be adequately ventilated, maintaining acceptable levels of dust, fumes, and artificial humidity. Section 25 emphasizes the necessity of sound fire precautions, and there are provisions for the safety of individuals near machinery or boilers. Furthermore, Section 33-K mandates precautions against hazardous fumes.

LNGFlex Limited will comply with the relevant provisions of these rules.

2.13 Land Acquisition Act (LAA) 1984

The Land Acquisition Act (LAA) of 1984 primarily establishes rights regarding land acquisition for public purposes. While the LAA outlines detailed procedures for acquiring private properties, it falls short in adequately addressing resettlement and rehabilitation issues. Furthermore, the LAA designates land acquisition as a provincial subject, permitting provinces to interpret and apply it in various ways. The Federal EPA has introduced the National Resettlement Policy of 2002, which provides guidelines for compensation calculation, public participation and consultation, the

formulation of resettlement action plans, and ensures transparency and accountability.

Since no private land will be acquired for the proposed Project PLUTO, there are no anticipated social issues linked to land acquisition or resettlement. Therefore, the provisions of the LAA are not applicable to this project.

2.14 Pakistan Penal Code

The Pakistan Penal Code (1860) authorizes fines, imprisonment or both for voluntary corruption or fouling of public springs or reservoirs so as to make them less fit for ordinary use.

- Section 277: Fouling water of public spring or reservoir: Whoever voluntarily corrupts or fouls the water of any public spring or reservoir, so as to render it less fit for the purpose for which it is ordinarily used.

LNGFlex Limited will rigorously oversee its operations and will refrain from discharging any waste or effluent into the sea.

2.15 Sindh Antiquities Act 1974

The protection of cultural resources in Pakistan is guaranteed by the Antiquities Act of 1975. This law prohibits new construction near protected antiquities and grants the Government of Pakistan the authority to restrict excavation in areas that may contain items of archaeological significance.

Under this Act, the project proponent is required to:

- Ensure that no activities occur within 61 meters (200 feet) of a protected antiquity.

- Report any archaeological discoveries made during the project to the Department of Archaeology, Government of Pakistan.

The purpose of the Act is to safeguard antiquities from destruction, theft, negligence, illegal excavation, trade, and export. As of now, none of the sites protected under the Sindh Antiquities Act of 1974 have been identified in the immediate vicinity of the proposed site for Project PLUTO in the KPT area.

2.16 Sindh Cultural Heritage (Preservation) Act 1994

The Sindh Cultural Heritage (Preservation) Act, 1994 serves as the provincial law aimed at safeguarding cultural heritage, with objectives aligned closely to

those of the Antiquity Act, 1975. The project PLUTO is anticipated to fully comply with the regulations stipulated by this act.

2.17 The Biodiversity Action Plan

The protection of Pakistan's biological heritage is fundamentally linked to the involvement of local communities and the support from competent institutions committed to conservation and sustainable use. The Government of Pakistan has acknowledged these critical measures in devising the National Conservation Strategy and by ratifying the Convention on Biological Diversity (CBD) in 1994.

The Biodiversity Action Plan (BAP) represents Pakistan's inaugural effort to address the planning requirements outlined in the NCS. This plan consolidates the three processes mandated by the Convention, providing a comprehensive assessment of the country's biodiversity status and trends. It establishes strategic goals and objectives while outlining a clear plan of action that includes coordination arrangements and implementation measures. The development of the BAP is a significant step toward mitigating biodiversity loss in Pakistan.

The primary goal of the BAP is to advocate for the conservation and sustainable use of biodiversity, ensuring equitable sharing of benefits derived from it, which is essential for the nation's wellbeing and security. Some key objectives pertinent to the project include:

Objective 3: Enhance the enforcement of biodiversity-related laws.

Objective 5: Develop and institutionalize monitoring systems for key biodiversity elements.

Objective 7: Conserve biodiversity outside of protected areas.

Objective 11: Protect and promote community-based biodiversity management systems.

Objective 21: Strengthen Environmental Impact Assessment (EIA) procedures for projects, programs, and policies.

Objective 24: Create national funding mechanisms to support prioritized biodiversity conservation and management efforts.

LNGFlex Limited shall adhere to the provisions of the BAP, ensuring that all operational aspects align with the established objectives and frameworks outlined in the plan.

2.18 National Climate Change Policy

LNGFlex Limited shall adhere to the provisions of this policy wholeheartedly. The primary objectives of Pakistan's National Climate Change Policy (NCCP) are as follows:

- Pursue sustained economic growth while addressing climate change challenges.
- Integrate climate change policy with other related national policies.
- Emphasize pro-poor, gender-sensitive adaptation, while promoting cost-effective mitigation.
- Construct climate-resilient infrastructure.
- Monitor the impact of climate change on the country's water, food, and energy security, and execute remedial measures.
- Mitigate risks from increased frequency and intensity of extreme weather events like floods, droughts, and tropical storms.
- Establish climate-resilient agriculture and food systems across all agro-ecological zones.
- Support the transition to cleaner, lower-emission, and less carbon-intensive development.
- Enhance policy coherence to achieve the United Nations' Sustainable Development Goals (SDGs), as detailed in the Sustainable Development Report 2020 (SDR2020) and our Nationally Determined Contributions.
- Strengthen decision-making and coordination on climate change among ministries and provinces.
- Leverage financial opportunities available nationally and internationally.
- Develop economic incentives to bolster public and private investment in adaptation and mitigation efforts.
- Improve awareness, skills, and institutional capacity among relevant stakeholders.
- Encourage tree plantation, conservation of natural resources, nature-based solutions, and long-term sustainability.

2.19 Climate Change Act 2017

This Act, consisting of 19 sections divided into five Chapters and one Schedule, establishes the requirements to meet Pakistan's obligations under international conventions relating to climate change and address the effects of climate change. The Act is divided as follows: Preliminary (Chap. I); Pakistan Climate Change Council (Chap. II); Pakistan Climate Change Authority (Chap. III); Pakistan Climate Change Fund (Chap. IV); Miscellaneous (Chap. V).

The Prime Minister shall, by notification in the official Gazette, establish the above mentioned institutions to: co-ordinate and supervise enforcement of the provisions of this Act; monitor implementation of international

agreements relating to climate change specified in the Schedule; coordinate, supervise and guide mainstreaming of climate change concerns into decision-making by Federal and Provincial Government's ministries, divisions, departments and agencies so as to create enabling conditions for integrated climate-compatible and climate-resilient development processes in various sectors of the economy; approve and monitor implementation of comprehensive adaptation and mitigation policies, strategies, plans programmes, projects and other measures formulated by the Authority to meet Pakistan's obligations under international conventions and agreements relating to climate change including in particular the Sustainable Development Goal I; monitor implementation of the National Adaptation Plan and its constituent provincial and local adaptation action plans, the National Appropriate Mitigation Action Framework and National Communication submitted to the concerned Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), etc.

2.20 National Forest Policy 2015

The goal of the National Forest Policy is the expansion of National Coverage of Forests, Protected Areas, Natural Habitats and Green Areas for restoration of ecological functions and maximizing economic benefits while meeting Pakistan’s obligations to international agreements related to Forests. Policy objectives under the forest policy include enhancing public awareness, implementing a national level mass afforestation programme to expand and to maintain forest cover to meet international standards and to promote standardized and harmonized scientific planning of forests, research and education.

2.21 Disaster Management Act, 2010

This Act was enacted to provide for the establishment of a National Disaster Management System for Pakistan. Sindh Disaster Management Authority enforces the Act. The Act defines ‘disaster’ as a catastrophe or a calamity in an affected area, arising from natural or man-made causes or by accident which results in a substantial loss of life or human suffering or damage to, and destruction of, property. Disaster management includes preparedness and response. The Act provides establishment of disaster management authorities at national, provincial and district levels. The authorities require preparing and implementing disaster management plan for their area.

2.22 Building Code of Pakistan, Fire Safety Provisions 2016

The Building Code of Pakistan - Fire Safety Provisions - 2016prescribes regulations related to fire prevention, life safety regarding fire, and the fire protection of buildings and structures. All federal and provincial governments,

organizations, and authorities, whether public or private, are required to adopt and enforce these provisions as notified. Any construction or alteration contravening the code is deemed a violation of professional engineering standards as outlined in section 2 of the Act.

The responsibility for the implementation and enforcement of this byelaw lies with the Authority Having Jurisdiction (AHJ) within their respective areas, including but not limited to:

- Building Control, Housing and Development Authorities
- District Administration
- Tehsil or Town Administration
- Municipal Administration
- Station Headquarters (Army, Air Force, Navy)
- Cantonment Administration
- Union Council Administration
- Autonomous Bodies
- Industrial Estates
- Directorates of Civil Defense
- Export Processing Zones
- Other Federal/Provincial Authorities as notified

This byelaw takes effect upon notification, and the relevant AHJs must implement it without delay. All pertinent AHJs are tasked with ensuring compliance and adapting their regulations or byelaws as necessary.

The byelaw is applicable to both new and existing structures:

→ *New Buildings:* Must adhere to the provisions immediately upon construction approval.

→ *Existing Buildings:* Must comply within three years of notification, with essential fire protection measures, such as alarm systems and emergency plans, implemented no later than one-year post-notification.

Non-compliance with this byelaw or any conditions of permits or approvals could lead to penalties as stipulated by the AHJ's regulations. LNGFlex Limited acknowledges the provisions of this Act and commits to adhering to them throughout all phases of Project PLUTO.

2.23 Karachi Ports Trust Act 1886 as amended in 1994

Section 90: Port to be pollution free etc.

(90.1)The Board shall be responsible for maintaining the environment in the areas under the jurisdiction of KPT on land and within Port limits seaward, free from pollution.

(90.2) No discharge of solid, liquid and gaseous waste; or oily, noxious, radioactive and hazardous industrial effluents in concentrations exceeding NEQS or oily bilge, sludge, garbage, residues and mixtures containing noxious solid and liquid wastes from ships or de-ballasting of unwashed cargo tanks, tank washings from oil tankers or garbage, organic matter; or other pollutants as may be specified by the Board shall be made in the areas under jurisdiction of KPT on land and within Port limits Seaward.

(90.3) Any person contravening the provisions of sub -section (2) shall be liable to penalty not exceeding ten million rupees for each contravention in addition to the charges for cleaning of the Port and removal of pollution there from.

LNGFlex Limited is committed to adhering strictly to the provisions of the Act.

2.24 The Sindh Occupational Safety and Health Act, 2017

LNGFlex Limited shall adhere to the provisions of the Sindh Occupational Safety and Health Act, 2017. This Act provides essential occupational safety and health conditions across all workplaces to protect individuals from risks of injury resulting from workplace activities. Moreover, it promotes a working environment that is suited to the physical, physiological, and psychological needs of everyone engaged in work.

2.25 World Bank Guidelines on Environment

The principal World Bank publications that contain environmental guidelines are listed below:

- Environmental Assessment-Operational Policy 4.01. Washington, DC, USA. World Bank 1999
- Environmental Assessment Sourcebook, Volume I: Policies, Procedures, and Cross-Sectoral Issues. World Bank Technical Paper Number 139, Environment Department, the World Bank, 1991
- Environmental Assessment Sourcebook, Volume III: Guidelines for Environmental Assessment of Energy and Industry Projects. World Bank Technical Paper No. 154, Environment Department, the World Bank, 1991

- Pollution Prevention and Abatement Handbook: Towards Cleaner Production, Environment Department, the World Bank, United Nations Industrial Development Organization and the United Nations Environment Program, 1998

The first two publications listed here provide general guidelines for the conduct of an IEE/EIA and address the IEE/EIA practitioners themselves as well as project designers. While the Sourcebook in particular has been designed for the Bank projects and is especially relevant for the impact assessment of large-scale infrastructure projects, it contains enormous information which is useful to environmentalists and project proponents.

2.26 IFC Performance Standards

The International Finance Corporation (IFC) implements the Performance Standards to effectively manage social and environmental risks while enhancing development opportunities within its private sector financing across member countries eligible for support. These standards might also be adopted by other financial institutions that choose to apply them to projects in emerging markets. Collectively, the eight Performance Standards set out the criteria that the Proponent must fulfil throughout the duration of an investment by the IFC, World Bank, or other pertinent financial entities.

The objectives of the Performance Standards are as follows:

- **Impact Assessment:** Identify and assess both adverse and beneficial social and environmental impacts within the project's area of influence.

- **Impact Management:** Avoid or, when avoidance isn't feasible, minimize, mitigate, or compensate for negative impacts on workers, affected communities, and the environment.

- **Community Engagement:** Ensure proper engagement of affected communities regarding issues that may impact them.

- **Performance Improvement:** Promote enhanced social and environmental performance among companies through effective management systems.

This Environmental and Social Impact Assessment (ESIA) study has been conducted in compliance with national legislation and international guidelines, while also meeting the requirements set forth by the IFC Performance Standards. LNGFlex Limited is dedicated to adhering to these standards.

Performance Standard-1: Social & Environmental Assessment & Management System: This Performance Standard seeks to:

a) Identify and assess social and environment impacts in the project's area of influence;
b) Avoid, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment;
c) Ensure that affected communities are appropriately engaged on issues that could potentially affect them; and
d) Promote improved social and environment performance of the project through the effective use of management systems.

Under this Standard, the project is required to establish and maintain a social and environmental management system appropriate to the nature and scale of the project and in accordance with the level of social and environmental risks and impacts. The management system is required to incorporate the following elements:

- Social and Environmental Assessment;
- Management program;
- Organizational capacity;
- Training;
- Community engagement;
- Monitoring; and
- Reporting

Performance Standard-2: Labor and Working Conditions: This PS seeks to establish, maintain and improve the worker-management relationship; promote fair treatment, non-discrimination and equal opportunity for workers, and compliance with national labor and employment laws; protect the workforce by addressing child labor and forced labor issues; and promote safe and healthy working conditions, and to protect and promote the health of workers.

Performance Standard-3: Pollution Prevention and Abatement: The PS 3 seeks to avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities, and to promote the reduction of emissions that contribute to climate change. The Standard requires the project to consider during its entire lifecycle ambient conditions and apply pollution prevention and control technologies and practices that are best suited to avoid or, where avoidance is not feasible, minimize or reduce adverse impacts on human health and the environment while remaining technically and financially feasible and cost-effective.

Performance Standard-4: Community Health, Safety and Security: The PS 4 seeks to avoid or minimize risks to and impacts on the health and safety of local community during the project lifecycle from both routine and non-routine circumstances, and to ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimizes risks to the

community's safety and security. The PS requires the project to evaluate the risks and impacts to the health and safety of the affected community during the different phases of the project and establish preventive measures to address them in a manner commensurate with the identified risks and impacts.

Performance Standard-5: Land Acquisition and Involuntary Resettlement: This PS aims to address the adverse impacts associated with land acquisition and involuntary resettlement caused by the project. The PS seeks to:

- avoid or at least minimize involuntary resettlement wherever feasible by exploring alternative project designs
- mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by: (i) providing compensation for loss of assets at replacement cost; and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected
- improve or at least restore the livelihoods and standards of living of displaced persons
- improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

Performance Standard-6: Biodiversity Conservation & Sustainable Natural Resource Management

The PS 6 seeks to protect and conserve biodiversity and promote sustainable management and use of natural resources through adoption of practices that integrate conservation needs and development priorities.

Performance Standard-7: Indigenous Peoples: The PS 7 seeks to address the impacts of the project on the indigenous people. Specifically, the objectives of the PS are to:

- ensure that the development process fosters full respect for the dignity, human rights, aspirations, cultures and natural resource-based livelihoods of Indigenous Peoples
- avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not feasible, to minimize, mitigate, or compensate for such impacts, and to provide opportunities for development benefits, in a culturally appropriate manner
- establish and maintain an ongoing relationship with the Indigenous Peoples affected by a project throughout the life of the project
- foster good faith negotiation with and informed participation of Indigenous Peoples when projects are to be located on traditional or customary lands under use by the Indigenous Peoples
- respect and preserve the culture, knowledge and practices of Indigenous Peoples

No indigenous people - with a social and cultural identity distinct from the existing dominant society that makes them vulnerable to being disadvantaged in the development process of the Project are known to exist in and around the proposed site. No such people were found in the area during the present study either. Therefore, this PS is not applicable for the proposed project.

Performance Standard-8: Cultural Heritage objectives have been set in the IFC performance standards to achieve sustainable development.

The objectives of this PS are to protect cultural heritage from the adverse impacts of project activities and support its preservation, and to promote the equitable sharing of benefits from the use of cultural heritage in project activities.

No sites of cultural heritage are known to exist at or in the immediate vicinity of the Project location. There are also no indications of any old settlement in the area, nor is there any site covered under the listing of cultural heritage sites.

2.27 IFC- Environment, Health & Safety Guidelines for LNG

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry. These EHS Guidelines are applied as required by their respective policies and standards. EHS guidelines for LNG facilities are designed to be used together with the General EHS Guidelines document, which Provides guidance to users on common EHS issues potentially applicable to all industrial sectors.

The applicability of EHS Guidelines for Crude Oil and Petroleum Product Terminals include information relevant to land and shore-based petroleum storage terminals receiving and dispatching bulk shipments of crude oil, gasoline, middle distillates, aviation gas, lube oil, residual fuel oil, compressed natural gas (CNG), liquid petroleum gas (LPG), and specialty products from pipelines, tankers, railcars, and trucks for subsequent commercial distribution. This guideline covers Industry-Specific Impacts and Management and Performance Indicators and Monitoring.

The EHS Guidelines for Liquefied Natural Gas (LNG) Facilities include information relevant to LNG base load liquefaction plants, transport by sea, and re-gasification and peak sharing terminals. For coastal LNG facilities including harbors, jetties and in general coastal facilities (e.g. coastal terminals marine supply bases, loading/offloading terminals), additional guidance is provided in the EHS Guidelines for Ports, Harbors, and Terminals. For EHS issues related to vessels, guidance is provided in the EHS Guidelines for

Shipping. Issues related to LPG/Condensate production and storage in liquefaction plants are not covered in this Guideline.

Certain objectives have been set in IFC performance standards to achieve sustainable development. Those objectives are given below:

- To identify and assess social and environment impacts, both adverse and beneficial, in the area of influence of LNG project
- To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them
- To promote improved social and environment performance of companies through the effective use of management systems.

2.28 International Treaties and Conventions

Pakistan is signatory/member to various international treaties and conventions on conservation of environment and protection of wildlife. The country is obliged to adhere to the commitments specified in these treaties. The United Nations Conference on Environment and Development (UNCED), 1992 emphasized on Protection, rational use and development of resources; preventing further degradation and reducing the risk of long-term irreversible effects; conservation of biodiversity, and sustainable use of genetic resources.

World Heritage Convention obligates the states to ensure identification, protection and transmission of natural heritage to future generations. A world heritage site is a site (natural or cultural) recognized by the international community (World Heritage Convention founded by the General Conference of UNESCO in 1972) as possessing universal value and coming under a collective responsibility.

Other international conventions and programs to which Pakistan is a party relate to biodiversity conservation, for all of which there is a national legislation. Three conventions dealing with species are:

a) Convention on Conservation of Migratory Species of Wildlife Animals, adopted in Bonn, Germany in 1979 which Pakistan ratified in 1987;
b) Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), signed in Washington in 1973 of which Pakistan became a party in 1976;
c) Convention on Biodiversity (CBD), singed in Rio de Janiero in 1992 which Pakistan ratified in 1994.

d) Convention on Wetlands of International Importance especially as Waterfowl Habitat, signed in Ramsar in Iran in 1971, to which Pakistan became a party in 1978; and
e) Convention Concerning the Protection of the World Culture and Natural Heritage, signed at United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris in 1972.

2.29 International Convention on Biodiversity

The International Convention on Biodiversity was adopted during the Earth Summit of 1992 at Rio de Janeiro. The Convention requires parties to develop national plans for the conservation and sustainable use of biodiversity, and to integrate these plans into national development programmes and policies. Parties are also required to identify components of biodiversity that are important for conservation, and to develop systems to monitor the use of such components with a view to promoting their sustainable use.

2.30 Convention on Wetlands of International Importance, (RAMSAR) 1971

Pakistan is a signatory to the RAMSAR Convention, which obligates contracting parties to:

- Designate wetlands for the List of Wetlands of International Importance.
- Formulate and implement planning to promote the wise use of wetlands.
- Conduct Environmental Assessments prior to any transformations of wetlands and compile national wetland inventories.
- Establish nature reserves on wetlands, ensuring adequate management to enhance waterfowl populations on suitable locations.
- Train skilled personnel in wetland research, management, and wardening.
- Foster wetland conservation by aligning national policies with coordinated international actions and engage with other contracting parties regarding obligations related to shared wetlands and water systems.
- Advocate for wetland conservation issues with development aid agencies.
- Encourage research and facilitate data exchange.

Currently, 18 sites in Pakistan have been recognized as wetlands of International Importance, known as RAMSAR Sites. Among these are approximately 45 game sanctuaries and reserves spanning around 0.90 million hectares in Sindh. Notably, none of these wetlands are located within or near the area of Project PLUTO. Haleji Lake and Kinjhar (Kalri) Lake have been designated as Wildlife Sanctuaries and are crucial for breeding, staging, and wintering water birds; however, they are more than 100 km away from the proposed site of Project PLUTO in KPT.

2.31 IUCN Red List

It has been about 50 years now when IUCN first established the Red List. It is the world's most comprehensive source of information for conservation status of animals, fungi and plant species. The list categorizes the species as:

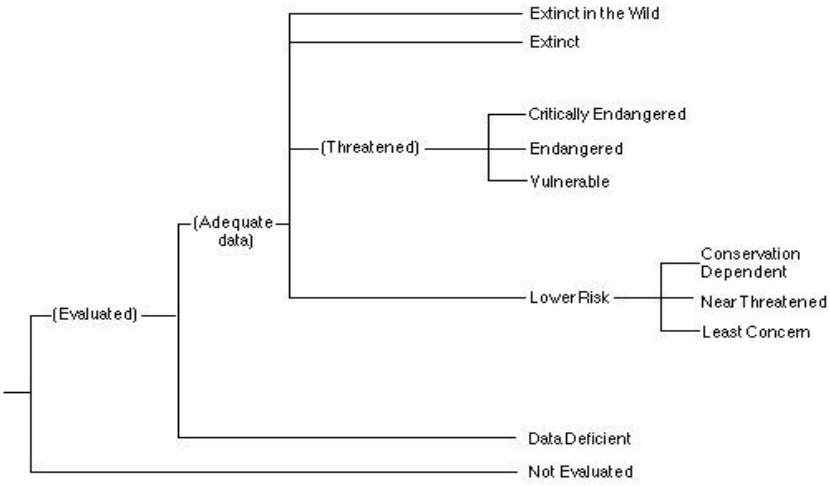


Figure 2.1 – IUCN Categorization of Threatened Species (source www.iucnredlist.org)

No faunal species classified under the IUCN Red List category were observed during the surveys conducted at the site for the ESIA study associated with Project PLUTO.

2.32 Liquefied Natural Gas (LNG) Policy, 2011

The LNG Policy 2011 aims to facilitate the potential investors in LNG sector, by bringing more clarity and predictability for investors, on the basis of their experience and the bottlenecks pointed out by the potential investors during various interactions with OGRA. The LNG Policy, 2011 covers Import Project Structure, LNG Procurement, Ownership & Operation of the LNG Terminal, RLNG Marketing & Transportation, and Regulatory Framework during construction period and operational period, Government Incentives, Pricing of RLNG, Government Guarantee, Freedom to Participate in the LNG Business, Technical Codes and Standards, Shipping of LNG, Other Permits and Licenses. Prior permission of GoP for Spot purchase of LNG will not be required. SSGCL/SNGPL will not sell gas priced under weighted average cost of gas mechanism, to industries, which are selected by GOP to use RLNG from time to time. Licensees will be required to furnish guarantee against their delivery commitment. In case of failure of the licensee to deliver LNG by stipulated date, its first right to 3rd Party Access will stand waived off. The involvement of Coast

Guards or any other agency to control activities of entry and exit of shipping traffic and requirement of security escort through Coast Guards at the expense of LNG developer, LNG Terminal Owner/Operator and LNG Buyer will no longer be necessary.

Port authorities have been obligated to convey their decision on acceptance of site within one month of submittal of NOC from Sindh Environmental Protection Agency, Quantitative Risk Assessment Study and Navigational Simulation Study.

Pakistan's policy for the sustainable development of the energy sector, including the provision of reliable and competitively-priced energy is based on the following objectives:

a) Optimization of the primary energy mix, based on economic and strategic considerations;
b) Maximizing the utilization of indigenous energy resources;
c) Enhancing private sector participation in the energy sector by strengthening the regulatory framework and institutional capacity;
d) Developing energy infrastructure; and
e) Developing human resources with emphasis on energy sector-specific technical skills and expertise

Natural gas plays a key role in Pakistan's energy balance which is currently around 50% of the country's primary energy supplies. With accelerating economic growth, the demand for gas is projected to increase sharply and the country's recoverable indigenous gas reserves will be insufficient to meet this demand. Gas shortages have already emerged and shall increase substantially in the following years if indigenous supply is not supplemented through imports. In order to address the shortage, strong emphasis is being laid on importing gas from neighbouring gas-producing countries through cross-border gas pipelines and also in the form of liquefied natural gas ("LNG"). Necessary measures are being taken for installation of LNG receiving, storage, re-gasification facilities and expansion of gas transmission infrastructure, for the distribution and sale of Regasified LNG ("RLNG") in the domestic market.

The LNG Policy aims to facilitate expeditious implementation of the LNG Projects. It has laid out the following framework for the Ownership & Operation of LNG Terminals:

The LNG Developer or LNG TO/O, as the case may be, will obtain a license to design, construct, operate and own a LNG terminal from OGRA under the Oil and Gas Regulatory Authority Ordinance, 2002 subject to satisfying the following criteria:

(a) Technical: At least one member of the consortium of LNG Developer or LNG TO/O, as the case may be, should have experience in developing and operating a liquefaction plant or a regasification terminal. The LNG terminal will be constructed based on technical standards as prescribed by the OGRA from time to time, in consultation and approval of Department of Explosives, including internationally acceptable industry technical standards as stipulated in Appendix-1.

(b) Financial: The LNG Developer or LNG TO/O consortium (on a several or joint and several basis) should have liquidity, revenues, net income and net worth above prescribed minimum thresholds (to be set by OGRA taking into consideration the financial obligations associated with the development and operation of the LNG import terminal).

(c) Health, Safety & Environmental ("HSE") Standards:

1. The LNG Developer, LNG TO/O or LNG Buyer as the case may be, will ensure that the project complies with World Bank HSE Guidelines, Pakistan's Environmental Protection Act 1997 rules, regulations and guidelines made there under, National Environmental Quality Standards, Pakistan's health, environment and safety standards and is consistent with the best international LNG industry practices.

2. The LNG Developer or LNG TO/O will undertake a comprehensive environmental impact assessment of the design, construction and operational aspects of the project including impact assessment of shipping associated with the project, in accordance with international standards and practices. The studies and approvals required at the planning, construction, commissioning and operating phases are defined in the Pakistan Environmental Protection Act, 1997.

3. All LNG terminals shall be surrounded by safety zones which shall meet the industry standards set forth in safety codes of the National Fire Protection Association of USA and as per the risk assessment studies so as to ensure protection of neighbouring communities and shipping traffic.

4. Site approval: The site (either land-based terminal or offshore terminal of any type) for setting up an LNG terminal shall be selected by LNG Developer or LNG TO/O, as the case may be, taking into account the following factors:

- Existing and projected population and demographic characteristics of the location;
- Existing and proposed land use near the location;
- Physical aspects of the location;

- Medical, law enforcement and fire protection capabilities near the location that can cope with a risk caused by the facility;
- Exclusion zone distances from the terminal to property and population as per international standards are complied with;
- Proximity to existing gas infrastructure and market;
- Need to encourage remote sitting;
- Any other significant community concerns; and
- Environmental considerations.

In applying for the license, the LNG Developer or LNG TO/O will have the onus of demonstrating compliance with the above criteria through risk assessment and simulation studies. Port Authorities will convey their decision on acceptance of site within one month of submission of NOC from SEPA, QRA study and navigational simulation study.

The licensee shall:

- Ensure delivery of LNG on fast-track basis.
- Furnish guarantee against its commitment.

In case of licensee's failure to deliver LNG by stipulated date its right to Third Party Access will be subject to cancellation/review by OGRA.

APPLICABLE CODES & STANDARDS / GUIDELINES / OPERATING PRACTICES FOR LNG HANDLING		
SOURCE	**LNG POLICY 2011 APPENDIX 1**	
NUMBER	**TYPE**	**TITLE**
NFPA 59A 2006	ENGG STANDARD	STANDARD FOR PRODUCTION, STORAGE & HANDLING OF LNG
BS EN 1473 2007	ENGG STANDARD	INSTALLATION & EQUIPMENT LNG, DESIGN OF ONSHORE INSTALLATIONS
API 620 APPENDIX R	ENGG STANDARD	LOW PRESSURE STORAGE TANKS FOR REFRIGERATED PRODUCTS
BS 7777	ENGG STANDARD	FLAT-BOTTOM, VERTICAL, CYLINDERICAL STORAGE TANKS FOR LOW TEMPERATURE SERVICE
BS EN 1160 1997	ENGG STANDARD	GENERAL CHARACTERSTICS OF LNG
ASME Code Section VIII Division 1 Appendix 44	ENGG STANDARD	Cryogenic tank design
ANSI/ASME 31.5	ENGG STANDARD	Refrigeration Piping
Q320582FRT16 – 2014	ENGG STANDARD	Technical Specifications for LNG tank skid-mounted filling equipment for vehicles

OCIMF	ENGG STANDARD	Design and Construction Specification for Marine Loading Arms
BUREAU VERITAS - Rule Note NR 645 DT R02 E, May 2019	ENGG STANDARD	Rules for the Classification of Floating Storage Regasification Units and Floating Storage Units
SGITTO 1992	GUIDELINE	GUIDELINES FOR HAZARD ANALYSIS AS AN AID TO MANAGEMENT SAFE OPERATIONS
EEMUA 147	GUIDELINE	CRITERA FOR DESIGN & CONSTRUCTION OF REFRIGERATED LIQUEFIED GAS STORAGE TANKS
IMO 290 E 1995	GUIDELINE	RECOMMENDATIONS ON SAFE TRANSPORT OF DANGEROUS CARGOES & RELATED ACTIVITIES IN PORT AREAS
PIANC 1985	GUIDELINE	DANGEROUS GOODS IN PORTS: RECOMMENDATIONS FOR PORT DESIGNERS & PORT OPERATORS
IAPH 1989	GUIDELINE	GUIDELINES ON PORT SAFETY & ENVIRONMENTAL PROTECTION
Health, Safety & Environment Standards		
OHSAS 18001	GUIDELINE	Health and safety Management Standard
ISO 14001/45001	GUIDELINE	Environmental Management systems
IMDG	GUIDELINE	International Maritime dangerous goods regulations
IMO 630E 1987	OPERATING PRACTICE	MANUAL ON CHEMICAL POLLUTION; SECTION 1; PROBLEM ASSMENT AND RESPONSE ARRANGEMENTS
UNEP 1988	OPERATING PRACTICE	AWARENESS & PREPAREDNESS FOR EMERGENCIES AT LOCAL LEVEL

2.33 Ports Act 1908 & Pakistan Territorial Waters & Maritime Zones Act 1976

The Ports Act 1908 ensures safe shipping in the sea and prevention of pollution in waters. Pakistan Territorial Waters and Maritime Act 1976 regulates the exploration, development, conservation, and management of living and nonliving resources in Pakistan's Exclusive Economic Zone (EEZ), which extends up to 200 miles from the country's coastal zone.

Ports Act 1908 and Pakistan Territorial Waters and Maritime Zones Act 1976 will both apply to the Project. The Project proponent will be mandated to ensure

safe shipping of the LNG Carriers (LNGC)s and to adopt measures for prevention of pollution of the sea and the resources in Pakistan's Exclusive Economic Zone (EEZ), which extends up to 200 miles from the country's coastal zone.

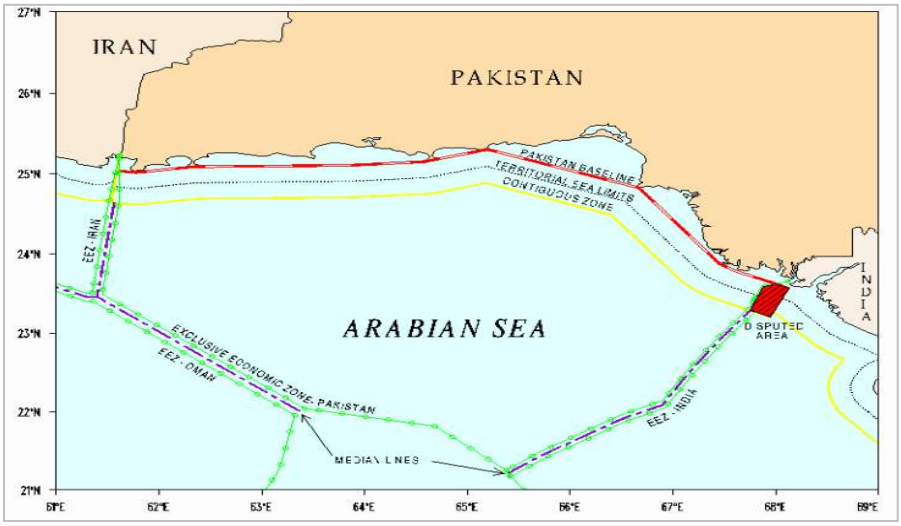


Figure 2.2: Pakistan's Exclusive Economic Zone

2.34 United Nations Convention on the Law of the Sea

The United Nations Convention on the Law of the Sea lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources. It enshrines the notion that all problems of ocean space are closely interrelated and need to be addressed as a whole.

The Convention was opened for signature on 10 December 1982 in Montego Bay, Jamaica. This marked the culmination of more than 14 years of work involving participation by more than 150 countries representing all regions of the world, all legal and political systems and the spectrum of socio/economic development. At the time of its adoption, the Convention embodied in one instrument traditional rules for the uses of the oceans and at the same time introduced new legal concepts and regimes and addressed new concerns. The Convention also provided the framework for further development of specific areas of the law of the sea.

The Convention entered into force in accordance with its article 308 on 16 November 1994, 12 months after the date of deposit of the sixtieth instrument of ratification or accession. Today, it is the globally recognized regime dealing with all matters relating to the law of the sea.

The Convention (full text) comprises 320 articles and nine annexes, governing all aspects of ocean space, such as delimitation, environmental control, marine scientific research, economic and commercial activities, transfer of technology and the settlement of disputes relating to ocean matters.

Some of the key features of the Convention are the following:

- Coastal States exercise sovereignty over their territorial sea which they have the right to establish its breadth up to a limit not to exceed 12 nautical miles; foreign vessels are allowed "innocent passage" through those waters;
- Ships and aircraft of all countries are allowed "transit passage" through straits used for international navigation; States bordering the straits can regulate navigational and other aspects of passage;
- Archipelagic States, made up of a group or groups of closely related islands and interconnecting waters, have sovereignty over a sea area enclosed by straight lines drawn between the outermost points of the islands; the waters between the islands are declared archipelagic waters where States may establish sea lanes and air routes in which all other States enjoy the right of archipelagic passage through such designated sea lanes;
- Coastal States have sovereign rights in a 200-nautical mile exclusive economic zone (EEZ) with respect to natural resources and certain economic activities, and exercise jurisdiction over marine science research and environmental protection;
- All other States have freedom of navigation and over flight in the EEZ, as well as freedom to lay submarine cables and pipelines;
- Land-locked and geographically disadvantaged States have the right to participate on an equitable basis in exploitation of an appropriate part of the surplus of the living resources of the EEZ's of coastal States of the same region or sub-region; highly migratory species of fish and marine mammals are accorded special protection;
- Coastal States have sovereign rights over the continental shelf (the national area of the seabed) for exploring and exploiting it; the shelf can extend at least 200 nautical miles from the shore, and more under specified circumstances;
- Coastal States share with the international community part of the revenue derived from exploiting resources from any part of their shelf beyond 200 miles;
- The Commission on the Limits of the Continental Shelf shall make recommendations to States on the shelf's outer boundaries when it extends beyond 200 miles;
- All States enjoy the traditional freedoms of navigation, over flight, scientific research and fishing on the high seas; they are obliged to adopt, or cooperate with other States in adopting, measures to manage and conserve living resources;

- The limits of the territorial sea, the exclusive economic zone and continental shelf of islands are determined in accordance with rules applicable to land territory, but rocks which could not sustain human habitation or economic life of their own would have no economic zone or continental shelf;
- States bordering enclosed or semi-enclosed seas are expected to cooperate in managing living resources, environmental and research policies and activities;
- Land-locked States have the right of access to and from the sea and enjoy freedom of transit through the territory of transit States;
- States are bound to prevent and control marine pollution and are liable for damage caused by violation of their international obligations to combat such pollution;
- All marine scientific research in the EEZ and on the continental shelf is subject to the consent of the coastal State, but in most cases they are obliged to grant consent to other States when the research is to be conducted for peaceful purposes and fulfils specified criteria;
- States are bound to promote the development and transfer of marine technology "on fair and reasonable terms and conditions", with proper regard for all legitimate interests;
- States Parties are obliged to settle by peaceful means their disputes concerning the interpretation or application of the Convention;
- Disputes can be submitted to the International Tribunal for the Law of the Sea established under the Convention, to the International Court of Justice, or to arbitration. Conciliation is also available and, in certain circumstances, submission to it would be compulsory. The Tribunal has exclusive jurisdiction over deep seabed mining disputes.

2.35 National Maritime Policy of Pakistan

The National Maritime Policy of Pakistan has recently been approved and notified (16th October 2002). Among other matters, the Policy advocates "Management of assets in a judicious manner with conscientious regard to the environment and international law". It also incorporates, "Ports, shipping, fisheries, offshore resource, petroleum, environment, tourism, R&D, human resource development and protection of maritime interest".

One of the Policy Objectives is for the "Protection & Conservation of the marine environment/ ecosystem".

Section IV of the Policy, among other institutions, holds the Port Authorities responsible under legislation to protect the marine environment within their prescribed limits. This includes tasks such as monitoring and combating spills.

2.36 International Maritime Conventions

Project Proponent and its suppliers will comply with International Maritime Conventions. These will include the conventions of the International Maritime Organization, International Labor Organization, United Nations, World Health Organization and others as appropriate.

The primary International Maritime Organization (IMO) safety standard governing the marine transport of LNG is the "International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk," (IGC Code – 1993 Edition).

MARPOL 1973 (modified in 1978: Ship-generated waste is regulated globally as part of the implementation of the International Convention for the prevention of pollution from Ships 1973 as modified by the Protocol of 1978 (MARPOL 73/78). The requirement of MARPOL 73/78 is established in 20 Articles, two Protocols and five annexes; these include contamination by oil, noxious liquid substances carried in bulk, harmful substances, sewage and garbage. Pakistan is signatory to all five annexes. Nevertheless, pollution prevention practices consistent with MARPOL requirements will be adhered to during all the phases of project. The Project proponent will be mandated to ensure safe shipping of the LNG Carriers (LNGC)s and besides adopting measures for prevention of pollution of the sea, will follow the International Convention for the prevention of pollution from Ships 1973 as modified by the Protocol of 1978 (MARPOL 73/78).

The Society of International Gas Tankers and Terminal Operators (SIGTTO 1997) and The International Navigation Association (PIANC 1997) guidelines for LNG Docking facilities will be referred to during project design and construction.

London Convention 1972: In 1972, The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter defines a Black List of toxic substances, and a Grey List of less hazardous substances that may only be dumped under a prior special permit, the dumping of any other wastes not specified in these lists requires a prior general permit. In 1990 this Convention was amended to require signatory countries to consider whether an adequate scientific basis exists for assessing the environmental impact of a substance (i.e. dredged material) before issuing a permit for dumping. Pakistan is signatory to the London Convention and a Notification came into force on 8th April 1995.

Under Article-IV, Annex-I the following substances are included in the "Blacklist".

Blacklist

- Organohalogen Compounds;
- Mercury and Mercury Compounds;
- Cadmium and Cadmium Compounds;
- Persistent Plastics and other persistent synthetic materials;
- Crude oil and petroleum products;
- High level radioactive wastes; and
- Materials produced for biological and chemical warfare.

Note (1): Item-viii gives exemption to the above listed substances which are "rapidly rendered harmless" provided they do not make edible organisms unpalatable or endanger human health or that of domestic animals.

Note (2): Item-xi gives exemption to dredged material containing the above substances as trace contaminants but subject such materials to Grey List status.

Under Article 4, Annex-2 the following less harmful substances are included in the 'Grey List "or special care substances. These substances can only be dumped into the sea after a special permit has been issued:

Grey List

- Wastes containing significant amounts of arsenic, lead, copper, zinc, organosilicon compounds, cyanides, fluorides, pesticides and their by-products.

- Additional list in the case of disposal of large quantities of acids and alkalis: beryllium, chromium, nickel, vanadium;
- Generally bulky wastes, which may cause a hazard to fishing or shipping;
- Radioactive wastes (other than high level);
- Incineration of waste at sea is also controlled; and
- Substances which, though non-toxic, may become harmful due to the quantities in which they are dumped.

The Project Proponent will follow the procedures adopted by the other units based in KPT area for dumping the wastes on guidelines of KPT.

Laws of Seas: The UN Convention on the Law of the Sea was adopted and opened for signature in 1982. On November 16th, 1994, it entered into force for 68 countries. Pakistan is signatory to the convention. It establishes a basic structure of obligations, objectives and principles covering all sources of marine pollution that include:

- Pollution by vessels (operational and accidental discharges from ships), and
- Dumping (the deliberate disposal of wastes at sea by ships, aircrafts, platforms, or other manmade structures).

KPT will be mandated to ensure safe shipping of the LNG Carriers (LNGC)s and follow the Laws of Seas for prevention of pollution by vessels, besides taking measures to avoid dumping of ship wastes into the seas.

Ballast water management convention: The International Convention for the Control and Management of Ships Ballast Water and Sediments was adopted by consensus at a Diplomatic Conference at IMO in London on Friday 13 February 2004.

General obligations of the Convention (Article 2) state that parties give full and complete effect to the provision of the Convention and the Annex in order to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.

Under Article 5 (Sediment Reception Facilities) parties undertake to ensure that ports and terminals where cleaning or repair work of ballast tanks occurs have adequate reception facilities for the reception of sediment.

The **National Fire Protection Association (NFPA)** develops fire safety codes and standards drawing upon the technical expertise of persons from diverse professional backgrounds that form technical committees. These committees address concerns about specific activities or conditions related to fire safety. The members of these committees use an open consensus process to develop standards for minimizing the possibility and effects of fire. NFPA has adopted two comprehensive standards, NFPA 59A that relate to LNG.

NFPA 59A Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG) 2009 Edition describes the basic methods of equipment fabrication as well as LNG installation and operating practices that provide for protection of persons and property. It also "provides guidance to all persons concerned with the construction and operation of equipment for the production, storage, and handling of liquefied natural gas." This comprehensive standard contains detailed technical requirements to ensure safety of LNG facilities & operations, including general facility considerations, process systems, stationary LNG storage containers, vaporization facilities, piping systems & components, instrumentation and electrical services.

The standard also incorporates, by reference, technical standards developed by a number of other professional organizations, such as American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE),

the American Petroleum Institute (API), the American Concrete Institute (ACI), and the American Society for Testing and Materials (ASTM).

The European codes and standards used would be explicitly mentioned in the detailed design. The technical design would be based on best industry practices and the technical standards and guidelines provided in LNG policy 2011 and guidelines provided along with the NOC issued by KPT, where applicable. Any international codes, guidelines and standards used will be justified based on international practices currently applicable at the time of design and it is the intention of the proponent to design the terminal using European standards.

3.0 Description of Project

3.1 Overview

Given the critical demand for gas and the current lack of supply, LNGFlex is aiming to develop a unique closed-loop ecosystem through the establishment of a Virtual LNG (VLNG) Supply Chain Network.

Liquefied Natural Gas (LNG) has emerged as a viable solution for importing natural gas into Pakistan, similar to operations at two existing terminals. LNG, essentially, is methane that has been cooled to a liquid state, reducing its volume by a factor of 600, which is essential for maritime transport of large volumes in a compact form.

The transportation of LNG occurs at -162°C in specialized insulated tanks aboard purpose-built vessels known as Liquefied Natural Gas Carriers (LNGCs). These carriers navigate long distances to transport LNG from liquefaction points to import terminals. Upon arrival, the LNG is transferred from the vessel to a floating storage unit (FSU) and subsequently moved to ISO tanks for transportation via trucks to various client locations. The final stage of the process, regasification, is completed on-site with a designated conversion kit.

An operational import terminal necessitates a dedicated marine facility capable of accommodating both the FSU and LNG carriers. This terminal must possess adequate depth, adjacent land for development, and be strategically located away from other port activities and residential areas to ensure safety.

The PDWCP basin at KPT is being considered as a potential site for establishing a dedicated LNG terminal, including essential storage and logistical facilities for LNG distribution to downstream applications.

LNGFlex has outlined its project goals to enhance efficiencies in the LNG supply chain, focusing on:

- **Direct negotiations with suppliers** to improve procurement efficiency.
- **Constructing a virtual pipeline using a stationary FSU** at KPT, equipped to fill ISO tanks for distribution.
- **Delivering LNG to small and medium industrial clients** and the transportation sector.
- **Transforming existing CNG stations into L/CNG stations** to optimize operations.

- **Leveraging partnerships with key stakeholders** across multiple nations.

VLNG is particularly advantageous in Pakistan, where demand for gas significantly surpasses supply, with only about 30% of the population connected to the pipeline system. Even these connections face interruptions, leading to losses in production and efficiency. VLNG offers a reliable solution for consistent gas delivery to targeted users.

While pipelines are generally the most effective method for gas transport, in Pakistan's context, where up to 15% of throughput is unaccounted for, VLNG presents a competitive, less capital-intensive alternative that can adapt to the country's growing needs.



Figure 3.1: The VLNG Supply Concept

3.2 Selection of the Preferred Site

A crucial starting point is the careful selection of an optimal site that ensures the smooth and safe operation of the proposed LNG terminal. Pakistan is fortunate to have two operational ports along the Arabian Sea coast, serving as vital economic lifelines for the country's import and handling of nearly all goods moved in and out of Pakistan. Given that LNG is classified as a Class-2 hazardous material, its location becomes significantly more critical compared to non-hazardous commodities.

To determine the most suitable site, a screening criterion was applied to evaluate various locations, assigning scores for each parameter across three categories: 1 (Negative – unfavorable), 3 (Neutral), and 5 (Positive – favorable).

Based on this scored matrix, the KPT Pakistan Deep Water Container Port (PDWCP), situated within the South Asia Pacific Terminal Limited (SAPTL) basin, emerged as the most appropriate location for constructing the LNG terminal. This site is defined by the coordinates 24° 48' 39.58" N & 66° 59' 25.46" E.



Figure 3.2: Location of Project PLUTO inside PDWCP

Key Features of the Proposed Site:

- The LNG terminal will be positioned within the PDWCP basin, which is accessed via the Tipu Sultan Channel.
- Both the basin and the channel have been dredged to a depth of -16 meters, although this depth may fluctuate due to siltation; a dredging plan is established to maintain the design depth. The channel's width measures approximately 400 meters.
- The maximum dimensions for vessels allowed in PDWCP are: Length Overall (LOA) of 400 meters; a draught of 14 meters in all-weather conditions, increasing to 16 meters during high water; and no restrictions on beam width. The relevant navigational chart for this area is Admiralty Chart PAK 30.
- The northern coastline of PDWCP basin remains undeveloped, providing opportunities for future growth.
- Operational container berths line the western side of the basin.
- Oil storage tanks are located northwest of the proposed LNG terminal, at

a distance exceeding 500 meters and approximately 845 meters to the north-northwest.

- The closest container berths are positioned to the west-southwest of the terminal, with a minimum separation distance of around 785 meters.

- The nearest populated area, Shirin Jinnah Colony, is situated to the north-northeast of the terminal, with its boundary located approximately 455 meters away.

- Prevailing wind directions for most of the year are from the west-southwest/southwest, shifting to northeast from November to February. The average wind speed generally ranges from 15 to 24 kilometres per hour throughout the year.

3.3 Estimated Throughput and Equipment Sizing

A comprehensive demand analysis conducted by LNGFlex indicates a significant underlying demand for gas and LNG in the greater Karachi area. Key considerations influencing throughput include:

- **Market Size**: The overall demand level dictates the potential throughput.
- **LNG Carrier (LNGC) Specifications**: The common size of LNG carriers and the volume they can transport are essential factors.
- **Floating Storage Unit (FSU) Capacity**: The FSU must have adequate capacity to store liquid LNG effectively.
- **LNGC Operation Frequency**: The frequency of trips made by LNG carriers impacts overall supply.
- **Flow Rate Management**: The flow rate from the FSU to the ISO tank filling facility, alongside the evacuation speed of filled LNG ISO tanks, plays a role in throughput efficiency.

Based on detailed throughput analysis, a proposed LNG dispatch scheme is outlined as follows:

- The design of the ISO tank filling facility should allow for simultaneous filling from a pipe manifold with**20 filling bays**.
- It is estimated that **filling one ISO tank** will take approximately **one hour**, with a discharge rate ranging from**80 to 100 cubic meters per hour**.
- Consequently, a **peak daily dispatch** of around **9,000 cubic meters (CUM)**of LNG is projected for delivery to end-users.
- The use of **40-foot ISO tanks** with a net LNG capacity of**36 cubic meters** is recommended, requiring **250 trailer-mounted ISO tanks** to achieve the stated throughput.
- To maintain the minimum daily throughput, the FSU will need

replenishment of LNG every **15 days** via LNGC, with a minimum parcel size of **150,000 CUM**, which will dock at Karachi Port, based on the peak daily dispatch estimates.

- The capacity of the FSU, accounting for potential shipment delays and emergency demand margins, is set at **150,000 CUM**.

The analysis of demand and throughput is summarized in the table below:

Table 2.1: Analysis of demand and throughput

Factor	Description	Explanation	Recommended Sizing
Demand	daily demand is upwards of 400 mmscfd	Small to medium sized industrial customers either off-grid or under supplied by network. Industrial areas namely Korangi, SITE, Lasbela Industrial Estate (LIEDA) and Nooriabad industrial Estate present sizeable demand centers especially for small to medium sized industries within ~ 100km of VLNG terminal	Daily throughput of ~ 200 mmscfd
LNGC	1. QFlex class LNGC: LNG volumes 165k to 215k cum 2. Standard LNGC: LNG volume 150k cum	Existing LNG terminals are designed to receive QFlex vessels in Pakistan. However, it is common to receive LNGCs of 150k cum, due to limitation of deployed FSU capacity.	1. QFlex class LNGC for Navigation assessment 2. Standard LNGC (150k cum) for Operational assessment
FSU	Vessel should have sufficient capacity to receive cargo from LNGC	The FSU is generally the most common LNG storage. The options of a new-built or a converted LNGC are available. Generally, the currently deployed FSUs have an average capacity of 150k cum	140,000 cum to 160,000 cum
LNGC frequency	Number of LNGC trips to proposed terminal	Port operational reasons and charges are considered	Once a fortnight
LNG flow rate for ship to shore transfer	Standard LNGC converted to FSU, has 8 LNG transfer pumps, each ~1800 cum/hour	The FSU shall supply LNG to 20 ISO tank filling skids, using its onboard transfer pumps. The flow rate from the FSU will be managed within the range of 1600 to 2000 cum/hour, considering all 20 skids to be operational simultaneously	ISO Tank filling Skid 80 to 100 cum/hour
ISO tank	A 40 Ft ISO Tank has a net capacity of 36	Cryogenic ISO Tanks manufactured by major companies (Chart, CIMC	ISO Tank specs. 40ft, 36cum, 6 barg

	cum (90%), allowing for the vapor space	Enric) can hold the LNG at -160ºC for 25 days, thus eliminating loses through BOG over over short distances. A 40ft ISO tank provides optimal means of transporting liquid LNG to downstream customers.	
Total inventory of ISO tanks	Considering the frequency of operations, the number of ISO tanks is determined on daily operations, spare for emergencies and business growth	For a user with average daily demand of 1 mmscfd, a storage of minimum two dedicated tanks are required to maintain a daily LNG supply. ISO Tanks are specialty items. Any damage to a unit, due to handling or during transport, would result in its prolonged non-availability. The spares need to be kept at hand for continued operations. The ISO tanks are long lead items, hence, for new customers additional tanks should be available.	A rolling stock of 500 ISO tanks recommended with a built in allowance for turnaround delays, road blockades, LNGC delays, downtime, etc.
Daily Evacuation of trucks	To meet the daily dispatch volumes, it is estimated that 250 trucks would be leaving the terminal, daily	Road exposure for trucks carrying LNG ISO tanks need to be minimized. The farthest point from terminal location at KPT is Nooriabad Industrial Estate at a distance of 190 km with a turnaround time for LNG truck is less than a day.	Detailed evaluation plan recommended prior to FEED
Number of ISO tank filling bays	Sufficient number of bays to meet the daily dispatch requirement, with a spare skid on standby	One ISO tank takes ~ 1 hour for filling, accounting for all the checks and coordination activities. KPT allows only daytime operations for transfers of dangerous good (LNG). Considering 12 hours/day operations, a single bay would be able to fill 13 ISO tanks. Considering 250 dispatches/day, 20 bays would be required.	20

3.4 LNGC & FSU

One of the crucial considerations for selecting a liquefied natural gas carrier (LNGC) is the terminal's location, as not all terminals are equipped to handle vessels exceeding specific capacities and dimensions. Factors affecting this include the availability of draft in the navigation channel and turning basin, the size of the jetty or berth, and the terminal's cargo handling capabilities. Key

dimensional data such as Length over All (LOA), Dead Weight Tonnage (DWT), Beam Width (BW), and Draught are essential in determining the suitability and compatibility of an LNGC with a designated LNG receiving terminal. A summary of the standard and design vessel key dimensions is provided in Table 3.2.

Table 3.2: summary of the standard and design vessel key dimensions

Vessel	Capacity (cum)	DWT (T)	Displacement (T)	LoA (m)	Lpp (m)	Beam (m)	Moulded Depth (m)	Draught Max (m)
Minimum	25,500	39,520	53,000	220	212	35	22.5	10
Min Ideal	130,000	44,600	100,400	274	263	43.4	25.4	12
Standard	145,000	74,400	110,000	288	274	46	26.8	12.3
Design	177,000	87,000	114,000	298.5	285	49	26.8	13

FSUs typically possess adequate storage capacity, whether in a single large chamber or multiple chambers, to accommodate the total volume of import shipments, the LNG slated for transportation via ISO tanks to downstream customers prior to the next shipment, and a buffer volume to mitigate the impact of potential shipment delays. The throughput considerations discussed in earlier, along with LNGC factors, significantly influence the selection of FSU size. Moreover, the choice between acquisition models (own vs. lease) and contract types (new build vs. converted) are critical considerations in this process. The following parameters and factors are instrumental in the FSU selection process, particularly regarding the suitability of the chosen KPT site.

Parameter	Factor	Value	Basis
LNGC capacity	Determined from availability analysis	150,000 cum	GIIGNL Annual Report – 2023
Incoming vessel frequency	Fortnightly	2 Ships/month	Throughput Model
Terminal Daily Throughput		~9000 cum	Throughput Model
Port infrastructure	Depths of PDWCP Basin	16M+	Port Bathymetry Map
	Depths of Tipu Sultan Channel	16M+	
	Turning Basin Diameter	600M	KPT Port Manual
	Tipu Sultan Channel Width	400M	
Berth design considerations	Land topography, Geotech study	Suitable	Hutchinson Port Geotech Study
Exclusion Zone	Based on LNG holding volume of FSU	500M (Día)	Ref. Grain LNG Terminal - UK
Safe distances	Based on Dispersion & Heat Flux radius	>500M	Actual distances measured

For the purpose of the project, LNGC (GRACE Acacia) has been selected. The major details include:

- **Capacity:** 150,000 CUM
- **Length Overall (LOA):** 288 meters
- **Beam Width:** 44.2 meters
- **Draught at 98% filling:** 11.35 meters

Based on the assessment and the VLNG Project timelines and budget, the best option would be to **acquire an FSU on LNGC conversion and on a long-term charter basis**.

3.5 Type of Terminal

LNGFlex Limited has performed a comprehensive analysis on the chosen site at KPT, taking into account various factors to determine the most suitable terminal type, as summarized in the table below.

Table 3.3: Analysis on Type of Terminal

Type of Terminal	Construction	KPT Port Limitations	Schedule	Cost	Remarks
Jetty with Trestle. FSU is moored alongside the Jetty	▪ Jetty Platform ▪ Access bridge ▪ Piping Trestle ▪ Mooring & Breasting Dolphins ▪ Dredging ▪ Shore protection ▪ Onshore Terminal Facility	▪ Due to its extension into the basin, minimum clearance requirement with turning basin boundary is limiting. ▪ Execution of the dredging and piling works will suspend during the ongoing ship movement in the area ▪ Disposal of dredged material, to a specified area, outside the basin and away from the fairway. ▪ Port permits for execution on daily basis due to work inside ship operating area ▪ Frequent mob/demobilization of construction ▪ equipment may be required, due to ongoing shipping operation	▪ Frequent work interruptions due to ongoing ship movement ▪ Pile load testing will take longer due to resource mobilization ▪ Jetty equipment installation due to shore side lifting & placement arrangement ▪ Frequent mob/demobilization of construction equipment	▪ Higher resource mobilization due to trestle and jetty construction for a longer time due to work interruptions ▪ Deployment of specialized equipment ▪ Testing of offshore structures ▪ Frequent mob/demobilization of construction equipment	▪ At KPT PDWCP location, generally this approach is estimated to incur a higher schedule and cost. There is a high possibility that KPT may take longer in approving this option and would require a very meticulous work methodology, as it encroaches on the existing infrastructure. The proposal may not be approved, unless the jetty location is taken further away from the ship movement area, resulting even higher schedule and cost.

Quay wall with berth. FSU is moored alongside the berth	▪ Dredging ▪ Qua Wall ▪ Berth ▪ topside ▪ Onshore Terminal Facility	▪ Port limitations are minimal due to: ▪ Near shore execution results in minimal encroachment to existing ship movement area. No work suspension is foreseen ▪ The dredged material may be utilized onshore for landfill for berth topside and OTF construction ▪ A bulk permit for construction may be issued by KPT, as existing ship movement is not ▪ affected	▪ Uninterrupted work execution ▪ No piling works ▪ Minimal offshore related works ▪ Minimal offshore testing requirements, if any ▪ No mob / demobilization of construction equipment is foreseen	▪ Normal resource mobilization ▪ Minimal use of specialized equipment ▪ Lower schedule, due to less or no work interruption ▪ No mob/demobilization of construction equipment is foreseen	▪ Due to its location, near shore and onshore, the KPT approvals are expected to be granted for construction. ▪ The schedule and costs are lower for the reasons mentioned. ▪ There are numerous terminals with quay wall/berth side FSU placement
Floating Terminal with FSU & Floating Terminal permanently moored alongside berth	▪ Dredging ▪ Quay Wall ▪ Berth topside	▪ Same as above, for Quay wall and berth option	▪ The schedule is expected to be longer compared to the other two options due to delivery of the two units. The floating terminal would be a new construction.	▪ The costs would be higher as two marine based units would be required. The OTF, in case of VLNG would still be required ▪ Extensive dredging to accommodate both floating units ▪ Longer quay wall and berth face would be required for shore side mooring of both units, hence more area required, along with its development	▪ Floating Terminals are regas or liquefaction platforms, with small capacity LNG storage and used in tandem with an FSU with a bigger storage capacity. These are not considered viable for VLNG application, where an FSU can directly supply VLNG to shore.

Based on the findings and analyses, the **quay wall with berth** is identified as the preferred option across all four parameters: ease of construction, KPT limitations, schedule, and cost.

3.6 Berth Design

The concept focuses on creating a quay wall along the shoreline using sheet piling, requiring dredging on the seaside of the sheet piles. A berth platform will be built on the shore side, with dredging needed to form a pocket wide

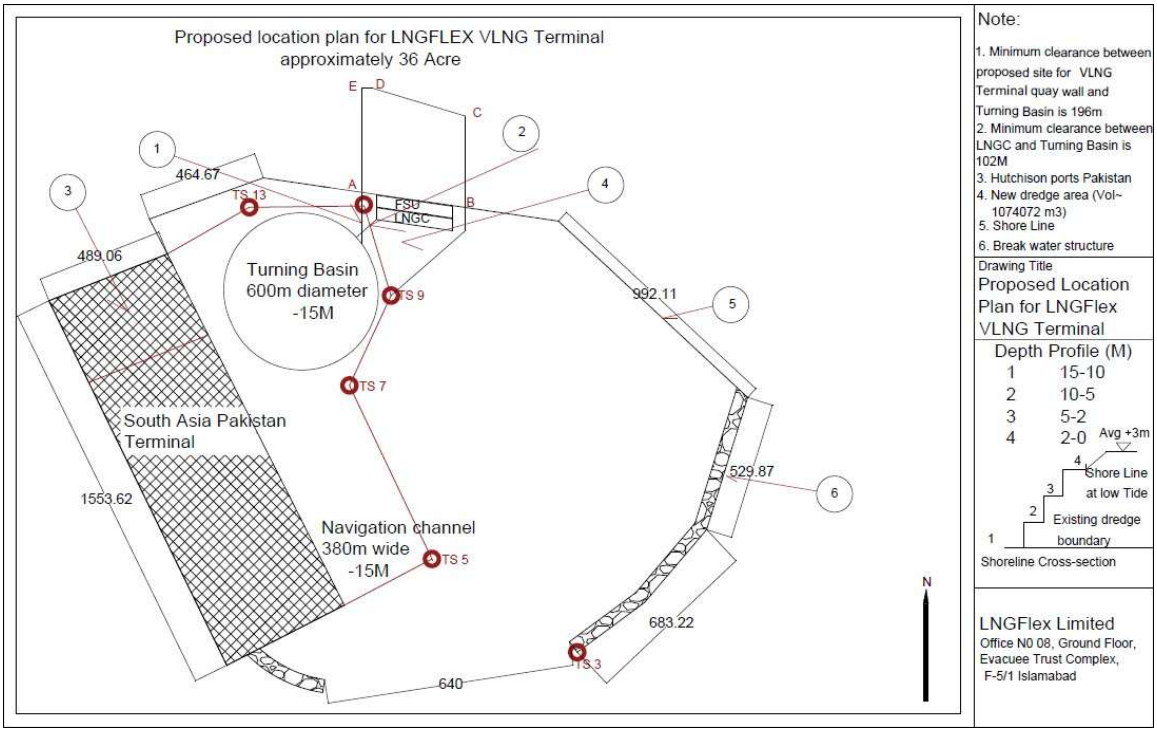
enough for both Floating Storage Units (FSU) and Liquefied Natural Gas Carriers (LNGC). This approach allows for space creation towards the shore, thus avoiding operational constraints posed by existing port features, such as the turning basin. The dredging spoils will be utilized to fill the shore side area of the sheet piles, all while maintaining normal port operations. This method significantly reduces the length of piping connections between the FSU and shore facilities, and the overall dredging costs are expected to be offset by eliminating the need for a jetty and its associated structures.

The proposed berth for Project PLUTO would entail:

- A **new berth with a 400-meter-long quay wall**, featuring a concrete pad of approximately **400 x 40 meters** (to be finalized at detail design).
- The berth will facilitate **simultaneous mooring of an FSU and an LNGC**, with a capacity of **150,000 CUM**, dimensions**: LOA: 288 meters, Beam Width: 44.2 meters, Draught at 98% filling: 11.35 meters**.

The construction requirements outlined include:

- Extending the **PDWCP basin boundary marked by buoys TS-9 and TS-11** to the shoreline as indicated by AB.
- Dredging the area to a **depth of -16M** to align with the basin depth, with a total estimated dredged volume of **1,074,072 CUM**. The generated spoil will be utilized as fill material for the berth and onshore terminal facility.
- **Relocation of Navigation Buoy TS-11.**
- Creation of the **400M long quay wall using sheet piling** along the shoreline.
- Construction of a **400 m x 40 m berth**, equipped with fenders and bollards for securing the FSU.
- Installation of **tanker loading skids and FSU connection manifolds** on the berth topside, with final numbers to be determined.
- Development of the **Onshore Terminal Facility (OTF)** on an adjacent **36-acre** site marked by boundary ABCDE.



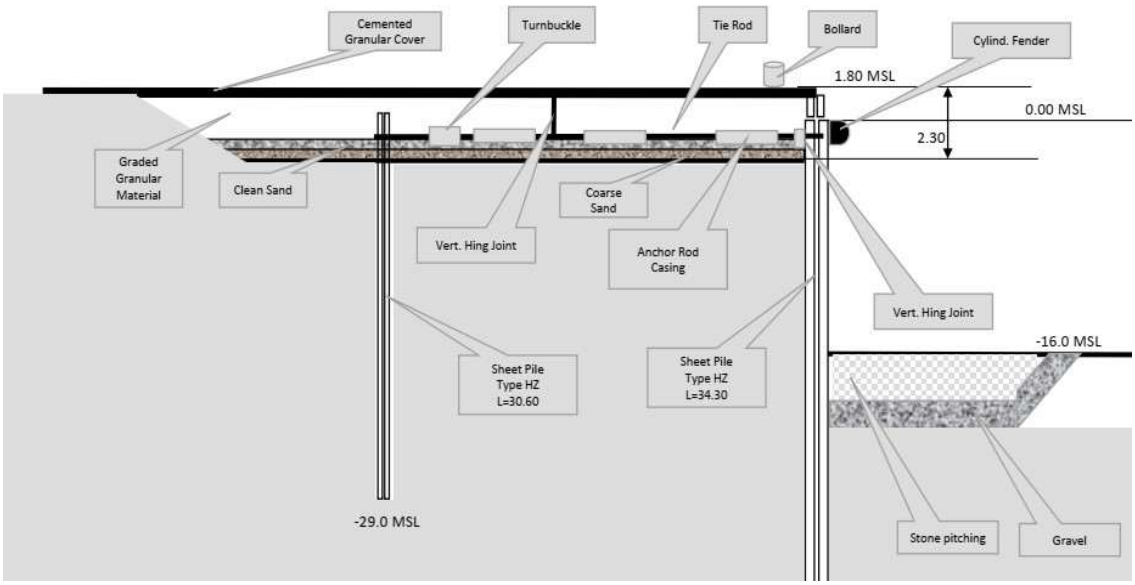


Figure 3.3: Berth Design

The berth topside will include essential installations such as a ship mooring system (bollards, quick release hooks, etc.), **two LNG marine unloading arms, one vapor return arm**, piping manifolds, space for **20 ISO tank filling bays**, and

a docking and mooring guidance system, along with a firefighting system. Specifications for the equipment will be finalized during the detail design stage.

3.7 Onshore Terminal Facility

Onshore part of the terminal would include the following components:

- Auxiliary service & utility units, incorporating all safety-related equipment, both at the berth and onshore.
- An ISO tank handling and transport system.
- Maintenance facilities.
- Roads and additional infrastructure.

3.7.1 ISO Tank Filling Bays

Self-contained tank loading skids will feature LNG loading arms and hoses, vapor return arms and hoses, custody metering, PLC controls, ESD controls, and utility connections. It is proposed to install **20** loading stations, each with a loading capacity of **100 CUM/hour**. The definitive capacity of the loading station will be established during the FEED stage.

3.7.2 Onshore Terminal Facility (OTF) Package Systems with Suggested Capacities (Utilities):

- **Marine Loading Arms:** Three units made of SS 316L material, with a 16" diameter. Two MLAs will have an output of approximately**5400 cum/hour each** for LNG unloading from the FSU, while one MLA will cater to vapor return to FSU, with a capacity of **77400 cum/hour**.
- **Piping Manifold:** Designed for the transfer of LNG to the loading ISO Tanks filling skids and the return of vapors from the filling skids to the FSU. The LNG section will support discharges from at least **three** FSU-based LNG unloading pumps, each rated at approximately**1800 cum/hour** (totaling around **5400 cum/hour**). This system will consist of a fireproof cryogenic piping structure built to endure temperatures as low as**-160°C**, featuring a double pipe (concentric type) with a carbon steel casing pipe and a stainless-steel carrier pipe. Vacuum insulation will be provided. The vapor return line will utilize carbon steel and will be sized for a vapor flow rate of **77400 cum/hour**. The piping manifold will include safety devices, directing discharge from these devices back to a closed loop to the FSU.
- **N2 Generation System:** This will utilize a Pressure Swing Adsorption (PSA) Unit with a capacity of **600NMC of N2 @ 6 bar(g)**, suitable for purging and supplying instrument air for control systems after drying.
- **Compressed Air System:** Providing **600NMC of compressed air @ 6 bar(g)**, this system will support general-purpose use, pneumatic equipment, and

instrument air for actuators and instrument clusters.

- **Gas Generator Set:** A **2 MW** generator set from Caterpillar or Jenbacher (GE), alongside sub-station equipment supplying **110VAC to 220VAC & DC 24V** for general purposes and utilizing BOG from LNG transfer operations.
- **Fire Water & Monitoring System:** This comprehensive system will include hydrants with hose reels, fire monitors with fogging nozzles, tower-mounted fire monitors, and fire curtain monitors. A fire water storage tank capable of supporting one hour of firefighting activities, utilizing seawater, will be included, along with two main and two jockey pumps. All components will be UL/FM certified, and a breaching valve for fire tender connection will be specified (the fire tender itself is to be provided by Port Authorities).
- **Instrumentation & Control Systems:** DCS, ESD, PLCs, history, and data loggers will monitor loading stations and weigh bridges.
- **Waste Management:** Waste generated from the FSU and site operations will be handled by municipal trucks designated for transport to an off-site disposal location outside the KPT area.
- **Stainless Steel Piping:** The system will also encompass stainless steel piping, fittings & valves, and cryogenic hoses for LNG loading connections to ISO tanks.

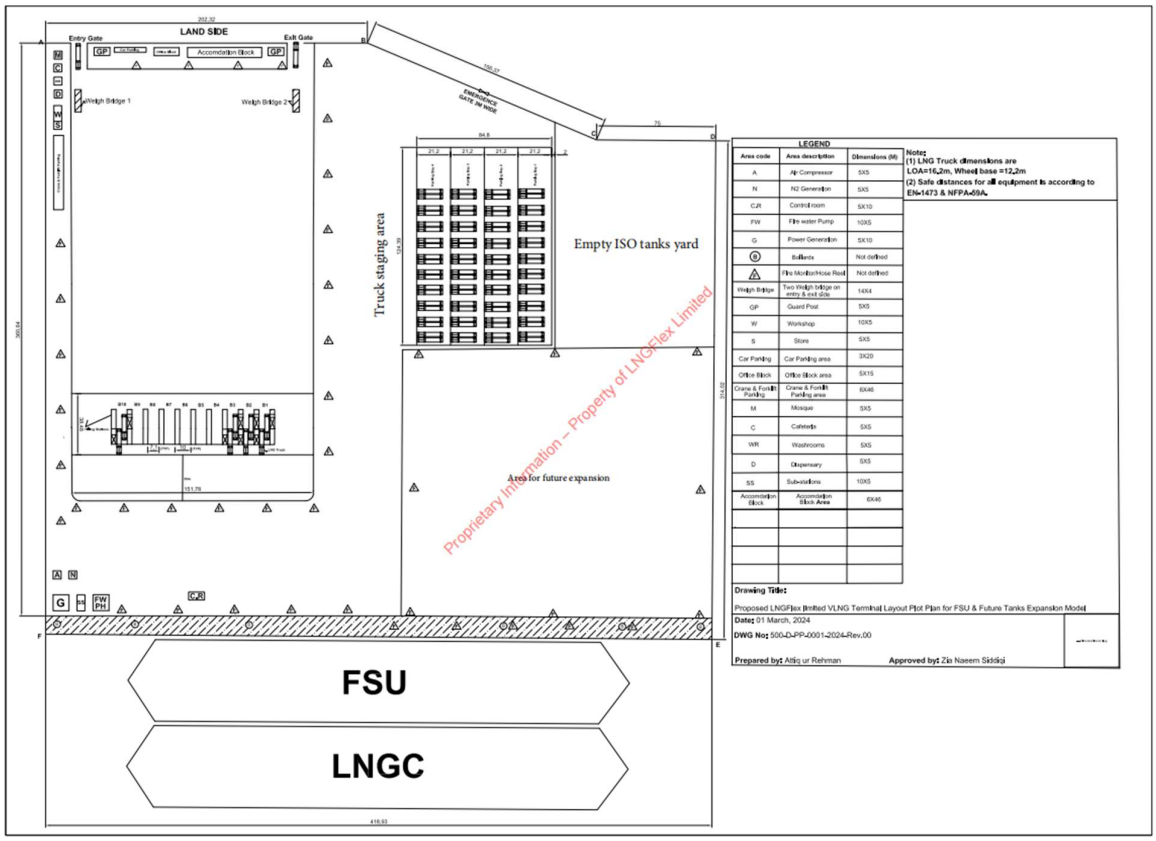


Figure 3.4: Facility Plot Plan

3.8 Operating Scheme

3.8.1 General Philosophy

The VLNG terminal operates through a framework comprising three key stations that connect the Floating Storage Unit (FSU) to the Onshore Receiving Facility (OTF) via the Berth. The first station is responsible for managing the FSU's operations and ensuring safety protocols at the Berth. The second station focuses on the Berth's operations, while the third one oversees the OTF, which is built on the Berth and the surrounding land. Notably, these control systems operate in parallel, promoting integrated functionality.

For connectivity, the installation of electrical and communication cables is carefully planned for the Berth and the OTF. This integrated setup enhances communication between the Berth and the OTF through advanced technologies like telephone, radio, and Wi-Fi, enabling efficient and secure data transfer without the need for physical wiring.

3.8.2 LNGC proposed Navigation Scheme

The navigation process begins at the limits of the fairway at the start of the Tipu Sultan Channel. The LNGC is to be guided by a pilot boat through the channel until it reaches the breakwater, where it will be assisted by four power tugs to enter the turning basin. Once in the turning basin, the LNGC will stop its engines and will be maneuvered by the tugs. They will align the LNGC's port side parallel to the FSU before pushing it toward the FSU for mooring. For departure, the LNGC will follow a similar navigation pattern. After unloading, the tugs will guide the LNGC back to the turning basin, repositioning it so that the bow faces the navigation channel for an exit from the port. The proposed navigation route for incoming and outgoing LNGC operations is illustrated in the accompanying figure.

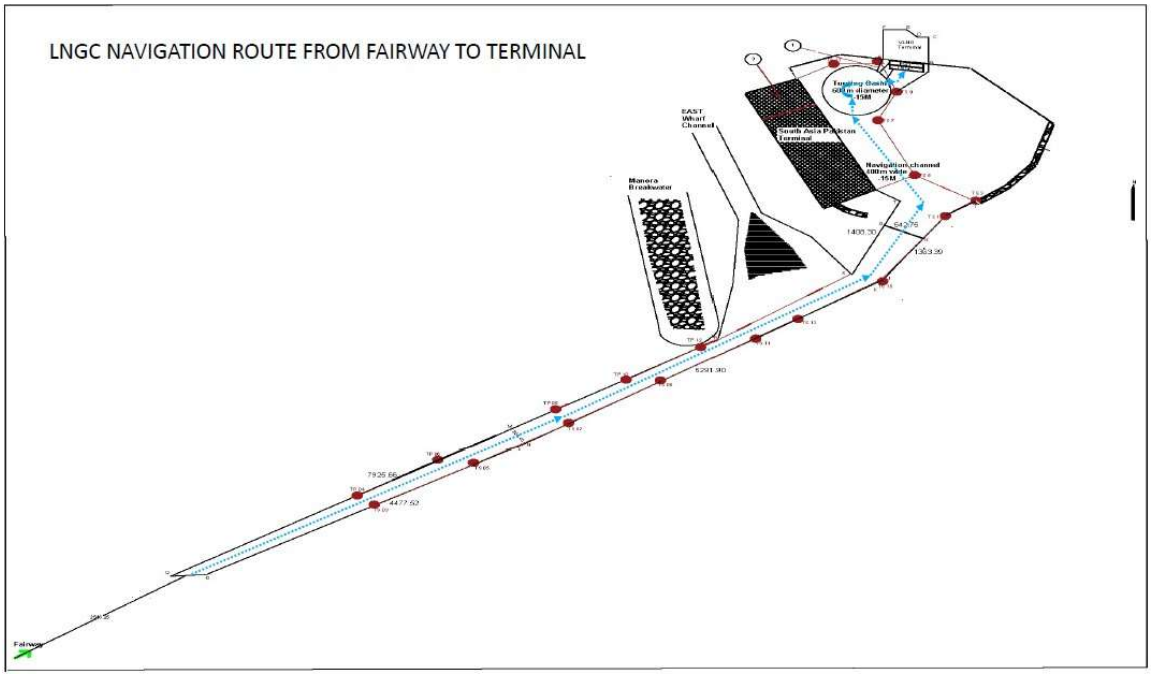


Figure 3.5: LNGC Navigation Route

3.8.3 LNGC and FSU Mooring Scheme

The FSU is securely moored at the berth using four mooring bollards and quick release hooks. While alongside, it is supported by two breasting dolphins. The LNG carrier is connected to the FSU with two mooring ropes from the FSU and two additional ropes tied to bollards or quick release hooks at the berth. Rubber fenders are positioned between the LNG carrier and the FSU for protection.

3.8.4 Ship to Ship Transfer Scheme (LNGC to FSU)

The cargo transfer from the LNG Carrier (LNGC) to the Floating Storage Unit (FSU) will utilize cryogenic flexible hoses. The LNGC example provided, Grace Acacia, is equipped with four membrane tanks, offering a total cargo capacity of 150,000 cubic meters of LNG. It features two LNG discharge pumps, each rated at 1,800 cubic meters per hour. Upon reaching peak discharge capacity, the entire cargo of 150,000 cubic meters is projected to be transferred to the FSU within 12 hours of initiating the transfer.

3.8.5 Ship to Shore Transfer Scheme (FSU to LNG ISO Tank Loading Skids)

There are three EA Marine Loading Arms (MLAs) with a diameter of 16 inches each, positioned on the seaside of the berth. Two of these MLAs are designated for cryogenic service to facilitate the transfer of LNG from the Floating Storage Unit (FSU), while one MLA is utilized for vapor return to the FSU. These MLAs are connected to a piping transfer and distribution manifold that interfaces with the proposed 20 ISO tank loading skids on the berth platform.

A critical safety feature of the MLAs is the Quick Release Coupling, which is automatically actuated in emergencies and triggers the Emergency Shutdown (ESD) system. The FSU is designed to discharge LNG directly to the ISO tank loading skids via the MLAs and the piping manifold, and it receives vapor back into its storage tanks from the loading skids through onboard receiving systems.

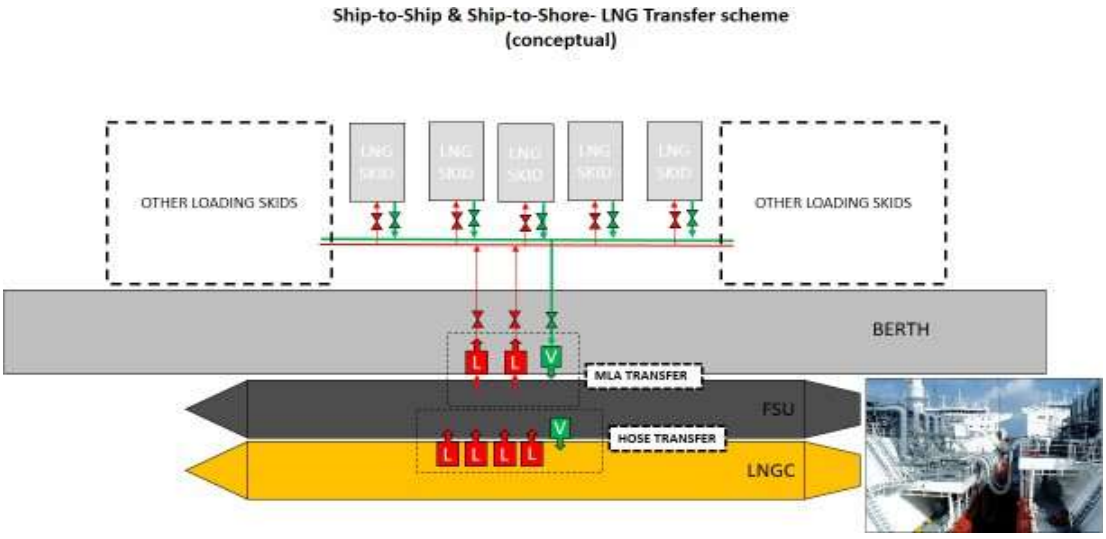


Figure 3.6: Ship to Shore Transfer Scheme

3.8.6 ISO Tanks loading scheme

It is proposed to install 20 EA self-contained loading skids for filling LNG ISO tanks. Each skid consists mainly of LNG loading and vapor return arms, along with flexible hoses for connecting to the ISO tanks. Additional features include nitrogen purging and instrument air connections for control valves. A custody transfer meter is included for accurately measuring the LNG quantity loaded into the ISO tanks, along with PLC control panels, ESD control panels, and essential safety equipment.

The loading stations will receive LNG directly from the FSU pumps. Upon the arrival of ISO tanks at the loading station, the following checks must be performed prior to initiating the loading operation:

- **Temperature Check:** The ISO tank's temperature should be below -160 °C; if not, pre-cooling is necessary.
- **Air Content Check:** The contents of the tanks must be checked for air presence. If air is detected, nitrogen purging will be executed to eliminate it.
- **Leakage Inspection:** All ISO tank piping and valves should be tested for leaks using nitrogen.
- **Hose Connection:** LNG and vapor hoses need to be securely connected to the ISO tank manifold.
- **Filling Limit Setting:** The filling limit should be established through the custody meter control.
- **Filling Operation:** LNG will be transferred to the ISO tank, with vapor returned to the FSU.
- **Post-Filling Procedures:** After completion, hoses must be disconnected, purged with nitrogen, and readied for the next ISO tank filling.

The estimated total time for these checks is approximately 30 minutes; if cooling down and purging are required, this duration may extend to 60 minutes. The estimated time for LNG filling is approximately one hour per ISO tank with a net capacity of 36 CUM.

3.9 Proposed End User Facility

The user facilities are spread over a large geographical area, each with its own environmental challenges. This ESIA is location specific, to the terminal at KPT. Separate site specific environmental assessment will be conducted for user facilities by the respective proponents and approval will be obtained from SEPA.

3.9.1 Small to Medium Enterprise (SME) Industrial Sectors & Housing Colonies

Many small to mid-size industrial units utilize captive power plants that operate on natural gas. However, industries, particularly in the textile and steel sectors, have expressed concerns over the high cost of gas, which affects their competitiveness in both international and local markets.

In addition, large-scale housing colonies are encountering challenges in securing bulk connections from SNGPL/SSGC and are largely reliant on alternative gas sources for their residents. VLNG offers a secure and dependable gas supply to these customers. LNGFlex stands out as a provider of natural gas at competitive rates for both SMEs and housing colonies.

Typical Arrangement and Operation Scheme:

1. **LNG Delivery**: LNG is transported to the station using specialized cryogenic tank trailers. Each trailer can hold up to 18.5 tons of liquefied gas, which converts to approximately 25,600 m^3 of gaseous natural gas upon regasification.
2. **Cryogenic Storage**: The received LNG is stored on site in cryogenic storage tanks built to maintain low temperatures, reaching as low as -162 degrees. The storage units come in various sizes, with an average capacity between 40-60 m^3, allowing multiple containers to be set up based on usage needs.
3. **Regasification**: LNG is converted back to gas in a regasification unit, which includes an LNG pump that moves LNG from storage to air vaporizers for the gasification process.
4. **Natural Gas Pressure Regulation**: Given that consumers require specific operating pressures, a Natural Gas pressure regulation station is installed downstream of the vaporizer. This station adjusts the NG pressure to meet the needs of various end-user equipment like boilers, generator sets, and furnaces.
5. **Odorization**: The gasified LNG is odorless; thus, in accordance with regulatory safety standards, an odorizing station is included to add a small quantity of odorizer to the gas stream, enabling the detection of any potential leaks.
6. **Consumer Facility**: Finally, the depressurized and odorized gas is supplied to the consumer facility, ensuring readiness for usage.

3.9.2 LCNG Stations

The majority of existing CNG stations are facing imminent closure and losing business due to gas shortages and unannounced load shedding. This situation is increasing reliance on the more expensive options of petrol and diesel, which are significantly more harmful to the environment compared to CNG.

LNG presents a considerable opportunity to address the CNG shortfall by converting it to LCNG, which requires only minor modifications to the current infrastructure.

A typical arrangement for the LCNG setup includes the following operations:

- LNG is decanted from ISO tanks into onsite LNG storage tanks.
- LNG from the storage tank is pumped through an LNG pump to the air vaporizer unit, where it is gasified into LCNG.
- The gasified LCNG is stored under pressure in buffer tanks, which can either be newly installed or repurposed from existing CNG stations.
- Finally, the LCNG is dispensed into vehicle storage tanks through CNG dispensers.

Additionally, a separate LNG supply from the storage tank is available to LNG dispenser units for vehicles equipped with LNG operable engines.

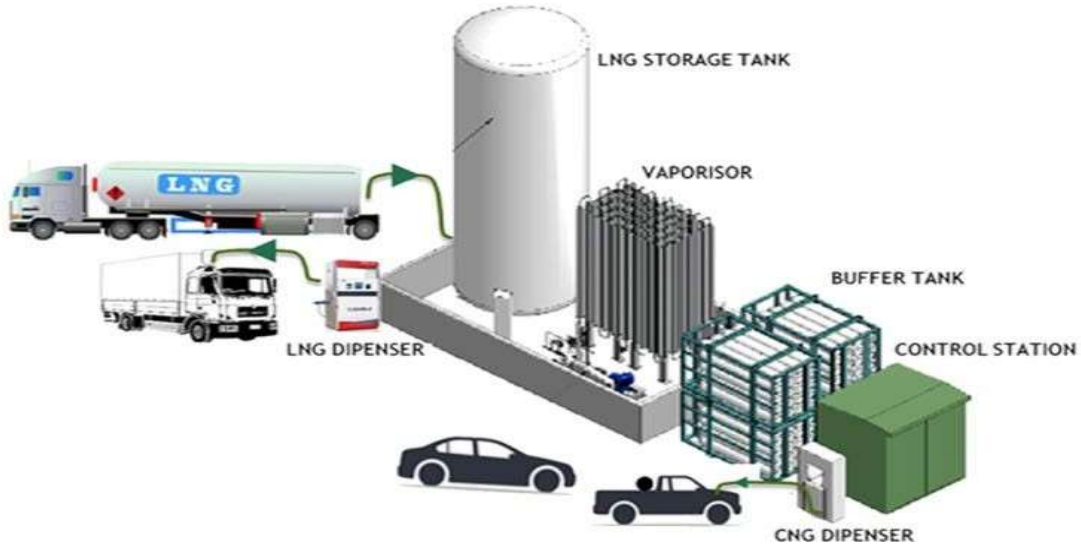


Figure 3.7: LNG Supply

3.10 Road Congestion & Transportation Assessment

The proposed site at KPT is currently surrounded by active terminals that handle the dispatch of liquid products and containers by road, contributing to road congestion at the KPT exit. With an estimated 250 ISO Tank trucks expected to depart from the VLNG Terminal each day, this situation will worsen, significantly delaying the logistics chain.

Therefore, it is crucial to undertake a comprehensive traffic and transportation network study conducted by a qualified consultant, aimed at determining the optimal number of LNG dispatches that can be managed daily. Additionally,

this study should recommend necessary measures to enhance the road infrastructure to fully support the VLNG Terminal's operational potential and propose alternative solutions to address the present challenges.

The environmental implications of road transportation will be evaluated in a subsequent IEE/EIA study following the traffic impact assessment.

4.0 Description of Existing Environment

4.1 Introduction

The environmental baseline in this chapter addresses the physical, biological and socio-economic aspects of the project area.

4.2 Karachi Port

Karachi Port is a deep natural port featuring a navigable channel that stretches 15.6 km and an approach channel with a depth of 16 meters. To streamline operations and maintenance, the channel is segmented into five sectors.

The port offers 24/7 safe navigation for tankers, modern container vessels, bulk carriers, and general cargo ships up to 75,000 DWT. There are 30 dry cargo berths—17 on the East and 13 on the West side—alongside three liquid cargo handling berths (OPI, OPII, and OPIII). Among the dry cargo berths are two dedicated, privately operated modern container terminals: the Karachi International Container Terminal (KICT) and the Pakistan International Container Terminal (PICT).

Additionally, the Pakistan Deep Water Container Port (PDWCP) has been developed by Karachi Port Trust, located on the east side of Keamari Groyne. This terminal has been handed over to South Asia Pakistan Terminals (SAPT), a subsidiary of Hutchison Port Holdings, on a Build-Operate-Transfer (BOT) basis. SAPT has been successfully managing the container terminal for over 18 months, and the PDWCP basin and channel have been dredged to -16mCD.

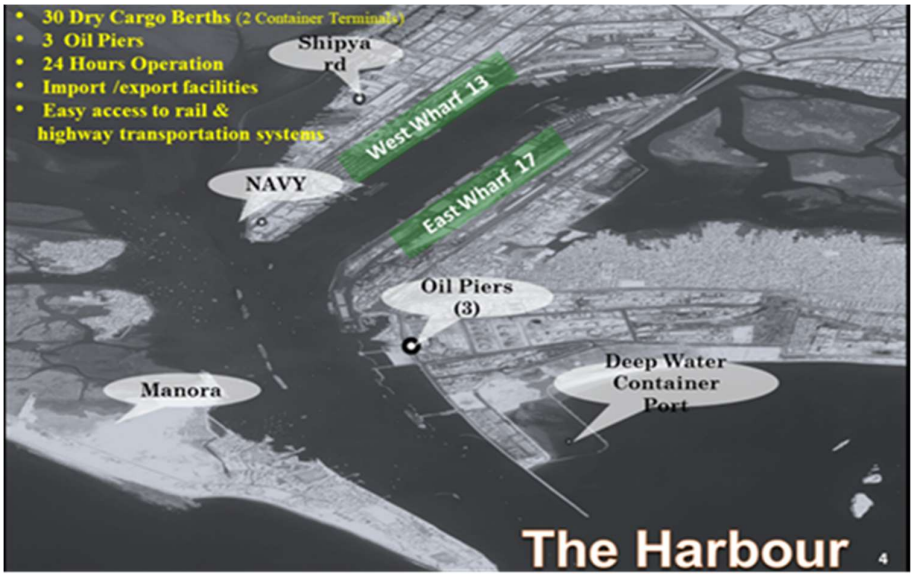


Figure 4.1 Karachi Port

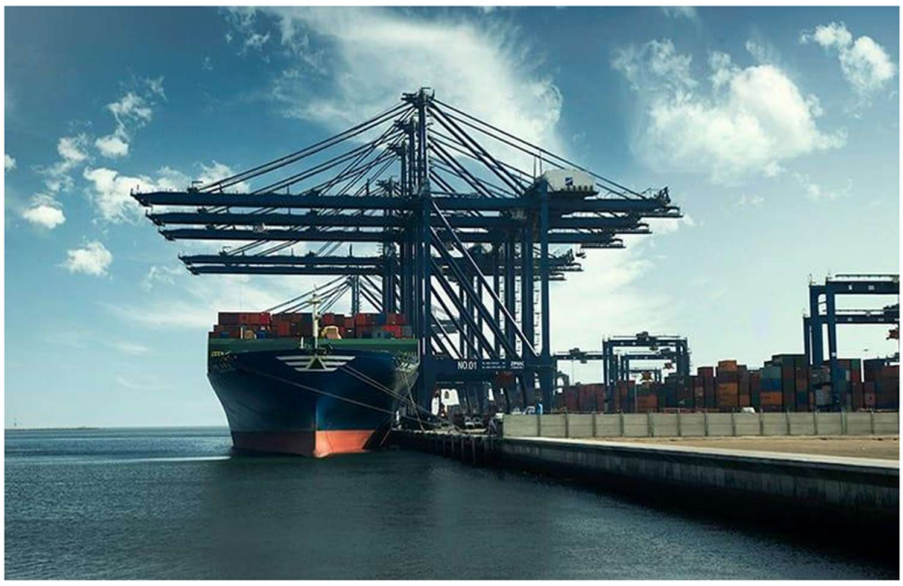


Figure 4.2: Pakistan Deep Water Container Port (PDWCP)

4.2.1 Aids to Navigation

The existing channel begins at the first pair of channel buoys in the approach channel and extends to the Juna Bandar's extreme end in the upper harbour of the main channel. The channel is clearly marked with 12 buoys (S-1 to S-23; odd numbers) on the starboard side (Green) and 13 buoys (P-2 to P-26; even

numbers) on the port side (Red). To ensure safe navigation in the approach channel, two new leading lights (FLL and RLL) are installed on the Oyster Rock Breakwater (ORB). The existing Oil Pier-I is situated in the Lower Harbour, positioned between the channel buoys S-23 and P-26.

The Pakistan Deep Water Container Port (PDWCP) has been established to the east of Keamari Groyne, featuring a 10.6 km long channel that leads from the first pair of buoys in the approach channel to the northern end of its basin. The declared depths for the channel, basin, and berths at the PDWCP are all set at 16m. Additionally, a Preferred Mid channel buoy marks the starting point of the PDWCP entrance channel (Tipu Sultan Channel), which is marked with 7 buoys (TS-1 to TS-13; starboard, Green) and one buoy (TS-4; port, Red).

The third container terminal at Karachi Port (SAPT) operates within the PDWCP, equipped with four berths, each measuring 375m in length. Furthermore, KPT has plans for capital dredging in the near future, aiming to deepen the lower and upper harbours to 14m below datum and the approach channel to 18m below datum to accommodate larger vessels.

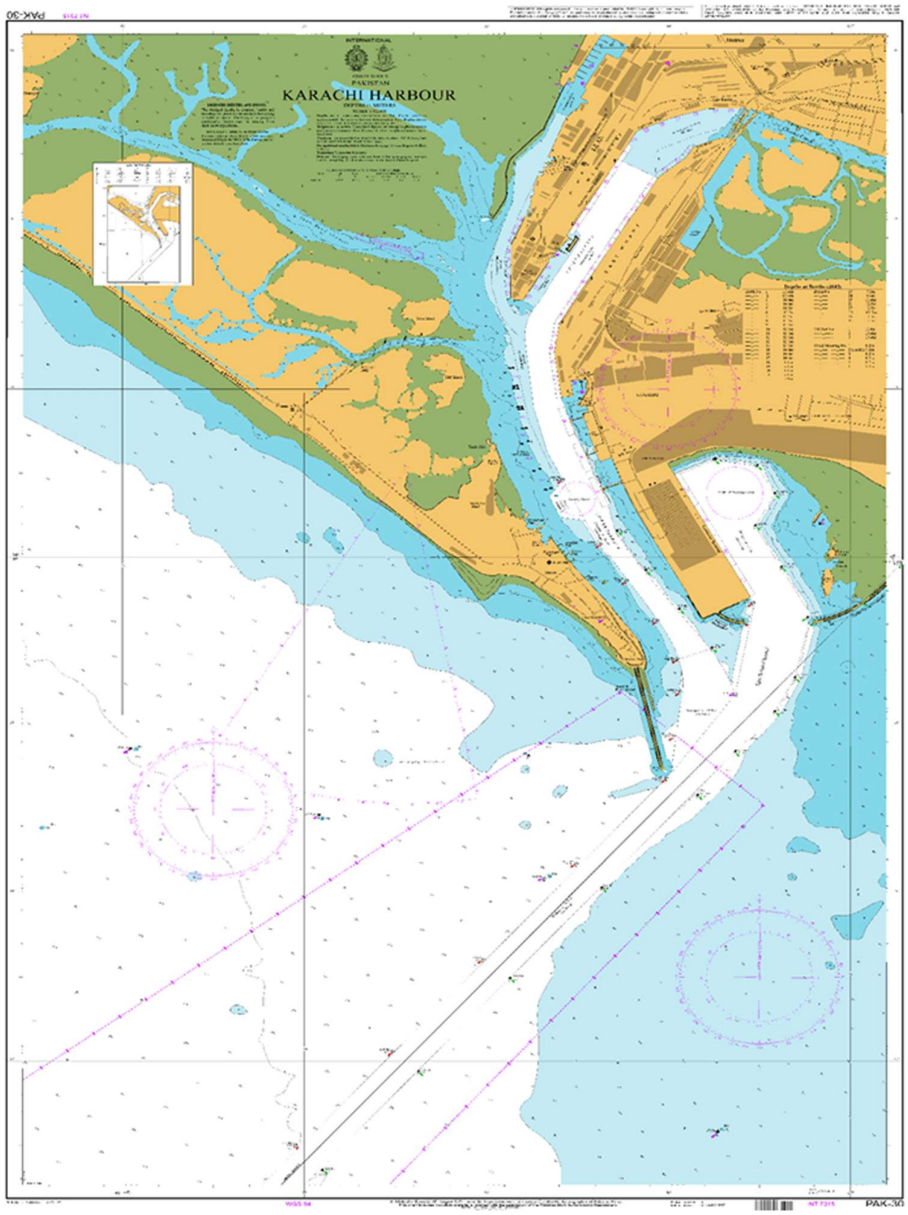


Figure 4.3: Karachi Harbour Chart Pak30

4.2.2 Topography of the Macroenvironment

The macroenvironment of Project area is part of the synclinorium that lies between Cape Monze and the Korangi Creek, while the microenvironment lies in the east of Manora Channel from the Oyster Rock to Korangi Creek. It includes the large shallow intertidal and sub-tidal areas spreading out to 1-5 km with a very gentle surface gradient of about 1:50. The present sandy beaches

of Clifton were way beyond Bath Island which, according to the above map of Karachi Harbour (1889), creeks and islands, was itself surrounded by mud flats.

The Cape Monze cliff that projects into the Arabian Sea is part of the 3-9 meter contour that characterizes the coastline up to the Rann of Kutch. In the sand mass along the coastline there are 30 to 60m high cliffs that have been undercut by storm surges. Intense erosion resulted in cliffs, sea caves, arches and blow holes that can be observed on the coastline from Hawkes Bay to Manora Channel and onwards to Korangi Creek.

The coastal region of the synclinorium is seismically active and has been undergoing continuing uplift. The uplift has already resulted in the formation of rocky headlands and in exposing portions of continental shelf. Protected pocket bays and lagoons between the nearly formed headlands have been rapidly filled by alluvial and fluvial deposits. The material brought to the coast was taken over by currents and wind for the formation of wide sandy beaches and migrating sand dunes[1].

The synclinorium was part of the delta built by the Indus River by progradation. Renn Pethani, Gharo Creek and main channel of River Indus were among the main estuaries that flooded the coastline with fine sand. The Indus delta has receded and retreated towards the southeast. This dried up the numerous estuaries and creeks that characterize the tidal delta and marshy mud flats. The remnant estuaries developed into a complex system of sea water creeks separated by mud flats and small islands. Mass shifting induced by tectonic movement is at work on a continental scale in the macroenvironment.

[1] (Rodman E. Snead, Annals of the Association of American Geographers 57, 550-1967)

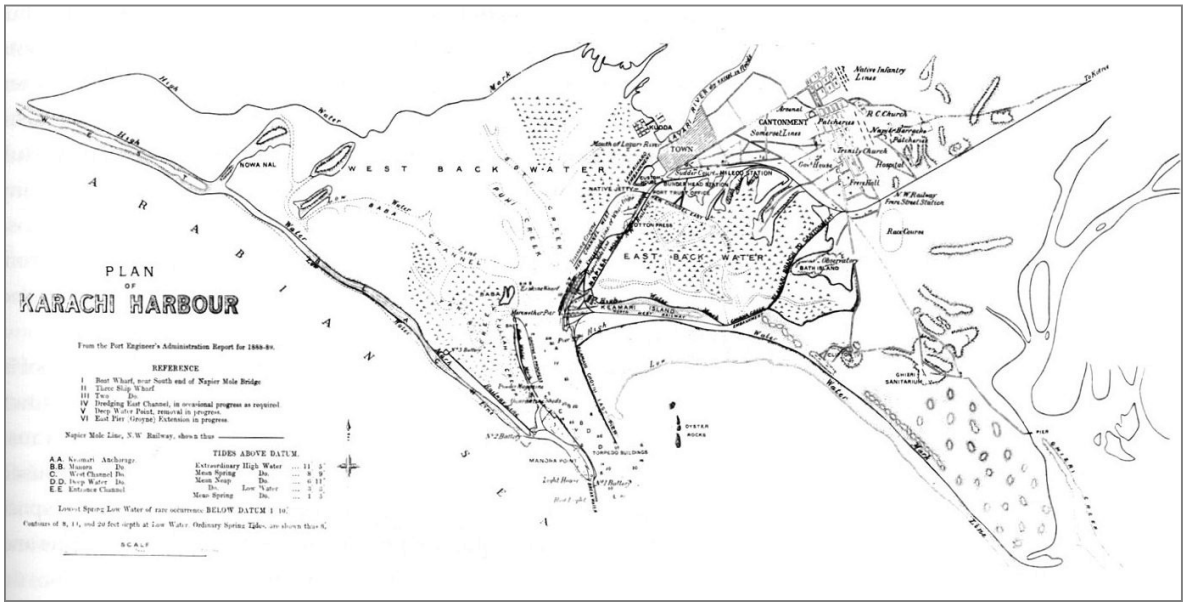


Figure 4.4: Karachi Harbour Map 1889

4.2.3 Topography of the Microenvironment

The topography of the Project area is completely altered from what was swampy mud flats. The entire area from the Manora Channel to Clifton has been reclaimed by filling the low marshy lands. The flat sandy plain built along the seacoast on the recently filled silt and sand sediments has following three types of coastal sediments.

- *Sand bar deposits:* The sand bar deposits have medium to coarse sand, micaceous and shifting sand dunes as the main constituents.

- *Coastal sand dune deposits:* These comprise medium size sand and shifting sand dunes.

- *Beach sand deposits:* Medium to coarse grained, unconsolidated sand with pebbles and broken shells are the main constituents of beach sand deposits. These have been marked but keep on shifting by wind into small coastal dunes.

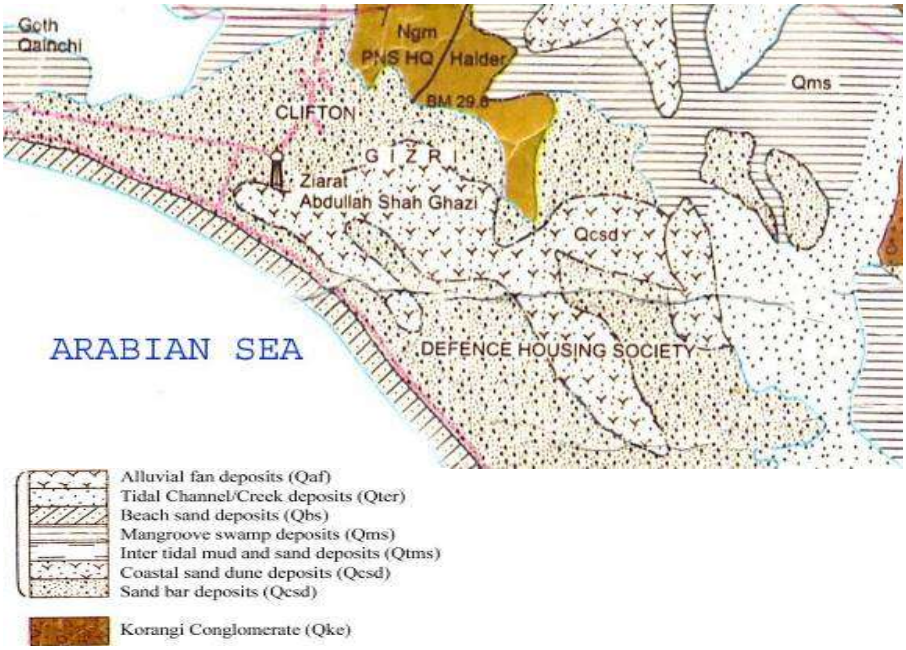


Figure 4.5: Surface Geology Map of Clifton Area, Karachi

4.2.4 Geology & Landforms

Geologically the macro environment is composed of the Middle and Upper Tertiary rock formations that include fresh, and slightly weathered recent and sub-recent shoreline deposits. The shoreline deposits are derived from Gaj / Manchhar formations of lower Miocene to Middle Miocene/Upper Miocene to Pliocene age. The deposits have the inter-bedded sandstone and shale together with subordinate amounts of large size gravels or conglomerate as the principal constituents.

The seabed is predominantly sand and silt while the sediment of the coast beyond Gizri/Korangi Creek is fine grained and the soil is typically of continental shelf/Indus delta origin. The gravels or conglomerates are loosely bonded with medium to coarse brown sand and are derived from Manchhar Formations of Pleistocene age. The Gaj formation consists mostly of limestone with subordinate shales and sandstone. The limestone is hard, sandy and extremely fossiliferous. This formation overlies Nari formation which consists of harder limestone beds and shales.

Manchhar formation overlies Gaj formation and is spread all along the coastal areas of Karachi but is best exposed in Clifton, Ibrahim Hydri, Gizri, Korangi and Landhi areas. This formation is composed of sandstone, clay beds, cemented sand and gravel (pseudo Conglomerate). Sandstone is thick, porous and friable and also contains bands of conglomerate.

The clay/shale has different colours varying from grey, brown, chocolate and orange, but the most frequent variety is light brown and dark grey in colour. Sandy layers are also found inter-bedded with clay and gravel.

The mudflats are recent deposits of the delta area while soil cover is the drift type that has been slightly withered with time and marine activity. It seems to have been transferred with the flood flows from Malir River and the Indus on the east.

Historically the coastal region is found to be of tertiary and post-tertiary origin. The region has been formed by the upheaval of land from the Tethys Sea, which once extended up to the northern border of Pakistan but, gradually withdrew with the rising of the Himalayas. The underlying rocks are mostly of marine origin, highly folded, faulted and fissured everywhere. They consist mainly of fine micaceous sand. The soil is derived from land drainage and river discharge. It is rich in salts such as sodium chloride, sulphates and carbonates, which come from shell fragments. The pH of the soil ranges from 8.2 to 8.4. In addition to Oyster Rocks there are hard subsea rocks at the tip of Keamari Groyne extending seawards.

4.2.5 Seismotectonics of the Area

Seismotectonic Study for macroenvironment of Project site aims at elucidating the impact of tectonic movement induced seismicity on the microenvironment. Seismicity in the Karachi region is related to the pressure potential being built at the convergence of the three lithospheric plates: Indian, Arabian, and Eurasian at the Triple Junction formed by the intersection of Owen fracture zone, the Makran subduction zone and the Ornach-Nal fault. The Murray Ridge extends northward into Pakistan, to unite the Ornach-Nal-Chaman Fault system onshore, displaying a strike-slip boundary between the major tectonic plates of India and Eurasia[2].

Karachi and its environs fall in the synclinorium, described earlier as being part of Indus deltaic region. Recession of the delta and its retreat towards the southeast dried up its numerous channels, estuaries and creeks that characterize the synclines and are part of the active faults. Tectonic instability of this region can be attributed to this large number of reverse and tear faults and the recently described wrench faults.[3]

[2] (Baloch, S.M. & Quirk, D.G., Mesozoic to Neogene Tectonism and Evolution of Murray Ridge, Pak. Jour. of Hydrocarbon Research, Islamabad, 13).

[3] (Riding the mobile Karachi arc, Pakistan: Understanding tectonic threats Ghulam Sarwar and Anwar Alizai, Journal of Himalayan Earth Sciences 46(2) (2013) 9-24).

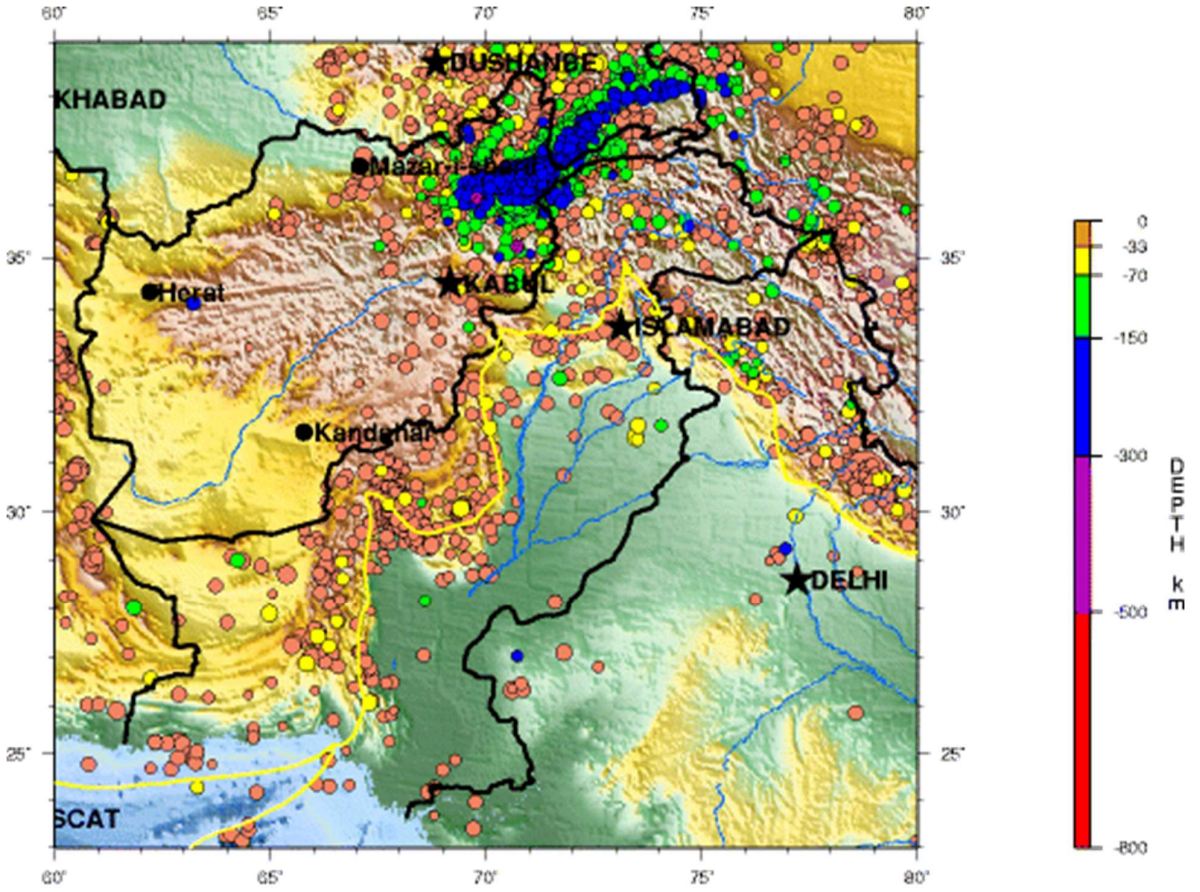


Figure 4.6: Seismicity & Natural Disasters - Pakistan, 1990-2000.

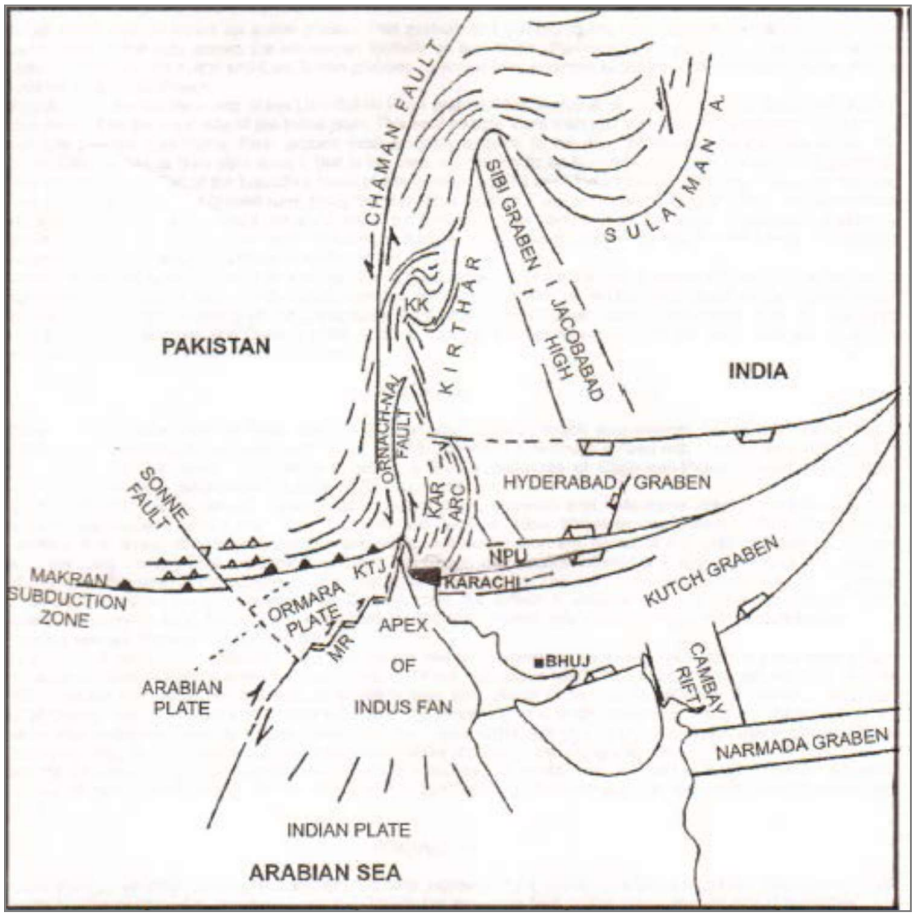


Figure 4.7: Schematic plate tectonic sketch map showing the Karachi Arc and its regional tectonic framework.

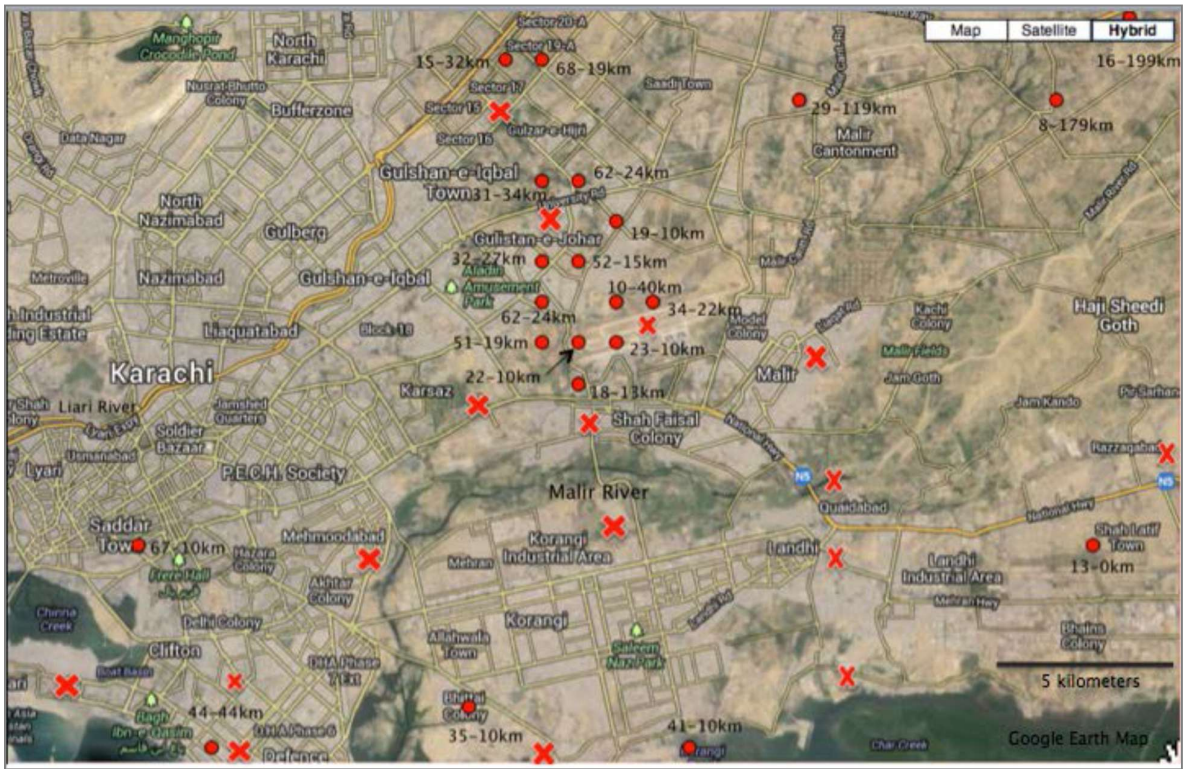


Figure 4.8: Earthquake epicenter plots for the time period 1902-2013.

The first number refers to the list numbers on Tables 1 and 2 whereas the second number represents depth of hypocenter in kilometers. The Red Crosses represent neighborhoods plagued by recurrent seismic activity, usually of low magnitude[4].

Sarwar and Alizai have compiled a list of earthquakes during the 1902-2013 period and also produced the above map that gives a distribution of hypocenters of earthquakes during the same period. From the distribution of hypocenters it has been inferred that the entire Karachi Arc and surrounding areas are seismically active with hypocenters ranging in depth from 0-500 kilometers. From the depth of hypocenters it is inferred that active deformation has taken place at multi-levels ranging from shallow to deep in the basement. Quite a few of the recent epicenters are found within or in close proximity to parts of Karachi that have faced recurrent earthquake activity.

Seismic activity in the region is the result of the triple junction as well as the Karachi Arc, located in southeastern Pakistan, as a large fold and thrust belt that shows Neogene thin-skinned eastward movement (Sarwar and DeJong,

[4] (Source: Pakistan Meteorological Department, June 2013 & Ghulam Sarwar and Anwar Alizai, Journal of Himalayan Earth Sciences 46(2) (2013) 9-24)

1979; Schelling, 1999). Seismic activity in and around the region shows that the Karachi Arc has been active since long in prompting the eastward movement of the delta. It is possible that the movement is related to the rebound that takes place after mass shift. Sarwar has suggested that the eastward creep of Karachi Arc is directly related to active subsidence of the Hyderabad graben that underlies it and also defines the northern and southern limits of the Karachi Arc.[5]

It may be added that subsidence such as that on Southern coast of Sindh, occurs naturally as a result of plate tectonic activity above active faults, and in places where fluid is expelled from underlying sediments and is common at river deltas that may have receded. Earthquakes arise and result from the release of the force along the growth fault plane. As a result, many different growth faults are created as sediment loads shift basin ward and landward.

The seismic zoning for Karachi is Zone 2B, i.e., moderate damage, with a seismic factor of between 0.16g and 0.28g (ACEP, 2000). The PIANC seismic design Coefficients are quoted in following Table.

Table 4.1: Seismic Design Coefficient

Earthquake Event	Return Period (years)	Seismic Coefficient (%g)	Design Life (years)	Probability of Occurrence (%)
PIANC L1	75	15	50	50
PIANC L2	475	20	50	10

These coefficients comply with the guidelines set down in the Karachi Building code of ACEP / KBCA, "Seismic Zones of Karachi and Recommendations for Seismic Design of Buildings", April 2000.

4.2.6 Meteorological & Climatic conditions

Meteorological conditions in this region of the Arabian Sea are governed by the two monsoon seasons, the south west monsoon in summer from May to September and the North East monsoon in winter from December to February.

Temperature, Humidity and Rainfall (Source Pakistan Meteorological Department statistics (1931-2017))

The summer begins in May with maximum temperature in May/June crossing 40°C, and then the temperatures gradually cool down in September onwards. Pakistan Meteorological Department statistics (1931-2017) of Karachi shows the maximum temperature 47.8°C in May 1938 and minimum temperature 0°C

[5] (Sarwar, G., 2004. Earthquakes and the Neo-Tectonic Framework of the Kutch-Hyderabad-Karachi Triple Junction Area, Indo-Pakistan. Pakistan Journal of Hydrocarbon Research, 14, 35-40).

in January 1934. During last three years higher temperatures than normal have been observed particularly during May/June. Winter season in Karachi has also become very mild with mean monthly temperature as 20~22°C.

Temperature

- Mean annual temperature: 26.4°C
- Mean monthly maximum temperature: 32.0°C
- Mean monthly minimum temperature: 20.7°C
- The highest temperature: 47.8°C
- The lowest temperature: 0°C

Humidity: Humidity is a marked feature of the coastal region. It is generally higher in the morning in comparison with the afternoon. It also varies from place to place depending on its proximity to the sea. The average annual humidity for Karachi is 80%.

Humidity ranges generally maximum 55%-65% in January, 85%-90% in May and 85%-95% in October.

- Mean monthly humidity is: 54%~77%
- Mean annual humidity is: 66.0%

Rainfall

- Mean annual rainfall: 176mm
- Annual maximum rainfall: 481.5mm
- Annual minimum rainfall: 0.0mm
- Largest rainfall in 24 hours: 142.6mm
- Mean annual raining days: 18.7d

Maximum rainfall occurs in Karachi in July and August but it is not a regular feature. Record shows the maximum monthly rainfall is about 300mm.

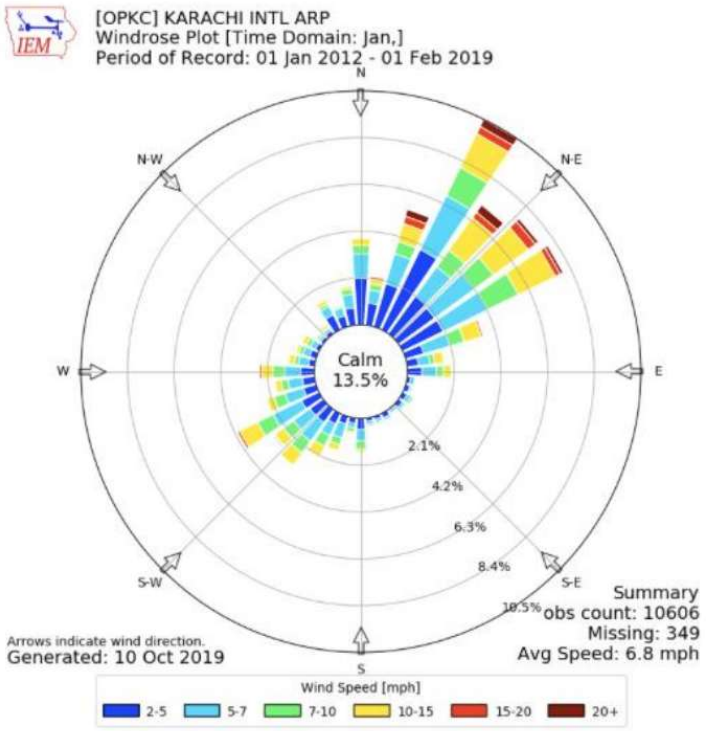
Heaviest monthly rainfall is recorded as 429mm in 1967.

During the winter, the rainfall is very small.

Winds: The two distinct and prevalent seasons are the SW monsoon from May to September and NE monsoon from December to February; variable winds occur in October-November and March. The wind direction during the SW monsoon is mostly Westerly in Karachi but varies from South, South-West to West with a force generally 4 to 5 on the Beaufort scale, occasionally reaching 6 to 7 on account of low atmospheric pressure due to disturbances. Wind rose for the winter monsoon period displays the same Westerly wind dominance

but also indicates a relatively larger North-eastern component when compared with the summer monsoon wind rose. The NE monsoon wind direction is from North to North-east with a wind force averaging about 2 on the Beaufort scale.

Weather data from Karachi Airport is provided by LNGE and the wind data considering the wind speed and wind direction have been compiled and represented in the wind roses below. The wind roses indicate the wind data for each month over a 7-year period.



Climate: The coastal meteorology and hydrography of Karachi is controlled by the seasonal change in the North Arabian Sea i.e., monsoonal system. The data collected from various studies along the coast clearly show the influence of NE and SW monsoon winds. A general summary of meteorological and hydrological data is presented in the following section in order to understand the coastal hydrodynamics investigated in this study. The entire coastal area of Sindh is included in the warm monsoon climatic region. The climate is characterized by pleasant weather due to a sea breeze which blows all year round except for local disturbances during winter and summer months. Mild winter extends from November to February and a few cold spells occur occasionally due to western weather disturbances. Similarly, summer extends

from March to June and hot weather sets in when ho winds start blowing from Rajasthan, India. When the pressure vacuum builds up in the north Arabian Sea or over Sindh-Kathiawar coast it stops the sea breeze over the Indus delta. Thereafter the temperature increases up to as high as 480C, making the hot weather along the coast very uncomfortable. Seasonal fluctuations in temperature and monsoon rains characteristically indicate the climate of dry tropical and sub-tropical climate zone in this tract. Atmospheric aridity is the chief characteristic feature of this area.

Precipitation: Karachi is located in a semi-arid climate zone, resulting in relatively low annual rainfall. Over the two decades of the 1970s and 1980s, the annual rainfall averaged between 150 - 250mm. Typically, Karachi experiences ten or fewer rainy days each year, with most precipitation occurring in brief periods of 2 to 7 days. Notably, around 70% of the rainfall happens during July and August, coinciding with the southwest monsoon season. The winter months, from December to February, are less wet, contributing approximately 11% to the annual rainfall. The remaining rainfall tends to occur in mild showers or drizzles, rarely exceeding 15mm at a time.

Cyclones originate in the Arabian Sea near Bombay and Gujarat in India, moving north-westward before veering off west into the sea, where they dissipate. Although Karachi escapes the full destructive impact of these cyclones, it does experience effects such as strong winds, rough seas, swells, and heavy rain. Historically, cyclones tend to impact the Sindh coast more than the Baluchistan coast. In the last century, several cyclonic storms have brushed against Pakistan's coastal areas, with notable years including 1895, 1902, 1907, 1944, 1948, 1964, 1985, 1999, 2007, and 2010. The cyclone that struck in May 1999 is recorded as the strongest ever observed in Pakistan.

One of the record events occurred in 2020 when the Pakistan Meteorological Department confirmed that Karachi received the heaviest rain in a single day in its history, with 231 mm falling in just 12 hours. This was the highest rainfall recorded over the last 90 years. During August 2020 alone, Karachi experienced 484 mm (19 inches) of rain. The overflow from nullahs and drains led to flooding on major roads and streets in residential areas, profoundly disrupting the lives of many inhabitants.

On August 27, 2020, six out of seven districts in Karachi were declared "calamity hit areas" by the Relief Commissioner of Sindh province under the Sindh National Calamities (P&R) Act 1958, with Karachi East and Malir being the most affected locales. Access was severely restricted in 70% of areas due to damaged roads and stagnant water, while 0.3% of houses sustained complete or partial damage, and 27% of bridges and walkways were partially damaged. Electricity outages were reported across all areas, lasting anywhere from 10 to 34 hours.

Critical localities where rainwater accumulated included Gujjar Nullah in Liaquatabad, Sher Shah Suri Road, and other encroached areas, which hindered proper drainage and exacerbated flooding. Encroachments such as those at Gulistan-i-Jauhar and Zaman Town further complicated the situation, as infrastructure from the Green Line project interfered with old drainage systems.

In response to substantial challenges, the Karachi Metropolitan Corporation commenced cleaning operations on its 38 drains under a World Bank project named SWEEP. Furthermore, district municipal corporations took on the responsibility of maintaining 514 smaller nullahs, with financial support from the Sindh government. The Sindh government allocated roughly $8 million from its own budget, including a stopgap measure of Rs200 million for drain cleaning. Significant clean-up efforts resulted in the removal of 3,966,193 tonnes of sludge across six districts, highlighting the considerable impact of the rainfall and the vital response measures undertaken.

4.2.7 Hydraulic Regime

Tide: The tides in Karachi are mainly semi-diurnal, indicating that there are two high waters and two low waters each day. There is also diurnal inequality present, meaning that the two high tides and two low tides have significant variations in their heights, resulting in a mixed tidal nature. The mean high water spring level is 2.91m above datum, while the mean low water spring level is 0.64m above datum. Water levels for Karachi Port can be found in the accompanying table.

Table 4.2: Water Levels in Karachi. (Source: Pakistan Tide Table 2018)

Water Levels	Abbreviations	Levels at Karachi Port Datum (mPD)
Highest Astronomical Tide	HAT	+3.5
Mean High Water Spring	MHWS	+2.91
Mean High Water Neap	MHWN	+2.3
Mean Low Water Neap	MLWN	+1.25
Mean Low Water Spring	MLWS	+0.64
Lowest Astronomical ide	LAT	-0.42
Maximum Tidal Range Possible		+3.71

The sole entrance to the harbour lies between Manora and Keamari, allowing the entire tidal volume of approximately 75Mm³ to flow through with each tide. This results in entrance channel velocities exceeding 1 m/s. In contrast, tidal currents further inside Karachi harbour are much weaker, as observed using KPT's physical model. The figures from the Tidal Flow Modelling study (HR Wallingford 2010) illustrate the peak ebb and flood flows for the recently constructed harbour during both spring and neap tides.

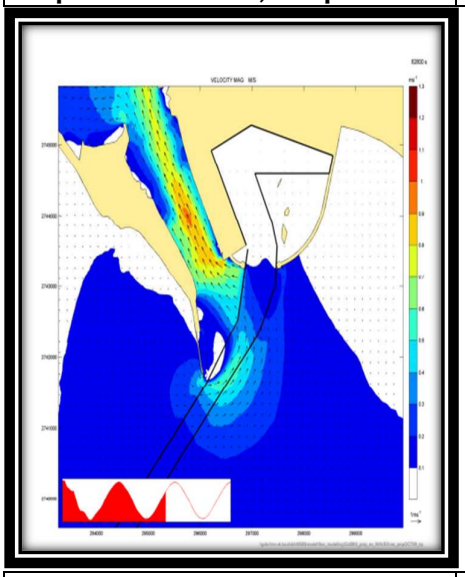
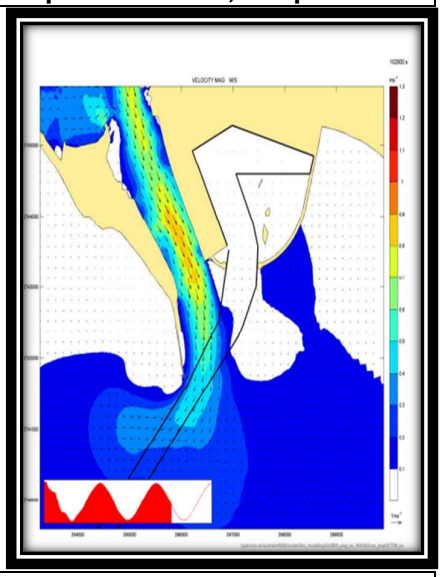
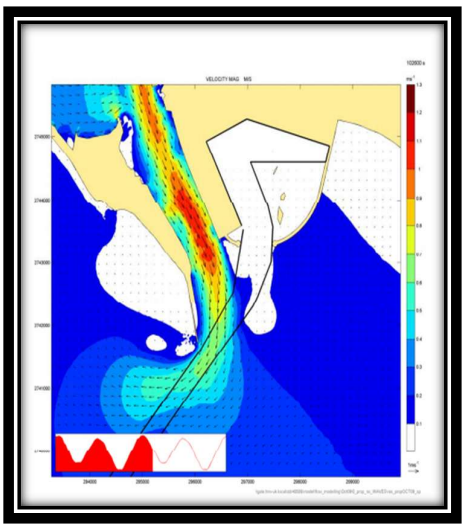
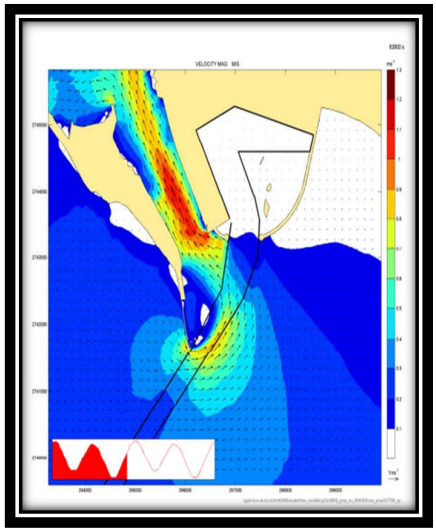
Current patterns at times of peak flood flow, Neap Tide	Current patterns at times of peak ebb flow, Neap Tide
	
Current patterns at times of peak flood flow, Spring Tide	**Current patterns at times of peak ebb flow, Spring Tide**
	

Figure 4.9: Current Patterns of tide.

Current Patterns: The above four diagrams (HR Wallingford 2010) show current patterns in the entrance area to Deep Water Container Port (DWCP) and also in the lower harbour of the main port, at times of peak flood flow and peak ebb flow during neap and spring tide. Maximum currents of 1.1ms-1 to

1.2ms-1 are shown in the lower harbour during spring tide with particular reference to times of peak flood flow.

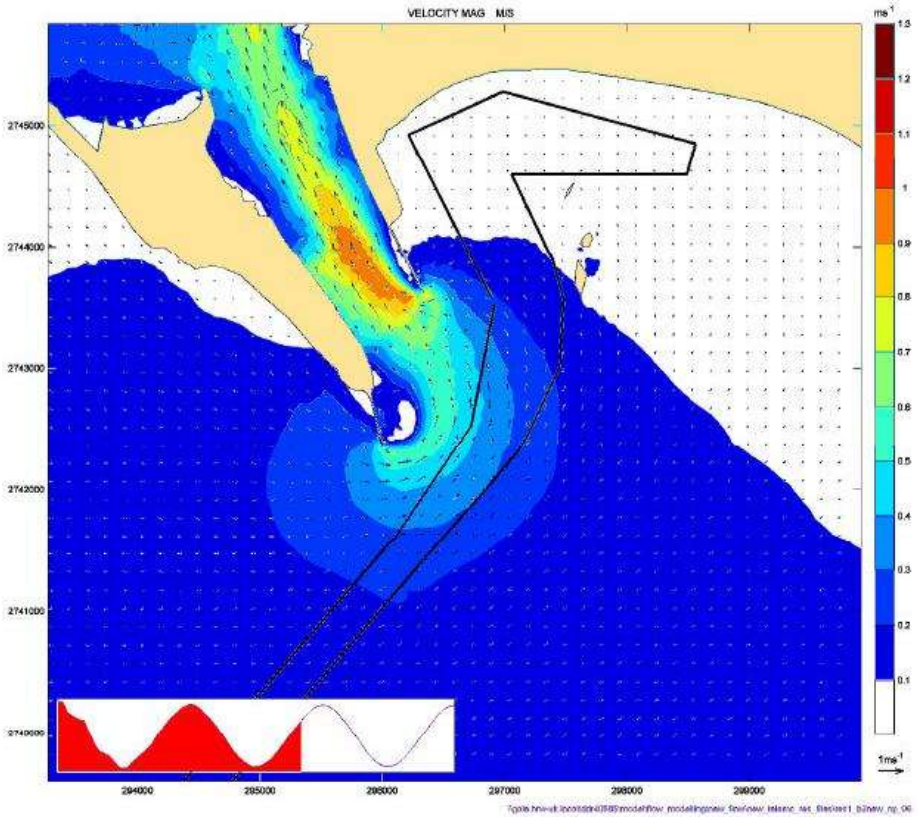


Figure 4.10: Current patterns at times of peak flood flow, neap tide, existing conditions, Source: HR Wallingford (2010)

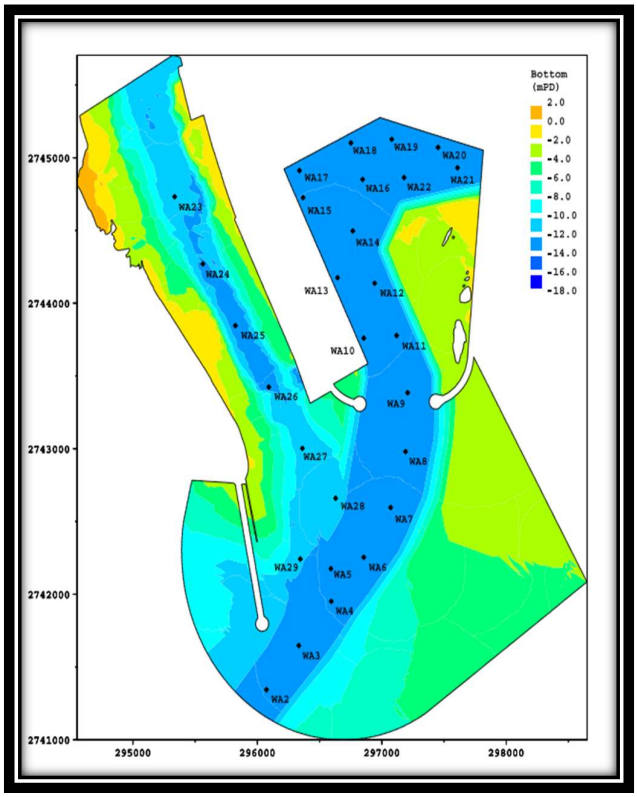
Wave Climate: Wave conditions at the entrance to the Port of Karachi are primarily influenced by southwesterly winds (180° to 270°) and waves coming from the Indian Ocean. The following table displays the anticipated offshore and near shore wave heights based on visually observed data.

Table 4.3: Wave conditions at the entrance to the Port of Karachi

Offshore			**Near Shore Unbroken Wave 6 km from Harbour Entrance Depth -14.8mPD**			
Direction (o)	Hs(m)	Tz(m)	Direction (o)	Hs(m)	Tz(m)	Tp(s)
210	4.0	8.5	210	3.7	8.4	11.0
240	4.1	8.7	228	3.6	8.5	11.1
270	2.7	7.0	244	2.2	6.8	9.0
180	4.4	9.0	205	4.0	9.0	11.5
210	6.1	10.6	211	5.8	8.7	13.6

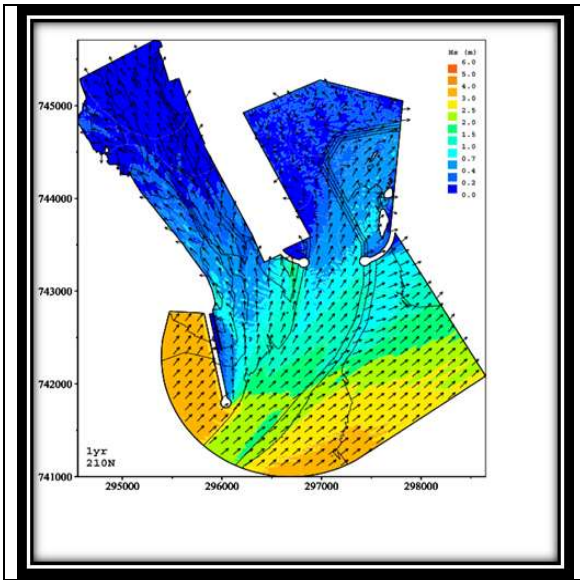
240	6.1	10.5	228	5.5	10.4	13.5
270	4.6	9.2	243	3.7	9.1	11.9
150	5.8	10.3	196	5.0	10.9	13.2
180	7.6	11.8	207	7.4	12.2	15.1
210	9.3	13.0	212	9.2	13.4	16.8
240	9.3	13.0	229	8.6	13.1	16.7
270	8.0	12.1	243	6.8	12.3	15.5
300	5.2	9.7	252	3.5	9.9	12.3

The HR Wallingford Modelling Study conducted in 2010 for the deep-water container port predicted significant wave heights at various wave prediction points, specifically from WA1 to WA29. The points WA2 to WA22, along with WA28 and WA29, are situated from the entrance channel of the deep-water container port, near the southern end of the New Manora Breakwater, extending to the northern end of the basin. Meanwhile, WA23 to WA27 are located within the Lower Harbour, as illustrated in the accompanying diagram.

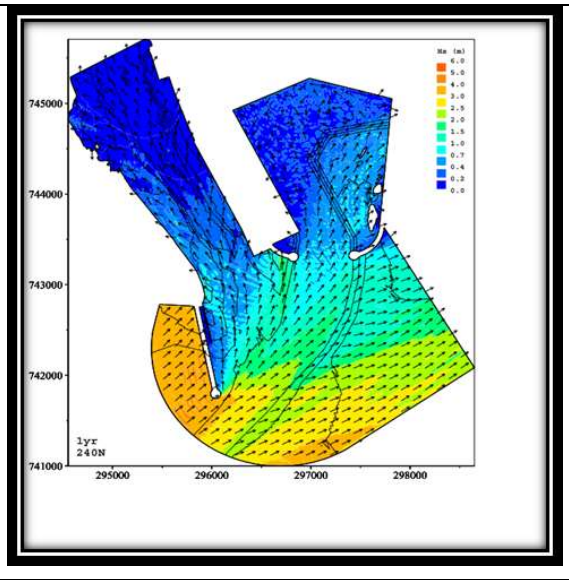


Wave Conditions – Modelling Study 2010 (Lower Harbour and Entrance to DWCP)

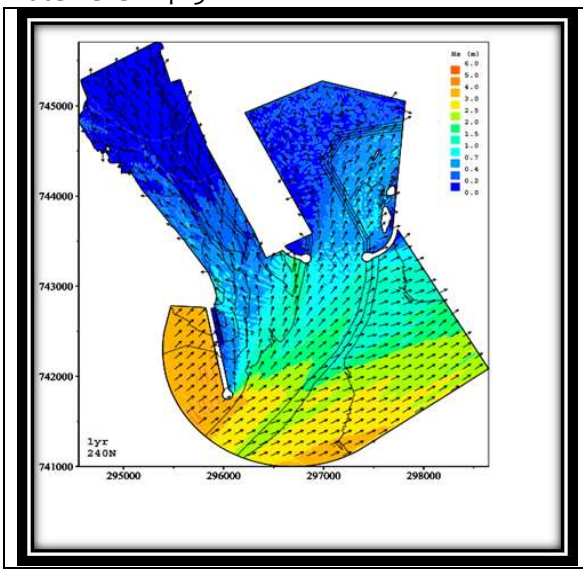
Significant wave height and mean wave direction
UK Met Office 1-year return period 210 N.
Water level = 2.4mPD



Significant wave height and mean wave direction
UK Met Office 1-year return period 240 N.
Water level = 2.4mPD



Significant wave height and mean wave direction
VOS 100-year return period 240 N.
Water level = 4.15mPD



Significant wave height and mean wave direction
VOS 100-year return period 240 N.
Water level = 4.15mPD

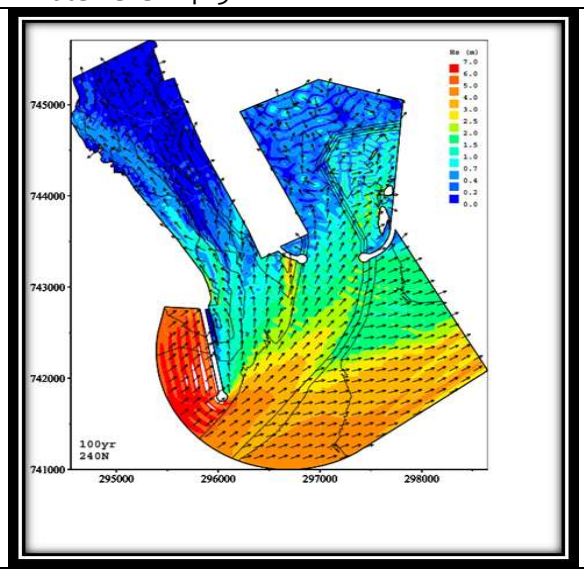


Fig 4.11: Wave Conditions – Modelling Study 2010

The table below shows the significant wave heights at wave prediction points.

Table 4.4: significant wave heights at wave prediction points.

Return Period	1 Year	1 Year	1 Year
Offshore Direction	**2100 N**	**2400 N**	**2100 N (-100 sensitivity)**
Tm	7.8	7.8	7.8
Tp	10.9	10.8	10.9
WA1	n/a	n/a	n/a
WA2	2.31	2.82	2.26
WA3	2.13	2.62	2.06
WA4	1.58	1.76	1.90
WA5	1.06	0.97	1.53
WA6	1.36	1.40	1.57
WA7	1.16	1.15	1.37
WA8	0.83	0.70	1.17
WA9	0.49	0.36	0.89
WA10	0.08	0.07	0.12
WA11	0.25	0.19	0.53
WA12	0.10	0.09	0.15
WA13	0.08	0.06	0.12
WA14	0.09	0.09	0.14
WA15	0.11	0.08	0.16
WA16	0.16	0.11	0.22
WA17	0.10	0.06	0.14
WA18	0.18	0.10	0.28
WA19	0.17	0.13	0.31
WA20	0.14	0.14	0.27
WA21	0.13	0.10	0.22
WA22	0.13	0.08	0.22
WA23	0.06	0.06	0.08
WA24	0.10	0.08	0.13
WA25	0.15	0.12	0.20
WA26	0.31	0.24	0.42
WA27	0.37	0.25	0.53
WA28	0.71	0.54	1.11
WA29	0.69	0.49	0.90

Note: It has been observed that after the construction of the new longer Manora Breakwater, the lower harbour and entrance to DWCP has been more protected from the sea waves.

A 2010 application of the ARTEMIS Wave Disturbance Model in the Keamari Groyne area shows significant wave energy reflecting off the east side of the channel into the Lower Harbour. This area experiences wave reflection from Keamari Groyne and diffracted waves from Manora Breakwater. Importantly, wave heights at the berth for the year return period do not exceed 1.08m.

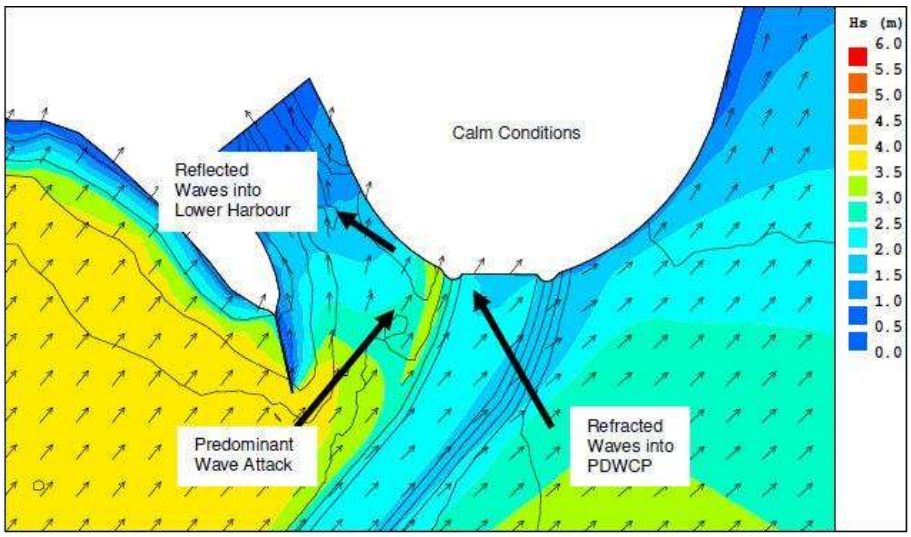


Fig 4.12 Hydraulic regime at Karachi
Source: KPT (2007).

The existing wave height and mean wave directions, illustrated in the model, indicate that the change in direction modifies energy density, leading to lower wave heights. Predictions suggest that waves will approach the port entrance from angles between 210°N and 230°N, with these waves being less erosive than those found further offshore.

Figures 4.13 and 4.14 indicate that wave heights outside of the harbour are relatively higher compared to those within the harbour and behind the Manora Breakwater. A noticeable difference in wave heights is observed between Points 30 and 29, and again between Points 29 and 28, where at Point 28, protection from the prevailing wave direction is provided by the Manora Breakwater. In the proposed PDWP area around Points 10, 11, and 12, wave heights are relatively lower than those further out in the approach channel but higher than those recorded within the harbour.

These existing conditions highlight that, without the Manora Breakwater, the port would be exposed to open sea and larger waves.

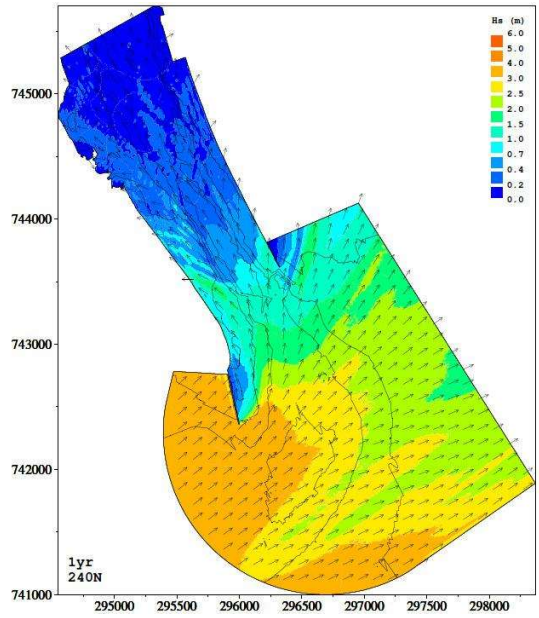
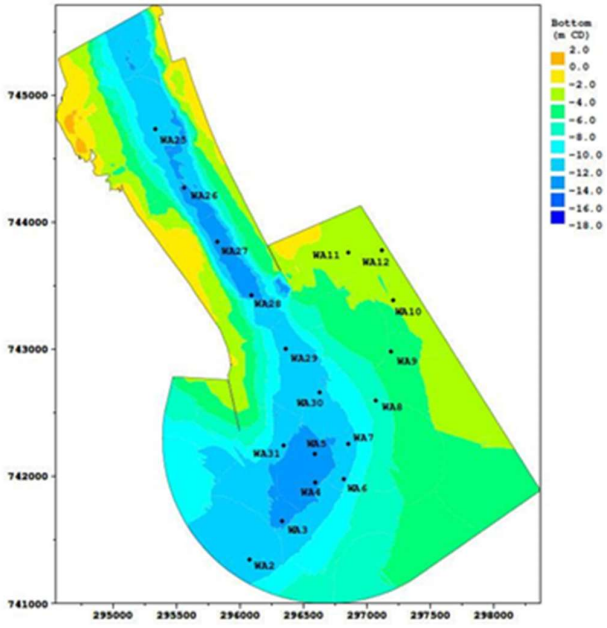


Fig 4.13: Existing Wave Height and Mean Wave Direction from ARTEMIS in the area around the proposed PDWCP



Source: HR Wallingford (2010)

Fig 4.14: ARTEMIS model of existing wave height prediction points

UK Met office 1 year return period 240° N, Water level = 2.4mPD.
Source: HR Wallingford (2010)

Table 4.5: Wave Heights. Source: HR Wallingford (2010)		
Return period	**1 year**	**1 year**

Offshore direction	210 °N	240°N
Mean period (Tm)	7.8	7.8
Peak period (Tp)	10.9	10.8
WA1	n/a	n/a
WA2	2.51	2.93
WA3	2.43	2.89
WA4	2.37	2.88
WA5	2.52	3.02
WA6	2.22	2.57
WA7	2.25	2.69
WA8	2.11	2.45
WA9	2	2.28
WA10	1.97	2.03
WA11	1.24	1.22
WA12	2.01	1.91
WA25	0.24	0.24
WA26	0.33	0.35
WA27	0.47	0.47
WA28	1.03	1.01
WA29	1.74	1.70
WA30	2.30	2.56
WA31	2.78	3.15

4.2.8 Water Quality

Samples were collected and analyzed from January 2007 to December 2008 by Karachi University at pre-designated sampling sites located at the Lyari River outfall (24°51'52"N; 66°57'52"E) to assess pollutant levels. This river is a significant source of pollution for Karachi Harbour, although dilution in the harbour waters notably reduces pollutant concentrations, except in areas with low water circulation.

Table 4.6: Chemical Pollution Profile of Lyari River Outfall (samples 2007-2008)

Parameters	Mean Values (mgl^{-1})
pH	7.1- 7.7
TDS	1095- 2026
TSS	128- 421
Ammonia	9.3 - 10.25
BOD5	200- 229
COD	456 – 664
Cyanide	0.057 - 0.11
Detergents	1.50- 1.73
Dissolved oxygen	BDL
Phenols	0.77- 0.84
As	0.027- 0.252
Cd	0.001 - 0.01

Cu	0.25- 2.89
Cr	0.005 - 2.00
Pb	0.20- 0.57
Ni	0.33 - 1.9
Zn	0.30- 0.60

Fresh analysis of water samples

Fresh samples were obtained from the project area and analyzed to validate the initial findings. The results indicated that the pH levels were consistently above 7, remaining within acceptable limits. However, both Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) were elevated, particularly during ebb tides, which suggests a preponderance of municipal effluents impacting the harbour's water quality. Consequently, bacterial contamination with fecal coliforms was observed.

Total coliforms (TC), fecal coliforms (FC), and enterococci (EC) serve as important bioindicators of fecal pollution, as they are typically found in the waste of humans and warm-blooded animals. Their presence indicates potential occurrences of harmful pathogens in marine waters. A higher concentration of these indicator bacteria correlates with an increased likelihood of infectious organisms being present in the water.

Table 4.7: Water Chemical Analysis Results

Sample	pH	BOD (mg/l)	COD (mg/l)	Salinity (ppt)	TSS (mg/l)	Temp. (°C)	Sulphate (mg/l)
W-1	7.5	425	875	28.4	241	35	414
w-2	7.7	386	960	28.8	249	35	398
Average values	7.6	405	918	28.6	245	35	406

Note: Samples were drawn during mid-ebb tide.

Table 4.8: Microbial tests of water samples from Karachi Harbour

S. No	Sample Code	MPN	Faecal Coliforms
1	DS1 BH2	1100	Positive
2	DS1 BH3	1100	Positive
3	SD1	1100	Positive
4	SD2	1100	Positive

*MPN = Most probable number of micro-organisms per 100ml

4.2.9 Analysis of Sediments Samples

Fresh sediment samples were collected from the Project Area and analyzed at the Institute of Environmental Sciences of Karachi University. The results and commentary are presented below.

Table 4.9: Results of Chemical Analysis

S.#	Sample codes	pH	Sulphate (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Lead (mg/L)	Ni (mg/L)	Cr (mg/L)

1	DS1 BH2	7.2	492	6.89	20.36	3.33	5.465	0.21
2	DS1 BH3	7.5	587	4.12	18.25	2.47	3.21	0.014
3	SEQS	6-9	600	-	-	0.5	1.0	1.0

Table 4.10 Results of the chemical analysis of Soil samples

S.#	Sample Code	pH	Sulphate (mg/Kg)	Nitrate (mg/Kg)	Phosphate (mg/Kg)	Lead (mg/Kg)	Ni (mg/Kg)	Cr (mg/kg)
1	SD1	6.4	280	12.89	2.36	4.43	5.465	19.21
2	SD2	6	190	6.12	8.05	3.27	6.21	14

The study on heavy metal pollution from effluents entering Karachi Harbour through the Lyari River and surrounding areas indicates that these pollutants are not entirely flushed out to the open sea during tidal cycles. Consequently, poor circulation leads to hydrogen sulfide production, which exerts stress on marine life. The tidal flats of Sandspit and Channa Creek in the Karachi Harbour region support lush mangrove vegetation. However, much of the central area of Karachi Harbour and parts of Korangi Creek lack benthic life within the sediments. The bottom sediments exhibit a black coloration due to the presence of hydrogen sulfide. This environment showcases severe stress on both fauna and flora caused by industrial and domestic pollution. Heavy metal analyses of the sampled materials reveal slightly elevated levels in both soil and water, albeit with lower concentrations of chromium in the water samples.

4.2.10 Sources of Pollution

Karachi Harbour is facing significant environmental challenges due to a diverse range of pollutants originating from both land-based and marine sources. This includes the waste generated by numerous fishing vessels that operate in Karachi Fish Harbour, as well as refuse from various industrial and commercial establishments located near the harbour and emissions from ships. The impact of these pollutants on the marine environment is severe, leading to a jeopardized marine ecosystem.

The untreated industrial effluents, laden with high levels of toxicity, alongside the raw sewage, have created oxygen-depleted conditions that strain marine life. Furthermore, vital mangroves, which are critical to the food chain and serve as valuable natural resources, are unable to thrive due to the toxic conditions. These mangroves are further compromised when sewage sludge and plastic debris cover their aerial roots.

Additionally, the floating debris and suspended plastic bags not only create operational challenges within the harbour but also contribute to an unappealing aesthetic. The accumulation of polyethylene bags presents significant risks by obstructing cooling water intake systems of crafts, sometimes resulting in substantial damage. This damage can lead to extended periods where these vessels are unavailable for berthing or un-berthing

operations, ultimately causing delays in ship movements and a compounded economic loss for the nation.

Several prominent drains are responsible for channeling land-based industrial and municipal waste into the harbour, with the discharge volumes as follows:

1. Lyari River: 220 mgd
2. Nehre Khayyam: 16 mgd
3. Soldier Bazaar Nalla: 30 mgd
4. Railway Nalla: 4 mgd
5. Pitcher Nalla: 7 mgd
6. Karli Nalla: 7 mgd



Figure 4.15 (A): Map showing major drains discharging wastewater in the port area

Lyari River

The Lyari River has an existing track that comprises 18 km of dry stretch outside the city in the north and a 26 km stretch within the city, running from Surjani Town to its confluence with Karachi Harbour. This latter section remains active year-round due to untreated wastewater flowing from the city as well as rain during the monsoon season. Starting at Surjani Town, it passes through Sohrab Goth, Gulshan-e-Iqbal, Liaquatabad, Tin Hatti, Garden East, Shershah, Agra Taj

Colony, and ultimately discharges into the western backwaters of Karachi Harbour. Among its five tributaries, Gujro Nalla and Orangi Nalla serve as the main drains for the Federal B area, FC area, Liaquatabad, and surrounding neighborhoods in Orangi Town, extending from Mangho Pir Road to Nazimabad.

The total catchment area of the Lyari River spans approximately 792 square miles, significantly contributing to the pollution of Karachi Harbour. Major industrial zones in areas such as SITE, North Karachi, and smaller industrial blocks release mostly untreated industrial wastewater and sewage into the river and its tributaries, either directly or through sewerage nallahs.

The water of the Lyari River carries various pollutants, including:

a) Municipal Effluents: The sewage consists of biodegradable organic matter, which can cause eutrophication and elevated biochemical oxygen demand when present in excessive amounts. Out of approximately 220 million gallons per day (mgd) of sewage generated, two treatment plants—STP-1 (SITE) and STP-III (Mauripur)—only treat 20 mgd and 35 mgd, respectively, while STP-III's optimum capacity is 54 mgd. Consequently, less than 30% of the total sewage is treated before entering the western backwaters of Karachi Harbour.

b) Industrial Effluents: Karachi is home to about 5,000 industries of various sizes that discharge untreated wastewater into the Lyari River. The effluents from textile, paints, leather, pharmaceuticals, oil, paper, and food industries contain hazardous chemicals, including phenols, cyanides, and biphenyls, which are toxic to marine life and can persist in the environment for years.

c) Solid Waste: The city generates around 16,000 tonnes of solid waste daily, of which the Karachi City District Government claims to collect 60%. The remaining 40%, is left scattered at various collection points, often ending up in open nallahs and eventually flowing into the Lyari and Malir rivers. Additionally, substantial amounts of solid waste are dumped directly along both banks of the Lyari River. As per the study findings, ~65% of plastics (i.e. polythene bags and plastic bottles) are the most common type of debris in the coastal waters of Karachi. ~15% of glass and metal, and ~20% of fishing gear and other debris were also existing, though in smaller quantities.

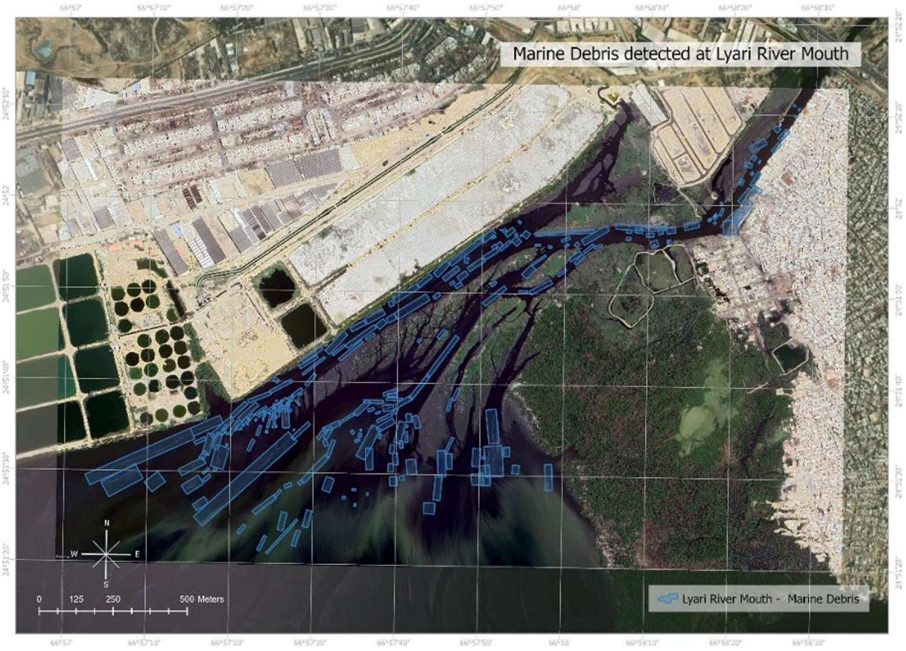


Figure 4.15 (B): Marine Debris detected at Lyari River Mouth

This accumulation of rubbish along the riverbanks leads to significant aesthetic degradation, especially after heavy rainfall, when large volumes of waste are swept into Karachi Harbour, exacerbating pollution issues.

Nehre-e-Khayyam

Approximately 16 million gallons of mostly domestic sewage flow daily through Nehre-e-Khayyam into the harbour via Boat Basin and Chinna Creek. This canal, originally intended to enhance the area's beauty with clean seawater, has been converted into a sewage drain due to the construction of multi-storied residential complexes. A wide variety of hazardous pollutants are currently being transported through Nehre-e-Khayyam into Boat Basin, highlighting the urgent need for sewage treatment before these wastewaters are discharged into the marine environment.

Soldier Bazar Nallah

Connecting the old city areas of Jamshed Town, Saddar Town, Keamari Town, and the Clifton pumping station to the mangrove forest north of Mai Kolachi Road, this nallah discharges approximately 27 million gallons per day of untreated industrial wastewater and sewage into the harbour.

Railway Nallah

This nallah links the old city areas of Saddar Town to Chinna Creek, contributing around 4 million gallons per day of municipal effluents.

Pitcher Nallah

Connecting old city areas of Lyari Town, Saddar Town, and Keamari Town to the western backwaters, Pitcher Nallah brings in about 7 million gallons per day of industrial and municipal effluents.

Karli Nallah

Linking old city areas of Lyari Town and Keamari Town to the western backwaters, this nallah also contributes around 7 million gallons per day of industrial and municipal effluents. The untreated effluents from Karachi and activities within the port are significant factors negatively impacting water quality and aquatic ecosystems in the harbour.

4.2.11 Ambient Air & Noise Quality

Primary source of air pollution on and along the major corridors of Karachi is transport sector, so the primary pollutants in ambient air quality in the City in general and project area in particular are directly linked with fuel consumption.

According to available estimates, country's consumption of petroleum products has shown exponential growth, of which one-half is consumed by the transport sector. The high content of Sulphur in diesel (0.5-1 %) and furnace oil (1-3.5 %) is a major contributor to air pollution. Vehicular emissions are major source of $PM_{2.5}$ and these fine particulates are responsible for respiratory problems in Karachi. The number of diesel trucks and buses have increased and a major share of the emission load from motor vehicles can be attributed to low quality diesel fuel and oil burning two-stroke engines.

Karachi has also witnessed an increase in vehicles fueled by compressed natural gas (CNG) in recent years and many formerly diesel fueled vehicles have been converted to run on CNG which has added another burden on the existing air-shed besides causing public safety issue. Buses and trucks cause significant air pollution and since the main sources of pollutants are traffic, and traffic has increased on the major corridors including the mass transit corridors (project area), it is assumed that air quality has deteriorated as a result.

The primary pollutants Oxides of Nitrogen (NOx), Sulphur dioxide (SO_2) particulate matter (PM10, PM with diameter of 10 microns or smaller and PM2.5, i.e., PM 2.5 microns or smaller) and carbon monoxide (CO). Most of the PM

emissions (>80%) comes from diesel-run vehicles. Sindh Environmental Quality Standards (SEQS) for these parameters in addition to lead (Pb) and ozone (O_3) are set by the Government and have been promulgated at provincial level by the Government of Sindh as well as standards for vehicle emissions in line with Euro II. Finally, the Government has promulgated tailpipe emissions standards.

All these standards are discussed in Section 03 of this EIA. Studies undertaken between 1987 and 1994 had raised concern on the deteriorating air quality and noise levels. Studies over the past decade, had quantified the problem and identified the tremendous growth in volume of traffic as the main factor responsible for increasing congestion all over Karachi roads and aggravating the problem. A 1990 survey[6] monitored CO at 9-10 ppm along the busy urban streets; maximum NO2 concentrations were 0.3-0.5 ppm during the daytime; with an ozone maximum around noon of 40 ppb and 50 ppb, below WHO's interim quality guideline. A 2005 study[7] that shows hourly readings over 24 hours for O_3, SO2, CO and NO2 measured at five locations in Karachi. O_3 concentrations were well within the WHO guideline of 100 µg/m^3 8-hr average; NO2 and SO2 also were well within the WHO guideline of 200 µg/m^3 (1-hr average) and 20 µg/m^3 (24-hr), respectively.

The Feasibility Study and Development of a Transport Control Plan of Karachi Metropolis (May 2007) presented data for these parameters of air quality for 26 locations. At that time all critical parameters were found to exceed the NEQS. This study has highlighted the increasing level of NOx, PM & CO to critical limits as the major environmental problem created by the Transport Sector. The main findings of this study are that the pollution load that is being mainly contributed by operation of trucks and buses on diesel oil, and the rickshaws on two stroke engines is composed of NOx and PM whose concentration has increased to critical limits while that of CO is approaching these limits at almost all the intersections in the Metropolitan area. High Noise level and rise in temperature and humidity are other irritants that are annoying for the living environment in general but the corridor of impact along the middle and northeast sections of the roads in particular.

[6] Ghauri et.al. 1994
[7] Hashmi et.al.

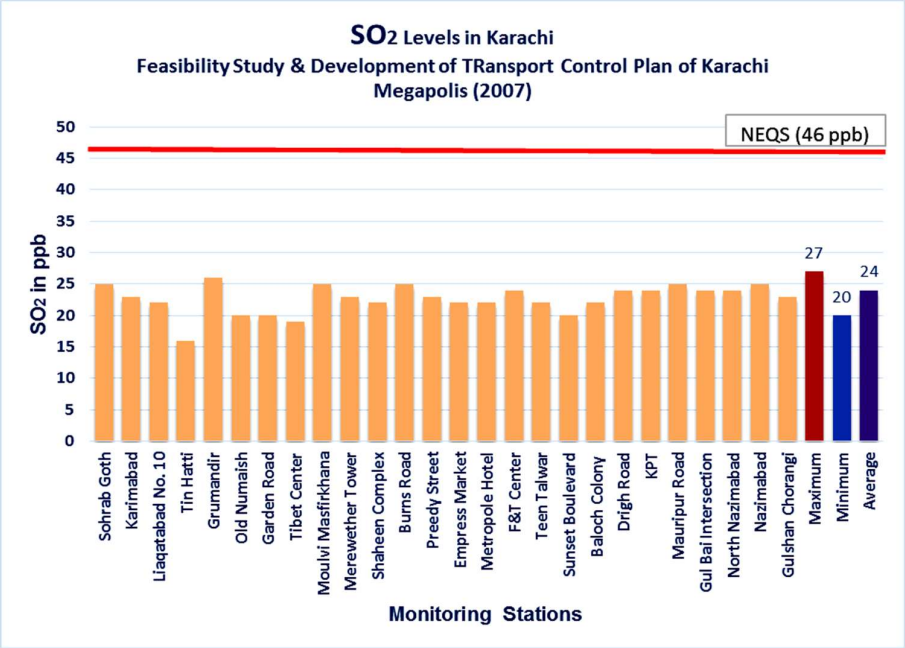


Figure 4.16: SO2 Levels in Karachi

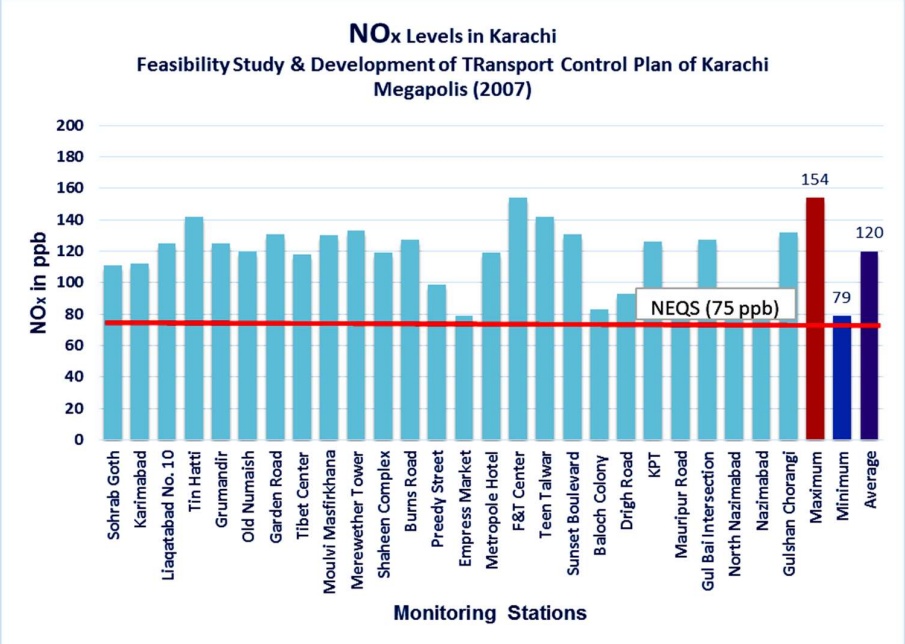


Figure 4.17: NOx Levels in Karachi

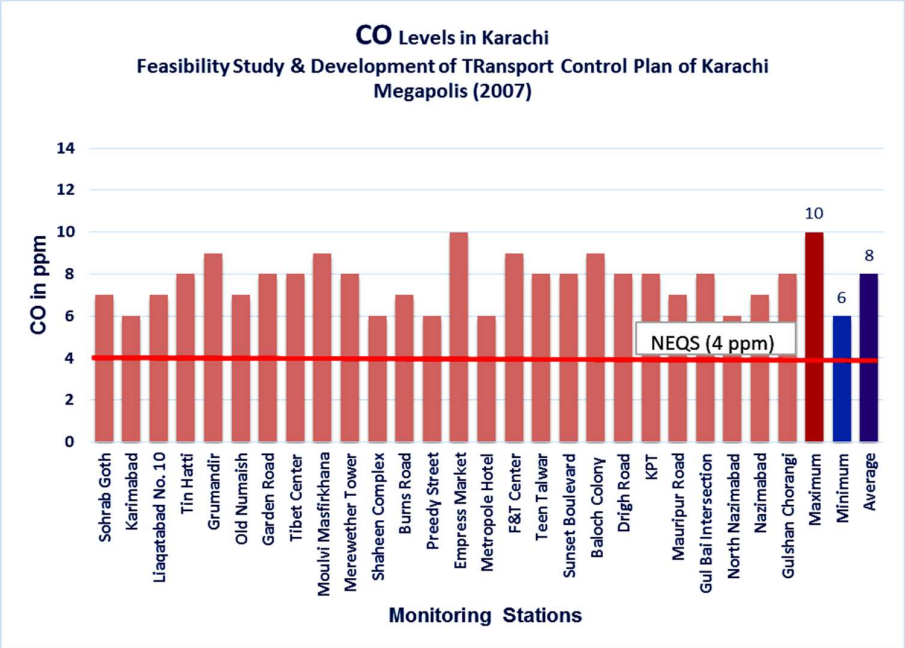


Figure 4.18: CO Levels in Karachi

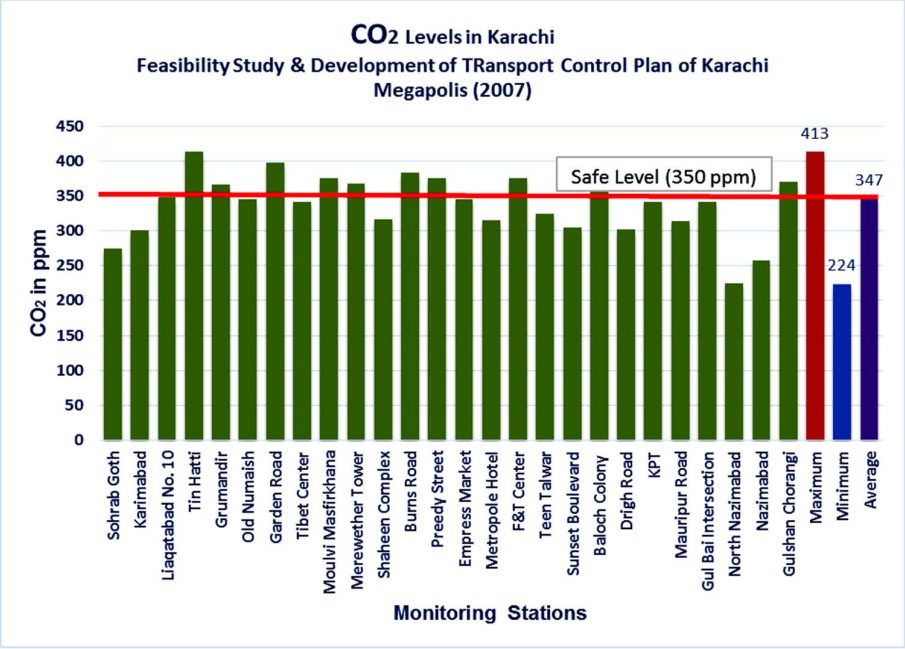


Figure 4.19: CO2 Levels in Karachi

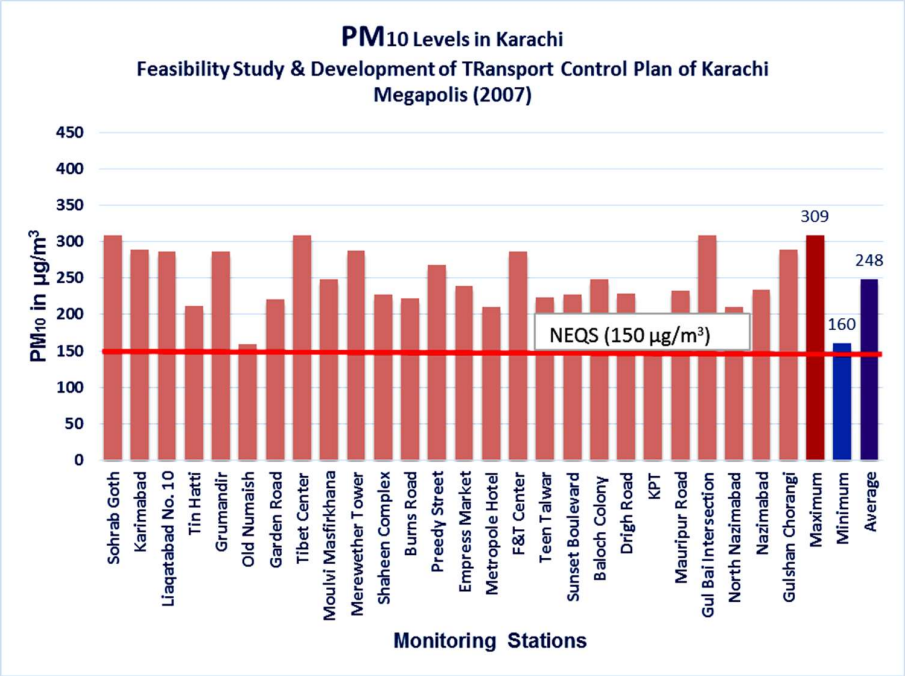


Figure 4.20: PM10 Levels in Karachi

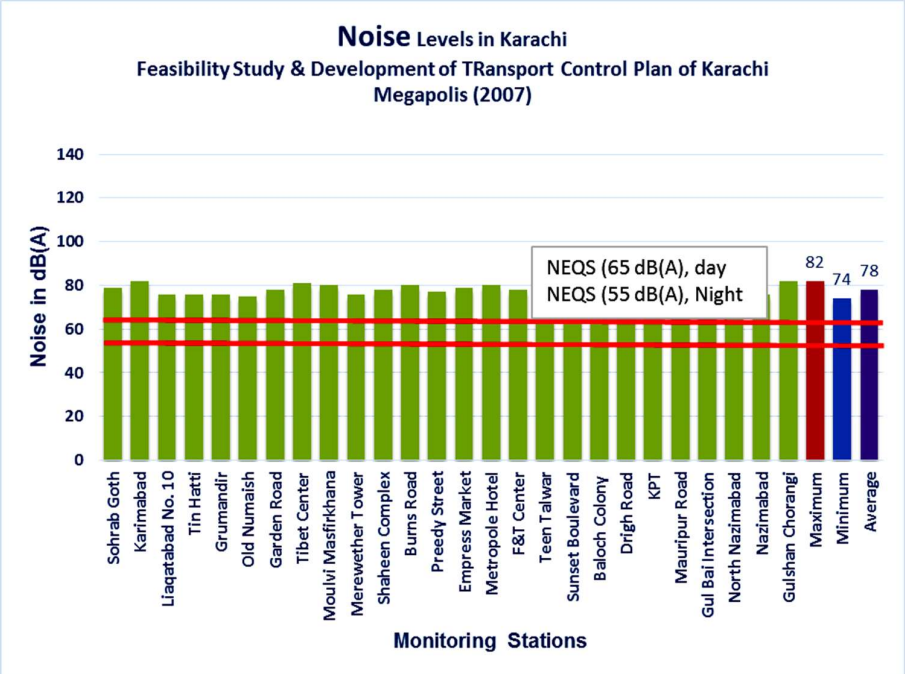


Figure 4.21: Noise Levels in Karachi

Finally, another report[8] quotes the World Bank's data with the following maximum values: PM2.5 201 µg/m³; SO2 173 µg/m³; NO2 122 µg/m³; O3 86 µg/m³; CO2 mg/m³. For reference, WHO's interim target for PM2.5 is 35 µg/m³, whereas its guideline is 10 µg/m³. WHO guideline for O_3: 100 µg/m3 8-hour mean. Both NO2 and SO2 are within WHO's guideline for short term average concentration. (200 and 400 µg/m³ respectively). Data by this same author show excessive levels of PM at major intersections, including some along the BRT corridor, as well as SO2, NO_X, O_3 and CO, all exceeding WHO limits, based on data taken by SUPARCO in 2004.

PAQI has been measuring particulate matter ($PM_{2.5}$) levels in Karachi since October 2016. The measurements show a $PM_{2.5}$ concentration of 47 micrograms per cubic meter of air (µg/m³) for October to December 2016. The World Health Organization (WHO) prescribes 10 µg/m³ as the guideline value for ambient air. Exceeding this value leads to serious public health issues.

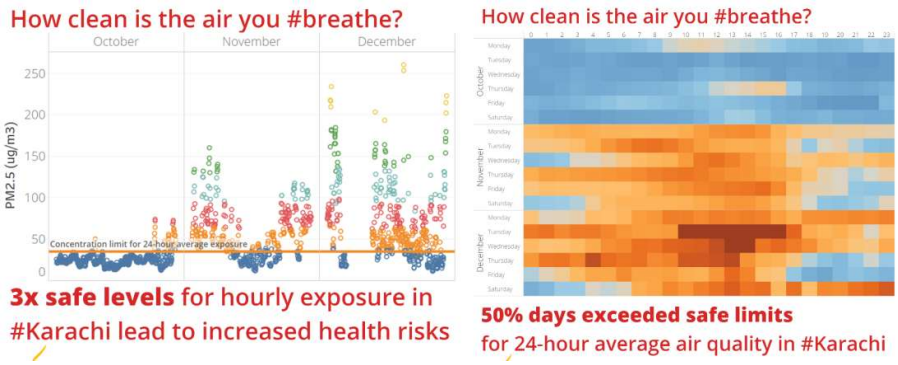


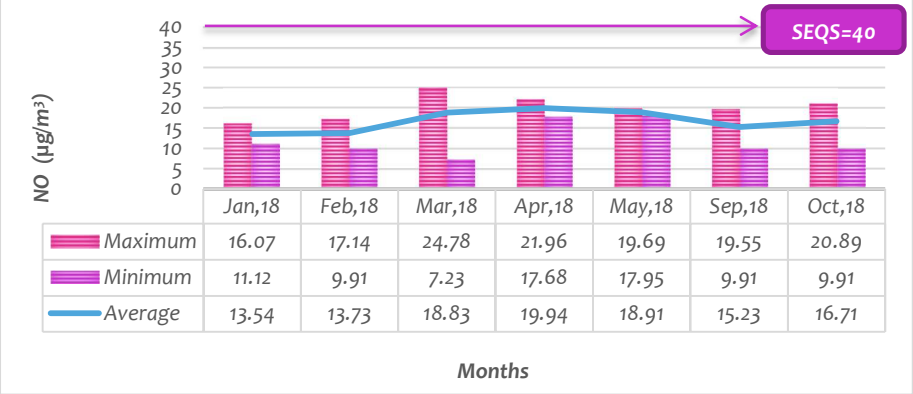
Figure 4.22: How Clean is Karachi's Air

Karachi's air quality is nearly 5x above this level, and twice the value for daily exposure. That is also 3x the safe levels recommended by the National Environmental Quality Standards for Ambient Air by the Pakistan Environmental Protection Agency (Pak-EPA).

Sindh Environmental Protection Agency (SEPA) has been uploading the data of ambient air quality on their website (www.epasindh.gov.pk) received from the monitoring stations of SEPA and analyzed by SEPA Laboratory team. The results presented below clearly show the levels of dust are far exceeding the limits set by SEQS. The reasons are obvious; indiscriminate cutting down of trees and vegetation on and along major corridors of Karachi as well the vehicles plying on road with no control. According to the report of Vehicular Emission Control Programme (VECOP) by the SEPA, regular monitoring and inspection was started from January 2010 and during the first 18 months, about 11,384 vehicles

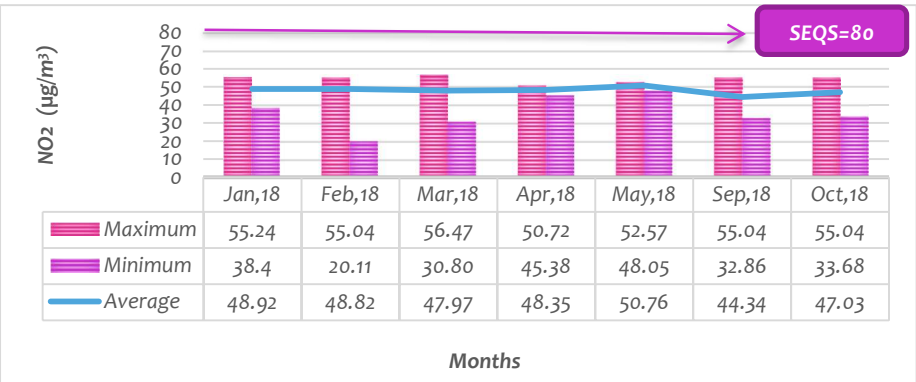
[8] Kalwar 2014

of all categories have been inspected and tested for their emission levels. Out of them, about 3,503 did not comply with the NEQS for vehicles and 1,947 were challenged by the traffic police for violation of the standards.



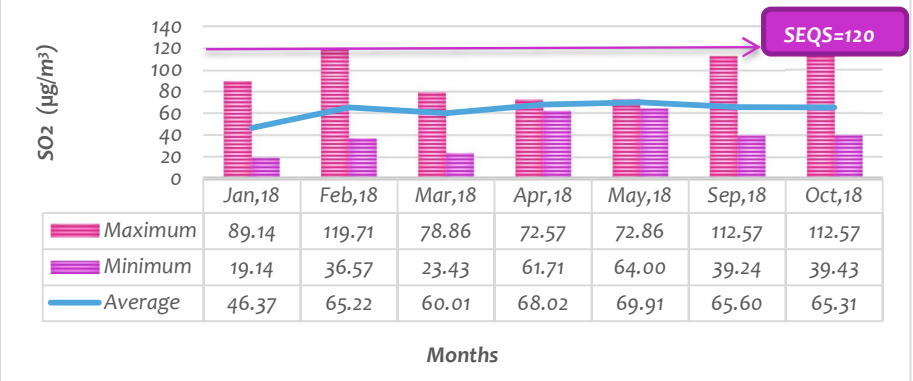
	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	16.07	17.14	24.78	21.96	19.69	19.55	20.89
Minimum	11.12	9.91	7.23	17.68	17.95	9.91	9.91
Average	13.54	13.73	18.83	19.94	18.91	15.23	16.71

Source: EPA Sindh



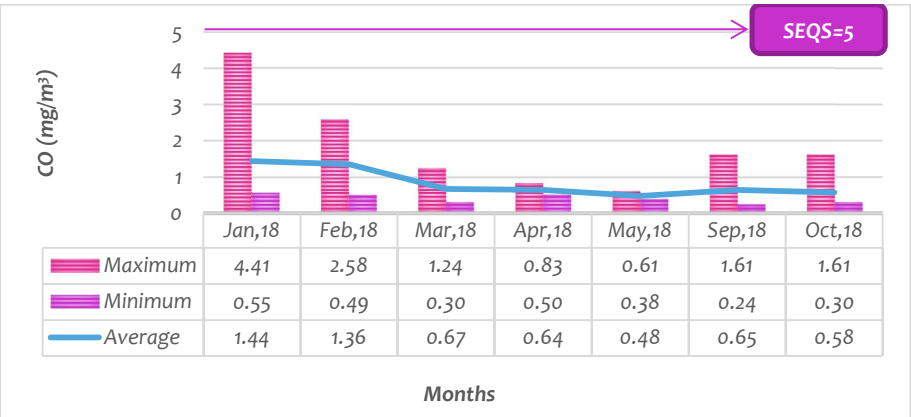
	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	55.24	55.04	56.47	50.72	52.57	55.04	55.04
Minimum	38.4	20.11	30.80	45.38	48.05	32.86	33.68
Average	48.92	48.82	47.97	48.35	50.76	44.34	47.03

Source: EPA Sindh



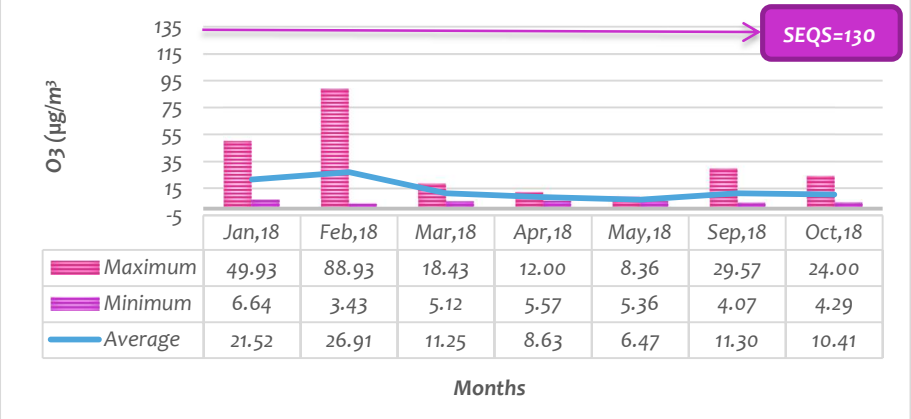
	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	89.14	119.71	78.86	72.57	72.86	112.57	112.57
Minimum	19.14	36.57	23.43	61.71	64.00	39.24	39.43
Average	46.37	65.22	60.01	68.02	69.91	65.60	65.31

Source: EPA Sindh



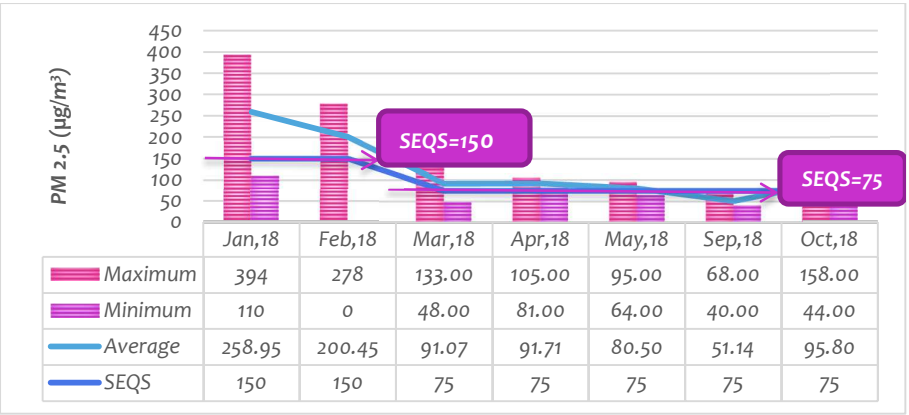
	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	4.41	2.58	1.24	0.83	0.61	1.61	1.61
Minimum	0.55	0.49	0.30	0.50	0.38	0.24	0.30
Average	1.44	1.36	0.67	0.64	0.48	0.65	0.58

Source: EPA Sindh



	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	49.93	88.93	18.43	12.00	8.36	29.57	24.00
Minimum	6.64	3.43	5.12	5.57	5.36	4.07	4.29
Average	21.52	26.91	11.25	8.63	6.47	11.30	10.41

Source: EPA Sindh



	Jan,18	Feb,18	Mar,18	Apr,18	May,18	Sep,18	Oct,18
Maximum	394	278	133.00	105.00	95.00	68.00	158.00
Minimum	110	0	48.00	81.00	64.00	40.00	44.00
Average	258.95	200.45	91.07	91.71	80.50	51.14	95.80
SEQS	150	150	75	75	75	75	75

Source: EPA Sindh

Figure 4.23: Ambient Air Quality of Karachi (Source: SEPA)

The ambient air quality monitoring was conducted on Feb 15, 2025 by M/s EHS Services through SEPA Certified Lab in the environs of project area. The results are presented below:

Table 4.11 24-Hr Avg. Ambient Air Quality Test Report of Project Area
Date: 15-02-2025 to 16-02-2025

S. #	Measuring Parameter	Unit	SEQS Limits	Test Result
01	Carbon monoxide	CO mg/m^3	10	3.66
02	Nitrogen Dioxide	NO_2µg/m^3	80	25.24
03	Nitrogen Oxide	NO µg/m^3	40	12.56
04	Ozone	O_3µg/m^3	130	4.2
05	Particulate Matter	PM 10 µg/m^3	150	119.22
06	Particulate Matter	PM 2.5 µg/m^3	75	28.19
07	SPM	SPM µg/m^3	500	220.6
08	Lead	Pbµg/m^3	1.5	0.2
09	Sulfur Dioxide	SO_2µg/m^3	120	7.06
10	Noise	dB(A)	75	68.65













4.2.12 Marine Ecosystems

Marine habitats on the Karachi Coast

The coast of Pakistan features a diverse array of habitats, particularly wetlands, which include mangroves forming intricate coastal systems like lagoons, marsh communities, algal beds, and estuaries. The coastline surrounding Karachi Harbour is characterized by mangrove regions alongside various creeks and backwater environments.

Mangrove forests within the macroenvironment of study area are illustrated in Figure 4.24, where they are indicated by red shading. This figure reveals that these mangroves are not directly adjacent to the Project area; instead, they are located to the west of the approach channel near PNS Himalaya, in both the Eastern and Western Backwaters, and to the west of Manora, close to the recreational beaches of Hawksbay and Sandspit. The mangrove ecosystems are predominantly composed of a specific species, *Avicenna marina.*

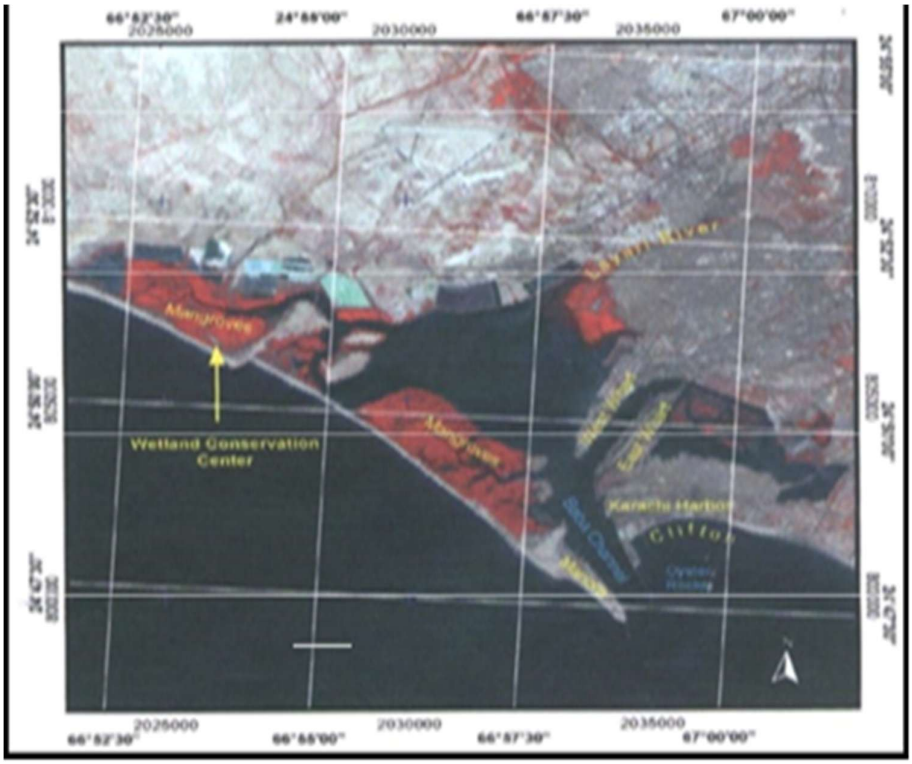


Fig 4.24 Mangroves in Karachi Harbor



Marine Life - Phytoplankton

Figure 4.25 displays a satellite image of the Arabian Sea, highlighting chlorophyll concentrations across the regions including Pakistan. Ribbons and swirls of yellow delineate areas with high chlorophyll levels. High concentrations of chlorophyll indicate thriving populations of phytoplankton, which are crucial oceanic plants that exist near the surface. These organisms play a dual role in marine ecosystems; they serve as a primary food source for a variety of marine animals and can also lead to problematic situations. Regions abundant in phytoplankton typically support robust fish populations. However, excessively high levels of phytoplankton can result in the formation of "dead zones," areas deficient in oxygen where marine life struggles to thrive. Dead zones emerge when phytoplankton die and settle on the ocean floor, where bacteria decompose them. If the decay process involves a significant quantity of plant matter, bacteria can deplete the available oxygen in that area. While high chlorophyll concentrations in the image may indicate potential challenges, they do not directly correlate to the presence of dead zones.

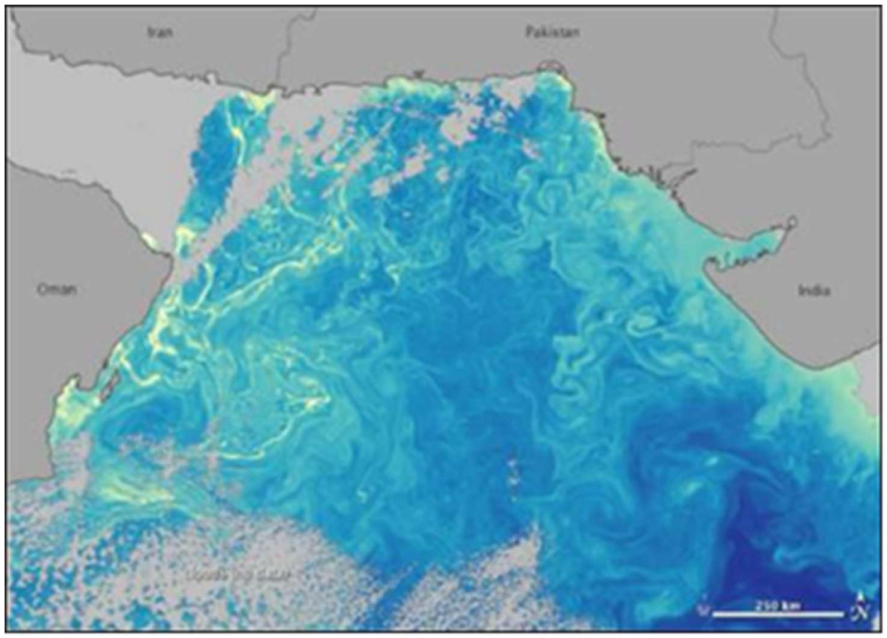


Fig 4.25 Satellite Image of Arabian Sea Source: NASA's Aqua satellite.

Phytoplankton Study on the Karachi Coast

The coastal waters along Clifton and Manora beaches appear to be highly productive. Studies on phytoplankton focusing on Karachi Harbour and Manora Channel have recorded the presence of 8 genera and 52 species of thecate dinoflagellates in Manora Channel. Additionally, 101 species of centric

diatoms belonging to 30 genera have been documented in the harbour, indicating a more diverse flora compared to that found in the Arabian Sea coastal waters (DHA, circa 2007). This diversity can be attributed to the varying salinities and the diverse aquatic habitats present in the creek system.

Over the past few decades, the species composition of diatoms in Karachi Harbour and outside Manora Channel has shifted. Notably, in the mangrove habitat of the Sandspit area, the bloom of*Navicula cancellata*, a pennate diatom, was reported for the first time during the NE monsoon season in 1992 (DHA, circa 2007).

Zooplankton

Studies on zooplankton abundance in the coastal waters of Pakistan indicate that the most common groups include copepods, chaetognaths, coelenterate medusa (jellyfish), pteropods (molluscs), krill euphausiids, fish eggs and larvae (ichthyoplankton), and crab and shrimp larvae (Zoea, Mysis) (DHA, circa 2007). These studies also show that the zooplankton biomass in the Arabian Sea remains high throughout the year, although the distribution and abundance may be affected by the two monsoon seasons (southwest and northeast) that occur in this region (DHA, circa 2007).

Benthos

The Manora Channel and the harbour's berthing area face sedimentation challenges due to the combined effects of Lyari River outflow and tidal movements, which carry sediments into the harbour.[1†source] Dredging is employed to manage sedimentation, but this process significantly impacts the natural benthos as it leads to regular removal of the bottom-dwelling organisms.

The water quality within the harbour is poor, with insufficient tidal exchanges occurring every 12 hours, resulting in the presence of floating oil and garbage, particularly plastic debris. Despite these unfavorable conditions, some marine species manage to survive; notably, the small xanthid crab*Nursia abbreviata*is found alongside mussels*Perna viridis*and*Modiolus matcalfi*, albeit in limited quantities.

Along Clifton and Defence Housing Authority (DHA) beaches, common benthic and inter-tidal macrofauna include various worms, molluscs, echinoderms, polychaetes, and crustaceans, with worms being the most prevalent due to their tube-building and burrowing abilities. Molluscs are mainly composed of gastropods, bivalves, and scaphopods (dentalium), while razor clams inhabit deep burrows and are sensitive to vibrations. Echinoderms such as brittle stars and sea stars are found in sub-tidal zones, while crustaceans include spider

crabs, hermit crabs, and ghost crabs, along with juvenile and larval penaeus and metapenaeus in coastal waters.

Table 4.12: Benthic invertebrates commonly found along Clifton and DHA beaches	
Family	Taxa
Sea Pens	*Vergularia* sp
Polychaetes	*Diopatra* sp
Molluscs	*Tonna maculate*
	Natica vitellus (moon shell)
	Natica didyma
	Natica lineate
	Babylonia spirata
	Tibia curta
	Cymia sp.
	Solen trucatus (Razor clam)
	Siliqua radiate
	Arca sp.
	Thais sp.
	Pinna sp.
	Donax sp.
	Mactra sp.
	Cardium sp.
	Dentalium sp.
	Crepedula sp.
	Rapana bulbosa
Crustaceans – crabs	Ghost Crabs
	Stomatopods
	Spider Crabs
	Hermit crabs
Shrimp	*Penaeus*
	Metapenaeus
Echinoderms	Star fish (*Asterina* sp)

Natural Fish Resource

A variety of fish species can be found off the coast of Karachi, including mullet (Lizasp.), scat (Scatophagussp.), catfish (Ariidae), sciaenid fish, triple spines (Pseudotricanthussp.), lady fish (Elopidae), file fish (Monacanthidae), and pony fish (Leiognathussp.) among others. The mangrove ecosystem around Manora serves as a crucial nursery area for many fish and shellfish species, offering shelter to various marine and brackish water species. Additionally, nursery areas exist in the Chinna Creek mangrove forest located approximately 3 nautical miles east of the project area. However, these species face significant threats from industrial effluents, largely untreated, from the city.

Turtles

The Sandspit/Hawksbay recreational beaches, situated about 6 km west of Manora, are vital habitats for the endangered green turtle (Chelonia mydas), which enjoys protected status. These beaches constitute the most critical nesting and breeding ground for turtles in Pakistan. Sea turtles are protected in Pakistan under several legal and regulatory provisions:

- According to the Second Schedule of the Sindh Wildlife Protection Ordinance 1972, all marine turtles in Sindh province are designated as Protected Animals.
- The Clause 5 (Export Restriction) in the Pakistan Fish Inspection and Quality Act 1997 prohibits the export and domestic consumption of aquatic turtles.
- Pakistan is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which protects all marine turtles under Appendix I.
- The Government of Pakistan recognizes the IUCN Red List of Threatened Species, which lists the green turtle as a threatened species.

Coral Reefs and Sea-Grass Beds

Coral reefs are not found near the Project Area, with the nearest reefs located about 20 nautical miles away, specifically near Churna Island, which is known to host over 60 species of coral. Additionally, sea-grass beds are present off the coast, the closest being approximately 6 nautical miles to the west of the Project Area.

Marine Mammals

Humpback Dolphin: The Humpback dolphin (Sousa plumbea) is a prevalent species in the Karachi region, commonly found across East Africa and the Indo-Malayan seas. There have been multiple recorded sightings along the coastal areas of Karachi, with the majority occurring from November to January. Notably, this dolphin was once observed in Karachi Harbour, having entered with the tidal flow (Roberts, 1997; Hasan and Ahmad, 2006).

Bottlenose Dolphin: The Bottlenose dolphin (Tursiops truncatus) is another frequently encountered species in the waters of the Arabian Sea, Indian Ocean, Indonesia, and Australia, and is also commonly found in the coastal waters of Pakistan (Roberts, 1997).

A study conducted by WWF Pakistan from 1997 to 1998 aimed to gather insights about marine mammals in the coastal ecosystem, particularly focusing

on protecting cetacean populations. The findings revealed minimal differences in species diversity across the study areas, including the western and eastern sides of Bandal Island, Phitti Creek main channel, and channels towards Khuddi Creek. During this study, only the Bottlenose dolphin was sighted at two distinct locations along the east coast of Karachi, specifically Phitti Creek and Khuddi Creek, where their movement was consistently from east to west. Additionally, a beached carcass of a black finless porpoise (Neophocaena phocaenoides) was observed on the west coast of Karachi. Importantly, there is currently no site-specific data on marine mammals near the oil piers; however, this absence of data should not be interpreted as a lack of species, as they may enter with the tidal flow.

Ornithology

The coast of Karachi boasts a rich diversity of bird species, making it an Important Bird Area (IBA) in Pakistan. The Outer Indus Delta, which surrounds Karachi, is also recognized as a Ramsar site. This site encompasses an estimated 300,000 hectares of land, including around 200,000 hectares of mangroves, which are partially protected within two large designated Protected Forests. The bird populations supported by the Outer Indus Delta are detailed in the provided data.

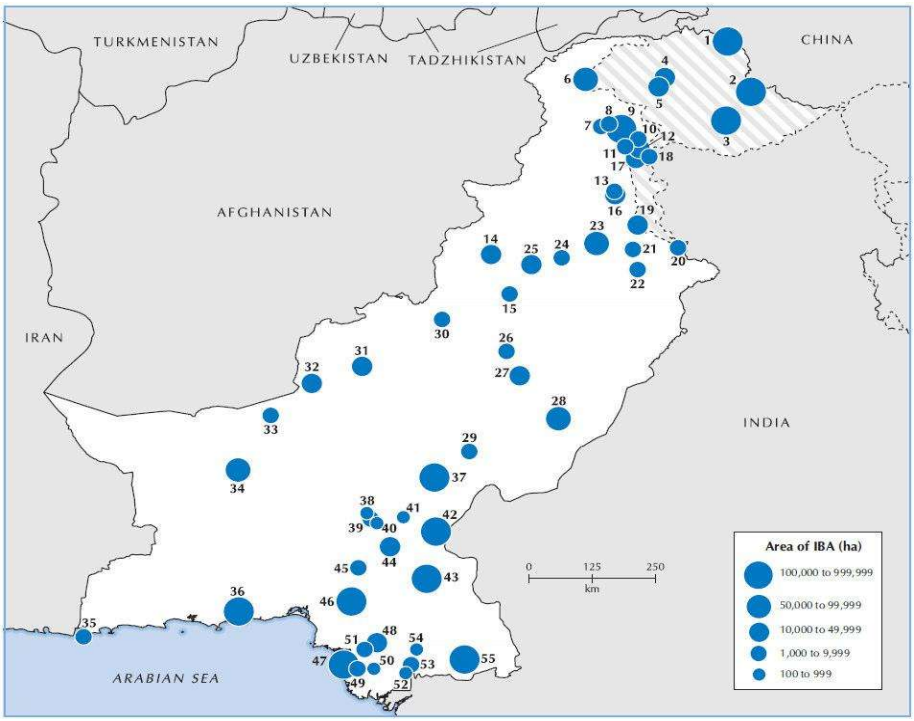


Fig 4.26: Location and size of Important Bird Areas in Pakistan
Source: Birdlife
http://www.birdlife.org/datazone/userfiles/file/IBAs/AsiaCntryPDFs/Pakistan.

Table 4.13: bird populations which are located within the Outer Indus Delta Ramsar site (as referred to in Ramsar Criteria 3)	
Bird species	
Common name	**Latin name**
Dalmatian pelican	*Pelecanus crispus*
Greater flamingo	*Phoenicopterus rubber*
Wigeon	*Anas phenelope*
Black-tailed godwit	*Limosa limosa*
Pochard	*Aythya farina*
Common coot	*Fluca atra*

Source: Information sheet on Ramsar Wetlands

More locally, over 50 species of birds are known to inhabit the area, encompassing both resident and migratory species. Many of these birds utilize the mangrove habitat in Chinna Creek for essential activities such as feeding and roosting.

Fisheries

The coastal fishery is crucial to Pakistan's national economy, directly providing jobs to around 300,000 fishermen, with an additional 400,000 employed in related industries. It is also a significant contributor to export earnings, with fish and fishery products valued at USD 117 million exported between July 2002 and May 2003. The Federal Government oversees fishing activities within Pakistan's Exclusive Economic Zone, which involves policy-making, inter-provincial coordination, research, quality control, training, exploratory fishing, stock assessments, fisheries management, fleet enhancement, data collection, and export facilitation.

Pakistan possesses a rich fishery potential thanks to its strategic location in the northern Arabian Sea, featuring a coastline of approximately 1,120 km and a broad continental shelf extending 200 nautical miles offshore. The coastal area has about 16,000 fishing boats that operate in both shallow waters and offshore, with fishing trips ranging from a few hours to 25 days, contributing to a total production of around 0.60 million tons per year.

Within local areas, fishermen utilize small boats to fish offshore from Clifton and DHA beaches, primarily during the SW monsoon when open sea fishing is not possible. However, pollution has significantly diminished the viability of these areas as fishing grounds or nurseries, resulting in a lack of commercially valuable fishing areas nearby.

Fishing Harbours of Pakistan

The major fishing harbours in Pakistan include:

- Karachi Fish Harbour: Operated by the Provincial Government of Sindh, it processes about 90% of the country's fish and seafood catch and 95% of fish and seafood exports.
- Korangi Fish Harbour: Managed by the Federal Ministry of Food, Agriculture and Livestock.
- Pasni Fish Harbour: by the Provincial Government of Baluchistan.
- Gwadar Fish Harbour: Operated by the Federal Ministry of Communication.

Karachi Fish Harbour Challenges

The export of seafood is hindered by various issues:

- High post-harvest losses due to improper handling and prolonged voyage times.
- Congestion at Karachi Fish Harbour, which houses over 16,000 fishing boats in the Sindh zone.
- Inadequate storage capacity of only 10,000 tons, insufficient for future demands.

Aquaculture

Currently, marine aquaculture is not practiced in Pakistan, but freshwater aquaculture is relatively advanced. The Government of Pakistan has initiated plans to enhance seafood exports through several measures, such as:

- Upgrading fishing vessels to mitigate post-harvest losses.
- Establishing modern peeling facilities for fish processing.
- Installing flake ice plants at harbours.
- Strengthening marketing efforts internationally.
- Promoting marine aquaculture.
- Fostering human resource development via training.
- Conducting regular monitoring through resource assessments and exploratory fishing.
- Acquiring equipment for handling and cleaning at fish harbours.
- Constructing a coastal highway.

4.2.13 Socioeconomic Status of the Macroenvironment

4.2.13.1 Population Distribution

The City is comprised of six urban districts with unevenly distributed population where the potential subprojects of the proposed KWSSIP will be identified, planned, constructed and operated. Population distribution across its 6 districts (Census, 2017), shown in the graph below, indicates much lower populations in Malir and Karachi South as compared to other districts. On the other hand,

Karachi West and Central have the highest residential population densities — some parts of the districts comprise of congested residential apartments which are extremely difficult to access.

Looking at the age composition from the 1998 Census, out of the total population 37.6% is under 15 years of age and 58% of the population between 15 to 50 years of age.

These numbers point to the fact that Karachi is a young city, which implies substantial future needs relating to municipal services, water supply & sanitation, housing, education, health, employment, and transportation etc. that the city has to address.

Karachi Division has six districts, of these; East, West and Malir (which also contain rural areas) report substantially higher annual growth rates. It is evident from high sex ratios in these districts, that there has been substantial in-migration to these districts. On the other hand, Central and South districts of Karachi report lowest annual growth rates, which could be due to, either substantial decline in fertility rate in these district or out-migration.

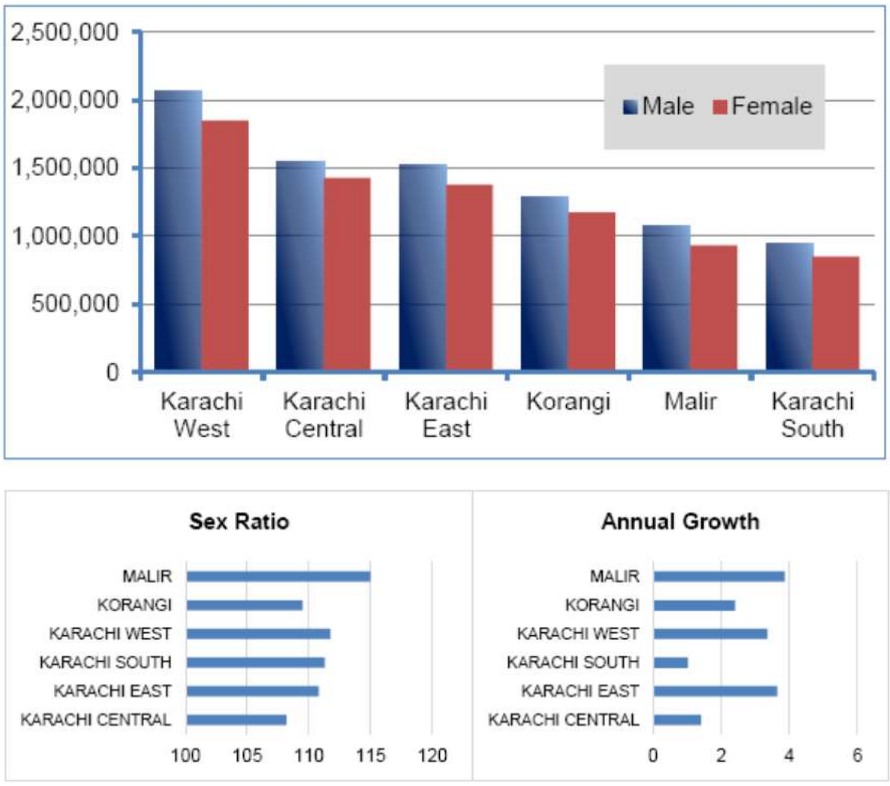


Figure 4.27: Population Distribution

4.2.13.2 Education and Literacy

According to UNDP, Pakistan has low gender development index (GDI) of 0.742 (2016) and low gender inequality index (GII)[9] of 0.546. However, over the years, Karachi has witnessed an increase in literacy; the narrowing of the male-female literacy gap; an increase in the age at which people get married (especially women); an increase in divorce rates; a reduction in the number of married people; and a trend towards the formation of nuclear families as opposed to extended ones.

In 2017, Karachi's literacy rate was 87 percent and nationally, Karachi ranked 59th in terms of school infrastructure and availability of facilities.[10] Karachi stands 43rd in national and first in district education. In 2016, Karachi's Education Score was 72.18, Enrollment Score was 73.70, Learning Score was 67.90, Retention Score was 58.00 and Gender Score 89.13 as presented in the following Graph.[11] The Figure 4 provides details of literacy and education ranking.

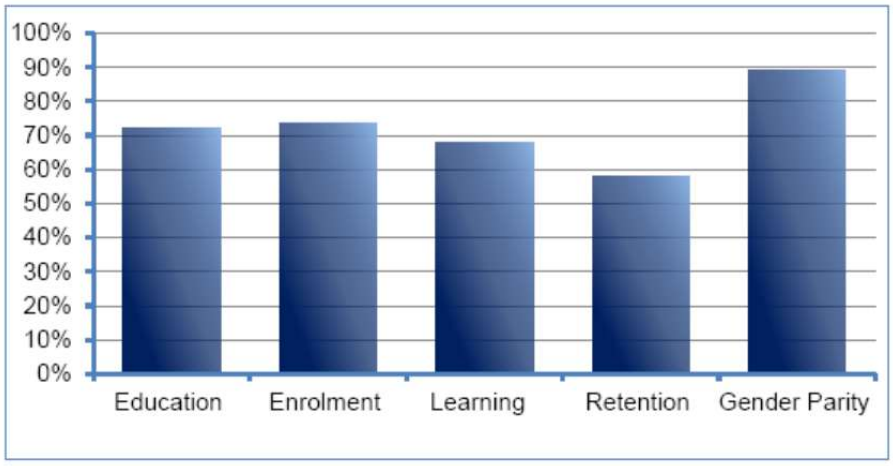


Figure 4.28: Literacy and Education Ranking

Education is one of the most important factors that distinguish the poor from the nonpoor. It is a vital prerequisite for combating poverty, empowering women, protecting children from hazardous and exploitative labor, protecting the environment and influencing population growth. However, literacy rate in Katchi Abadis exhibits a dismal picture. Overall literacy rate in Katchi Abadis is 71 per cent with a significant gender gap with 76 per cent for males and 66 per cent for females. The adult literacy rate in Katchi Abadis is low at 45 per cent, and

[9] GII reflects gender-based inequalities in three dimensions – reproductive health, empowerment, and economic activity. Empowerment is measured by the share of parliamentary seats held by women and attainment in secondary and higher education by each gender

[10] Federal Bureau of Statistics through PSLM survey, 2017

[11] SDPI, Pakistan District Education Ranking, 2016

ranges from 30 to 48 per cent in different areas with a primary enrollment rate at 54 per cent.

4.2.13.3 Karachi Human Development Index (HDI)

Pakistan has experienced a marginal increase in the value of HDI from 0.560 last year to 0.562 in 2017. Within the country, Karachi falls in high HDI[12] and is fourth in the national HDI ranking[13] in terms of human life – education, health, and standard of living. The graph below shows incremental improvement from 2005 to 2013. However, 2015 shows a downward trend mainly due to political confrontation between two major parties resulting in change in development priorities. Figure 4.29 provides HDI trends from year 2005 to 2015.

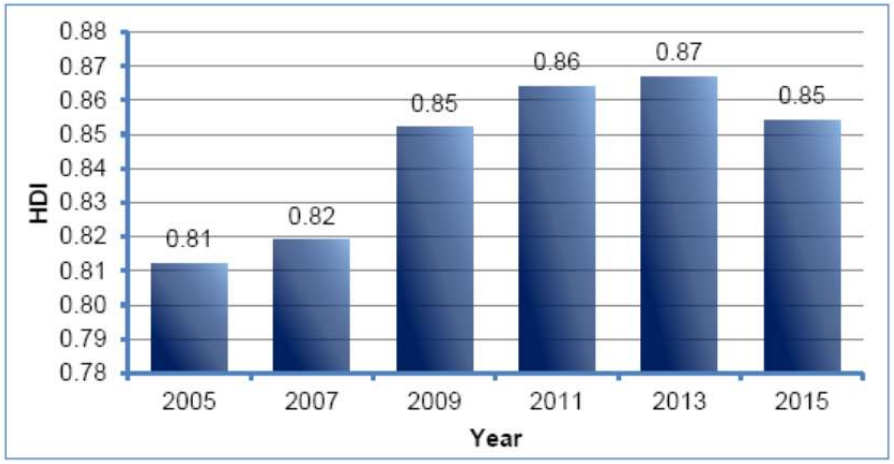


Figure 4.29: Karachi Human Development Index (HDI)

4.2.13.4 Health

Information on the health characteristics of a population is crucial to a proper understanding and interpretation of the health status of people, their potential health problems, and the resources required for providing services. However, current statistics were not available.

4.2.13.5 Infant and Maternal Mortality

The presence of private sector health facilities has helped in improving health related incidences of poverty. The current infant mortality rate under 5 years

[12] Pakistan Human Development Index Report 2017, UNDP, available at http://www.pk.undp.org/content/dam/pakistan/docs/HDR/HDI%20Report_2017.pdf

[13] HDI classifications are based on HDI fixed cut-off points. The cut-off points and HDI classification are as follows: less than and equal to 0.299 for very low human development; 0.300-0.499 for low human development; 0.500-0.599 for low medium human development; 0.600-0.699 for medium human development; 0.700-0.799 for high medium human development; and 0.800 or greater for high human development

[per 1000 live births] has improved to 59 and the maternal mortality to 180. These positive changes reflect increasing levels of awareness, education and the availability of decentralized governance of Sindh Katchi Abadis. An increasing number of young people in Karachi are benefiting from preventive health facilities and the adoption of family planning presence of private sector health facilities helped improve health related incidences of poverty. The current infant mortality rate under 5 years [per 1000 live births] has improved to 59 and the maternal mortality to 180. These positive changes reflect increasing levels of awareness, education and availability of decentralized governance of Sindh Katchi Abadis. The preventive health facilities and adoption of family planning practices by an increasing number of young peoples in Karachi practices.[14]

4.2.13.6 Disability in Urban Sindh

During the year 2017-18, 3,232 men and 5,680 women at the age of 15 or above were reported to have disabilities – almost twice the number in rural Sindh. [15]The disability statistics are based on the framework of WHO's International Classification to take into account six core functional domains namely, seeing, hearing, communication, cognition, walking, and selfcare[16].

4.2.13.7 HIV

Karachi is among the top cities in the world which have recorded an 'alarming' increase in HIV prevalence, according to a senior official of the Joint United Nations Program on HIV/AIDS (UNAIDS). In 2017, the Sindh Aids Control Program (SACP) reported 11,464 HIV patients who were undergoing treatment in Karachi out of which 11,225 were HIV positive patients while the remaining 239 were full-blown AIDS cases.[17]

4.2.13.8 Occupational Safety and Health Situation in Urban Sindh

The overall incidence of occupational injuries/diseases in the province indicates that approximately 5 percent of all employed work force (10 years & above) had suffered from an occupational injury/disease during 2014-15. The gender segregation shows that the incidence of occupational injury/ disease was higher among male workers compared to their female counterparts (5.24 percent vs. 3.02 percent respectively).[18]

[14] Sindh District –Based Multiple Indicators Cluster Survey (MISC) 2003-4, Planning & Development Department, Government of Sindh, Karachi, Nov. 2004
[15] The Pakistan Demographic and Household Survey, 2017-18
[16] Person who have difficulty in functioning according to domain, by the highest degree of difficulty in at least one domain, and percentage with a lot of difficulty or cannot do at all in more than one domain, according to background characteristics, Pakistan DHS 2017-18
[17] Dawn, April 27th, 2017
[18] PBS, Pakistan Labour Force Survey 2014-15

4.2.13.9 Housing

The poverty dimension in Karachi is further exacerbated due to the lack of housing facilities leading to the constant fear of eviction from illegal settlements and extortion by middlemen, police and various officials for the provision of various services and permission to live in the illegal settlements. Housing is one of the most pressing issues in Karachi. Given the continuous increase in the population of Karachi and the backlog in housing demand that exists, the housing needs of the city are estimated at approximately 80,000 units per year.[19]

There exists, however, a huge demand and supply gap in this sector. The shortfall in the supply of housing facilities is most severely experienced by the poor segments of the society due to severe lack of low-income housing provided by the public sector. Since partition, and due to a number of migrations into Karachi, this need for housing demand by poor and low-income inhabitants has been met by the sprawl of Katchi Abadis.

Housing needs in such settlements are met largely by informal developers with no government support whereby majority of the basic services like water, sanitation, education and health are developed with the investment of the inhabitants and the involvement of the informal sector and NGOs. Reasons behind shortage of water and sanitation services are: a) unregulated ongoing vertical development and construction of high rise buildings; b: the unchecked change land use from domestic to commercial as allowed by SBCA. Recently the Supreme Court of Pakistan has put a restraint on any conversion of land-use from domestic to commercial in Karachi and has barred the SBCA from issuing any such NOCs. Housing needs of approximately 50% of Karachi's population requiring low-income housing are met via densification of existing Katchi Abadis and slums, vertical growth of existing settlements and horizontal growth on vacant land and encroachment on natural drains.

Comparison of housing data from 1980 and 1998 reveals that the total stock of one room houses fell from 44.94% to 30.09% and the total stock of three-room houses increased from 13.96% to 21.12%; the number of houses with electric connections increased from 65.78% to 93.79%; the number of houses with piped water connections increased from 44.45% to 74.38%; and the percentage of houses with reinforced concrete roofs increased form 42.5% to 56.04%.[20]

These large sections of the city's population living in unplanned settlements have minimal or no access to basic services. Karachi's high intensity

[19] One sector requiring major planning and investment by the public sector and offering economic opportunities to the private sector. The city government should seriously think about regularizing/legalizing the involvement of a large number of informal developers prolific in the city's low income and poor settlements.

[20] Arif Hasan and Masooma Mohib, 2001

construction and densely built areas add to the immense pressure on the city's water, sanitation, sewerage and solid waste management services.

The current housing demand in Karachi is estimated at 80,000 new units per year. "The formal sector supplies 32,000 housing units and another 32,000 are built in katchi abadis. Meanwhile, 75.5pc of the city's residents are classified as poor, and as such they constitute the majority of the unmet demand. The result has been the continuous demand for katchi abadis.[21]

4.2.13.10 Economy

Karachi is the financial capital of Pakistan and contributes towards a substantial percentage of the national GDP and revenue. Karachi's economy has grown steadily in the past 18 years and per capita income has remained the highest in the country. Depending on the methodology used, Karachi's contribution to gross domestic product (GDP) is estimated to range from 11 to 20 percent. According to various estimates, Karachi generates approximately 65% of the total national revenue (federal and provincial taxes, customs and surcharges). At the Sindh provincial level, the city's share of the provincial tax receipts is as high as 70%.

Karachi is home to Pakistan's premier port which handles almost 95% of all foreign trade - in 2001 alone the Karachi Port handled more than 29 million tons of cargo. The city produces 30% of manufactured goods and about 42% percent of value-added products in large scale manufacturing. The per capita income of the city is also estimated to be four to five times higher than the national average. Nevertheless, the city has a large population around 50% of which lives in Katchi Abadis and slums.

The economy of the city includes diverse sectors like cement plants, corn mills, ship building, steel, textiles, chemicals, pharmaceuticals, automobiles, refined oil, shoes, machines and food production, wholesale and retail. Recent additions to the economic activity are in sectors such as telecommunication, electronic media, software outsourcing, call centers, medical services, and accounting.

Growth in the real estate and construction sector has fluctuated in response to speculative activities, fueled in part by cash inflows from outside the city and the country. However, the competitiveness of Karachi's traditional sectors of manufacturing and trade is declining, especially relative to other cities. The decline in the formal manufacturing sector has been accompanied by increased access to cheap imported goods, especially from China.[22]

[21] Arsam Saleem, 'Evictions, dispossessions and urban sprawl in Karachi, Karachi Urban Lab, 2018
[22] Sayeed, Asad, Khurram Husain, and Syed Salim Raza. 2016. Informality in Karachi's Land, Manufacturing, and Transport Sectors: Implications for Stability, Washington, DC: US, Institute of Peace Press

Furthermore, being the financial hub of the country, Karachi hosts the head offices of the majority of Pakistan's public and private banks. Karachi is also home to Pakistan's largest stock exchange, the Karachi Stock Exchange (KSC) 100 Index, which has been contributing significantly to GDP growth, and handles nearly all of the transactions in government securities and in the shares of most of the important industrial and financial institutions.

4.2.13.11 Employment

Underemployment and unemployment constitute a fundamental set of economic challenges that Karachi faces. Despite that, Karachi has emerged as a major trading, commercial, banking, insurance, retail, financial and economic hub of Pakistan; a growth that has attracted a vast number of migrants over the years. The City is the heart of manufacturing employment in the country[23]. Karachi has a high concentration of industrial activity and is home to the Sindh Industrial & Trading Estate (SITE), Korangi Industrial & Trade Estate, North Karachi Industrial & Trade Estate, etc. According to one study conducted in 1997, Karachi's large-scale industrial sector employed 71.6% of the total employed labor force in Sindh, and out of the total number of large-scale units in Sindh, 72.7% were located in Karachi producing 74.8% of the total large-scale output of the province.[24] According to the 1998 census, employment has fallen from 33.43% in 1981 to 27.58%, with the worst affected being the population above 60 years of age.

Table 4.14: Labour Force Participation 1981-98

Employment	1981		1998	
Male	1,235,104	95.06	1,920,895	94.33
Female	64,126	64.94	115,406	5.67
Total	**1,299,230**	**33.43**	**2,036,301**	**27.58**
Pop. 10 and above	3,886,152		7,384,156	

Source: Arif Hasan and Masooma Mohib, 2001

The pattern and nature of employment can be judged from one sample study that was conducted in 2005 and consisted of 5,000 households in 18 towns of Karachi Division which shows that out of the total population, 81% is employed, out of which 50% are self-employed, 31% are employed by the private sector, 3% by the semi-private sector and 16% by the public sector. Out of the self-employed, 32% are shopkeepers and 12% are laborers. However, out of the total population, a large proportion of the city population, i.e., 75% is employed by the informal sector comprising of small scale or cottage industry, trade and

[23] Transforming Karachi into a Liveable and Competitive Megacity, World Bank
[24] Khuhro, Hamida & Mooraj, Anwer (1997) Karachi, Mega City of Our Times, OUP, Karachi

provision of services including water, waste disposal, health, education and housing.[25]

The growth in the service sector has attracted many people to new jobs in the city; however, the existing infrastructure has been unable to cope with the growth. As a result, the poorer populations, though an integral part of the growing service sector, have been pushed out into relocation colonies far from the city center to make way for new development in line with the economic growth of the city. The distance of these relocation colonies from the city often results in a total disconnection from livelihoods and limited access to basic services — further deepening the cycle of poverty.

4.2.13.12 Informal Sector

The informal labor market is characterized by lack of regulation, lack of security in conditions of employment and ease of entry. It includes small, unregulated enterprises, often family-managed or self-employed enterprises that use traditional technology and labor-intensive methods.

While there is no comprehensive data available on the informal economy, according to some estimates, 75 per cent of those employed in the city of Karachi work in the informal sector. At present the informal sector activities are primarily based in and out of katchi abadis and are diverse in scope and nature — comprising of small scale or cottage industry, trade, and provision of services like water, waste disposal, health, education and housing. These activities thus provide a large number of families in Karachi with employment and a means of livelihood. Unfortunately, the fact that such economic activity is in the informal domain means that job security, sufficient wages or adequate health and safety safeguards are rare.

4.2.13.13 Social Infrastructure and Services

Karachi's economy and population continues to expand rapidly, but investment in urban infrastructure and services has not kept pace with this growth. Inadequate and unreliable infrastructure and services increase business and household costs, harm the urban and natural environment, and compromise the city's regional and global competitiveness.

4.2.13.14 Water Supply

As one of Pakistan's fastest growing metropolises, Karachi is challenged by increasing demand for water and sanitation services. Katchi Abadis in particular, face major challenges in service delivery. Unlike other major urban centers in Pakistan which are either located along freshwater bodies or depend

[25] ECIL, 2005

on groundwater sources, Karachi receives its supply of water from distant sources.

The two main sources of the city's water supply are primarily River Indus (through Keenjhar/Kalri) and Hub Dam, which are miles away. Although the city's main pipelines carry water for many miles, almost all of the Katchi Abadis and many of the formal settlements face an acute water shortage.[26]

This demand is inadequately met by a water supply of 360 to 530 MGD46[27] which is filtered at various water filtration plants including COD, Pipri, NEK, Hub and Gharo through an extensive generation, filtration, pumping/boosting and piping system. Against a demand of about 1080 MGD which is estimated for a population of about 20 million people, the KW&SB has the capacity of supplying approximately 640 MGD, out of which 20-40% is lost during transmission due to pilferage and leakages in the aging and dilapidated service delivery system. According to one study, if 40% of the leakages in the transmission routes could be plugged, water supply could be increased by approximately 81 MGD. The shortage is due to many reasons, such as insufficient supply from the two main sources (Indus & Hub Rivers), low levels of ground water, and inadequate and aging water transmission and storage facilities. [28]

An inefficient delivery system has forced people to make alternate arrangements through unregulated extraction, illegal online motors to boost pressure, etc., — with severe negative effects on water availability and water quality. Those most affected by this shortage are the poor who have no option other than buying water from high-priced private sources that operate in the city. In addition to the shortage of water in Karachi, substandard quality is another problem: drinking water seldom meets acceptable standards of filtration and treatment. A number of poor localities/squatter settlements have pooled money to build their own water supply systems by laying piped water networks that tap into government's main transmission lines or storage tanks. It has been observed that in settlements having larger dependence on community sources of water like boreholes, women play a crucial role in collection of water.[29]

Incidence of diverting water pipelines for personal usage are rampant leading to massive wastage and decrease in the already low water pressure supply at the tail end of the distribution chain. Water requirements peak during certain times forcing many households to obtain supplementary water supplies at high

[26] KW&SB
[27] Different estimates in different studies, which could be due to the time gap between them and methodology used
[28] ibid
[29] FGDs

costs. Tankers and pushcarts provide complimentary services in unauthorized colonies and slums.

The many challenges in delivering proper water services include: improving the quality of raw water, providing household connections to the poor, efficient provisioning of services, checking illegal tapping and transmission leakages, setting up distribution networks in highdensity informal settlements with metering, strengthening weak grievance redress and voice systems, proper pricing of water for cost recovery, etc. Lack of data and poor organization makes efficient provision of services nearly impossible.

The KW&SB is Karachi's prime provider of drinking water and wastewater removal services and provides an intermittent supply of water to Karachi's population. There is lo coverage in terms of piped-water supply connections, and even lower coverage of piped sewerage connections. Poor water and sewerage lead to environmental and health hazards which, in turn, lead to public and political dissatisfaction. Because of this dissatisfaction, the KW&SB is unable to raise its tariffs, and unable to collect much of what it bills. This leads to a lack of funds for maintenance and improvements and, in a vicious cycle, back to poor service delivery.

KW&SB is also constrained in meeting the city's water and wastewater needs. Supplementary services are provided by other water distributors, but these services are also unsatisfactory. The system provides inadequate coverage and service, endangers public health, and is financially unsustainable.

The KW&SB divides Karachi into 6 water Circles and 20 towns based upon population and the outlet and inlet points of the existing water pipeline network in the city. Each water Circle is headed by a Superintending Engineer. The KW&SB provides intermittent water to some part of the city. To supplement the water supply, KW&SB supplies water tankers on request only in formal settlement.

Table shows that there is a large variation in reliance on piped water between districts. Piped water supply is poorest in District West with less than half the population relying on it for drinking, whereas approximately 80 percent of the population in District Central were using piped water as a main water source for drinking. There are also marked differences in sources of water for drinking and other purposes within and amongst households.

Table 4.15: Water sources in Karachi, by districts (per cent)

District	Purpose	Piped	Public Tap/ Filtration Plant	Boreholes/ Tube well/ Hand pump	Tanker/ bottled	Other
Karachi	Drinking	66.2	3.7	3.8	23.2	3.0
	Other	71.0	0.3	18.0	9.1	1.7
East	Drinking	70.8	2.5	7.0	18.4	1.3
	Other	73.2	0.0	24.1	2.7	0.0
Central	Drinking	79.9	2.3	4.8	11.2	1.7
	Other	85.9	0.0	9.0	2.6	2.6
West	Drinking	46.9	2.2	2.4	40.7	7.8
	Other	63.6	0.0	13.6	18.2	4.5
South	Drinking	67.2	9.7	1.6	20.1	1.4
	Other	73.9	0.9	3.6	19.8	1.8
Malir	Drinking	64.8	2.5	2.8	26.7	3.2
	Other	30.8	0.0	61.5	5.1	2.6

Source: Multi Indicator Cluster Survey 2015-16 dataset

On average, approximately two-thirds of Karachi's population relies on piped water for drinking and 71 per cent for other purposes. About one-fourth of the population in Karachi purchases water through tankers or water bottles, or other sources.

In the two districts – East and Central, the reliance on piped water is slightly higher than the average. In District East, the reliance of other (privately installed) investments such as boreholes, tube wells or hand pumps is also slightly higher.

In the case of water supply, among the minimum critical sustainability criteria included is the provision of an average of 5 liters of water per capita per day for drinking and cooking. The Strategic National Master Plan for Water and Sanitation also makes it mandatory in addition to potable water. However, international guidelines widely followed, use a broader definition of daily human requirements for water, including basic consumption, hand washing and food preparation needs, suggesting a volume of about 20 liters per capita per day.[30]

4.2.13.15 Sewerage System

Karachi generates approximately 350-392 MGD of sewage. However, the three operational waste water treatment plants have a combined capacity to treat only 151 MGD and out of these three, only one is currently functional. The

[30] (e.g., World Health Organization, 2003; IFC, 2007; DFID, 1998).
World Health Organization (WHO). 2003. Domestic Water Quantity, Service, Level and Health

situation is further aggravated due to the aging sewer network and operational losses at the treatment plants. Consequently, only 40 to 80 MGD of sewage is actually treated50. A large amount of the sewage flows directly into open drains and storm water drains given the lack of an adequate disposal system. Through Malir and Lyari rivers — which have been transformed into huge open sewers — this sewage ultimately ends up in the Arabian Sea, causing extensive environmental damage.

The major polluters are industrial units (which dump untreated toxic waste into the rivers and the sea) and squatter settlements (both formal and informal including slums) which lack piped sewage collection as a result of which their waste flows through open drains into the rivers. It also important to note that the government treatment plants do not provide treatment of chemical waste, which is which makes it a serious issue for long term environmental impact.

There are no estimates of the number of settlements in the city linked to underground sewerage system. The KAs located close to the planned areas are using the Sewerage System laid for those areas. The sewerage network in Karachi is old, poorly maintained and not properly networked to treatment systems. This has resulted in system blockages, raw system overflows and environmental damage.

The collection, treatment and disposal of both domestic and industrial wastewater within the city are primarily the responsibility of KW&SB that operate an extensive sewer network and three sewage treatment plants (STPs). However, low treatment capacity and poor interconnectivity between elements of the sewerage system means that much of the wastewater generated in the city is discharged untreated into the storm water drainage system, from where it flows to Karachi Harbor and the Arabian Sea untreated.

Household sanitation within the inner city is reasonably good with a relatively high incidence of sanitary toilets within households and sewerage network connections. The 1998 population census revealed that 92.8 percent of households within the city had separate latrines, 4.1 percent had shared latrines, while only 2.1 percent had no toilet facility. There is a good record of collaboration between the government and the NGO sector regarding provision of sewerage in Karachi.

Over time, water and sanitation services are provided but growing population pressures, commercialization land use, and unorganized development due to housing shortages has led to unregulated urban growth and the development of unauthorized katchi abadis stresses service delivery in water and sanitation sector.

Apart from inadequate investment water and sewerage deficiencies, the overall shortage is due to the following factors: poor collection of revenue

from users; deficient maintenance because of under-trained staff and lack of required funds; lack of appropriate policies; and limited capacity of the management. Charges for water are low relative to both the costs and to the rates charged by private vendors. In most districts, there are no charges for sewerage and drainage services. Further the existing sewers have outlived their design life and suffer from insufficient hydraulic capabilities, heavy silt deposition and severe choking due to dumping of solid waste.

4.2.13.16 The Drainage System

There are two types of drainage in Karachi — storm water drainage and surface drainage. Karachi's drainage situation is complex; it has several natural and man-made drainage systems, two drainage basins, large natural drains, storm water drains along roads and combined 'sewer and storm' water drains.

According to the Orangi Pilot Project, Karachi has 41 major drains. These drains are about 167 KM in length and discharge into two non-perennial rivers, i.e., the Malir and the Lyari, which run through the city districts.[31] Gujjar Nala is among the main streams of Karachi beside the Orangi stream which is a tributary of the Lyari River. The Gujjar Nala is an ephemeral stream which flows through the megacity of Karachi from north-east (North Karachi Sector 11J) to the center and merges with Lyari River in Liaqatabad Area before draining into the Arabian Sea. Most of the Gujjar Nala passes through the Karachi Central District while the remaining passes through Karachi West District. The Nala carries waste generated from industrial and domestic activities — these activities can generate up to 472 MGD of waste water in Karachi. Minor drainage networks (about 1,000KM in length) are the responsibility of the town councils. However, conflicts arise from the fact that much of the storm water drainage network also functions as part of the wastewater disposal system as a result of which maintenance is largely neglected.

Katchi Abadi Authority reveals that there are 5,639 slums in Karachi and a majority of them are built alongside drains. Karachi faces the threat of flooding mainly due to unrestrained housing and encroachment on natural waterways coupled with dumping of solid waste into storm water drains. As the settlements keep swelling, the drains are constricted, blocking the natural water paths. According to KMC, Gujjar Nala used to be 200 feet wide and now its width has been reduced to 15 feet.[32] These compounding factors have increased the frequency and intensity of flooding in certain neighborhoods. Karachi has witnessed urban flooding in 2006, 2011, 2012, 2013 and 2017. The

[31] These drains include Gujjar Nala, Orangi Nala, CBM Nala, Chakra Goth Nala, Nasir Colony 2100 Road Nala, Chakore Nala, Soldier Bazaar Nala, PECHS Nala, Mahmood Abad Nala and other drains scattered across the city.
[32] KMC

city lacks a full assessment of the drainage system's conditions and performance required to develop an adequate city flood management plan.

Urban flooding is most likely to become an even more serious issue – directly affecting tens of thousands and possibly affecting millions indirectly. Different parts of the city are inundated during heavy downpours such as North Karachi, North Nazimabad, Drigh Road, NIPA, Orangi, Malir, Northern Bypass, and colonies located on either side of one of the city's longest drains, the Gujjar Nala. Many underpasses were inaccessible as they were completely submerged. These drains would normally bring rainwater from across the city to either Lyari River or Malir River, which would then drain into the Arabian Sea.

The key issue in the drainage sector is the maintenance of adequate storm water drainage infrastructure by: (i) avoiding encroachments by unplanned low-income settlements along drainage channels; (ii) improving the hydraulic performance of the drainage networks; (iii) ensuring that drainage lines are kept clear, clean and well-maintained (iv) separating wastewater systems from storm water systems so that responsibility for storm drain maintenance can be returned to those originally responsible; and (v) urgently developing a Storm-Water Drainage Master Plan, developing programs to establish and maintain drainage rights of way, and introducing a system of routine drainage maintenance.

4.2.13.17 Solid Waste

Solid waste management has become a daunting task for KMC and DMC authorities which seem to lack the capacity to deal with the escalating waste production. Statistics indicate that on a daily basis, approximately 12,000 tons of solid waste is generated in Karachi alone, out of which forty percent can be found on the city streets. Improper management of solid waste is causing the spread of infectious diseases and environmental pollution.

Solid Waste Management within the City is the combined responsibility of Sindh Solid Waste Management Board (SSWMB) and DMCs. In addition, the Cantonment Boards, Karachi Port Trust and Pakistan Steel Mills carry out their own waste collection and waste transportation. The key agencies responsible for collection are the town councils who either use their own equipment or contract private sector operators for managing and operating the primary collection system. KMC is responsible for the maintenance and operation of the land fill sites at Jam Chakro and Gond Pass located each at 35 km from the city center.

Public opinion and perception of solid waste management system is characterized by irregularity and inefficiency of the collection system as well as poor monitoring of the private waste service providers by the local authorities.

Most of the households recognized solid waste management as a major problem. It was also revealed that residents currently pay for waste management services to private waste pickers. Strategies to address solid waste problem will need to consider an adequate supply of containers, intensive public education and introduction of user fees for waste management services.

4.2.13.18 Power Supply

Supply of water depends on the availability and quality of electricity in the towns, although almost all of the households were reported to have an electric connection in their household. However, electric supply was found to be very erratic in informal settlements. Due to irregular electric connections, operation of water pumps is interrupted, and a steady supply of water is stalled. It has been observed that many settlements get water only once in a week. This has serious implications on enhancing coverage by generating a demand for piped water supplies because it invariably requires pumping.

Karachi Electric Supply Corporation (KESC) has a generating capacity which is 9 percent of the total power generated nationally (1,756 MW).It generates, transmits and distributes electricity to domestic, institutional and industrial users. Current peak demand outstrips supply by an estimated 518 MW or 24% of generation capacity.[33] This results in frequent load-shedding during periods of peak demand in summer with serious consequences for the economy. In recent years, frequent electricity load shedding has also led to civil unrest in some areas of the city.

In addition to the shortfall in supply, there are serious problems with the distribution network. Many of the feeders are overloaded which adds to transmission losses and outages. A significant number of feeders are very long which further increases transmission losses. While there are 1.4 million paying domestic consumers and 400,000 commercial, institutional and industrial consumers within the service area, it is estimated that more than 350,000 consumers are illegally connected to the system and do not pay for the power that they consume. The combined transmission, distribution and administrative losses are over 37 percent of supply.

4.2.13.19 Public Transport

There are various estimates regarding the number and types of public transport available in Karachi but broadly speaking, over 90% of the Karachi's public transportation is comprised of privately owned buses and mini-buses. [34]Out of these, various studies estimate that there are approximately 13,500 to

[33] KESC, Website, Dec. 2018
[34] largely owned and run by Pukhtuns

20,209 minibuses and coaches in Karachi. In addition, according to different estimates, there are 13,613 (2002) to 44,480 (2007) taxis and 23,337 rickshaws in the city[35]. This substantial involvement of the private sector in fulfilling the transport requirements of the city can be largely attributed to the limited capacity of the government to provide an efficient and affordable public transport system. It is important to note that the government owned Karachi Transport Corporation (KTC), shut down its services comprising of 800 buses in 1997 due to lack of funds and unsustainable losses.

Available public transport system in Karachi is also highly gender insensitive (as other sectors in Pakistan due to the overall socio-cultural context). A study by URC reports that women respondents complain about non-availability of female seats, having to sit on hot engine cover in buses, harassment, and unnecessary touching by male drivers and conductors.

The urgent need for a public transport system specifically for just one sub-set of the population can be gauged form the fact that morning peak hour traffic is largely generated by travel to educational facilities. A research study conducted by JICA in 2005 reports 15.43 million trips to educational facilities per day. Out of a total of 24.227 million trips made on a typical weekday, 60% are for schooling purposes. This number sheds light on the immediate need to address the transportation needs of the education sector. In order to substantially reduce traffic congestion, there is a need for providing student specific transportation on various routes, providing reserved seats for students, and involving private educational institutions to provide transport facilities for students.

4.2.13.20 Roads

The Karachi Metropolitan Corporation (KMC) is responsible for the maintenance and upkeep of all major roads within the city, and District Municipal Corporations (DMC) are responsible for the secondary/tertiary roads (176 KM in length) along with associated drainage and street lighting. Maintenance budgets come from federal, provincial and district sources and new construction and maintenance works are contracted out - although contractors frequently hire back the plant owned by the Works and Services department in order to undertake the works.

4.2.13.21 Fire Services

Under the Sindh Local Government Ordinance (SLGA) of 2013, the KMC is responsible for the maintenance of a fire brigade for the prevention and extinction of fires. However, the Karachi Fire Brigade does not possess

[35] Other modes of transportation consist of Suzuki pick-ups, horse-drawn victories and carts, and boats (operating between the port and certain settlements located across the bay). The Karachi circular railway also operates within the city however servicing a negligible fraction of the population.

adequate staff, fire stations and equipment to cover a city of over 13 million people which creates a serious shortfall in fire service coverage. There is a serious need for trained fire-fighting staff as well as hydrants – of which there are only nine in the city.

4.2.14 Socioeconomic Status of the Microenvironment

4.2.14.1 Cultural and Archaeological Heritage

The project area does not incorporate any features or sites of cultural or archaeological heritage. The nearest relevant building is the Keamari Clock Tower which was built in 1912 at a distance of approximately 1 km from the project site. It can be seen in following image of the boat basin, Keamari.



The other very old construction is the Manora light house as shown here. A very old tomb which is visited by hundreds of followers can be seen behind the light house office building.



4.2.14.2 Localities

There are 8 Union Councils of Karachi having a population of around half a million which are adjacent to the Karachi Port. The main villages / towns near the project area are Keamari, Manora, Sultanabad, Sher shah, Machar Colony, Bhuta village and Baba Bhit, Gabo pat, and Mauripur.

4.2.14.3 Mother Language

The most commonly spoken language in Karachi is Urdu, the national language. Other national languages spoken in Karachi are Sindhi, Punjabi, Pashto and Balochi and are widely spoken in the city.

4.2.14.4 Ethnicity / Tribes near the Project Area

The population near the project area is a mixture of various heterogeneous groups and cultures. The main tribes are Talpur, Memon, Syeds Baluchs, Somro, Mirzas, Sheikh, Khatris, Qureshis, Abbasis, Bhurgari, Lashari, Laghari, Ranghar, Panwhar, Halepota, Mari, Banglani, Gorchani, Khosa, Sameja, Gurgaj, Bhanbhro, Jat, Arain, Qureshi and Sheikh. Many people from Punjab and North West Frontier Province (NWFP) have settled in the project area.

4.2.14.5 Main Occupation Dwellers near the Project Area

The entire community in the nearby islands has a fisheries-based economy and there is a tendency among the young men to search for employment in shipping related services and on passenger / pleasure boats. The contribution of women in earning a living used to be very small as compared to men. However, with the promotion of educational awareness by the big school setup by Pakistan Navy League (an organization of retired Naval Officers) the girls are getting educated and are joining the teaching profession after acquiring PCT certificate. 20 girls from the same school have already obtained PCT certificate.

4.2.14.6 Industry

The Industry near the project area comprise of Oil Handling Setups in the Oil Installation areas and mostly marine related workshops, cargo/container storage depots, ship chandlers, etc in the Keamari Timber Pond Area. These give employment to thousands of skilled and unskilled workers. The Port Operations including cargo handling also employ thousands of workers.

4.2.14.7 Other Facilities of Life

The availability of basic amenities of life to the community living near the project area is an indicator of its socio-economic conditions.

Transportation: The three shipping ports in Pakistan are the Port of Karachi, Port of Gwadar and the Port Bin Qasim. These sea -ports have modern facilities and not only handle trade for Pakistan, but handle cargo for Afghanistan also.

The railway network in Pakistan is orientated mainly north south and connects Karachi with the major cities in the hinterland by Pakistan Railways (PR). Containers and bulk cargo for inland destinations are transported to inland rail terminals from Karachi to Lahore, Rawalpindi, Peshawar etc (KPT, 2007a). The Karachi City Station and Karachi Cantonment Railway Station are the city's two major railway stations.

Containers and bulk cargo traffic for Afghanistan are transported via rail to Chaman and Peshawar, where the cargo is loaded onto trucks for onward transportation to their destinations. There are plans within Pakistan to double the tracks between Karachi and Lahore and PR is working on public sector joint venture to improve container transport and logistics management, with the aim of promoting the use of rail for freight transport.

The Jinnah International Airport is located in Karachi. It is the largest and busiest airport of Pakistan.

Health Facilities: The city is home to a good number of public hospitals and a large number of private hospitals. In close vicinity to the project area, there is a Karachi Port Trust Hospital, providing health facilities to the KPT workers. A couple of organizations such as Agha Khan Foundation and Merck provide free medical service to the needy in Baba-Bhit Islands.

4.2.14.8 Education Facility

There is a rising trend of sending children to schools. As mentioned above a school at Baba Island being run by the Navy League has presently around 600 students. The Island's literacy rate has jumped from minimal to around 30% because of this school.

Education in Karachi is divided into five levels: primary (grades one to five); middle (grades six to eight); high (grades nine and ten, leading to the Secondary School Certificate); intermediate (grades eleven and twelve, leading to a Higher Secondary School Certificate); and university programs leading to graduate and advanced degrees. Karachi has both public and private educational institutions. Most educational institutions are gender-based, from primary to university level.

5.0 Stakeholder Engagement, Impact Assessment, and Proposed Mitigation Strategies

This chapter presents the screening of potential environmental, social, and economic aspects, along with an assessment of their severity based on alternative evaluations and stakeholder perceptions gathered during the initial stages of the Environmental and Social Impact Assessment (ESIA). The baseline data detailed in Chapter 4 supports this evaluation.

The screening process is a crucial component of the environmental assessment for the proposed Closed-loop Virtual LNG (VLNG) Terminal Project. It involves identifying significant environmental and social aspects prior to the construction, establishment, and operation phases. The aspects recognized during stakeholder consultations and the screening were evaluated for their severity, leading to proposed mitigation measures.

The Project Proponents will implement these mitigation measures to minimize, reduce, and offset any negative impacts. The screening process utilized a checklist method alongside professional judgment to identify the residual impacts that may remain even after mitigation measures are applied. The 'zone of operations' refers to the microenvironment of the LNG Terminal site in KPT, where most impacts are expected to occur.

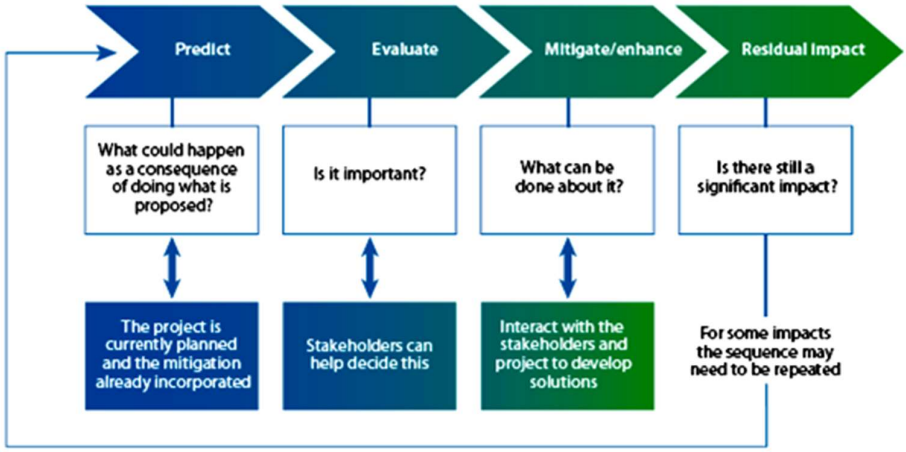


Figure 5.1: Impact Assessment Approach

5.1 Assessment and Analysis of Environmental Concerns Highlighted by Stakeholders

The Environmental and Social Impact Assessment (ESIA) process is fundamentally incomplete without substantial public participation. Under the Sindh Environmental Protection Act of 2014, along with the associated rules

and regulations, there is a clear mandate for vigorous public engagement in both the planning and execution of all development initiatives.

Public consultation serves as a vital mechanism for conveying the advantages and disadvantages of a proposed project to those who are directly and indirectly affected. This ensures that the ESIA process remains open, transparent, and rigorous characterized by defensible analysis aimed at achieving sustainability during the project's design, implementation, operation, and management. Stakeholders are given the platform to voice their concerns before the project's feasibility is determined, making it a significant part of the decision-making process.

Initially, public consultation took the form of group discussions held at various locations within the project area during the ESIA preparation. This approach was intended to mitigate potential adverse impacts of the project by fostering awareness among local communities about its possible benefits. Scoping meetings were conducted from January to mid-February 2025, engaging both institutional and grassroots stakeholders, which included governmental and non-governmental entities, community-based organizations (CBOs), academic institutions, and relevant experts. It is worth noting that no households or structures are situated within the exclusion zones of the proposed sites, and consultations were specifically directed toward communities in the broader project environment.

The feedback gathered from institutional stakeholders during these scoping sessions, as well as input from public consultations and focus group discussions, was carefully noted and analyzed. This feedback represents the environmental and socio-economic interests of the participants and has been integrated into project design wherever feasible. The consultation meetings and focus group discussions were organized as open forums, ensuring representation across various groups categorized by language, age, and income levels. This engagement is not a one-time event but a continuous process that will persist until stakeholder concerns, especially those of potentially affected local communities, are addressed satisfactorily.

The outcomes of these consultations led to the clear identification of issues deemed significant by both the community and stakeholders, highlighting the necessity for the ESIA to respond actively to these concerns. Strategies for mitigating potential environmental effects relevant to the community and other stakeholders have been built into the project planning phase and will be consistently implemented throughout the project's lifecycle. During scoping sessions, stakeholders were informed about the background, objectives, and essentiality of the proposed project, along with the rationale for undertaking the ESIA process.



Figure 5.2: Scoping Session

The stakeholders during the scoping process highlighted several critical observations regarding Pakistan's gas supply and demand situation. Pakistan's population has surged to approximately 250 million, resulting in an escalating gas demand that currently stands around 6.6 billion cubic feet per day (bcfd). This demand is anticipated to increase to7 bcfd in the near future, even as local gas production is expected to decline below 2 bcfd. Presently, the country operates only two LNG terminals, which are insufficient for ensuring a continuous and reliable gas supply.

As of 2022, Pakistan's total gas supply was recorded at 3.3 bcfd, encompassing 2.63 bcfd from domestic productionand630 million standard cubic feet per day (mmscfd) from imports. This troubling scenario indicates that Pakistan will need to import Liquefied Natural Gas (LNG) at a volume three times that of its local production, a situation that significantly impacts policy and regulatory frameworks and ultimately affects consumers.

The constrained gas supply has severely impacted vital industries such as textiles, ceramics, gas, and steel, all of which depend on a steady gas supply to maintain operations and meet production deadlines. The disruptions in gas supply have led to dire consequences for the textile sector, as reported by the All Pakistan Textile Mills Association (APTMA), resulting in halted production and factory closures. This interruption not only endangers the country's industrial output but also threatens employment levels, an issue that Pakistan is currently ill-equipped to manage.

Moreover, the government's imposition of capacity charges has resulted in heightened financial strains, further diminishing Pakistan's global competitiveness. In 2015, with assistance from the World Bank, the government took the step to start importing LNG for power generation; however, Pakistan has not participated in the LNG market since June 2022. The situation has been exacerbated by increasing global LNG prices due to the Ukraine crisis along with decreasing foreign exchange reserves, which have complicated LNG procurement efforts.

The previous year saw significant defaults in deliveries from major LNG suppliers, compelling Pakistan to rely more heavily on oil for electricity generation. The LNG supply chain remains predominantly under state control, suggesting that encouraging third-party access for LNG imports and fostering private sector engagement in the LNG supply chain could substantially improve procurement processes and lower costs through competition, much like successful examples observed in countries such as Japan, South Korea, and India.

Allowing the private sector to import directly from the spot market and enabling zero-rated industries to independently import could yield positive outcomes. Additionally, the development of a virtual pipeline offers a promising avenue for enhancing competition within the LNG market and reducing reliance on traditional gas suppliers. Transitioning to LNG could effectively decrease dependence on local gas, costlier petroleum products, and Liquefied Petroleum Gas (LPG), thereby fostering a more robust and resilient energy landscape for Pakistan.

Environmental Expert, Dr. Ozair Khan, has observed a significant increase in aquatic pollution levels in the Karachi Port Trust (KPT) coastal area, situated along the southern coast of Pakistan, over recent decades. This alarming trend can be largely attributed to the unrestricted discharge of sanitary waste into the water.

Comprehensive physical and chemical analyses performed on water samples collected from this region have revealed troubling results. The concentrations for key pollutants such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrate, phosphate, phenol, cyanide, and oil and

grease frequently surpass the permissible limits established by international standards. In fact, these levels have reached significantly higher than acceptable thresholds.

Additionally, the presence of hazardous metals in seawater samples has been documented, with their concentrations following the order: Nickel (Ni) > Chromium (Cr) > Copper (Cu) > Lead (Pb) > Cadmium (Cd) > Arsenic (As). These elevated levels are a direct consequence of the indiscriminate release of untreated industrial and domestic wastewater.

Through meticulous examination conducted both pre- and post-monsoon, six locations, including those near KPT, the Lyari River outfall, and Karachi Harbour, have been identified as highly polluted zones, primarily due to the substantial discharge of sanitary effluents at these sites.

The CEO of Engro Elengy Terminal Limited acknowledged the efforts of LNGFlex Limited and emphasized the importance of thorough site screening. He highlighted the necessity of conducting a series of support studies, including:

- **Navigational Simulation Study**: Essential for ensuring the safe arrival and departure of LNG carriers, taking into account ship dimensions, channel specifics, and the presence of other vessels.
- **Mooring Analysis Dynamic Simulation Study**: This study will determine the appropriate mooring equipment design to secure both the Floating Storage Unit (FSU) and LNG carrier (LNGC) against the influences of wind, tidal changes, and tidal currents.



Fig 5.3: Meeting with EETL

- **Quantitative Risk Assessment (QRA) & Navigation Fast Time Simulation Study**: A comprehensive risk analysis designed to assess any accidents that may involve terminal operations and associated equipment, focusing on impacts to existing facilities and local populations.
- **HAZID**: This analytic approach will identify the requirements for safe terminal operations and pinpoint potential hazards along with their mitigation strategies.
- **HAZOP**: Crucial for developing safe designs of various process units and interconnections, this study is necessary at the Front End Engineering Design (FEED) stage.
- **Port Congestion Study**: Considering the existing container traffic at the selected site, this analysis will evaluate the impact on the arrival and departure of LNGCs and assess the availability of the navigation channel

and turning basin.

- **Road Transport and Safety Assessment**: An extensive study assessing traffic and transportation networks, aimed at optimizing the number of daily LNG dispatches and suggesting improvements for road infrastructure to fully realize the VLNG Terminal's potential.

These studies are vital for ensuring the safe and reliable operation of terminal activities by LNGFlex Limited.



Figure 5.4: Meeting with SEPA

The Sindh Environmental Protection Agency (SEPA) has underscored the importance of involving all stakeholders during the scoping phase of the Environmental and Social Impact Assessment (ESIA). The assessment should prioritize sustainable development within the project's area of influence.

For the proposed VLNG Terminal project, it is crucial that it complies with the safety and security standards set forth in the LNG Policy 2011, as well as adhering to pertinent local and international regulations, including those established by SIGTTO. Additionally, it is imperative that studies are conducted

on the dredging spoil disposal arrangements to guarantee safe and scientific disposal methods.

SEPA has expressed concerns regarding the lack of commitment to post-environmental monitoring against the Environmental Management Plan (EMP) and approval conditions. They recommended that LNGFlex Limited establish a dedicated Health, Safety, and Environment (HSE) department helmed by qualified personnel to ensure the effective implementation of HSE protocols.

Furthermore, the site preparation phase should prioritize local labor, and Corporate Social Responsibility (CSR) initiatives should be strategically designed to enhance the welfare of the local population, focusing on areas such as health, technical education, and skill development, which would yield long-term benefits.



Figure 5.5: Meeting with WWF & IUCN

Senior Executives of WWF Pakistan, IUCN, and Sindh Forest Department have expressed serious concerns regarding the pollution in the port areas of Karachi

and the imminent threats to the ecosystem posed by human activities. The Sindh Forest Department (SFD) has been making significant advancements in the conservation and management of mangrove forests in the province. They have undertaken the planting of mangroves on 55,555 hectares along the Sindh coastline, predominantly in the Indus Delta, through ambitious projects spanning from 2020 to 2024. These collaborative initiatives with WWF-Pakistan and IUCN have resulted in a noteworthy increase in Pakistan's mangrove forest cover from 1,338.16 km² in 2016 to 1,573.57 km² in 2020 [REDD+; Subnational GHG Inventory 2022].

Despite the positive progress made by the SFD and various conservation organizations, the mangroves in Karachi are facing significant challenges. The SFD reports a loss of approximately 200 hectares of mangrove forests along the coastline between 2010 and 2022. This alarming trend is primarily driven by land encroachment, residential developments, and infrastructure projects.

Satellite data provided by WWF-Pakistan's GIS lab vividly illustrates the extent of mangrove degradation along Karachi's coast. Vast expanses of mangroves have been completely cleared for residential projects, and the ongoing cutting down of mangroves continues to be prevalent. The mapping conducted by WWF indicates that mangrove habitats have been encroached upon or are threatened by urban development.

It has been emphasized that these vital mangrove forests are under severe jeopardy due to unchecked urbanization, illicit logging, and pollution. The decline in mangrove cover not only increases the susceptibility of local communities to marine disasters but also diminishes essential ecosystem services such as biodiversity maintenance, air purification, and carbon sequestration. WWF has advocated for collaborative endeavors among stakeholders to conserve and manage these indispensable natural resources, underscoring the ecological, economic, and social benefits that mangroves offer.

Moreover, land reclamation has been identified as a primary driver of mangrove destruction in Karachi, with urban sprawl resulting in extensive clearing for developmental purposes. Illicit land allocations exacerbate the situation, paving the way for lucrative yet detrimental construction projects. This relentless pursuit of immediate financial gains often overlooks the long-term environmental consequences.

In addition to land reclamation, the commercial felling of mangroves poses a significant challenge. Loggers target mature trees around Port area, severely impacting the ecosystem by clearing trees that stand approximately 30 feet tall. These loggers typically allow the felled trees to dry for a week before transporting them to the local market.

While acknowledging the fact that Project PLUTO by LNGFlex Limited doesn't involve cutting of trees including mangroves, it was advised by IUCN, WWF and SFD that the developer should collaborate to participate in mangrove plantation for wider environmental and economic benefits to Pakistan in the cause of Climate Change Mitigation and Adaptation.

The National Forum for Environment & Health (NFEH) reaffirmed its support for sustainable development, welcoming initiatives along Karachi's coastal regions while stressing the necessity of reducing negative environmental impacts. A detailed evaluation of the existing pace of development around KPT and PQA is imperative, as the cumulative effects of multiple projects could lead to serious and lasting environmental issues. The diminishing space between residential and industrial sectors presents administrative challenges and enhances the risk of environmental harm, highlighting the need for a buffer zone to separate these areas.

Concerns persist regarding the environmental and community effects of the proposed LNG Terminal, particularly since local residents have not realized significant advantages from earlier development projects. Employment opportunities for local populations remain limited, with only a small fraction finding work in the industrial sector. While the fishing community supports development, believing it can benefit the nation, it is essential that local residents are included in the development process.

As the fishing industry faces decline, individuals are increasingly switching to other professions, but this transition is challenging for those lacking appropriate skills. Conversely, those with different skills are discovering better job opportunities in various sectors. Protecting local fishing grounds is critical in light of the proposed developments, as earlier initiatives have already hindered traditional fishing routes, forcing fishermen to travel greater distances, which has increased their operational costs and reduced their earnings.

The residents of Shireen Jinnah Colony warmly embraced the Project with open arms, eagerly anticipating that the project once completed, shall create opportunities for the benefits of the local population. Their optimism, however, is tempered by pressing concerns regarding environmental issues, particularly the inadequate sewerage system and improper solid waste disposal practices prevalent in the area. The community also grapples with challenges like frequent electricity and gas shortages, as well as the lack of access to clean drinking water, which are identified as major obstacles to their quality of life.

One of the longstanding issues that residents are deeply troubled by is the malfunctioning Shireen Jinnah pumping station, which has been plagued by sewerage problems for an extended period. The residents are adamant that

the station's rehabilitation is a top priority, as it holds the key to significantly enhancing the area's drainage infrastructure. The community's collective efforts to halt coal handling operations in the vicinity have yielded positive results, thanks to the unwavering commitment of the residents and the intervention of the esteemed Supreme Court of Pakistan.



Figure 5.6: Meeting with Communities

In light of these challenges and victories, the residents of Shireen Jinnah Colony remain hopeful for a brighter future, where their basic needs are met, and their environment is safeguarded for generations to come. The ongoing collaboration between the community, authorities, and relevant stakeholders is crucial in addressing these issues effectively and ensuring sustainable development in the area.



Figure 5.6: Meeting with Communities

5.2 Screening of Alternatives

Identification and assessment of feasible alternatives to project design and implementation is a key component of Environmental & Social Impact Assessment (ESIA) procedures. Alternatives serve to illustrate and contrast the environmental implications and consequences of various options available to achieve the proposed objectives. This process enables both the project proponent and the authorities responsible for granting authorization to make informed choices or decisions.

The selection of a preferred alternative considers multiple factors, including cost, delivery schedule, environmental and social impacts, and the expenses associated with their mitigation. Various drivers influence potential alternative options and scenarios, such as project site availability, current technologies, necessary design modifications, operational conditions, capital and recurrent

costs, and the associated environmental and social issues along with their impacts and mitigation costs.

The "No Project" alternative is also evaluated to justify the necessity of the Project. In light of these different drivers, potential alternatives within the Project are confined to particular aspects.

5.2.1 No Project Alternative

Assuming that Project PLUTO does not proceed, the onshore and offshore environment will remain unchanged, and existing port infrastructure will go unused, preventing the identified environmental and social impacts from occurring. However, the growing gas supply-demand gap presents a concerning scenario for authorities, necessitating alternate sources to bridge this gap. Currently, Pakistan imports nearly all its oil, with roughly one-third being utilized for electricity generation due to a persistent gas shortage. Reports indicate that Pakistan's gas fields may deplete within the next decade, with demand projected to rise to 7 BCFD while local production could drop below 2 BCFD. This situation implies a need for Pakistan to import LNG at three times the volume of locally produced gas, a critical issue that the 'no action' alternative fails to address.

The energy procurement options for Pakistan include:

- Continuing crude oil imports for refining.
- Importing petroleum products such as high sulfur furnace oil, gasoline, high-speed diesel, and LPG.
- Increasing local gas production.
- Importing natural gas via pipelines.
- Importing LNG through LNG carriers (LNGC) and supplying as LNG/RLNG.

Insufficient refining capacity limits the first option, while importing petroleum products, as seen in the second option, involves rising costs and demands alternative hydrocarbon sources or energy methods. Additionally, environmental degradation from carbon emissions remains a significant concern. For the third and fourth options, indigenous oil and gas resources are largely depleted, and while pipeline gas imports are feasible, they have become entangled in international politics, lacking immediate solutions. Consequently, LNG imports emerge as the most viable alternative for promptly addressing the energy crisis.

Importing LNG through LNGC is economically advantageous, as RLNG contains extractable hydrocarbons beyond methane depending on its source. Natural gas is an environmentally friendly fossil fuel, while using HSFO and HSD for power generation is undesirable due to their high sulfur content and

subsequent emissions of SOx and NOx. Thus, importing LNG not only fulfills the energy demand but also aligns with broader environmental benefits, positioning the proposed project as a sustainable solution to meet anticipated increases in energy consumption.

5.2.2 Evaluation of Alternative Options for Site Selection

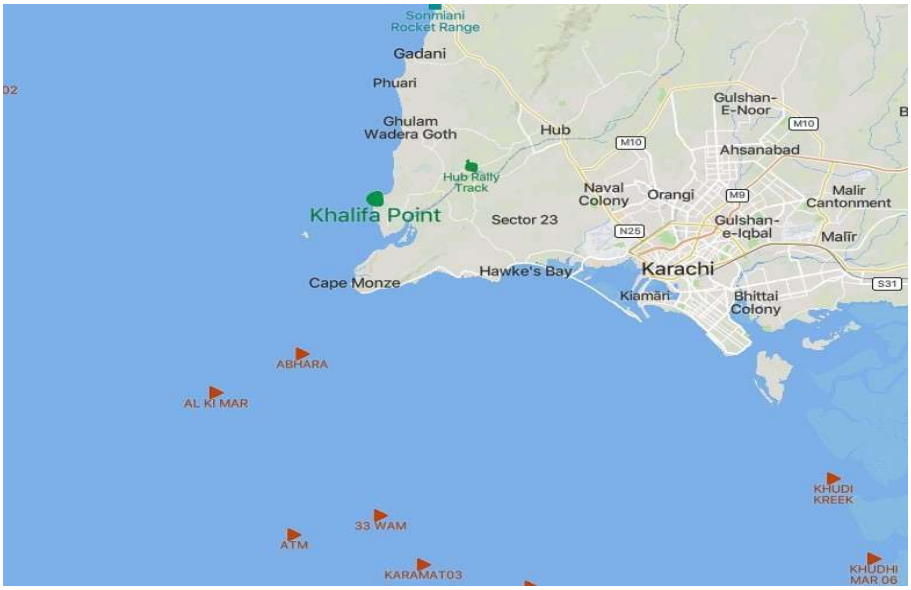
The guidelines set forth in the LNG Policy 2011 should be taken into account when selecting a site for an LNG facility.

Table 5.1: Safety Parameters for Siting LNG facility	
Approach Channel Width	Approximately 5 times the beam design (Should be demonstrated using simulation studies)
Turning Circle Dia	2 to 3 times the LOA (Should be demonstrated using simulation studies)
Tug Power	Recommended 60 Ton Bollard Pull Tugs. 3/4 in number. (Should be demonstrated using simulation studies)
Traffic Control	Vessel Tracking System (VTS) recommended for LNG carrier control.
Operating Limits:	To be established as per maximum wind
Speed Limits	Between 10-14 knot depending on hydraulic conditions prevailing
Under-Keel Clearance	1: 10 for sheltered channel 1:15 for exposed channel 1 Meter for berth
Navigable Depth	Not less than 10m CD but dependant on the vessel deployed for FSU and LNGC.
Ignition Source	Should be excluded from within the pre-determined radius from the jetty manifold.
Mooring Layout	Should hold the carrier safety alongside in all condition of wind and current (spacing about 150-290m and 40-50m inshore of berthing face).
Hooks	Quick Release hooks must be provided.
Emergency Release System	At each hard arm at the terminal. Emergency Release System (ERS) should be interlinked to the ship's Emergency Shutdown System (ESS).
Operating Limits	Should be established for berthing, stopping, cargo transfer, hard arm, disconnection and departure from berth.
Standard Area Limits: 150-250m around the vessels & jetty (Berthed / Discharging Cargo) (Refer Dispersion Modelling)	
LNG terminal, berths should not be sited on the outside of channel bends	
Pilots are mandatory on all vessels over 200 gross tons	
A minimum of two fast patrol craft required to enforce moving safety and security zones and to clear the channel and berth area in advance of the LNG vessel.	
Two dedicated handling boats, with a minimum of 400 HP required for mooring services.	

Table 5.1: Safety Parameters for Siting LNG facility
Buoys with range markers and radar reflectors on the tower are required for safe navigation

The following locations were considered to select an optimal site for the VLNG project:

Khalifa Point at Hub: This is a coastal cape located west of Isa, a small town in the Lasbela District, Baluchistan, Pakistan. At this site, two projects are operational: the HUBCO Power Plant, which is coal-based and features a coal receiving jetty, and the BYCO Refinery, which employs a Single Point Mooring System (SPM) for the transfer of crude oil.

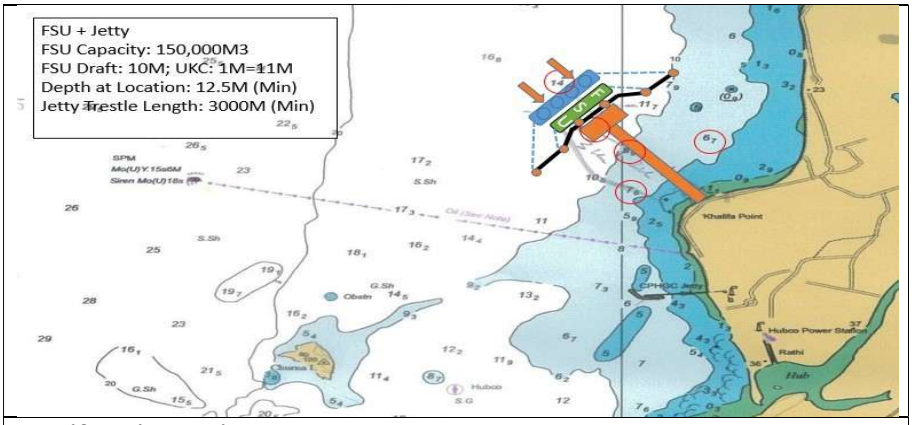


Development Options for VLNG Terminal:

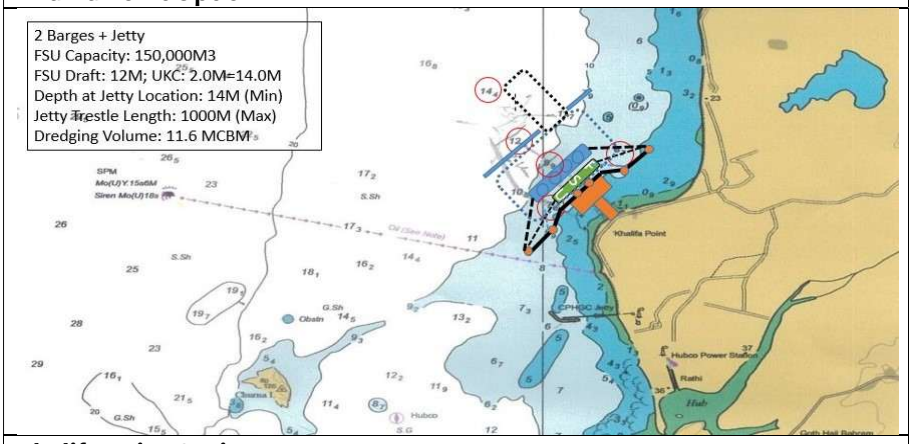
Option One: This involves the construction of an offshore jetty connected to the land by a trestle approximately 3.0 KM long. However, due to the deep and open sea location, operations would be limited to fair weather conditions.

Option Two: This option entails the creation of a basin and navigation channel with a draft of 14 m, bringing the LNG carrier closer to shore. This would require substantial dredging, around 12 million cubic meters, and the construction of a breakwater.

The two options are summarized for further consideration.



Khalifa Point Option 1

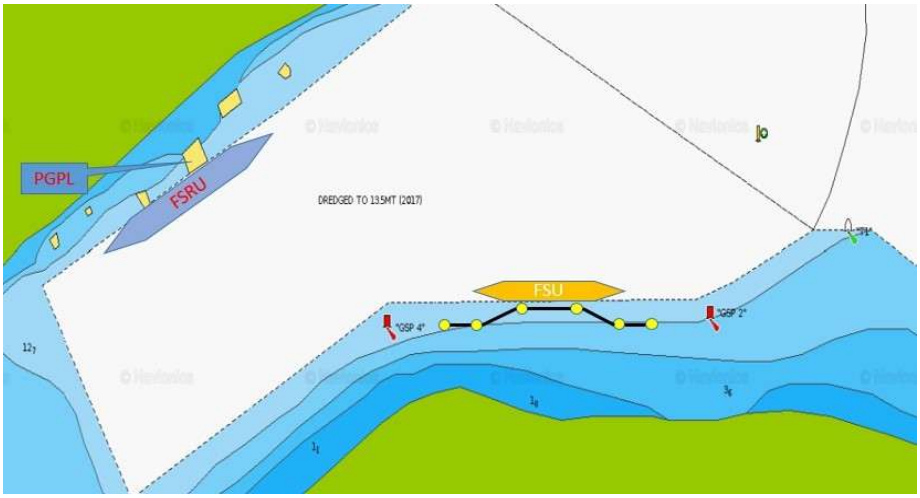


Khalifa Point Option 2

PQA Gasport Basin: The Pakistan Gasport features an FSRU-based LNG terminal located within the Port Qasim Authority (PQA). A new basin has been created, alongside the turning basin, to facilitate both the FSRU and the LNG Carrier (LNGC). The LNGC navigates through the PQA's main channel to reach the FSRU. The VLNG terminal's site was evaluated for use within the existing basin. Operations at the VLNG terminal would necessitate a floating platform adjacent to the FSU for the installation of ISO tank loading skids. These ISO tanks are intended to be transported by barge to the PQA container berth, approximately 4-5 nautical miles away, while crossing the main navigation channel for subsequent offloading onto trucks for further distribution.

However, PQA, upon reviewing the proposal, determined that the suggested location was unsuitable, as the traffic through the main navigation channel is already at capacity, making it impossible to accommodate an additional LNGC. Furthermore, the operation of barges would not be permitted if an LNGC is present at the PGPL terminal, leading to regular disruptions in the VLNG business.

The specifics of the proposed location are detailed below.





PQA Chan Waddo Creek: Chan Waddo Creek is situated adjacent to the primary PQA navigation channel, separated by a landmass known as Buddu Island, rendering it a completely isolated site. This separation has resulted in a natural basin, with average water depths of approximately 20 meters. The PQA has designated this area as an LNG Zone for the future expansion of LNG activities.

A potential location for the VLNG Terminal has been proposed by PQA, where operations would involve filling ISO tanks on a jetty platform and subsequently transporting these tanks on a barge to a PQA berth. This journey would utilize a natural channel that is about 7 meters deep and would involve crossing the PGPL basin as well as the main navigation channel.

It is important to note that barge operations would not be permitted if an LNG Carrier (LNGC) is present at the PGPL terminal, which could lead to frequent disruptions in the VLNG business.

Further details regarding the proposed location are outlined below:



Keti Bander: Keti Bander, one of the oldest harbors along the Arabian Sea coast, was excluded from the site screening criterion for several reasons:

- It is primarily utilized for fishing trawlers.
- The harbor has a very low draft, necessitating extensive dredging.
- The road network, essential for VLNG transport, is underdeveloped and would require significant capital investment to meet ISO tank transport standards.
- Roads in the area would be submerged during the monsoon season and high tides.
- There are security concerns due to its proximity to the Indian border.

KPT Pakistan Deep Water Container Port (PDWCP): The Karachi Port Trust (KPT) operates the South Asia Pacific Terminal Limited (SAPTL) alongside various other container terminals at its East and West wharfs. This terminal has been established to accommodate larger container ships (greater than 50,000 TEUs) arriving at KPT. The infrastructure includes a breakwater, a navigation channel (Tipu Sultan Channel), and a turning basin, all dredged to an average depth exceeding 16 meters.

Four container berths are situated to the west of the basin, leaving the entire northern coastline available for future development. The site is exceptionally well-suited for establishing a VLNG terminal due to:

- Easy road access
- Adequate depths that minimize dredging requirements
- Existing breakwater infrastructure, enabling all-weather operations for LNG carriers and floating storage units.

According to the screening criteria used for site comparison, KPT Pakistan Deep Water Container Port (PDWCP) inside the South Asia Pacific Terminal Limited (SAPTL) basin was identified as the most suitable location for the construction of an LNG terminal. The site coordinates are 24° 48' 39.58" N; 66° 59' 25.46" E.

A high-level summary of the scored screening matrix is presented in the table below:

S. No	Factor	Weightage	Sites Considered			
			Khalifa Point	PQA Main Channel	PQA Gasport Basin	KPT PDWCP
1	Port location/infrastructure	18%	4%	9%	11%	18%
2	Berth location assessment	18%	6%	12%	12%	18%
3	HSSE and Social	22%	12%	12%	13%	17%
4	LNGC support	16%	8%	14%	14%	16%
5	Downstream/Product Evacuation	13%	4%	8%	8%	13%
6	Regulatory Ease	13%	6%	3%	3%	12%
Total		**100%**	**39%**	**56%**	**60%**	**95%**

The project team has exercised professional judgment to evaluate the appropriateness of the project's location. The final determination of the preferred alternative relies on an in-depth analysis of the site safety criteria that have been assessed in the thorough Quantitative Risk Assessment and other relevant studies carried out by Project Proponents.

5.2.3 Evaluation of Alternative Options for Terminal Selection

LNGFlex Limited has conducted an in-depth analysis of the site selected at KPT, carefully considering various factors to identify the most suitable type of terminal. The analysis evaluated three options:

1. **Jetty with Trestle:** The Floating Storage Unit (FSU) is moored alongside the jetty.
2. **Quay Wall with Berth:** The FSU is moored alongside the berth.
3. **Floating Terminal:** The FSU and the floating terminal are permanently

moored alongside the berth.

These options were scrutinized based on construction capabilities, port limitations, project scheduling, and overall costs. After thorough evaluation, the conclusion was reached that the quay wall with berth emerged as the preferred option across all four criteria: construction ease, alignment with KPT limitations, scheduling feasibility, and cost-effectiveness.

5.3 Screening of Potential Impacts

The screening of possible impacts from both the construction and operational phases of the proposed LNG import terminal at Project PLUTO's location in KPT encompasses several key areas:

- Site Preparation
- Construction of Berth
- Waste Discharges
- Air Quality
- Noise Level
- Man-Made Hazards
- Natural Hazards
- Sensitivity
- Operational Risks and Hazard Management
- Socioeconomic Impacts

5.4 Evaluation of Environmental Impacts for Site Preparation

The site preparation works will involve dredging to create a pocket for the berth that can accommodate both the Floating Storage Unit (FSU)and the Liquefied Natural Gas Carrier (LNGC). One notable advantage of this approach is the ability to construct spaces towards the shore side rather than the seaside, thereby circumventing operational restrictions posed by existing port features, including the turning basin.

FasTFT, a software developed based on AutoCAD, is utilized to calculate the required amount of dredging. Using the Grid method, the total dredging

volume is calculated to be **1,074,072 cubic meters (CUM)**. It is proposed that the spoil generated from dredging will serve as fill material for the berth and for the development of the adjacent plot designated for the onshore terminal facilities.

The dredging activity typically results in a loss of biota in the affected area; however, this impact is short-term and localized. It has been observed that the benthic population is mainly confined to the upper10 cm of the substrate. Following the completion of construction, habitats and associated organisms tend to quickly re-establish or recolonize, with a regeneration time of approximately2-3 weeks in the newly constructed berthing and turning basin.

Siltation and sedimentation impacts at the dredging site are expected to be both localized and temporary. The potential impacts will be minimized through the application of appropriate dredging techniques. The increase in local water turbidity levels linked to dredging operations is directly associated with the type and volume of material being excavated. Additionally, sloughing of material along slope edges and turbulence caused by operational tug boats can further elevate localized water turbidity.

Suspended solids concentrations near a dredger can reach tens of milligrams per liter (mg/l) above background levels within 5 m (16 ft) of the cutter head. However, these concentrations diminish exponentially with distance from the cutterizer towards the surface and laterally and downstream. Typically, at the near seabed, concentrations are reduced to a few tenths of a mg/l within 300 m (984 ft) laterally from the cutter head, although current conditions may extend this radius further downstream.

During the Northeast (NE) monsoon, the concentration of suspended sediment in the shallow creek fluctuates between 25-178 ppm. Higher turbidity levels during the Southwest (SW) monsoon can reach approximately 300 ppm, posing risks to benthic organisms including interstitial fauna, fish eggs, and larval stages. To manage these effects, regular turbidity measurements will be conducted to ensure compliance with permissible limits.

The excess dredged material will be temporarily stored on the designated shoal, potentially impacting existing soft-bottom/sand benthic habitats. While this could lead to habitat loss, the newly formed shoal from the excess spoil is expected to create foundational support for new benthic habitats until the material is cleared away. Infaunal organisms can withstand burial of up to 4 inches, thus sedimentation impacts on benthic organisms are predicted to be minimal.

Dredged material will either be transported directly to the designated disposal site approved by the KPT or stored in temporary on-site areas. Some sedimentation and temporary turbidity may occur during the dewatering

phase of the dredged material. There will be no blasting involved during site preparation as rocks are not present in the dredging area.

To prevent oil spill incidents during the fuelling of dredge barges and vessels, a Spill Control Plan will be developed in collaboration with an Independent Monitoring Consultant (IMC) and enforced throughout the construction phase. Upon the completion of dredging operations, long-term impacts on benthic communities within the approach channel and turning basin are anticipated to be minimal. Despite short-term alterations to existing biological habitats, new habitats will quickly re-establish due to the natural current movements, mitigating long-term sedimentation impacts.

Land reclamation will be achieved by placing dredged spoils from berth and turning basin expansions into predetermined fill and stockpile sites, reducing sedimentation risks from runoff. To manage any sediment movement, techniques such as dykes with control weirs will be employed.

Turbidity control booms will also be installed around any fill areas that are not permanently contained. This proactive measure is expected to minimize adverse effects on marine resources from short-term sedimentation and turbidity. During terminal operations, periodic bathymetric surveys will be conducted by KPT and terminal operators to monitor bottom elevation changes and sediment accumulation.

The primary concerns related to dredging include increased turbidity, suspended sediments, and loss of benthic organisms. Each maintenance dredging event will involve turbidity monitoring to ensure adherence to international standards. If turbidity levels exceed permissible limits, dredging operations will be temporarily halted to make necessary adjustments.

Appropriate compacting techniques will be implemented for enhancing reclaimed soils, with these activities concluding before the re-establishment of new near-shore habitats. Once the proposed works are finalized, no significant adverse long-term operational impacts from site filling and soil compacting are expected.

5.5 LNG Terminal Installations

Impacts associated with the LNG Terminal will encompass both the construction and operational activities at the LNG import terminal. The proposed Floating Storage Unit (FSU) is intended to be constructed at an existing industrial facility abroad and then transported to PDWCP-KPT Karachi. Thus, the sole potential impacts of constructing the proposed FSU on the aquatic resources of PDWCP would involve the potential introduction of exotic species through ballast water and the effects of anti-fouling paint usage.

To facilitate the construction of the berth, the following steps would be necessary:

- The PDWCP basin boundary, delineated by buoys TS-9 and TS-11, will need to be extended up to the shoreline denoted as AB. This extension would necessitate dredging the area to a depth of -16 meters to align with the basin depth. The estimated total volume of dredged material is 1,074,072 cubic meters, with the intention of utilizing the spoil generated from dredging as fill material for the berth and the development of the adjacent plot for constructing onshore terminal facilities.
- The relocation of Navigation Buoy TS-11.
- The construction of a 400-meter-long quay wall along the shoreline using sheet piling.
- The establishment of a berth measuring 400 meters in length and 40 meters in width, equipped with fenders and bollards for securing the FSU alongside.
- The installation of tanker loading skids and FSU connection manifolds on the berth topside, with the specific number to be determined.
- The development of the Onshore Terminal Facility (OTF) on the adjacent land parcel delineated by boundary ABCDE, covering approximately 36 acres.

Pilings will be installed in previously dredged areas where no benthic habitats are expected to be present during borehole installation. To minimize potential impacts during pile installation, measures such as the use of non-toxic, clay-free, biodegradable drilling fluid will be implemented. Mooring points will be constructed above the water surface to reduce direct impacts on marine communities resulting from these construction activities.

Construction activities and vessel traffic are not anticipated to disrupt local fishing operations or impede fishermen's access to their fishing grounds temporarily. ***As the entire PDWCP is a developed port area devoid of mangroves, the project's construction and operational phases are not expected to have any direct or indirect impact on the mangrove ecosystem.***

During the ***operational phase, terrestrial ecology is projected to remain unaffected, with no reported presence of rare or endangered plant or animal species in the area.*** Anticipated impacts on marine mammals once the facility is operational are minimal, thereby obviating the need for mitigation measures.

The LNG terminals globally maintain an outstanding safety record and are unlikely to affect the terrestrial ecology of the area. Upon regasification, LNG transforms into natural gas, and any fugitive emissions or spillage necessitate no special remedial measures beyond adequate ventilation and diffusion in the atmosphere, integral components of the project design. Hazards from potential accidental LNG releases are detailed in the subsequent Risk

Assessment section. A Quantitative Risk Assessment (QRA) study has been conducted, with detailed findings provided in subsequent sections. ***The normal operation of the LNG Terminal is not expected to have any adverse impacts on terrestrial ecology.***

Mitigation Strategies

- **Site Protection**: Areas beyond the defined site limits will be preserved, with no disturbances or damage allowed. Indigenous species of trees and shrubs will be planted in collaboration with KPT and will be monitored by an Independent Monitoring Consultant (IMC).
- **Long-Term Impact Assessment**: ***There are expected to be no long-term impacts following the completion of construction activities, especially regarding the installation of berthing facilities.*** With suitable substrate, sunlight, and temperatures, benthic communities should be able to re-establish around the LNG terminal site. However, increased ship traffic may lead to long-term effects due to pollutant accumulation in the water and sediment, negatively impacting biological communities. To counteract potential impacts from pollutants and invasive species, all bilge discharge procedures will adhere to standard MARPOL regulations.
- **Benthic Habitat Recovery**: Impacts on benthic habitats are anticipated to be minimized through the natural reestablishment of bottom conditions and the resettlement of associated fauna. The natural dynamics of currents and tides are expected to restore the pre-construction distribution of soft bottom sediments, which will then be recolonized by infaunal organisms.

5.5.1 Waste Discharges

The project's operations are not expected to have significant effects on the hydrology or current dynamics of the channel. Furthermore, the volume of water discharges from the site is expected to be minimal, making it unlikely to measurably affect hydrologic patterns or currents that could disrupt local fisheries resources.

Water withdrawals and discharges associated with the proposed project's operations include several important components:

Ballast Water Withdrawals

During LNG (Liquefied Natural Gas) offloading, LNG carriers (LNGCs) will take on ballast water to ensure balance in cargo weight. This ballast water is crucial for the ship's stability, as it influences trim and list while meeting structural requirements. Additionally, LNGCs will use seawater for cooling while docked, with the required cooling water volume varying based on the ship's size and propulsion system.

Ballast Water Discharge

LNGCs are expected to arrive at the channel fully loaded, negating the need to discharge ballast water. Consequently, ***the potential impacts from ballast water discharge into the main channel are not foreseen.***

Storm Water Discharges from Shore-Side Facilities

The design phase will address appropriate stormwater discharge sites from the facility, ensuring that stormwater is not mixed with other effluents. Rainwater from storms will drain from the proposed FSU's above-water surfaces through scupper drains. The volume of storm water discharge will depend on rainfall amounts, with runoff at ambient temperature upon discharge to the channel. If any surface area is contaminated with oil and grease, the rainwater will be collected in a bilge holding tank for treatment onshore. ***No significant impacts on water quality from rainwater discharge are anticipated.***

Sewage Discharge

The onboard crew will generate greywater (from showers, sinks, and laundry) and sewage (from toilets). Prior to discharge, this wastewater will be treated according to SEQS, with treatment processes integrated into the project design.

Anti-Fouling Measures

Automatic biocide dosing, quality control, and feedback systems will be included in the project's design. The FSU operator is required to use anti-fouling paint on the FSU hull to minimize biological growth. This paint will be applied at the FSU provider's shipyard outside Pakistan and will not be reapplied during the project's lifespan. Some anti-fouling paints inhibit biological growth by leaching copper, but non-toxic, silicon-based anti-fouling paint will be used to prevent the attachment of organisms. This approach will mitigate impacts on benthic organisms, as the silicon-based paint creates an excessively slippery surface for organisms to adhere, ensuring compliance with the International Convention on the Control of Harmful Anti-fouling Systems on Ships adopted by the IMO.

5.5.2 Air Quality

Because LNG is primarily composed of methane, the release of vaporized LNG would not be associated with criteria air pollutants. The dispersion of methane vapors may lead to a temporary change in ambient air quality. Wildlife or humans located near the water surface in Hazard Zone I (within 500 m) could risk asphyxiation if natural gas has not dispersed adequately. However, the

exposure duration to appreciable pollutant concentrations would be brief, posing a minimal health risk to sensitive onshore receptors, especially considering the distance from a potential LNG spill at or along the LNG carrier transit route.

If an LNG release were to ignite, it would produce combustion emissions. Natural gas combustion in spill scenarios often results in incomplete combustion, generating criteria pollutants, hazardous air pollutants, unburned hydrocarbons, and soot (carbon particulates). The concentration of these ambient air pollutants is likely to exceed Sindh Environmental Quality Standards (SEQS) during the fire, leading to soot deposition and decreased visibility. The closer the receptors are to the release, the higher the pollutant concentrations would be during the short duration of the fire. Emissions from an LNG pool fire would be temporary and influenced by various factors including weather conditions and response actions.

Acute exposures to LNG or smoke from LNG-related fires could cause health issues such as exacerbation of asthma, irritation of the eyes, nose, and throat, and difficulty in breathing. Those exposed immediately downwind of the fire at the edge of the safety and security zone, particularly sensitive populations (children, elderly, or those with chronic illness), may experience more severe symptoms. This potential impact is most significant in Hazard Zone I (500 m) and diminishes in Hazard Zones II (up to 1600 m) and III (up to 3500 m). Nonetheless, due to rigorous safety and security measures during marine transit, the likelihood of an LNG spill is extremely remote, making significant air quality impacts unlikely.

Carbon dioxide (CO2) is a principal greenhouse gas that significantly contributes to global warming due to high volumes emitted from fossil fuel combustion. Modelling results for CO2 emissions were assessed against Threshold Limit Values (TLV) and Immediately Dangerous to Life and Health (IDLH) standards, which are set at 5,000 ppm and 40,000 ppm, respectively. Additionally, the Occupational Safety and Health Administration (OSHA) has established a permissible exposure limit (PEL) of 5,000 ppm for CO2 over an 8-hour workday. The modelling results indicate predicted concentrations of CO2 are within acceptable health and safety limits. The accompanying table presents average CO2-e emissions per megajoule (MJ) delivered for various ship types.

Table 5.2: Average CO_2-e emissions per MJ delivered using different ship types

Ship size (m^3)	137,000	145,000	155,000	210,000	265,000
Diesel Consumption (t/day)	35	35	25	30	35
t CO_2-e/t Diesel fuel	3.4064	3.4064	3.4064	3.4064	3.4064
LNG BOG consumption (t/day)	369.53	389.69	416.56	Nil	Nil

t CO_2-e/t LNG BOG	2.4173	2.4173	2.4173	2.4173	2.4173
GHG Index (t CO_2-e/t LNG)	0.028779	0.027896	0.011376	0.010083	0.008859
Average inflow gas quality (Btu/scf)	1092.2	1092.2	1092.2	1092.2	1092.2
Average emissions (g CO_2-e/MJ of LNG delivered)	1.5702	1.5220	0.6207	0.5501	0.4833
Source: Life Cycle Assessment (LCA) of Liquefied Natural Gas (LNG) by Paul Jonathan Barnett					

Mitigation Strategies

Construction Impact Management: Construction impacts on air quality will be managed through the adoption of effective construction management practices and adherence to Standard Operating Procedures, including appropriate dust suppression techniques. To minimize air quality impacts from the project's power production system, advanced technology will be employed to reduce emissions in compliance with SEQS and relevant international standards. The design of the power production system will focus on high efficiency and advanced combustion controls to lower fuel consumption and pollutant emissions.

Emission Monitoring Systems: Floating Storage Units (FSUs) and Liquefied Natural Gas Carriers (LNGCs) typically feature integrated monitoring systems that both record and manage emissions. Project Proponents will also carry out regular emission monitoring to complement data obtained offshore.

Dust Emission Control: To minimize fugitive dust emissions, dredged fill material will be pumped in slurry form through pipelines into dewatering basins near final reclamation areas. Construction equipment for final grading will utilize fill material with high moisture content to reduce the likelihood of generating dust. Additional measures to mitigate airborne particulate emissions may include:

- Applying water to exposed soil areas as needed.
- Prompt final grading and landscaping of exposed areas.

Short-term Emission Management: Emissions from vehicles and engine-driven construction equipment will be short in duration, corresponding only to active construction periods. Nonetheless, mitigation strategies, including routine maintenance of machinery and restrictions on unnecessary idling, will be enforced.

Compliance and Monitoring: All construction and operational emissions must adhere to air quality standards established by SEQS. By complying with

relevant legal requirements, any air quality impacts during the project's operation are expected to be negligible and remain so throughout its lifespan, backed by regular monitoring and analysis.

Cumulative Emission Control: Regulating emissions and monitoring microenvironment air quality levels aids in protecting against the cumulative effects of gases contributing to photochemical smog or acid rain. Project Proponents, in collaboration with KPT, will maintain an ongoing inventory of primary pollutants in the microenvironment.

5.5.3 Noise

Noise emission is a significant concern for the microenvironment of the workplace. The construction of LNG terminals and associated activities will elevate the ambient noise levels in the surrounding area. Particularly disruptive activities such as pile driving, dredging, drilling, and earthworks, along with machinery like compressors, contribute to increased noise pollution.

The impact of noise levels can vary considerably over time. Noise events that occur at night tend to be more disturbing to communities than those during the daytime. To account for this, noise equivalent levels are estimated by weighting the hourly Leq over a 24-hour period (Leq[24]), which includes adding 5 dB for evening hours (7 p.m. to 10 p.m.) and 10 dB for nighttime noise (10 p.m. to 7 a.m.). Environmental Assessment procedures utilize both Leq(24) and the day-night equivalent sound level (Ldn) to correlate the fluctuating qualities of environmental noise with their impacts on people, with Ldn accounting for the heightened sensitivity to nighttime sounds by adding 10 dBA to those levels.

In workplace environments, the effects of noise emissions on worker health are crucial. Industries and construction sites must either manage high noise levels at the source or provide workers with personal protective equipment (PPE). The assessment of noise emissions during the construction phase is informed by previous evaluations of similar construction activities in the KPT and PQA areas, where the construction equipment mirrors that planned for the new project. This allows for valid extrapolations of expected noise emissions based on established baseline measurements.

A table 5.3 compiling the noise emission levels from commonly used construction equipment would further elucidate specific contributions to the overall noise levels.

Table 5.3: Noise emissions from construction equipments

Source at Construction Site	Sound Level at Operator	
Background*	86	

Table 5.3: Noise emissions from construction equipments		
Earth Moving Equipment		
	Average value in dB(A)	Range in dB(A)
Front End Loader	88	85-91
Back Hoe	86.5	79-89
Bull Dozer	96	89-103
Roller	90	79-93
Scraper	96	84-102
Grader	<85	
Truck	96	89-103
Paver	101	100-102
Material Handling Equipment		
	Average value in dB(A)	Range in dB(A)
Concrete Mixer	<85	
Concrete Pump	<85	
Crane	100	97-102
Derrick	<85	
Power Units		
Generators	<85	
Compressors	<85	
Impact Equipment		
	Average value in dB(A)	Range in dB(A)
Pile Driver (diesel and pneum)	98	82-105
Pile Driver (gravity, bored)	83.5	62-91
Pneumatic Breaker	106	94-111
Hydraulic Breaker	95.5	90-100
Pneumatic chipper	109	
Other Equipment		
	Average value in dB(A)	Range in dB(A)
Poker Vibrator	94.5	87-98
Compressed Air Blower	104	
Power Saw	88.5	78-95
Electric Drill	102	
Air Track Drill	113	
Noise Standards		Noise Level
OSHA (at workers ear)		90 dB (A)
Day Time Community (at property line)		65 dB (A)
*Source: *British Columbia, "Construction Noise", Workers Compensation Board of BC*		

The construction activity for the establishment of the VLNG Terminal facility will utilize nearly all the equipment listed in the provided Table. This includes dredging barges and pumps—such as winches, cranes, and pipes for pulling, as well as power generators for dredged spoil compaction, piling, concrete batching, and sand pumping. Additional equipment includes jetting equipment, pipe compression test gear, and welding generators, as well as

power for temporary systems such as fuel, water, and sewage, alongside engines for tugs, launches, and ferries. The indicated equipment is notably noisy, making it essential to implement protective measures at the workplace and provide personal protective equipment (PPE) for workers. Noise levels during construction will be maintained well below the daytime limit of 75 dB(A) and the nighttime limit of 65 dB(A), as mandated by the Sindh Environmental Quality Standards (SEQS).

Fortunately, there are no developed residential areas in proximity to the site within the PDWCP, although noise from construction activities may be audible in the macroenvironment of the project area. Data from similar activities suggests that expected noise levels may approach the daytime limit of 75 dB(A). Measures are planned to address instances when noise may exceed SEQS limits, including providing earplugs for construction workers exposed to high noise levels, with mandatory PPE for those working in noisy environments.

Acoustic Effects

The acoustic effects along the marine side of the LNG Terminal Project may lead to amplified noise, particularly during low tides, especially with sudden bursts of sound like pile driving. However, ***due to the open land, acoustic waves from noise emissions will dissipate, resulting in only a mild impact reaching the shoreline.***

Several factors influence the potential impact of noise emissions from LNG terminal operations, including the distance to residential areas, local acoustic barriers, and the community's noise tolerance levels. LNG cargo unloading, storage, and re-gasification operations are generally low-impact activities. Overall, noise emissions during operational phases are expected to be significantly lower, primarily arising from equipment such as pumps, engines, and the unloading of LNG carriers at the jetties.

Noise Levels

Typically, LNG terminals and storage facilities are not noisy, with noise levels outside these facilities usually reaching acceptable levels of 70 dB(A). Noise may be slightly increased due to prevailing winds, but it remains a non-issue in offshore settings.

Marine vessels' noise emissions primarily originate from engine operations, which are effectively muffled due to their deep placement within the vessel structure. Only one vessel will dock at the berth at any given time, with expected increases in noise emissions being minimal (<3 dBA). Moreover, sound from marine vessels will occur intermittently, likely obscured by wind noise in offshore locations.

Mitigation Strategies

No additional mitigation measures are necessary beyond standard operating procedures, which include regular maintenance of equipment and the provision of PPE to workers in high-stress areas.

5.5.4 Manmade Hazards

Spills, leakages, or accidental releases of fuels, lubricants, or other hazardous substances during the operation of the proposed LNG project pose significant risks to water resources. According to the MARPOL 73/78 requirements, no oil or mixtures exceeding 15 parts per million can be discharged within 50 miles of the shore.

Identified Hazards

The manmade hazards that may impact the project include:

- Fuel Spills
- Fire and Explosion
- Marine Hazard
- Workplace Hazard
- Fuel Spills

Fuel oil spills can adversely affect soil, groundwater, and surface water, particularly during the project's operational phases. To manage these risks, operations will adhere to the spill management plan. Occasional equipment leaks from fuel and hydraulic systems are anticipated, but their impact will be limited through the following measures:

Mitigation Measures

- **Preventive Maintenance:** Scheduled mechanical preventive maintenance for equipment will help avoid and reduce the potential for leaks.

- **Secondary Containment:** Fuel tanks will be equipped with a secondary containment system to limit the impact of any tank failures. This containment will be impervious to fuel oil and sized to hold the entire tank's contents.

- **Spill Response Training:** Operators will receive spill response materials and training to effectively tackle pipe leaks and minimize land area impact from any release. Additionally, lines will be flushed to minimize risks post-transfer.

- **Chemical Storage:** During operations, chemicals will be stored securely in a warehouse with secondary containment arrangements, equipped with appropriate sorbent and clean-up materials to ensure effective spill management.

Fire and Explosion Hazards: The operations are not expected to pose fire and explosion hazards to surrounding islands, inhabitants, workers, or marine resources due to minimal quantities of flammable materials present on site. The use of portable extinguishing systems and personnel training on fire safety will further mitigate risks associated with small fires.

- **Cryogenic Risks**: Spills, leaks, or intentional draining of cryogenic or low-temperature liquids (such as LNG) could expose personnel to significant hazards, including oxygen deficiency, freezing injuries, and potential fire or explosive air-gas mixtures.

- **Hazard Analysis**: Fire and explosion hazards related to LNG facilities, particularly during receiving and subsequent operations, are outlined in a separate section titled "Risks." The Hazard/Risk Analysis examines various potential hazards and their effects on public safety regarding the site operations.

Mitigation Measures

- **Gas Detection and Fire Suppression**: Impact from potential fire and explosion incidents will be reduced through the implementation of gas detection systems and fire suppression systems that comply with international guidelines.

- **Control Systems and Procedures**: Established control systems and operational procedures will minimize risks of fires or explosions, ensuring safety for operations, the island, and personnel.

- **Secondary Containment**: In accordance with NFPA 59A standards to protect personnel and facilities, secondary containment areas will be established.

- **Firewater Systems on LNG Carriers**: LNG carriers will include firewater systems capable of delivering at least two jets of water to various critical areas on deck and containment systems. Relief valve capacities in cargo tanks will be designed to manage overpressure from potential fire situations, along with water spray systems for cooling and crew protection.

- **Fire Protection Systems:** The fire protection infrastructure will feature:

- *A deluge system for the accommodation house control room and main cargo valves.*
- *A traditional firewater system for fire monitors and stations on the ship.*
- *A dry chemical fire extinguishing system specifically for hydrocarbon fires.*
- *A CO_2 system for protecting machinery in key areas such as the ballast pump room and emergency generators.*
- *Additionally, certain areas will have powder-type extinguishing and CO_2 smothering systems for effective fire response.*

Marine Hazard: Shipments of LNG will be transported to the project site via the KPT navigational channel. LNG carriers will be equipped with safety devices, and the crews will receive training in safe handling and emergency response procedures. All carriers will comply with the IGC Code and the standards set by the International Maritime Organization (1993). Coordination of ship arrivals and departures will be managed by KPT.

Mitigation Measures

LNG shipments will adhere to the IGC Code and International Maritime Organization (1993). Each shipment will undergo inspection and safety checks prior to unloading/loading operations and before the vessel departs from the terminal.

There has been no recorded serious incident involving an LNG carrier in product transport as proposed for the LNG project. With the implementation of management controls and observance of internationally accepted codes and standards, the Project Proponents anticipate no marine safety-related impacts from LNG shipments.

Workplace Hazard: During the operation phase, workers may be exposed to potential hazards due to increased activities at the project site. Risks include exposure to materials at extremely low temperatures, oxygen depletion, heightened fire hazards, and risks related to high-pressure systems.

Mitigation Measures

All LNG carriers and shipping vessels shall comply with the International Convention for the Prevention of Marine Pollution from Ships (MARPOL). This international convention aims to prevent operational or accidental pollution of the marine environment by ships (IMO 1978). Therefore, any impact on water

resources from accidental releases is unlikely; in the rare event of a spill, the impact would be temporary and localized.

A Health and Safety Plan will be established for the operation phase, emphasizing the use of personal protective equipment and inherently safe equipment.

5.5.5 Natural Hazards

Natural disasters can occur near the project area, including severe storms, flooding, and earthquakes. TheHR Wallingford Modelling Study – 2010 for the deep-water container port indicated significant wave heights at various prediction points (WA1 to WA29). Points WA2 to WA22, as well as WA28 and WA29, are situated from the entrance channel of the deep-water container port (close to the southern end of New Manora Breakwater) to the northern end of its basin. Following the construction of the new, longer Manora Breakwater, it has been noted that the lower harbor and entrance to the DWCP have experienced enhanced protection against sea waves.

Additionally, the Geological Survey of Pakistan has classified the KPT area, where the site under examination is located, as being in a Seismic Zone 2B. A seismic risk factor of 0.3 is recommended to be factored into the design for operational basis earthquakes (OBE), which pertain to potential damage from moderate-level earthquakes (MM-VI to VIII). The design of the LNG facilities should account for these parameters.

5.5.6 Protected Areas

There are no designated Protected Areas near the project site. Additionally, this ESIA study did not identify any antiquity artifacts within the KPT microenvironment. No sites of cultural heritage are recognized at or immediately around the LNG Terminal location. Furthermore, there is no evidence of old settlements in the area, nor is there any designated site under cultural heritage listings. Consequently, the operation of the LNG facility is not expected to have any impacts, and therefore, no mitigation measures are necessary.

5.5.7 Risks

This section outlines the properties of LNG, along with the typical risks associated with an LNG release or leak.

5.5.7.1 Release of Liquefied Natural Gas

At atmospheric pressure, LNG boils at -162°C, presenting a cryogenic hazard that can cause embrittlement of carbon steel structures and frost burns to

exposed personnel. Boil-off gas from LNG carriers is usually warmer than -130 °C, and natural gas at around -120 °C is lighter than air.

Evaporated natural gas is cold and heavier than air, which means it will spread due to gravity. While LNG is non-carcinogenic and non-toxic, it acts as an asphyxiant because it can dilute or displace the oxygen present in the atmosphere, potentially leading to death by asphyxiation if exposure is prolonged. Because natural gas is colorless and odorless, confined spaces warrant special attention. In cases of large, uncontrolled releases, personnel in the immediate vicinity may experience low oxygen levels (typically <6-15 V%), necessitating both technical and procedural solutions to mitigate this risk.

When natural gas mixes with air, it can become flammable, but only within a narrow concentration range (usually between 5% and 15% for pure methane). Insufficient air results in inadequate oxygen for combustion, while excess air dilutes the gas too much to ignite. In the event of a spill, LNG vapors will disperse with the wind, appearing as a white cloud.

The cryogenic characteristics of LNG facilities pose risks to personnel and infrastructure, as exposure to extremely low temperatures can lead to frost burns for personnel and embrittlement of carbon steel, which could result in structural failure. Therefore, adequate protection against both cryogenic and fire hazards is essential.

5.5.7.2 Non-pressurized liquefied natural gas spill

LNG is stored in bulk storage tanks at its atmospheric boiling point (approximately -162°C). Any boil-off gas is collected, and the pressure relief valves are configured to maintain very low net positive pressure. Most spill scenarios from the storage tank occur at atmospheric pressure combined with the liquid head of LNG, meaning the static column of liquid above the release point. Notably, there is no pressure-induced flashing of LNG to methane; the phase change occurs due to rapid heat transfer and boil-off.

In cases of small spills from a height, most LNG vaporizes before reaching impoundment trenches, soil, or water, primarily because of heat transfer with the surrounding air and surfaces. Conversely, in very large spills, the available air cannot provide enough heat to vaporize all the LNG, leading to pool formation. Spilled LNG undergoes several simultaneous physical processes, including pool formation, spreading, and boil-off. The pool formation of cryogenic boiling liquids is dynamic in nature.

5.5.7.3 Pressurized liquefied natural gas spill/leakage

Within the LNG fuel supply chain, LNG may be stored and transferred under pressure through various means, including truck storage tanks, LNG cargo tanks, and smaller intermediate storage units such as LNG buffer tanks and ISO containers, as well as piping systems.

The spill rate of LNG in these scenarios is influenced both by the pressure in the intermediate storage tank and the static head. When LNG has been stored for an extended period, the immediate flashing may also depend on the level of superheating. Due to the pressure in pressurized storage, the reach of liquid sprays and jets can be considerable; however, the formation of liquid pools remains similar to those seen in non-pressurized LNG spills.

5.5.7.4 Dispersion

Methane gas, along with any heavier associated hydrocarbons, escapes from the pool and initially forms a dense gas at -162°C. The condensation of moisture from the atmosphere further increases the density of the gas above the pool. As the gas cloud disperses due to wind, it expands from gravitational effects and mixes with ambient air influenced by atmospheric turbulence. This mixing is also affected by heat exchange with the air and the re-evaporation of the condensed moisture. Eventually, the cloud reaches a neutral density point where dense gas effects diminish, and atmospheric turbulence becomes the primary factor in mixing. Depending on the circumstances, the cloud may turn buoyant since methane is significantly lighter than air (with molecular weights of 16 g/mol compared to 29 g/mol); however, the presence of heavier hydrocarbons and the cold temperature may limit its buoyancy, potentially diluting the cloud to a point where it does not pose significant flammable hazards.

5.5.7.5 Rapid Phase Transformation

Rapid phase transformation (RPT) occurs when LNG rapidly transforms into methane vapor, particularly upon submersion in water. This process is a physical phase change and does not involve combustion, thus it cannot be described as a detonation. The pressure pulse produced from small LNG pockets that evaporate quickly due to superheating in water propagates at the speed of sound, dissipating like any other pressure wave. This is unlikely to cause damage to the major structural components of a ship. Furthermore, no extensive modeling for RPT is performed, as it is not expected to extend the hazard range beyond that of an existing major spill.

5.5.7.6 Flash Fire

Dispersing clouds of methane and other hydrocarbons can be ignited when their concentration in the air is between the Lower Flammable Limit (LFL) and the Upper Flammable Limit (UFL) for the specific temperature and pressure. Most ignitions occur at the edges of these clouds as they encounter strong ignition sources, such as open flames, internal combustion engines, or sparks. Once ignited, the cloud will experience a "flash back" across its entire flammable mass, burning at the UFL boundary until all hydrocarbons are consumed, often leading to ignition of the pool.

The movement of flash fire zones through flammable clouds occurs at various speeds, influenced by factors like material flame speed, concentration (rapid combustion at stoichiometric concentrations versus slower at LFL and UFL), temperature, condensed moisture, turbulence, and congestion that enhances turbulence. When the flash fire reaches the evaporating LNG spill, it ignites and leads to a pool fire.

5.5.7.7 Pool Fire

If an LNG spill occurs near an ignition source, the evaporating gas can create a combustible gas-air concentration that ignites above the LNG pool. A pool fire may develop following a flash fire, producing significant thermal radiation. Notably, large LNG fires tend to be smoky, with experience indicating minimal smoke for pool fire diameters exceeding 30 meters, as the smoke absorbs considerable thermal radiation. Additionally, the spreading LNG spill pool may thin out, and once combustion is integrated with evaporation, the pool size will shrink significantly, resulting in a sustainable pool fire diameter.

5.5.7.8 Fireball/BLEVE

Fireballs are extremely rapid combustion events primarily linked to Boiling Liquid Expanding Vapor Explosions (BLEVE), which occur only with pressurized liquids. When these liquids are released quickly, the gases vaporize abruptly, generating intense speeds and turbulence. This phenomenon allows a flame front to propagate swiftly across the entire flammable region. Since these releases typically involve little air mixing, the fireball can burn through the complete outer envelope, resulting in a substantial release of heat over a duration usually ranging from 20 to 40 seconds.

Fireballs can also arise from significant gas discharges, such as major failures of town gas tanks; however, these are generally less radiant compared to those resulting from a BLEVE and necessitate specific high turbulence conditions that are unlikely to occur during an LNG spill in open environments. The typical BLEVE mechanism involves a pressure vessel filled with liquefied gas (for

instance, a recondenser) that is either exposed to an external fire or is undergoing catastrophic failure due to other factors.

5.5.7.9 Vapor Cloud Explosion

A vapor cloud explosion (VCE) can occur when a large flammable mass of hydrocarbon vapor ignites in a confined or partially confined space. The combustion of a stoichiometric mixture of hydrocarbon in air leads to an approximate 8 times increase in volume of hot combustion products compared to the ambient reactants. This substantial increase is primarily due to the high temperature of the combustion gases and also results in part from an increase in the number of moles of gas.

In confined environments, such as enclosed boxes, the resultant pressure can reach up to 8 bar (about 120 psi). Conversely, in open outdoor spaces, the lack of confinement means that methane gas burns relatively slowly, at about 10 m/s, with the combustion gases rising vertically. Experimental evidence indicates that in dispersed unconfined LNG vapor clouds, the overpressures generated are negligible, typically less than 1 mbar.

Within methane (natural gas) clouds, flame propagation tends to be slow, and many flames may not sustain throughout the entire cloud, often extinguishing prematurely. Importantly, a flame velocity of greater than 100 m/s necessary to create significant explosion overpressures will not be achieved over water without congestion or confinement.

5.5.7.10 Jet Fire

Dispersing clouds of hydrocarbons can ignite when their concentration is above the Lower Flammable Limit (LFL) and below the Upper Flammable Limit (UFL). Most ignitions occur at the cloud's edge when it encounters a strong ignition source, such as an open flame, internal combustion engine, or sparks. Once ignited, the cloud will rapidly flash back across its entire flammable mass, which is defined as the portion that exists within the flammable range, between the UFL and LFL. The burning will typically continue at the UFL boundary until all hydrocarbons are consumed, leading almost invariably to a flashback to the ignition source and resulting in a residual jet fire.

Several factors influence this process, including the flame speed of the material, the concentration of hydrocarbons (which reaches maximum speed at stoichiometric levels and lower speeds at LFL and UFL), temperature, the presence of condensed moisture, turbulence levels, and any obstacles that may enhance turbulence.

5.5.7.11 Risk Assessment

Risk assessment is a process by which the results of a risk analysis are used to make judgments, either through relative ranking of risk reduction strategies, or through comparison of the risk assessment with risk targets /criteria. The risk assessment stage (see Figure 5.7) determines whether the risks are tolerable, or if risk mitigation measures are required to reduce the risk to a level which can be considered as low as reasonably practicable.

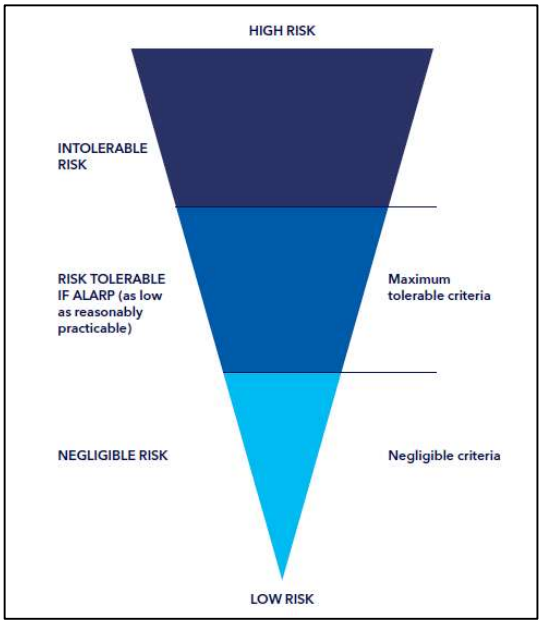


Figure 5.7: Framework for Three-band Risk Criteria

The Quantitative Risk Assessment has been performed for Pluto project to estimates the process risk to operations activities associated to flammable hazards (such as jet fires, flash fires) and overpressure hazards (such as vapour cloud explosions).

The analysis has been performed through the following steps:

- Identification of Accidental Events;
- Evaluation of Frequencies of Occurrence;
- Assessment of the Consequent Scenarios;
- Risk Evaluation and Assessment.

Results have been expressed in terms of Local Specific Individual Risk (LSIR). Comparing LSIR result with risk tolerability criteria, it can be stated that the LSIR values fall within the "Low risk area" (LSIR < 1 ×10-6 ev/y) and the "Medium risk area" (1 ×10-6 ev/y ≤ LSIR < 1 ×10-4 ev/y).

It is recommended to consider the implementation of risk reduction measures to ensure the risk is managed and minimized. Some examples are reported below:

- implement an adequate Emergency Shut-Down system, to reduce the quantity of hazardous substances released in the event of an accidental leak;
- implement an adequate Fire & Gas system, to promptly detect accidental leak and hazardous scenarios and to reduce the duration of the accidental releases;
- ensure the independence between instrumentation serving safety systems and that used for basic process control systems;
- carry out the design and construction of plant/equipment in accordance with internationally recognized standards and regulations;
- select proper materials and sealing devices in relation to the circulating fluid;
- consider using highly reliable control instrumentation and, for critical variables, redundant systems;
- adopt safety valves and depressurization valves on pipelines and equipment, in accordance with internationally recognized standards and regulations;
- consider minimizing the flanged connections, to reduce the frequency of occurrence of the loss of containment events.

The detailed report of QRA and HAZID / HAZOP is attached as Annex.

5.5.8 Socioeconomic Impacts

The socioeconomic impacts of the gas sector can yield significant benefits when managed wisely and sustainably, acknowledging its inherent limitations. It has played a crucial role in:

- **Indirect Employment Generation:** The gas sector has generated immense indirect employment, creating opportunities in various related industries.

- **Direct Employment:** While the direct employment impact has been modest, it still contributes positively to job creation.

- **Sustainable Development:** Although the contribution to sustainable development has been marginal, there is potential for increased impact with proper planning and execution.

The Project is set to stimulate economic growth at both the national and regional levels by enhancing energy availability. An increase in natural gas supply can reduce reliance on traditional fuels like diesel and coal, thereby addressing energy needs across transportation, industrial, and residential sectors effectively. Additionally, the Project will foster local economic development through internal revenue generation and job opportunities.

Host communities will enjoy benefits through a variety of corporate social responsibility (CSR) programs initiated by the Project Proponent, which will further contribute to local welfare. The overall cumulative effect on the national economy is expected to be strongly positive, aligning with the government's long-term development goals. Increased licensing income and other revenue streams will bolster government finances and stimulate economic growth by diversifying and expanding business ventures in Pakistan.

Moreover, the operation of the project will create both positive and negative impacts on coastal communities' livelihoods. While job opportunities and the establishment of vendor industries will be beneficial, challenges may arise as well. Recognizing the complexities in supporting the entire population near Karachi Port Trust (KPT) due to various constraints, LNGFlex Limited is committed to planning and implementing support activities under a CSR scheme. This may include:

- **Improving Landing Facilities:** Enhancements to local fishing facilities to support the community.
- **Enhancing Fish Handling:** Upgrading techniques aboard fishing vessels to improve quality.
- **Biodiversity Initiatives:** Promoting biodiversity through the planting and sustainable management of mangroves.
- **Quality of Life Improvements:** Providing basic amenities to coastal communities to uplift their standard of living.

Through these initiatives, the Project aims to create a more prosperous, sustainable, and resilient community while maximizing the socioeconomic benefits derived from the gas sector.

6.0 Environmental Management Plan (EMP)

This section presents the Environmental Management Plan (EMP) specifically for the operational phases of the proposed Project PLUTO, which focuses on the Closed-loop Virtual LNG (VLNG) Terminal at Karachi Port Trust (KPT). The EMP is designed to offer a comprehensive approach to managing and monitoring environmental concerns, as well as outlining the institutional framework necessary for its implementation. The purpose of this EMP is to establish commitments to environmental protection, thereby safeguarding the environmental values potentially impacted by the project's development, and aiding the governing authorities in determining suitable approval conditions for the project.

Earlier sections assessed the environmental impacts associated with various project activities and suggested mitigation strategies to alleviate these impacts. For effective environmental management, the SEP Act 2014 stipulates the necessity of developing an EMP to direct the organization's processes and employees towards ongoing improvement.

6.1 Need for EMP

The Environmental Management Plan (EMP) is essential for achieving the following goals:

Implementation of Measures: It outlines actions to be taken during the implementation and operation of the proposed LNG Project to eliminate or mitigate adverse environmental impacts, ensuring they are reduced to acceptable levels.

Defining Responsibilities: The plan specifies the roles and responsibilities of the project proponent regarding the EMP's implementation and identifies areas for shared responsibilities with other stakeholders.

Communication and Training: It establishes requirements for communication, documentation, training, and management of mitigation measures.

Monitoring Effectiveness: The EMP includes actions to assess the effectiveness of mitigation measures through a monitoring mechanism, identifying relevant parameters to confirm their successful implementation.

6.2 Scope of the EMP

The EMP recognizes the social and cultural aspects of responsible environmental management alongside biological and physical dimensions, portraying the Project Proponent as a "human ecosystem."

- **Management Systems:** These encompass all systems involved in managing the Project's operational activities, including financial systems, contractor engagement, and purchasing policies.

- **Knowledge Systems:** These processes are aimed at building knowledge and capacity regarding environmental issues, principles, and sustainable behaviors, incorporating training, communications, campaigns, and connections with operational departments.

- **Energy Management:** This refers to the planning, design, operation, and maintenance of energy-related aspects of Project Activities.

- **Water Management:** This includes considerations of supply, usage, and disposal of water that are relevant to the planning, design, operation, and maintenance of the Project Activities.

- **Materials Management:** This covers services and activities that promote waste avoidance, resource recovery (such as reuse and recycling), and environmentally responsible disposal of solid and liquid waste materials.

- **Planning, Design, and Development:** This includes the planning and development of the Project's built environment and related infrastructure.

- **Pollution Prevention:** It addresses planning and management strategies to minimize air and water pollution, as well as land contamination resulting from routine activities.

- **Transport:** This encompasses programs, projects, systems, and procedures that encourage walking, cycling, and public transport for commuting, accommodation, and related travel.

- **Biodiversity & Open Space:** This includes management and maintenance practices that support the conservation and enhancement of biodiversity and the sustainable use of open spaces within the Project and across other properties.

- **Occupational Health & Safety:** This pertains to identifying hazards related to LNG operations and implementing risk assessment and control measures.

- **Community Health and Safety:** This addresses risks linked to LNG carriers, communicable diseases, and pollution hazards.

6.3 EMP Process

The EMP consists of the following areas and defines the methods and procedures for its implementation.

- Organizational structure; roles and responsibilities of project personnel;
- Specific requirements of implementation of EMP;
- Mitigation or impact management matrix;
- Monitoring plan with emphasis on specific parameters to monitor.

6.4 Project Proponent's Commitment to EHS

LNGFlex Limited, as the Project Proponent, is dedicated to managing and operating its assets in alignment with its core values, ensuring the protection of public health, safety, and the environment. Compliance with relevant Environmental Health and Safety (SHE) laws, regulations, and internal standards is paramount.

To address environmental concerns effectively, the Project Proponent will establish a Safety, Health, and Environment (SHE) department. The SHE manager will lead this department and report directly to the Chief Executive Officer. Additionally, an SHE officer will be appointed to coordinate activities with contractors and the team, overseeing operations in sensitive areas throughout the project stages.

6.5 Management Approach

The environmental management process requires a specific methodology to effectively address relevant issues. The SHE Head/Manager will delegate roles and responsibilities for operations at the terminal. A certain degree of redundancy is anticipated across all management tiers to ensure that compliance with the environmental management plan (EMP) is consistently verified.

Compliance with the EMP is the obligation of Project Proponents at each project stage. Contractors and subcontractors will be expected to operate in an environmentally friendly manner under the oversight of the Project Proponent's SHE department. Regulatory bodies, including the EPA, will be consulted as necessary for guidance on environmental management, and they will receive periodic updates on local environmental conditions from Project Proponents and their teams.

Key Approaches to Environmental Management

- Adhering to applicable legislation and regulations.
- Conducting regular reviews of environmental impacts.
- Developing suitable indicators to monitor significant impacts.
- Establishing annual objectives and targets, with public progress reports.
- Monitoring the environmental management practices of suppliers.
- Utilizing sustainable materials (e.g., recycled paper and water-based inks) for office supplies, along with eco-friendly raw materials that can be recycled.
- Maintaining open communication with both internal and external stakeholders regarding environmental concerns.
- Ensuring the health and safety of workers and the community.

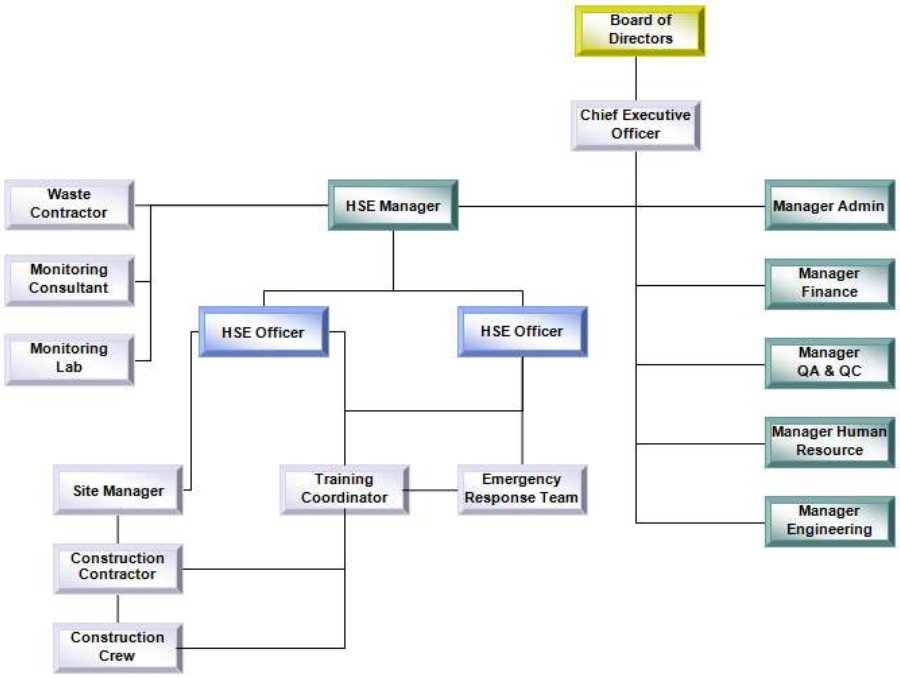


Figure 6.1: Indicative Organogram for Environmental Management

6.6 Training

All employees at LNGFlex Limited will receive the necessary training to effectively engage with the Environmental Management Plan (EMP). This training will equip workers with knowledge on minimizing waste generation. The SHE Head/Manager, in collaboration with the contractor, will assess the training needs for both the contractor staff and supervisory personnel, including the Environment Specialist.

The trainings outlined in the EMP include:

- Site Induction Course
- Emergency Response and Preparedness Training
- Familiarization Training with Site Environmental Controls
- Health & Safety Training for Employees and Contractor Staff aligned with the SHE procedures of both the Proponent and Contractor.
- Health & Safety Training for Community Members, particularly fishermen, focused on emergency situations and safe navigation while fishing.

6.7 Communications

For effective monitoring, management, and documentation of environmental performance during operations, the Safety, Health, and Environmental (SHE) issues are addressed in daily site meetings. Environmental concerns raised will be addressed through discussions between the SHE officer and the contractor, with any significant issues relayed to higher management for action. A weekly environmental report will be compiled by both the SHE department and the contractor, with copies provided to the higher management of both the Project Proponent and the contractor. Additionally, monthly reports will be submitted to the Sindh EPA.

Communication Strategies for Effective Management:

- **Kick-off Meeting:** This meeting is essential to clarify environmental responsibilities, raise awareness about the Environmental Management Plan (EMP), and align the work plan with the EMP prior to activity commencement.
- **Quarterly Meetings:** Following the kick-off meeting, these meetings will be held quarterly, unless a change to monthly meetings is warranted. Their

purpose is to assess the progress of activities, discuss challenges and ideas, and re-evaluate project deadlines as necessary.

- **Peer Review:** This process allows for critical feedback on assessments from professionals not directly involved in the project, ensuring that conclusions and documentation align with best practices.

- **Minutes of Meetings:** Minutes will be documented at the end of quarterly meetings, summarizing discussions, issues, and decisions along with their implementation timelines. Key points will be recorded for general employees and shared with higher management for their records.

- **Management, Coordination, and Information:** To mitigate environmental risks, it is imperative that management authorities have access to high-quality, relevant data for decision-making. This includes ensuring that the implementation staff and SHE department are informed and that all relevant stakeholders are involved in the management process. High-level coordination between the contractor and Project Proponent staff is crucial, along with the completion of a HAZOP study to ensure safety and compliance.

Table 6.1: Specific Responsibilities for Management & Coordination

S.#	Strategic Objective	Proposed Implementation Process	Suggested In-charge	Suggested Priority
01	To ensure high level of necessary information exchange.	▪ Make review document available to interested parties. ▪ Disseminate relevant information held by SHE department among the staff. ▪ Produce newsletter for publication annually for general awareness in all staff. ▪ Meetings using input from previous reports, advices receive from Stakeholders	▪ SHE Head/Manager ▪ SHE Officer ▪ SHE Head/Manager ▪ SHE Head/Manager	▪ High ▪ High ▪ On-going ▪ High
02	To ensure management plan is implemented, monitored and reviewed.	▪ Adopt management structure as proposed. ▪ Appoint full-time officer(s) with responsibility for long term	▪ SHE Head/Manager ▪ SHE Manager	▪ High ▪ High

Table 6.1: Specific Responsibilities for Management & Coordination				
S.#	**Strategic Objective**	**Proposed Implementation Process**	**Suggested In-charge**	**Suggested Priority**
		management and accurate monitoring. ▪ Examine annual progress report and review with respect to the monitoring progress. ▪ Conduct self-monitoring regularly	▪ CEO and SHE Head/Manager ▪ SHE Head/Manager	▪ On-going ▪ High
03	To improve decision-making process for management.	▪ Develop an appropriate form of management process, specific to the environmental issues ▪ Develop a fully comprehensive database of impact and mitigation understandable for the management.	▪ SHE Officer ▪ SHE Manager/ SHE officer	▪ High ▪ High
04	To ensure coordination between contractor and Project Proponent.	▪ Obtain support for a Memorandum-of-Understanding between management and Contractor for the implementation of: ✧ EPA Requirements ✧ EMP ▪ Continue regular liaison between management of Project Proponent and contractor.	▪ SHE Head/Manager ▪ SHE Officer	▪ High ▪ On-going
05	To develop strategic policies for better Environmental management.	Develop strong coordination between SHE department and top management.	▪ SHE Head/Manager	▪ High

6.8 Operation Phase

To successfully implement the EMP during operations, it is essential to adopt mitigation measures, a monitoring plan, and emergency procedures thoroughly. Training will be necessary at each phase, and any changes to management processes will be documented & made accessible to employees.

Mitigation Plan

The environmental impacts and corresponding remedial actions, along with designated personnel responsible for ensuring adherence to these mitigation measures, can be found in Chapter 05. Essentially, the mitigation matrix serves as the mitigation plan. Detailed descriptions of these impacts and measures are provided in earlier chapters.

Emergency Response Plan

A specific Emergency Response Plan for the Project will be developed, focusing on the various activities involved. This plan complements the EMP and outlines the required actions and responses for all Project personnel, employees, and contractors. Emergency response management will be overseen by a small team of senior managers, known as the control committee, who will direct all response activities through the Emergency response unit, alongside plant security, communications, public relations, safety, and environmental affairs, and material procurement departments. Each department will have specific responsibilities in the event of an emergency.

Possible Risks

Internal risks may arise from operational conditions or human error, potentially leading to personal accidents or spills.

Risk Management Procedures

Contingency Management at the Site:

- **Early Detection:** Implement alarms, detectors, and safety systems to ensure prompt recognition of potential hazards.
- **Immediate Automatic Reactions:** Activate feed shut-off valves for fluids, electrical processes, and other safety mechanisms without delay.
- **Emergency Area Confinement:** Establish protocols to isolate affected areas effectively.
- **Chemical Product Spills:** Prepare for potential or actual spills of chemicals on-site.
- **Occupational Accidents:** Address serious or fatal incidents linked to product contamination, non-compliance with operating protocols, negligence, falls, internal traffic incidents, burns, natural events, misuse of equipment, and personal protective gear.
- **Environmental Contamination:** Monitor and mitigate gas leaks, land spills, and maritime pollution.
- **Natural Risks:** Recognize and prepare for potential natural disasters, including:
    - Strong earthquakes

  - Tsunamis (flooding)
  - Typhoons/Cyclones
  - Lightning strikes
- **External Risks:** Assess threats from criminal activities, terrorism, or vandalism.
- **Personnel Transportation Risks:** Instruct all personnel to promptly report any transport incidents to the SHE Department for necessary support and notifications to health facilities and emergency services.
- **Evacuation Maps:** Clearly display evacuation maps, indicating assembly points, routes, and employee responsibilities.

Note: A comprehensive Site Plan fulfils the requirements for contingency maps, displaying both primary and alternate evacuation routes clearly.

Alarm Signals for Evacuation:

- Use various alarm systems including bells, horns, sirens, or a verbal public address to initiate an evacuation.

Emergency Equipment Listing:

- Maintain a documented inventory of emergency equipment in accordance with Hazardous Materials Storage Ordinance.

Training Programs:

- **General Personnel Training:** Implement training on:
  - Internal alarm notifications
  - Evacuation and re-entry procedures & assembly points
  - Emergency reporting protocols
  - Coordination with external emergency response teams
- **LNG Handlers Training:** Conduct annual training covering:
  - LNG handling protocols
  - Safe storage practices
  - Usage of fire and spill control equipment
  - Emergency procedures for spills
- **Emergency Response Team Training:** Ensure team members are proficient in:
  - Rescue procedures
  - Operational shutdowns
  - Emergency equipment usage and maintenance
  - Annual refresher courses and quarterly emergency drills.

By following these structured risk management procedures, the safety and preparedness of personnel and the facility can be significantly enhanced.

Table 6.2: Emergency Equipment Inventory			
Equipment Category	*Equipment Type*	*Location*	*Description*
Personal Protective Equipment, Safety, and First Aid Equipment	Face Shields First Aid Kits/Stations (describe) Hard Hats Plumbed Eye Wash Stations Portable Eye Wash Kits (i.e. bottle type) Respirator Cartridges (describe) Safety Glasses / Splash Goggles Safety Showers Self-Contained Breathing Apparatuses (SCBA) Other (describe)		
Fire Extinguishing Systems	Automatic Fire Sprinkler Systems Fire Alarm Boxes / Stations Fire Extinguisher Systems (describe) Other (describe)		
Communications and Alarm Systems	Chemical Alarms (describe) Intercoms / PA Systems Portable Radios Telephones Underground Tank Leak Detection Monitors Other (describe)		
Additional Equipment			

Emergency Response Training

Spill Clean-Up Procedure

Develop and practice a comprehensive spill clean-up procedure, including identifying the location of emergency equipment and understanding its usage. Ensure that all personnel on-site are familiar with emergency telephone numbers for reporting significant spills. The onsite spill kit should comprise:

- **Booms** to contain liquids
- **Materials** to prevent spills from entering drains
- **Absorbent materials** for spill absorption

Keep absorbent materials in a clearly labelled and easily accessible area.

Response Strategy

Upon the occurrence of an emergency, the response plan will be executed under the following conditions:

1. **First Stage: Notification**

    - **Internal Communication:** Establish radio communication systems for command posts and response personnel. Implement message forms to record essential information, including the informant's name, emergency location, number of affected individuals, and an assessment of injuries or damages.

    - **External Communication:** Notify the Harbour Master's Office immediately in the case of marine spills through the fastest means possible, utilizing telephone and fax as well as official reporting forms. Inform local authorities and, in the event of serious incidents, notify the Government and National Police, coordinating with Legal Counsel. Relatives of the injured should be informed promptly after hospital evacuation, and press notifications should be handled by designated management personnel post-investigation. If facilities are impacted, the Insurance Company must also be notified in coordination with Administration and Finance Management.

2. **Second Stage: Initial Assistance/Rescue**

Conduct a joint evaluation of the event's status, site conditions, and environmental factors to ensure safe rescue operations and first aid provision. Trained emergency teams should be ready, with backup personnel available. Evacuate non-essential staff to a secure area equipped with communication tools to account for personnel status. In case of fire, initiate immediate response measures.

3. **Third Stage: Response Operations**

Response operations will encompass:

- Firefighting utilizing extinguishers, water networks, or foam
- Oil and fuel spill control using absorbent materials or containment methods
- Gas dispersion and secure area access control
- Medical assistance and evacuation of injured staff

- Complete evacuation of personnel in life-threatening situations (e.g., earthquakes, tsunamis)

- Implementation of a monitoring program and mitigation plan.

4. Fourth Stage: Evaluation of the Plan and Damages

After response operations conclude, analyze the effectiveness of the plan and assess damages to formulate recommendations for future improvements. These recommendations will be incorporated into the annual revision and approval of the Contingency and Risk Prevention Manual, alongside a comprehensive record of incurred damages and resource usage.

Emergency Response Manuals

Commit to drafting written emergency plans for pipelines, plants, and marine terminals addressing potential emergency scenarios, based on results from a Quantitative Hazard and Risk Assessment.

Monitoring and Review

Conduct comprehensive monitoring of all activities to assess operational impacts on the environment. Utilize self-monitoring and reporting tools in compliance with EPA regulations. The SHE Officer will coordinate with the SHE Manager, responsible for monitoring procedures. Identify appropriate monitoring techniques and establish a frequency for selected parameters. Maintain a record of all observed nonconformities, reporting them along with corrective actions to the CEO, while also advising on anticipated impacts and recommendations.

Review

Carry out an environmental assessment of the proposed project based on project descriptions, site inspections, existing environmental conditions, and projected changes resulting from LNG facility operations. Reviews will address any modifications in project design and changes pertinent to record keeping and management plans following impact assessments.

Table 6.3: Mitigation Matrix Operation Phase

S.#	Aspect	Possible Mitigation Measures	Responsibility	Monitoring Frequency
1	Air Quality	Smoking should be prohibited at all sites	SHE Officer	Daily Monitoring
		Fire-fighting equipment should be available in all activity areas at all times	SHE Officer and Contractor	Monthly Monitoring
		Staff should be provided with personal	SHE Manager	Weekly

		protective equipments		Monitoring
		Safety valves should be provided with silencers	SHE Manager	Daily Monitoring
		Machinery and equipment should be housed in separate enclosures	Managers (Engg. & SHE)	Daily Monitoring
2	Noise	Working hours should be adjusted so as not to exceed 8 hours exposure in a single shift.	Managers (& SHE)	Daily Monitoring
		Earthmoving equipment (if any) should be kept in good condition by proper maintenance and servicing	SHE Officer	When it is required
		Use of horns should be prohibited within the activity area.	SHE Officer	Weekly Monitoring
3	Soil	Fuel, oil and other hazardous materials if stored on land area, should be provided with impervious lining	SHE Officer and Contractor	Daily Monitoring
		Combustible and explosive material should not be stored in storage area	SHE Manager	Daily during
		Fuel tanks and hazardous material should be marked appropriately	SHE Manager	When required
		Fuel storage areas should be checked regularly to identify leakage	SHE Officer	Daily Monitoring
		Safety equipments and utensils should be available at site at all times	SHE Officer	Daily Monitoring
		Vehicle Maintenance Yard should be developed at a designated location	SHE Manager	Daily Monitoring
		Where possible, segregation of solid waste during handling should be followed to manage it effectively	SHE Officer	Weekly Monitoring
4	Water Quality	Sewage should be treated appropriately at each unit	SHE Manager	Monthly Monitoring
		Vehicle cleaning should be prohibited near water bodies	SHE Manager	Daily Monitoring
		Weekly/monthly water/wastewater/ groundwater quality monitoring should be conducted throughout operation	SHE Officer	Monthly (Operation) Monitoring if required
5	Solid Waste	Solid waste should be collected and stored in environment friendly manner	SHE Manager	Weekly Monitoring
		Certified solid waste contractor should be hired for disposal of waste	SHE Manager	Weekly, if required
		Solid waste should be kept in closed container	SHE Officer	Weekly Monitoring
	Dredging	Placing dredged material directly into planned reclaim area	Contractor	Daily Monitoring
		Turbidity control booms will be placed as required around any fill areas not permanently contained	SHE Officer	
		Exposed soil materials will be protected by surface treatments such as armoring, pavement and vegetation	Contractor/SHE Officer	

6	Occupational Health & Safety	All procedures of Project Proponent related to SHE will be followed in letter and spirit.	SHE Manager	Daily Monitoring
		Grievance Policy of reporting incidence in place will be maintained Regular safety audits will be done	SHE Officer	Daily Monitoring
7	Community Health & Safety	Grievance Redressal Mechanism will be implemented by Project Proponent to ensure that community complaints are recorded.	SHE Manager	Monthly Monitoring

Table 6.4- Environmental Monitoring Plan

Stage	*Monitoring Component*	*Parameters*	*Location*	*Monitoring frequency*	*Standard*	*Responsibility*	*Supervision*
Operations	Benthic Flora and Fauna	Visual checks and sampling of benthic material to assess the situation.	Sea Water	Once in a year	Comparison with previous records	SHE Dep.	IMC
	Wastewater	Wastewater minimization Storage and handling Recycling and reuse Treatment before disposal Primary Pollutants of SEQS	All effluent the discharge points	Monthly	SEQS	SHE Dep.	IMC
	Sea Water Quality	pH, BOD, COD, TDS, TSS, DO, Oil and Grease	Vicinity of Project Area	All the sea water quality sampling will be carried out in low and high tide on quarterly basis during operation phase.	World Bank guidelines	SHE Dep.	IMC
	Solid Waste	Solid waste quality and quantity and disposal methods/locations Visual checks to assess the situation.	Project Area	Quarterly	N.A	SHE Dep.	IMC
	Aquatic Ecosystem	Key water quality indicators, Plant and animal species richness & composition, Conductivity,	Project Area	Quarterly	N.A	SHE Dep.	IMC

		Temperature, BOD, TSS, water level, Heavy metals, Vegetation cover, Heavy metals, Water level, Fish population structure its density & productivity					
	Fire & Safety	Fire Hazards & Safety Protocols	All Operational Areas	Continuous	N.A	SHE Dep.	IMC
	Air Emissions	CO, SOx, NOx, PM_{10}, $PM_{2.5}$, SPM	All operational areas including storage areas	Monthly	WHO/USEPA guidelines, SEQS	SHE Dep.	IMC
	Noise	Noise intensity measurement	All operational areas	Quarterly	OSHA, SEQS, World Bank Guidelines	SHE Dep.	IMC
	Hazardous spill	Spill on Land, Spill on Water	All operational areas	Continuous	SOPs	SHE Dep.	IMC
	Traffic management	Traffic Management Plan	Terminal approaches and exits	Continuous	Traffic Management Plan	SHE Dep.	IMC
	Health and Safety of workers	Accidents PPEs Annoyance Diseases	Terminal area	On quarterly basis	HSE Manual	SHE Dep.	IMC
	Accidents	Inspection and record checking.	Port area.	On quarterly basis	HSE Manual	SHE Dep.	IMC
	Compliance monitoring	○ EIA Commitments ○ Mitigation Measures ○ Conditions of Environmental Approval ○ SOPs	All areas	Monthly	EMMP	IMC	SEPA

6.9 Standard Operating Procedures

6.9.1 Wastewater/Storm water management

Purpose of Wastewater/storm water Management

The purpose of the adopted procedure is to provide guidelines and simplify the process of categorizing, quantifying, managing, and disposing of wastewater wherever and whenever arising during the project's construction and operation phase. Wastewater management is a critical component of company's operating policies. Wastewater management includes the proper disposal/recycling and reuse of the wastewater generated during construction and operation phase. The procedure is designed to assist in a company's wide effort to provide protection for the environment and to comply with company's corporate requirement, environmental laws and regulations regarding proper wastewater management.

Scope

Wastewater as part of construction and operational stages shall be managed as per this procedure. An integrated wastewater management system for the LNG Terminal is essential to reduce wastewater; this will be provided as a design input.

Substitute techniques must be investigated, including source reduction, recycling and reuse wherever possible with a view towards maximizing the benefits and minimizing the cost of each method of wastewater management.

Guidelines for proper handling, categorization, recording, minimization, and disposal of all types of wastewater associated with company operations and projects are part of this procedure that need to be documented. IFC EHS Guidelines for LNG facilities will be followed in operation phase.

This procedure shall be followed at all construction sites by all company personnel and contractors working for this proposed project.

Definitions

Wastewater

Any water arising after use/consumption shall be including of liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most general terms, it refers to the municipal wastewater that contains a wider range of pollutants arising due to the mixing of wastewaters from different sources.

Hazardous Wastewater

Plant wastewater comes in the category of hazardous wastewater. If it has one or more of the following properties:

- Oily water
- Toxicity (may cause risk of injury to health of organisms or the environment)
- Concentration of contaminants too high above safe acceptable limits

Non-hazardous Waste:

The wastes are categorized as non-hazardous wastes, if they do not possess any of the hazardous contaminant mainly comprising of consumed water arising from washing area and sanitary wastewater.

Procedure

Main concern to manage the wastewater is listed below:

- Eliminate wastewater production wherever possible.
- Minimize wastewater production.
- Recycle or Reuse
- Wastewater disposal in an environmentally safe manner through adequately designed facility

Wastewater Minimization

Generation of wastewater will be minimized through the following steps taken by working personnel at the facility:

- Through efficient use of raw water (minimizing the wastewater).
- Extensive management schemes will be formulated for both phases during construction and operations (water management).
- It is expected that segregated and /or treated wastewater will be made available for subsequent use during operations phase (recycling and reuse).

Storage and Handling

Wastewater shall be stored/retained in lined ponds or storage tanks till proper onsite treatment or remote disposal.

Recycling

Reuse of wastewater is a best way to reduce the quantity of the wastewater that requires subsequent treatment and disposal.

Treatment

- Biological treatment of wastewater through retention in septic tanks prior to disposal
- Sludge produced as a by-product of biological treatment be disposed of properly through burial pits
- Some of the wastewater will be reused for cleaning or washing purpose. The treated water should comply with Sindh Environmental Quality Standards (SEQS).

Disposal

Proper disposal should be done following the treatment through discharge into water bodies or sewerage system where available.

Waste Management Options

- All storm water run-off and pump-out from facility construction-sites will be inspected and directed to sedimentation basins to remove suspended solids (e.g., silt);
- Sewage will be collected and temporarily stored in tank(s) until it is transported to a designated wastewater treatment facility;
- Standard mobile sewage tankers should be engaged to collect and transport sewage from portable latrines and temporary storage tanks
- Oil spills in port waters could result from a variety of sources including on-shore industries; unsupervised bilge pump-outs; collisions and sinking of vessels; illegal discharges from vessels; accidents when transferring waste oil to storage facilities and accidents when refuelling vessels.
- To reduce the risk of oil spills occurring from a vessel, Maritime Safety Regulations ensure the safety of navigation, including the provision of navigation aids is maintained.
- Direct discharge will only be considered as a contingency option.
- During preparation of the final EMP, Project Proponent will undertake an evaluation of the proposed release of hydro-test water during construction of the storage tanks for LNG and condensate on-site. This will include an

analysis of the additives which will be present, their fate and anticipated environmental effects.

Recording & Reporting

Visually acquired wastewater management-related monitoring data will be recorded in field logbooks. These logbooks will be maintained as part of the Construction Spread Wastewater Management Records at each designated area or facility within a spread, wherever the stated wastewater management activities occur.

These monitoring data will include as applicable.

- Time, date and identify of individual performing the monitoring activity.
- Description of the process or activity being monitored.
- Findings or results of the monitoring activity.
- Description of activities to address deficiencies or problems; and
- Problems / Deficiencies, Remedial Measures.
- It is responsibility of the management to identify and implement appropriate remedial measures based on identified problems/deficiencies and to properly record and verify all EMP compliance initiatives

6.9.2 Noise and air emissions

Purpose

The purpose of this guideline is;

- To monitor contents of polluting substances in the atmospheric air;
- To control observance of approved limiting permissible emissions at manmade sources;
- To monitor natural sources and a number of manmade sources of emission at work sites at the construction phase;
- To monitor noise emissions;
- Sources of noise emissions.

Scope

Scope of work include

- Evaluation of present ambient air quality and noise level at existing area.
- Evaluation of impact of traffic movement at the proposed site and noise level.
- Evaluation of impacts on roads and in the adjacent area due to construction and operation.
- Recommendations for mitigation techniques to redress the expected impacts both for design phase and operational phase.

Definitions

In common use the word noise means unwanted sound or noise pollution. Excessive noise permanently damages hearing, but a continuous low level sound can be dangerous too.

Procedure

Air emissions (continuous or non-continuous) from LNG facilities include combustion sources for power and heat generation (e.g. for dehydration and liquefaction activities at LNG liquefaction terminals, and re-gasification activities at LNG receiving terminals), in addition to the use of compressors, pumps, and reciprocating engines (e.g. boilers, turbines, and other engines).

Emissions resulting from flaring and venting, as well as from fugitive sources, Principal gases from these sources typically include nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), and, in case of sour gases, sulphur dioxide (SO_2). For LNG terminal, air quality impacts should be estimated by the use of baseline air quality assessments and atmospheric dispersion models to establish potential ground level ambient air concentrations during facility design and operations planning. These studies should ensure that no adverse impacts to human health and the environment result.

Emissions of greenhouse gases together with NOx and SOx are expected from power generation units. All reasonable attempts should be made to maximize energy efficiency and design facilities to minimize energy use. The overall objective should be to reduce air emissions and evaluate cost effective options for reducing emissions that are technically feasible.

The main noise emission sources in LNG facilities include pumps, compressors, generators compressor suction/discharge, recycle piping, air dryers, heaters, air coolers at liquefaction facilities, vaporizers used during re-gasification, and general loading/unloading operations of LNG carriers/vessels.

Atmospheric conditions that may affect noise levels include humidity, wind direction, and wind speed. Vegetation, such as trees, and walls can reduce noise levels. Installation of acoustic insulating barriers can be implemented, where necessary.

Noise and Air Emissions Management Options

Noise and air emissions monitoring includes;

- Strategic environmental planning (e.g., plant sitting and fatal flaw analyses)
- Pollution control device feasibility, troubleshooting, and cost evaluations
- Innovative solutions and flexible permitting.
- Regulatory tracking and rulemaking negotiation on behalf of corporations and trade associations including New Source Review (NSR) Reform, Maximum Available Control Technology (MACT) standard development
- Enforcement assistance, economic evaluations, expert testimony.
- Environmental Management System (EMS) development
- Air permitting such as Prevention of Significant Deterioration (PSD), New Source Review (NSR), and state construction permits
- Air quality modelling and monitoring of air and noise emissions.
- Risk Management Plans
- Emission release inventories (Toxic Release Inventories, Global Warming and Green House Gas Inventories)
- Leak Detection and Repair
- Pollution control technology assessment,
- emission inventory development,
- capture efficiency,

- control equipment performance and equipment specifications and warrantees,
- compliance assessment,
- non-compliance resolution,
- negotiation of commercial terms for air pollution and control equipment and control systems, and
- Development of parametric monitoring, periodic monitoring, and compliance assurance monitoring.
- IFC EHS Guidelines for LNG facilities will be followed in operation phase.

6.9.3 Erosion protection requirements

Purpose Erosion Protection

Erosion control projects protect public and private land value and can help reduce sediment pollution by minimizing the degrading effects of erosion. Erosion control projects utilizing natural materials also conserve plant, fish, and wildlife habitat, as well as wildlife access to the land. Erosion control is necessary at the project sites which are interfacing with land and shore.

Scope

Soil erosion by water and wind affects the natural environment. Soil loss, and its associated impacts, is one of the most important, yet probably the least well-known of today's environmental problems. The scope of this activity is to control the erosion through practice of preventing or controlling wind or water erosion.

Definitions

The natural process by which the surface of the land is worn away by the action of water, wind, or chemical action is termed as Erosion. Shore erosion protection works are structures or measures constructed or installed to prevent or minimize erosion of the shoreline in the critical area i.e. is most likely to be the area influenced by the project.

Procedure

The best erosion control methods involve the restoration of natural environments along the shoreline. Replanting bay grasses and shrubs and

utilizing biodegradable materials as well as offshore breakwaters can stabilize soil while enhancing habitats at the same time. Structural barriers, such as bulkheads, compact soil, alter the composition of the land, and often undermine natural ecology.

Management Options

Adequate management and/or structural best management practices to minimize accelerated erosion prevent sediment pollution to the waters of the coastal area and maintain the resource base. Generally, this will require a conservation plan that meets the soil loss tolerance. Soil loss tolerances denote the maximum level of soil erosion that allows high levels of sustainable economic crop productivity.

- Wherever possible, non-structural erosion control measures, such as marsh creation, should be used to stabilize eroding shoreline.

- Where no significant erosion is occurring, structural shore erosion control measures should not be encouraged.

- Structural erosion control measures should only be used in areas designated for this activity and when non-structural measures are impractical or ineffective.

- A conservation plan includes best management practices to address erosion and sedimentation control and protection of the soil resource. In the absence of a complete conservation plan, an erosion and sedimentation control plan consisting of appropriate numbers and locations of sediment removal best management practices, must be developed, installed and maintained.

6.9.4 Cleanup and revegetation

Purpose

This involves removal of excess excavated material (not used as backfill), restoring the site surface to final contours, and stabilization of slopes. After clean-up, disturbed areas are stabilized, smoothed, mulched, reseeded, and fertilized as required. After construction is complete and clean-up is in progress, temporary erosion controls may be removed and permanent landscaping and erosion control measures installed where required as part of final facility reinstatement.

Scope

Topsoil is segregated from sub-soils during this operation. Top soil is stored in temporary topsoil stockpile areas for later use in re-vegetation programs. Regular visual inspection is conducted to monitor the growth of vegetation and to ensure that no erosion occurs on slope areas while the trees and other vegetation get established to protect the slope surfaces. The re-vegetation programs will be continued by the Project.

Procedure

To determine the number of protected species if any in or around the construction zone in order to assess damage inflicted on the natural environment through the loss of these species and the damage to their ecotopes in the course of clearing construction sites;

- To determine number of rare species growing within the determined populations in the clearance zone.
- To determine proximity of the rest of the species population to the pipeline route in order to assess the constructions possible impact on the whole of the population.
- To assess the condition of rare species in the impact zone prior to and in the course of the construction, as well as during commissioning of the facilities.

Management of Clean-up and revegetation

Responsibilities

The SHE Officer is responsible for verifying that clearing and re-vegetation is performed in compliance with applicable environmental requirements and specifications.

Instructions

The SHE Officer will verify that the layout at the facility work area and temporary use areas conform to project.

- The SHE Officer will verify that clearing and revegetation is performed in accordance with construction Specifications, which include requirements for timber removal, slash disposal, and dust control.
- The SHE Officer will verify that any debris resulting from clearing activities that may block stream flow, contribute to flood damage, or result in streambed scour or erosion is immediately removed from the stream area.

- The SHE Officer will verify that all necessary measures are taken to minimise erosion and transport of sediment and silt from graded and disturbed work areas. Erosion control specifications and site-specific erosion control plans will be followed to ensure that disturbed areas are stabilised and erosion is minimized to the greatest extent practicable.

- Environmental inspection will be conducted during clearing and grading activities and in coordination with Construction Superintendent.

Recording & Reporting

The SHE Officer will document on a Daily Environmental Inspection Reports (DIR) the progress of clearing and revegetation activities and status of compliance.

6.9.5 Waste management plan

Purpose of Waste Management

The purpose of this procedure is to provide guidelines and simplify the process of categorizing, quantifying, managing, and disposing of solid wastes. Waste management is a critical component of company's operating policies. Waste management includes the proper handling, collection, storage, manifesting, transportation, and disposal/recycling of the solid waste generated. The procedure is designed to assist in a company wide effort to provide protection to the environment & to comply with company's corporate requirement, environmental laws and regulations regarding proper waste management.

Scope

The waste management plan will be developed by the pipeline / jetty construction contractors to ensure that the Management of solid waste generated as a result of the construction of the pipeline and associated activities is consistent, efficient, and in conformance with the laws and regulations. With respect to monitoring, the waste management sets out the following objective:

- To monitor and inspect waste management-related facilities and activities directly resulting from executing the scope of the contract in order to ensure compliance with the Waste Management Plan (WMP). Guidelines for proper handling, categorization, recording, minimization, recycling and disposal of all types of waste associated with company operations and projects are part of this procedure.

Definitions

Waste

Any material, for which no further use is intended, is considered a waste. It can be solid, semi-solid or liquid. Additionally, abandoned materials and materials intended to be recycled are considered wastes. It is very important to understand this concept, because even though something is going to be recycled, it must be managed as a waste until it is actually recycled.

Hazardous Waste

Waste is categorized as a hazardous waste if it has one or more of the following properties:

- Ignitability (flash point less than 600°C);
- Corrosivity (pH less than or equal to 2.0, or greater than or equal to 12.5);
- Reactivity (inherently unstable under ordinary conditions or when exposed to water);
- Irritability (when in contact with body causes inflammation)
- Toxicity (may cause risk of injury to health of organisms or the environment.)

Non-hazardous Waste:

The wastes are categorized as non-hazardous wastes, if they do not possess any of the hazardous characteristics as defined above. However, non-hazardous waste may still present hazards to employees who handle them. All recommended safety and handling practices must be followed.

Procedure

Priorities to manage the waste are listed below:

- Eliminate waste production whenever and wherever possible. Use the material only for its intended purpose on site
- Minimize waste production
- Reuse
- Recycle waste on site.
- Dispose of waste through properly designed waste disposal facility.

- IFC EHS Guidelines for LNG facilities will be followed in operation phase.

Coding system for different type of waste	Coding system for different type of waste
Waste material	**Color or code**
GLASS	(BLUE)
METALS	(GREEN)
PLASTIC	(WHITE)
OILY RAGS	(BLACK)
USED OIL	(RED)
RUBBISH / TRASH	(YELLOW)

Waste Minimization

To minimize waste, the following steps shall be taken by all personnel working on project sites:

- Only the needed amount of materials shall be ordered. Before purchasing hazardous material, all alternatives for non-hazardous material should be explored.

- Prior consideration shall be given to the sizes of containers available when ordering products that could potentially generate waste. The intent is to avoid unused products and/or their containers from becoming wastes that require special handling.

Waste Categorization

All wastes generated at project facilities shall be categorized in two major categories (i.e. Hazardous wastes and Non-hazardous wastes) as per the definitions in section C. Each category has different types of requirement for handling, storage and disposal.

Labelling

- Name of the waste (e.g., waste oil, solvents).

- Waste category (e.g., toxic, ignitable).

- Facility name and address (disposal site, etc.).

- Date of waste accumulation: (date when waste was placed in drum).

- Wastes are segregated and located in designated areas to optimize control; storage areas.

Segregation

Waste management becomes very complicated if different types of waste are mixed together. A small amount of hazardous waste, mixed with a non-hazardous waste or recyclable material, can make the whole mixture a hazardous waste. Disposal costs and liabilities for hazardous waste are very high, so it is extremely important to identify wastes and keep them segregated.

The scheme of segregation is as follow:

- All hazardous waste shall be segregated from other types of hazardous wastes as well as non-hazardous wastes at the point of generation of waste.

- At all facilities, containers, with colour coding for easy identification, shall be kept to collect and segregate common wastes. A proposed scheme is as under:

- Food waste shall be collected in separate containers.

- All containers must be properly and clearly labelled. The label must clearly mention the name or type of waste. Also, if the waste is hazardous, it should be clearly labelled on the container along with its hazardous characteristics (e.g. flammable, toxic, radioactive, etc.). This is important to workers and to emergency response teams, who need to know what they are dealing with. Missing or unreadable labels must be replaced.

Storage and Handling

- Waste that will be sent for recycling or off-site disposal shall be temporarily stored at waste storage facilities available at different sites such as Junkyard, Scrap yard, pits, etc.

- The oily sludge, contaminated soil and other hazardous liquid waste shall be stored in lined pits with HDPE liner. Liner shall be of sufficient thickness (at least 20mil) and adequate strength to withstand tears and punctures.

- All other wastes awaiting disposal shall be kept in closed containers separately. Care must be taken to prevent wastes giving rise to secondary environmental problems, such as odours or soil and groundwater pollution through rainwater leaching.

- All stored wastes must be clearly labelled with type of waste and warning signs.

- Daily estimates of hazardous and no hazardous waste and volumes generated on site.

- Waste segregation, waste storage containers, general housekeeping and the provision of adequate resources will be monitored.

- All workers handling wastes shall use proper PPE.

Recycling

Recycling and reuse minimize the quantity of waste requiring disposal. Some of the wastes can be reused within the facilities while others can only be recycled at off-site recycling centres. For example, recycling of used oil is possible in some of the Lube Oil Recycling companies; batteries may be sent back to manufacturer or distributor for recycling. Waste shall not be sold to the unauthorized contractors/companies, who may not have proper recycling facilities, to avoid misuse and to reduce associated liabilities. The possibilities of recycling of each waste are discussed in relevant documents.

Treatment

Some of the wastes, such as wastewater from camps, oily wastewater from process, etc., require proper treatment before disposal. The treated water should comply with Sindh Environmental Quality Standards.

Disposal

Disposal becomes the only available alternatives, if reuse and recycling options are exhausted. A material should be classified as a waste for disposal only if no other useful purpose can be identified and if the material cannot be beneficially reused or recycled. The choice of a suitable disposal option for any waste depends on both environmental and economic considerations. The final disposal shall be done through EPA approved waste management contractors.

Recording & Reporting

Project Proponent has to record the information about source, composition, quantity, and final disposal of the waste. This information is needed for regulatory compliance, risk assessment and setting reduction targets and objectives as well as corporate statistics.

The Waste Tracking Form shall be used to record this information by all Project Proponent teams, while waste is being dispatched outside facility or Project's controlled location. It will be made necessary to sign off the Waste Tracking Form, before the waste is dispatched outside.

Waste Tracking Form			
Location of Generation: Reporting Team: Submitted by (Name): Submitted on (Date):			
Type of Waste	*Approx. Quantity*	*Unit*	*Disposal Location*
Checked and Signed	dated:		

6.9.6 Environmental Inspection by SHE department

Purpose

This procedure identifies environmental responsibilities for the project offices and for the construction site SHE Incharge. It also provides procedural guidance for environmental training, inspection, monitoring functions during construction.

Scope

Primary scope of environmental inspector/monitor is to comply with the environmental requirements of the project. Project Proponent is also responsible for inspecting, documenting, and ensuring that construction meets environmental responsibilities through an integrated program of personnel orientation and training, and inspection of construction activities. In addition, the company will assist in implementing environmental management plans through its program of construction inspection.

Definitions

Consists of examining construction activities in the field to verify and document those activities are carried out in compliance with construction & environmental Permits, specifications relating to environmental protection, and mitigation plans approved for the proposed LNG Terminal Project.

Procedure

The company will establish a plan detailing the procedures and documents required for implementing environmental management plan thereby complying with the environmental legislations and regulations during the construction and operational phase of the project.

Management Options

Functions and responsibilities that will be assigned to company's SHE department include:

- Orientation of LNG project personnel in environmental requirements and procedures particularly in context to the sensitive resource issues at the construction site.
- Environmental training particularly in environmental monitoring is to be imparted to all project personnel.
- Inspection of facilities construction activities for compliance with environmental regulations,
- Specifications, stipulations, drawings, mitigation plans, and procedures.
- Documentation of all training, inspection, and monitoring activities should be exercised.
- Coordinate with the owner's environmental representatives and management personnel on environmental issues.
- Provide technical support to Owner for obtaining environmental permits or other Authorizations as needed or modified during facilities construction.

Recording & Reporting

Environmental compliance records will be completed daily (as applicable) on standard reporting forms. Other records may include daily logbooks, meeting notes, correspondence, or records of telephone conversations. Compliance reports and other appropriate records will be logged into the field ES&H office and copies transmitted to the project office.

Forms will be used to document field inspection activities. They become permanent documents when completed by the SHE personnel and reviewed and signed by the appropriate supervisor, as required. Documentation that will be used by field environmental compliance personnel is summarized below.

Daily Environmental Inspection Checklist

The purpose of the checklist (to be prepared by SHE department) is to document the results of the environmental inspection activities conducted during the day with respect to compliance of observed construction activities relative to applicable environmental requirements.

The SHE Head/Manager reviews the report for adequacy and accuracy and identifies potential problem areas. Construction signoff is required only if there is a noncompliance requiring action and/or acknowledgement by Construction. Copies of all checklists are filed in the site SHE files.

Weekly Inspection Report

A weekly inspection report is prepared by the site SHE personnel after completing a general inspection of site and submitted to the field SHE Head/Manager with copies to the Environmental Lead. The report includes:

- Summary of inspection and monitoring efforts on the spread over the past week;
- Identification of any non-compliance and steps taken to correct non-compliance;
- Any other issues or problems encountered in carrying out inspection activities (e.g., schedule delays);
- Government representatives on-site during the week;
- Inspection and monitoring plans and schedules for the upcoming week.
- General site audit and completion of the "Weekly Inspection Checklist".
- The Owner will have a standing invitation to accompany project personnel on this audit. The checklist will be modified over time to reflect pertinent issues related to the phase of construction presently occurring.

6.10 Contingency planning-accidents & malfunctions

6.10.1 Fire Contingency Plan

Because flammable/combustible materials are present at this site, fire is an ever-present hazard.

All personnel and subcontractors are not trained professional fire-fighters. Therefore, if there is any doubt that a fire cannot be quickly contained and extinguished, personnel will notify the Site Superintendent by radio and vacate the area. The Site Superintendent will immediately notify the local Fire Department.

The following procedures will be used to prevent the possibility of fires and resulting injuries:

- Sources of ignition will be kept away from where flammable materials are handled or stored.
- The air will be monitored for explosivity before and during hot work and periodically where flammable materials are present. Hot work permits will be required for all such work.
- No Smoking" signs will be conspicuously posted in areas where flammable materials are present.
- Fire extinguishers will be placed in all areas where a fire hazard may exist.
- Before workers begin operations in an area, the foreman will give instruction on egress procedures and assembly points. Egress routes will be posted in work areas and exit points clearly marked.
- The following procedures will be implemented in the event of a fire:
- Anyone who sees a fire will notify their supervisor who will then contact the Site Superintendent and the Health and Safety Officer by radio. The Health and Safety Officer will activate the emergency air horns and contact the local Fire Department.
- When the emergency siren sounds, workers will disconnect electrical equipment in use (if possible) and proceed to the nearest fire exit.
- Work crews will be comprised of pairs of workers (buddy system) who join each other immediately after hearing the fire alarm and remain together throughout the emergency. Workers will assemble at a predetermined rally point for a head count. When a small fire has been extinguished by a worker, the Site Superintendent and the Health and Safety Officer will be notified.

Evacuation Procedures

In the event on-site evacuation of remedial action personnel is necessary, the following actions will be taken:

- The emergency signal will be activated (one single long blast on the air horn).
- No further entry of visitors, contractors, or trucks will be permitted. Vehicle traffic within the site will cease in order to allow safe exit of personnel and movement of emergency equipment.
- Shut off all machinery if safe to do so.

- All on-site personnel, visitors, and contractors in the support zone will assemble at the entrance to the site for a head count and await further instruction from the Site Superintendent.

- All persons in the exclusion zone and contamination reduction zone will be accounted for by their immediate crew leaders (e.g., foremen). Crew leaders will determine the safest exits for employees and will choose an alternate exit if the first choice is inaccessible.

- During exit, the crew leader will try to keep the group together. Immediately upon exit, the crew leader will account for all employees in his crew.

- Upon completion of the head count, the crew leader will provide the information to the Site Superintendent.

- Contract personnel and visitors will also be accounted for.

- The names of emergency response team members involved will be reported to the Site Superintendent.

6.10.2 Hazardous spill contingency plan

In the event of an emergency involving hazardous material spill or release, the following general procedures will be used for rapid and safe response and control of the situation.

Emergency contacts provide a quick reference guide to follow in the event of a major spill. Hazmat spill responses will be coordinated through the local Emergency Response Centre.

Notification Procedures

If an employee discovers a chemical spill or a vapor or material release, he or she will immediately notify the Site SHE personnel.

The Site SHE personnel will obtain information pertaining to the following:

- The material spilled or released.

- Location of the release.

- An estimate of quantity released and the rate at which it is being released.

- The direction in which the spill, vapor or smoke caused by the release is heading.
- Any injuries involved.
- Fire and/or explosion or possibility of these events.
- The area and materials involved and the intensity of the fire or explosion.

This information will help the Site SHE personnel to assess the magnitude and potential Seriousness of the spill or release.

Procedure for Containing/Collecting Spills

The initial response to any hazardous spill or discharge will be to protect human health and safety, and then the environment. Identification, containment, treatment, and disposal assessment will be the secondary response.

If, for some reason, a chemical spill is not contained within a dike or sump area, an area of isolation will be established around the spill. The size of the area will generally depend on the size of the spill and the materials involved. If the spill is large (greater than 55 gallons) and involves a tank or a pipeline rupture, an initial isolation of at least 100 feet in all directions will be used. Small spills (less than or equal to 55 gallons) or leaks from a tank or pipe will require evacuation of at least 50 feet in all directions to allow clean-up and repair and to prevent exposure. When any spill occurs, only response personnel will be allowed within the designated affected area. If possible, the area will be roped or otherwise blocked off.

If the spill results in the formation and release of a toxic vapor cloud, further evacuation will be enforced. In general, an area at least 500 feet wide and 1,000 feet long will be evacuated downwind if volatile materials are spilled. If an incident may threaten the health or safety of the surrounding community, settlement, etc., it will be consulted and determine if the public will be informed and possibly evacuated from the area. The Site SHE personnel will inform the proper agencies in the event of its being necessary.

The designated Response personnel will take the following measures:

- Avoid breathing vapors of spilled material.
- If possible and safe to do so, turn off any ignition source or gas emergency shutoff valve.
- Make sure all unnecessary persons are evacuated from the hazard area.

- Put on protective clothing and equipment.
- If a flammable material is involved, remove all ignition sources, and use spark and explosion proof equipment for recovery of material.
- Determine the major components in the waste at the time of the spill and remove all surrounding materials that could be reactive with the spilled material.
- If wastes reach a storm sewer; try to dam the outfall by using sand, earth, sand bags, etc. If this is done, pump this material out into a temporary holding tank or drums as soon as possible.
- If volatile emissions may occur, spray the spill area with foam, if available.
- Apply appropriate spill control media to absorb discharged liquids.
- For large spills, establish diking around leading edge of spill using booms, soil or other appropriate material. If possible, use a diaphragm pump to transfer discharged liquid to drums or a holding tank.

Emergency spill response clean-up materials and equipment

The supply of appropriate emergency response clean-up and personal protective equipment on hand will be inventoried and visually inspected on a weekly basis.

The materials listed below will be kept onsite for spill control depending on the types of hazardous materials present. The majority of this material will be located in the support zone, in a supply trailer or storage area.

- Activated charcoal (carbon) to adsorb organic solvents (hydrocarbons) and to reduce flammable vapors.
- Appropriate solvents for decontamination of structures or equipment.

The following equipment will be kept onsite and dedicated for spill cleanup:

- Plastic shovels for recovering corrosive and flammable materials.
- Sausage-shaped absorbent booms for diking liquid spills, drains, or sewers.
- Sorbent sheets for absorbing liquid spills.
- Over pack drums for containerizing leaking drums.

- 55-gallon open-top drums for containerization of waste materials.

Once a hazard has been recognized, take immediate action to prevent the hazard from becoming an emergency. This may be accomplished by the following:

- Daily safety meeting
- Task-specific training prior to commencement of activity
- Lock-out/tag-out
- Personal protective equipment (PPE) selection/use
- Written and approved permits for hot work, confined space
- Air monitoring
- Following all standard operating procedures
- Practice drills for fire, medical emergency and hazardous substances spills.

6.10.3 Housekeeping

In order to reduce the possibility of accidental spills and safety hazards, good housekeeping practices will be followed. They include prompt removal of small spills, regular maintenance of walking areas, regular removal of refuse, and staging of similar materials together.

6.10.4 Security

All rules and regulations set up by SHE Manager will be followed by all personnel on site.

6.10.5 Training

All site personnel are trained to operate the equipment that is present at the site.

6.10.6 Fire Detection and Warning

Portable Fire extinguishers will be used in buildings and as protection during "Hot Work" activities throughout the site. As construction progresses and systems are commissioned within specific buildings, personnel will be informed of the differential of alarm sounds.

- Large office accommodation will be protected by the use of hard-wired smoke detection devices with battery backup.
- A suitable means of raising the alarm in the event of a fire or other emergency at the LNG terminal will be established.
- IFC EHS Guidelines for LNG facilities will be followed in operation phase.

The alarm system will be appropriate to ensure all personnel can be notified immediately of any emergency situation and evacuation, or other actions required. The alarm system will be tested on a regular basis.

6.10.7 Site accommodation

Site accommodation (all temporary facilities) shall be designed and laid out in such a manner so as to reduce the risk of fire to the minimum.

- Good housekeeping shall be observed at all times throughout buildings with desks cleared at the end of each working day and sensitive documents locked away in flame proof cabinets/ lockers.
- All site accommodation shall have sufficient multipurpose dry powder extinguishers located at the access door with signs indicating their positions.
- Additional CO_2 extinguishers shall be provided to cover other electrical equipment.
- All fire extinguishers are visually checked on a regular basis through weekly area inspections and quarterly in accordance with equipment tagging process.

6.10.8 Fire drills

- The Fire Safety Coordinator shall ensure that monthly d rills are carried out that ensure all personnel are familiar with the evacuation procedure and their respective muster points.
- Simulated fires shall be carried out to ensure the readiness and competency of the fire brigade to fight a major fire. During the drill equipment shall be tested and shall adequately work. In the event any piece of equipment should fail it shall be immediately replaced.

- Review of brigade competency shall be determined during the drills. Brigade members shall be retrained if any evidence of in-competency exists.

6.10.9 Materials storage

- The SHE Head/Manager must be informed of all flammable gases and liquids being brought onto site.
- Oxygen and fuel gas cylinders shall not be stored together. Singular oxygen, acetylene carts will be acceptable as long as they are in use together.
- No flammable materials including solids, gases or liquids shall be stored next to any temporary facilities.
- Storage of flammable gases shall be a minimum of 5 meters from any occupied building suitably secured and with a prominent sign stating "DANGER HIGHLY FLAMMABLE".
- Storage facilities for flammable gases will be inspected by the Site ES&H Manager prior to being used.
- Material storage within the warehouse facility will maintain an excellent standard of housekeeping at all times. Flammable material packaging shall be removed to a safe location as it becomes redundant. Sprinkler systems shall be investigated in warehousing facilities, and were possible installed.
- Materials shall be stored in compliance with OSHA and SEPA regulations.

6.10.10 Firefighting equipment

The following firefighting equipment shall be maintained in good order at the Project and Equipment will also be suitable for fighting bush fires in and around the LNG Project:

- Fire Extinguishers of adequate size and number
- Fire hose and nozzles
- Bunker gear
- Air packs
- 1 water tank with pumping capabilities

- Fire pumps of sufficient size to fill tank
- Assorted accessories for connecting hoses and fighting fires (wrenches, hose clamps, axes, etc.
- Rescue gear for high level rescue (if this is assigned to this group)
- Equipment shall be maintained and tested to ensure serviceability in the event of a fire.
- Tests shall be conducted monthly.
- A water fill station including a storage tank of adequate size to meet construction fire requirements shall be installed to facilitate the filling of the pumper truck and tanker.
- The plant fire suppression system shall be prioritized and serviceable as soon as practical during construction.

6.10.11Training

All employees shall receive general firefighting training (i.e. fire extinguisher use). Employees who are members of the fire brigade shall receive at a minimum the following training:

- Use and limitations of the firefighting equipment
- Firefighting strategies and methods
- Use of respiratory equipment and its limitations
- Donning bunker gear and its care
- Care and maintenance of firefighting equipment and hoses
- Confined space entry and fire fighting in a confined space
- First aid
- High level rescue (if the site assigns this responsibility to this group)

6.11 Environmental Compliance

Proponent will be responsible for regular audit and review of environment and safety management of the LNG facility. This will include both on-site auditing

and review of performance reports. Additional onsite inspections and investigations will be undertaken in the event of significant environmental incidents. These will be undertaken in conjunction with the relevant government agencies.

Plant management will participate in the audits and inspections and investigations. Plant management will also be responsible for regular review of the environmental performance of the site and site personnel, and for the reporting on the implementation of commitments made in the EMP.

There is also likely to be some compliance auditing associated with the licensing of the LNG Plant, for each government recommendation and proponent commitment, the following information:

- The recommendation or proponent commitment being addressed;
- The issue to be addressed by the proponent;
- How the issue is to be addressed by the proponent;
- Where the issue is addressed in the EMP;
- When the issue is to be addressed by; and
- To whose satisfaction the issue is to be addressed.

6.11.1 Audits

In particular, there will be:

- Annual audit reports.
- A triennial review and improvement of the EMP.

Proponent recognizes that periodic external compliance audits and inspections will be made to monitor, assess and validate the level of Proponent performance and compliance pursuant to the commitments made in the accepted Environmental Management Plan.

7.0 Conclusion

The Oil and Gas Regulatory Authority (OGRA) has recently granted a provisional license to LNGFlex Limited for establishing a Virtual LNG (VLNG) Terminal at KPT. This initiative marks the first of its kind in Pakistan, aimed at facilitating the supply of natural gas primarily to off-grid consumers. The provisional license was issued following the completion of all formalities under the Ogra Ordinance 2002, LNG Policy 2011, and LNG Rules 2007, enabling the conduct of regulated activities in the LNG sector.

LNGFlex is pioneering this new LNG supply model in Pakistan by engaging the private sector in developing natural gas infrastructure, thereby alleviating the government's responsibility for meeting basic energy needs. The innovative supply concept using ISO Containers and Cryogenic Bowsers is expected to greatly enhance energy availability for the commercial and industrial sectors, yielding widespread benefits for the population and contributing to Pakistan's social and economic development.

The overall impact on the national economy is projected to be overwhelmingly positive, with the project poised to generate significant additional resources for the nation, aligning with the government's long-term development strategy. Increased licensing income, along with other revenue sources, will bolster government revenues and foster economic growth through expanded and diversified business opportunities in Pakistan.

To mitigate risks associated with the handling of LNG/RLNG, a comprehensive set of monitoring and mitigation measures has been put in place. The Environmental Management and Monitoring Plan, alongside safety and security protocols, will ensure that the project does not lead to unmitigated adverse environmental impacts or compromises stakeholder safety.

The Environmental & Social Impact Assessment (ESIA) study indicates that the proposed VLNG Terminal, known as Project PLUTO, aligns with sustainable development objectives by providing a reliable energy source, thus aiding economic development. The study recommends approval of the ESIA report, contingent upon the implementation of suggested mitigation measures and strict adherence to the Environmental Management Plan (EMP) by LNGFlex Limited.

LNGFlex Limited
Islamabad, Pakistan

Project Pluto - VLNG project at KPT

Quantitative Risk Assessment (QRA)

Doc. No. P0044005-2-1-H3 Rev. 1 – December 2024

Rev.	Description	Prepared by	Checked by	Approved by	Date
1	Second Issue	F. Ovidi	L. Gaggero	M. Pontiggia	13/01/2025
0	First Issue	F. Ovidi	L. Gaggero	M. Pontiggia	20/12/2024

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TABLE OF CONTENTS

			Page
LIST OF TABLES			**2**
LIST OF FIGURES			**2**
ABBREVIATIONS AND ACRONYMS			**3**
1	**INTRODUCTION**		**4**
	1.1	GENERAL	4
	1.2	SCOPE OF THE DOCUMENT	4
2	**QRA METHODOLOGY**		**5**
	2.1	IDENTIFICATION OF ACCIDENTAL EVENTS	5
	2.2	EVALUATION OF FREQUENCIES OF OCCURRENCE	5
		2.2.1 Loss Of Containment (LOC) frequency assessment	5
		2.2.2 Event Tree Analysis (ETA)	5
	2.3	ASSESSMENT OF THE CONSEQUENT SCENARIOS	6
	2.4	RISK EVALUATION AND ASSESSMENT	7
		2.4.1 Vulnerability Criteria for Stationary Thermal Radiation (Jet/Pool Fire)	7
		2.4.2 Vulnerability Criteria for Instantaneous Thermal Radiation	8
		2.4.3 Vulnerability Criteria for Overpressure	8
		2.4.4 Location-Specific Individual Risk (LSIR)	9
		2.4.5 Risk Tolerability criteria	9
	2.5	QRA MAIN ASSUMPTIONS	9
3	**QRA RESULTS**		**10**
		3.1.1 Identification of Accidental Events	10
		3.1.2 Frequencies of Occurrence Assessment	10
		3.1.3 Consequence Assessment	11
	3.2	RISK ASSESSMENT	12
		3.2.1 Location-Specific Individual Risk (LSIR)	12
		3.2.2 Risk Tolerability assessment	13
4	**CONCLUSIONS AND RECOMMENDATIONS**		**15**
REFERENCES			**16**

LIST OF TABLES

		Page
Table 2.1:	Stationary Thermal Radiation Vulnerability	8
Table 2.2:	Instantaneous Thermal Radiation Vulnerability	8
Table 2.3:	Overpressure Vulnerability	8
Table 2.4:	Location-Specific Individual Risk (LSIR) tolerability criteria	9
Table 3.1:	Release Point (RP) main characteristics	10
Table 3.2:	Outcome scenario frequency (events/year)	11
Table 3.3:	Damage Distances at Threshold Levels	11
Table 3.4:	LSIR iso-risk curves colour scheme	12
Table 3.5:	Location-Specific Individual Risk (LSIR) tolerability criteria	14

LIST OF FIGURES

		Page
Figure 2.1:	Event Tree	6
Figure 3.1:	LSIR iso-contours	13

ABBREVIATIONS AND ACRONYMS

BOG	Boil-Off Gas
ETA	Event Tree Analysis
FSU	Floating Storage Unit
HAZID	Hazard Identification Anlysis
HSE	Health Safety and Environment
IRPA	Individual Risk per Annum
KPT	Karachi Port Trust
LFL	Lower Flammable Limit
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LOC	Loss Of Containment
LSIR	Local Specific Individual Risk
NOC	No Objection Certificate
OGP	Oil and Gas Producers
PROBIT	Probability Unit
QRA	Quantitative Risk Assessment
RP	Release Point
STS	Ship-To-Ship
VLNG	Virtual Liquefied Natural Gas

1 INTRODUCTION

1.1 GENERAL

LNGFlex Limited (hereinafter “LNGFlex”) is developing the Project Pluto as the Pakistan’s first Virtual Liquefied Natural Gas (VLNG) Terminal at Karachi Port, designed to meet the country’s rising energy needs.

LNGFlex is developing a closed-loop VLNG integrated end to end LNG supply chain project encompassing:

- ✓ import of Liquefied Natural Gas (LNG) through LNG Carriers (LNGC);
- ✓ storage of LNG in a permanently berthed Floating Storage Unit (FSU) at Karachi Port Trust (KPT), Pakistan;
- ✓ filling of ISO tanks using pipe manifold connected to ISO tank loading bays;
- ✓ transportation of ISO tanks to customers;
- ✓ regasification of LNG at customer premises.

LNGFlex has already obtained a comprehensive License from Oil & Gas Regulatory Authority (OGRA) and an No Objection Certificate (NOC) from KPT to proceed with the technical studies for establishing the suitability of the selected site for the intended purpose.

1.2 SCOPE OF THE DOCUMENT

RINA Consulting S.p.A. (hereinafter “RINA”), an Italian Company with an experienced Operating Units dedicated to HSE studies, was commissioned to carry out a Quantitative Risk Assessment (QRA) for the Project Pluto.

The purpose of this document is to show the results of the QRA by means the quantification of risk for operators due to the process activities, under normal operations, associated to Pluto plant. It estimates the process risk to operations activities associated to flammable hazards (such as jet fires, flash fires) and overpressure hazards (such as vapour cloud explosions).

2 QRA METHODOLOGY

Quantitative Risk Assessment is a systematic process, which assesses the overall risks of the complete facilities due to hazards from fire, explosions, toxic gas, etc.

The QRA considers the risk to personnel from all major risk contributors during normal operations.

QRA has been developed relying on international standards and best practices, and it has been performed through the following steps:

- ✓ Identification of Accidental Events;
- ✓ Evaluation of Frequencies of Occurrence;
- ✓ Assessment of the Consequent Scenarios;
- ✓ Risk Evaluation and Assessment.

Each step part of the activity listed above is further detailed in the following.

2.1 IDENTIFICATION OF ACCIDENTAL EVENTS

The reference Release Points (RP) for Loss of Containment (LOC) events have been identified on the basis of the HAZID results (see RINA Doc. No. P0044005-2-H2 “HAZID Report” for details).

Two hole diameters have been considered for each LOC events based on Oil and Gas Producers (OGP) data report and criteria, in particular:

- ✓ hole with effective diameter of 10% pipe diameter/equipment main connection diameter;
- ✓ full-bore catastrophic rupture of the pipe/equipment main connection.

2.2 EVALUATION OF FREQUENCIES OF OCCURRENCE

2.2.1 Loss Of Containment (LOC) frequency assessment

Frequency Assessment for LOC events has been calculated by means of the loss of containment data given in the literature, and specifically in the:

- ✓ Oil and Gas Producers (OGP) Data report Ed. 2019[2], which has a section dedicated to failure frequencies for LNG process equipment.

In particular, the following release frequencies have been used for the relevant Release Points (RP):

- ✓ Transfer hoses: no data are available in OGP data base for LNG/BOG ship transfer hoses, hence data of failure frequencies for LNG/BOG truck transfer hose has been used;
- ✓ Transfer arms: failure frequencies data for LNG/BOG ship transfer arms has been used;
- ✓ Lines: failure frequencies data for piping with diameter within range 300 mm (12”) - 500 mm (20”) has been used;
- ✓ Equipment: the only equipment considered in the analysis is the BOG compressor, present only on the FSU. Failure frequency of general centrifugal compressor has been used.

2.2.2 Event Tree Analysis (ETA)

Starting from the LOC release frequency, the frequency of each specific scenario (Jet/Pool Fire, Flash Fire, Explosion and Dispersion) has been calculated by Event Tree Analysis (ETA), adopting ignition probability values from international literature (IP-UKOOA, “Ignition probability review, model development and Look-Up correlations”, 2006) [4].

The following figure illustrate the Event Tree format used for the current project.

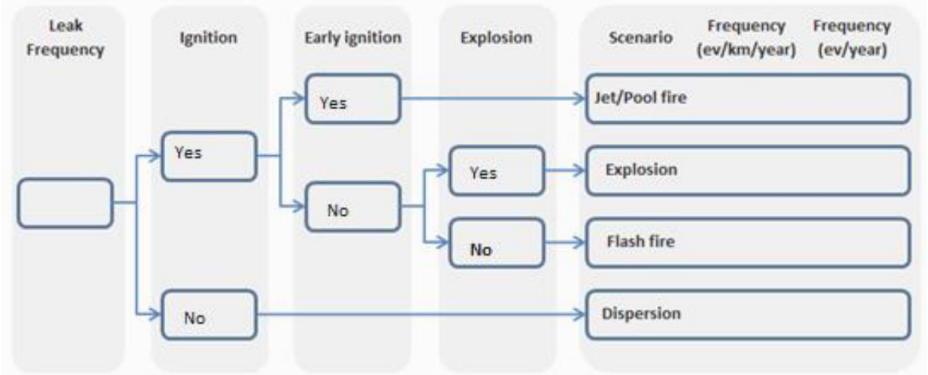


Figure 2.1: Event Tree

Ignition probability has been calculated accordingly to the IP-UKOOA report based on the following formula:

$$Pignition = 10^{\ a \log 10(\dot{m}+b)}$$

where:

- ✓ $Pignition$ is the total ignition probability;
- ✓ $\dot{m}$ is the mass release rate (kg/s);
- ✓ a and b are fitting coefficient of the experimental correlation.

Fitting coefficients have been assessed based typical correlation data, as provided in the IP-UKOOA report.[4]

The overall probability of ignition has been divided 50% of events early ignition and 50% delayed ignition.

The probability that a given scenario evolves into an explosion rather than a flash fire has been evaluated by the calculation software based on the flammable mass within the flammable limits and the level of congestion in the area.

2.3 ASSESSMENT OF THE CONSEQUENT SCENARIOS

The evaluation of damage distances following a credible release (consequence assessment) has been performed with the PHAST Software (latest version) [1]. Below is an overview of the main modelling inputs.

The release point is defined in accordance with the layout position of the line or equipment from which the release occurs.

Conservatively, and given the current stage of the project (Pre-Feasibility), the release elevation has been uniformly set to 1 m for all identified release points and the physical effects have been calculated at this same height (1 m).

For all the LNG accidental events the following operating conditions have been assumed as release conditions:

- ✓ Pressure = 8 barg;
- ✓ Temperature = -161 °C.

For the BOG accidental events the following operating conditions have been assumed as release conditions:

- ✓ Compressed BOG from FSU to LNGC:
  - Pressure = 10 barg;
  - Temperature = saturation temperature at operating pressure.
- ✓ All other BOG equipment and lined:
  - Pressure = 0.5 barg;
  - Temperature = saturation temperature at operating pressure.

Two representative meteorological conditions have been used for the analysis, namely:

- ✓ 2F – Stability class F with a wind speed of 2 m/s: stable class, representative of night conditions with moderate clouds and moderate wind;

- ✓ 5D – Stability class D with a wind speed of 5 m/s: neutral class, representative of windy and sunny day.

Results have been calculated considering the following thresholds:

- ✓ Stationary Thermal radiation (Jet/Pool Fire):
  - 6.3 kW/m^2 – irreversible injuries (second-degree burns),
  - 12.5 kW/m^2 – significant damage (severe burns, eye damage, potential thermal shock, etc.),
  - 37.5 kW/m^2 – lethality due to burns and thermal shock;
- ✓ Instantaneous Thermal Radiation (Flash Fire):
  - LFL/2 – representative threshold for occasional lethal events due to isolated and localized pockets of flammable mixture,
  - LFL – direct lethality due to flame envelope of a flash fire;
- ✓ Overpressure (Explosion):
  - 0.07 barg – irreversible injuries,
  - 0.3 barg – indirect lethality caused by falls, the projection of the body onto obstacles, impacts from fragments, and building collapses,
  - 0.5 barg – direct lethality due to shock wave.

2.4 RISK EVALUATION AND ASSESSMENT

Risk for scenarios with consequences onto people has been evaluated by means of calculation of individual risk index:

- ✓ Local Specific Individual Risk (LSIR).

LSIR has been calculated by means of in-house developed software according to the vulnerability criteria described in the following paragraphs.

2.4.1 Vulnerability Criteria for Stationary Thermal Radiation (Jet/Pool Fire)

To correlate thermal radiation exposure to vulnerability, a PROBIT (PROBability unIT) function has been used. This function transforms the percentage of people affected by a selected binary outcome (in this analysis fatality/no fatality) into "probability unit" linearly dependent upon the logarithm of the absorbed thermal dose.

The thermal dose unit (V) which combines the heat flux intensity and exposure time, has been calculated using the following Equation:

$$V = I^{4/3} \times t$$

where I is the radiant heat flux in W/m^2 and t is the exposure duration in seconds. According to TNO "Purple Book - Guidelines for Quantitative Risk Assessment [7]" an exposure duration of 20 s has been assumed. Death probability has been calculated by using the Tsao-Perry modification of the Eisenberg PROBIT model:

$$Y = -36.38 + 2.56 \ln(V)$$

where Y is the PROBIT value.

As per TNO "Purple Book - Guidelines for Quantitative Risk Assessment" specifications [7], people inside fireproofed shelters, buildings or enclosures are assumed to be safe. People inside not fireproofed buildings or enclosures are supposed to be exposed to the vulnerability rates reported in the following table, if the incident radiation on the buildings is greater than 12.5 kW/m^2.

Table 2.1: Stationary Thermal Radiation Vulnerability

Thermal Radiation (kW/m^2)	Fatality Probability (%)	Exposure Time (s)
6.3	3	20
12.5	30	20
37.5	100	20

2.4.2 Vulnerability Criteria for Instantaneous Thermal Radiation

For Flash Fire scenarios, it has been assumed that personnel within the area up to the LFL concentration have a 100% fatality probability, according to TNO guidelines “Purple Book - Guidelines for Quantitative Risk Assessment [7].”

According to the same guidelines, the fatality probability outside the LFL area is assumed to be 0%. In this analysis, a conservative 30% fatality probability has been assigned to personnel within the flammable cloud at the LFL/2 concentration. Additionally, conservatively, this analysis does not account for the possibility of individuals being inside gas-tight pressurized shelters, buildings, or enclosures, where the fatality probability is considered zero.

The following table shows the vulnerability values associated with the threshold values for instantaneous thermal radiation.

Table 2.2: Instantaneous Thermal Radiation Vulnerability

Flammable concentration	Fatality Probability (%)
LFL/2	30
LFL	100

2.4.3 Vulnerability Criteria for Overpressure

To assess the overpressure vulnerability, the probability of fatality has been considered equal to 100% for personnel exposed to overpressures equal or greater than 0.5 barg and equal to 30% for personnel exposed to overpressures equal to 0.35 barg, in accordance with indications provided in IOGP Risk Assessment Data Directory, Report No. 434-14, "Vulnerability of Humans"[3].

According to the guidelines, the fatality probability for overpressure greater that 0.5 barg has been assumed to be 100% and, a conservative 50% fatality probability has been assigned to personnel exposed to overpressure of 0.3 barg.

The following table shows the vulnerability values associated with the threshold values for overpressure.

Table 2.3: Overpressure Vulnerability

Overpressure (barg)	Fatality Probability (%)
0.07	1
0.3	50
0.5	100

2.4.4 Location-Specific Individual Risk (LSIR)

The overall fatality frequency has been calculated, for each risk area, adding the risk associated with all the fire/explosion scenarios. Thus, the location-specific individual risk (LSIR) for a hypothetical individual continuously present in a particular area 'k' of the plant has been calculated with analytic equation:

$$LSIR_{LOPCk} = \sum_{i=1}^{m} \sum_{j=1}^{n} (F_{ij} * P_{ij})_k$$

Where:

- ✓ m: is the number of loss of containment events;
- ✓ n: is the number of incident scenarios developing from each loss of containment event "j";
- ✓ Fij: is the frequency of the incident scenario;
- ✓ Pij: is the fatality probability, calculated from the consequences Cij, related to each incident scenario.

Iso-risk curves are be provided for LSIR allowing to identify the area of installation intrinsically riskier and providing an indication of the risk levels affecting the area surroundings the facility.

2.4.5 Risk Tolerability criteria

The risk tolerability criteria applied in the present study are summarized in the following table.

Table 2.4: Location-Specific Individual Risk (LSIR) tolerability criteria

Risk Zone	Risk tolerability criteria (occ/year)
Low risk area	LSIR < 1×10^{-6}
Medium risk area	$1 \times 10^{-6} \leq$ LSIR < 1×10^{-4}
Medium - High risk area	$1 \times 10^{-4} \leq$ LSIR < 1×10^{-3}
High risk area	LSIR ≥ 1×10^{-3}

2.5 QRA MAIN ASSUMPTIONS

The main technical assumptions adopted in the development of the QRA for the Pluto Project are described in the "Assumptions Sheet Report" (RINA Doc. No. P0044005-2-H1) [5], to which reference is made for further details.

3 QRA RESULTS

3.1.1 Identification of Accidental Events

Starting from the HAZID results, the following Loss of Containment (LOC) events have been identified:

1. HAZID Scenario no. H-01.04: Release of LNG from LNGC Transfer Hoses to FSU;
2. HAZID Scenario no. H-01.04: Release of LNG from FSU Loading Arms to onshore piping manifold;
3. HAZID Scenario no. H-01.04: Release of LNG from onshore piping manifold;
4. HAZID Scenario no. H-01.04: Release of LNG from LNG skid truck loading arm to ISO tank;
5. HAZID Scenario no. H-01.06: Release of BOG from vapor return hoses from FSU to LNGC (including no. 1 BOG compressor);
6. HAZID Scenario no. H-01.06: Release of BOG from BOG lines and equipment (including no. 1 vapor return arm from ISO tank to FSU).

The main characteristics and the total number of elements considered for each Release Points (RP) associated to LOC events listed above are summarized in the following table.

Table 3.1: Release Point (RP) main characteristics

ID Event	Ref. HAZID scenario	Description	Pipe Diameter (“)	Pipe Length (m)	No. of elements	Congestion Level (Note 1)
RP1	H-01.04	Release of LNG from LNGC Transfer Hoses to FSU	12	40	4 transfer hoses	High congestion
RP2	H-01.04	Release of LNG from FSU Loading Arms to onshore piping manifold	12	40	2 transfer arms	High congestion
RP3	H-01.04	Release of LNG from onshore piping manifold	18	100	1 manifold	Low congestion
RP4	H-01.04	Release of LNG from LNG skid truck loading arm to ISO tank	12	40	5 skid/transfer arms	Low congestion
RP5	H-01.06	Release of BOG from vapor return hoses from FSU to LNGC	12	40	1 transfer arm 1 compressor	High congestion
RP6	H-01.06	Release of BOG from BOG lines and equipment	18	100	1 manifold 1 transfer arm	Low congestion

Note:

(1) High congestion level has been assumed for releases originated form the FSU and LNGC, considering the confinement provided by the ships and the berth. Low congestion level has been assigned to the releases originated onshore.

3.1.2 Frequencies of Occurrence Assessment

Frequency Assessment for Loss of Containment events has been calculated by means of the loss of containment data given in Oil and Gas Producers (OGP) Data report Ed. 2019 [2][3], as described in paragraph 2.2.1.

Frequency Assessment for accidental scenarios has been calculated by means of Event Tree Analysis (ETA), as described in paragraph 2.2.2.

Frequency values reported in the following table represent the final scenario frequency for both weather categories considered in the analysis (i.e., 2F and 5D).

Table 3.2: Outcome scenario frequency (events/year)

ID	Release diameter	Release Frequency (ev/y)	Scenario frequency (ev/y)		
			Jet / Pool Fire	Flash Fire	Explosion (Note 1)
RP1	10% pipe diameter	1.60E+00	1.59E-02	1.59E-02	--
	Full bore	1.60E-01	2.10E-03	2.10E-03	--
RP2	10% pipe diameter	4.00E-04	3.98E-06	3.98E-06	--
	Full bore	4.00E-05	5.24E-07	5.24E-07	--
RP3	10% pipe diameter	4.00E-05	3.98E-07	3.98E-07	--
	Full bore	7.00E-06	1.13E-07	1.13E-07	--
RP4	10% pipe diameter	1.50E-02	1.49E-04	1.49E-04	--
	Full bore	1.50E-03	1.97E-05	1.97E-05	--
RP5	10% pipe diameter	2.40E+00	2.39E-02	2.39E-02	--
	Full bore	2.40E-01	2.97E-03	2.97E-03	--
RP6	10% pipe diameter	5.20E-05	2.60E-07	2.60E-07	--
	Full bore	9.10E-06	4.55E-08	4.55E-08	--

Note:

(1) The calculation software determined a null frequency of occurrence for explosion scenarios for all the reference events, due to either an insufficient explosion flammable mass (i.e. < 100 kg, calculated through the software Phast) or a low congestion level of the area of interest.

3.1.3 Consequence Assessment

The following table reports the consequence modelling results for the fire scenarios,

Table 3.3: Damage Distances at Threshold Levels

ID	Release diameter	Weather condition	Damage Distances at Threshold Levels (Note 1)					
			Jet / Pool Fire (Note 2, Note 3)			Flash Fire		Explosion
			6.3 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	LFL/2	LFL	(Note 4)
RP1	Full bore	2F	75.1	54.1	23.6	121.0	59.9	--
		5D	75.1	54.1	23.6	25.7	N.R.	--
	10% pipe diameter	2F	4.3	3.2	0.0	N.R.	N.R.	--
		5D	4.3	3.2	0.0	N.R.	N.R.	--
RP2	Full bore	2F	75.1	54.1	23.6	121.0	59.9	--
		5D	75.1	54.1	23.6	25.7	N.R.	--
	10% pipe diameter	2F	4.3	3.2	0.0	N.R.	N.R.	--
		5D	4.3	3.2	0.0	N.R.	N.R.	--
RP3	Full bore	2F	91.9	68.7	37.8	202.0	91.4	--
		5D	91.9	68.7	37.8	52.9	N.R.	--
	10% pipe diameter	2F	6.1	4.9	2.5	N.R.	N.R.	--
		5D	6.1	4.9	2.5	N.R.	N.R.	--

ID	Release diameter	Weather condition	Damage Distances at Threshold Levels (Note 1)					
			Jet / Pool Fire (Note 2, Note 3)			Flash Fire		Explosion
			6.3 kW/m²	12.5 kW/m²	37.5 kW/m²	LFL/2	LFL	(Note 4)
RP4	Full bore	2F	62.0	46.6	25.6	143.6	64.2	--
		5D	62.0	46.6	25.6	31.5	N.R.	--
	10% pipe diameter	2F	3.3	2.8	1.9	N.R.	N.R.	--
		5D	3.3	2.8	1.9	N.R.	N.R.	--
RP5	Full bore	2F	21.4	21.4	21.4	61.9	33.8	--
		5D	16.7	16.7	16.7	44.4	23.8	--
	10% pipe diameter	2F	2.8	2.8	2.8	3.1	2.1	--
		5D	2.2	2.2	2.2	2.5	1.8	--
RP6	Full bore	2F	4.6	4.6	4.6	6.7	4.2	--
		5D	5.3	5.3	5.3	5.5	3.7	--
	10% pipe diameter	2F	N.R.	N.R.	N.R.	1.1	0.5	--
		5D	N.R.	N.R.	N.R.	0.9	0.5	--

Note:
(1) N.R. = Not Reached at height of interest.
(2) For LNG releases, distances refer to the greater distances obtained between the Jet Fire and the Poll Fire scenarios.
(3) For BOG releases, distances refer to distances obtained for the Jet Fire scenarios.
(4) Since the calculation software determined a null frequency of occurrence for explosion scenarios for all the reference events (see also paragraph 3.1.2), the corresponding damage distances are not reported.

3.2 RISK ASSESSMENT

3.2.1 Location-Specific Individual Risk (LSIR)

In order to elaborate Location-Specific Individual Risk (LSIR) maps, the methodology described in paragraph 2.4 has been applied. LSIR iso-risk curves are provided in the following figure allowing to identify the area of installation intrinsically riskier and providing an indication of the risk levels affecting the area surroundings the facility, considering the following colour scheme:

Table 3.4: LSIR iso-risk curves colour scheme

Colour Scheme	Fatality per year (ev/y)
White area	LSIR < 1×10^{-7}
Dark Green area	$1 \times 10^{-7} \leq$ LSIR < 1×10^{-6}
Light Green area	$1 \times 10^{-6} \leq$ LSIR < 1×10^{-5}
Yellow area	$1 \times 10^{-5} \leq$ LSIR < 1×10^{-4}
Orange area	$1 \times 10^{-4} \leq$ LSIR < 1×10^{-3}
Light Red area	$1 \times 10^{-3} \leq$ LSIR < 1×10^{-2}
Dark Red area	LSIR ≥ 1×10^{-2}

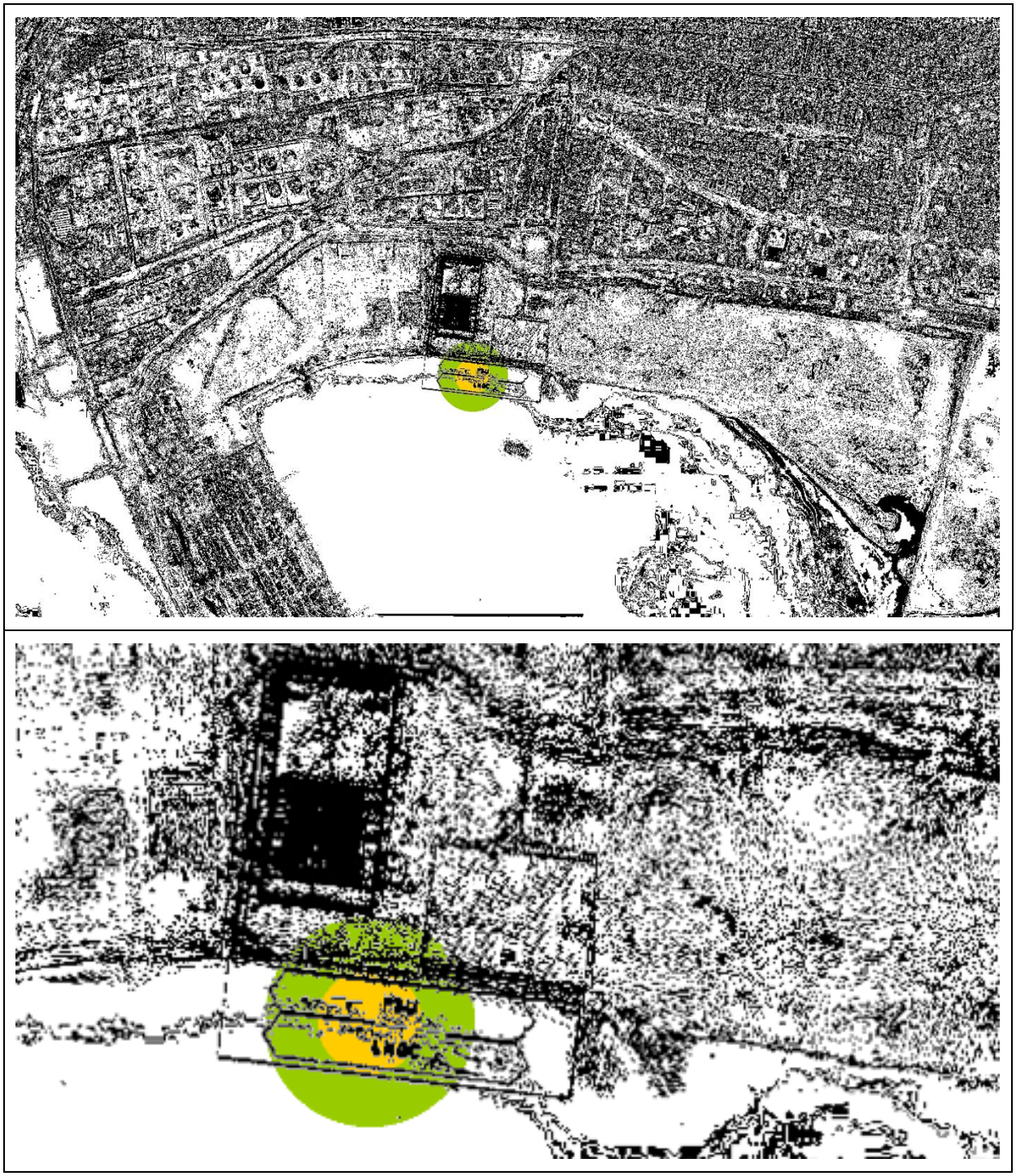


Figure 3.1: LSIR iso-contours

3.2.2 Risk Tolerability assessment

According to the risk tolerability criteria summarized in the following table and considering the results of LSIR iso-risk curves shown in Figure 3.1, the LSIR values fall within the “Low risk area” and the “Medium risk area” regions.

Table 3.5: Location-Specific Individual Risk (LSIR) tolerability criteria

Risk Zone	Risk tolerability criteria (occ/year)
Low risk area	LSIR < 1×10^{-6}
Medium risk area	$1 \times 10^{-6} \leq$ LSIR < 1×10^{-4}
Medium - High risk area	$1 \times 10^{-4} \leq$ LSIR < 1×10^{-3}
High risk area	LSIR ≥ 1×10^{-3}

4 CONCLUSIONS AND RECOMMENDATIONS

The Quantitative Risk Assessment has been performed for Pluto project to estimates the process risk to operations activities associated to flammable hazards (such as jet fires, flash fires) and overpressure hazards (such as vapour cloud explosions).

The analysis has been performed through the following steps:

- ✓ Identification of Accidental Events;
- ✓ Evaluation of Frequencies of Occurrence;
- ✓ Assessment of the Consequent Scenarios;
- ✓ Risk Evaluation and Assessment.

Results have been expressed in terms of Local Specific Individual Risk (LSIR).

Comparing LSIR result with risk tolerability criteria, it can be stated that the LSIR values fall within the “Low risk area” (LSIR < 1×10^{-6} ev/y) and the “Medium risk area” (1×10^{-6} ev/y ≤ LSIR < 1×10^{-4} ev/y).

In the next project development stages, it is recommended to consider the implementation of risk reduction measures to ensure the risk is managed and minimized. Some examples are reported below:

- ✓ implement an adequate Emergency Shut-Down system, to reduce the quantity of hazardous substances released in the event of an accidental leak;
- ✓ implement an adequate Fire & Gas system, to promptly detect accidental leak and hazardous scenarios and to reduce the duration of the accidental releases;
- ✓ ensure the independence between instrumentation serving safety systems and that used for basic process control systems;
- ✓ carry out the design and construction of plant/equipment in accordance with internationally recognized standards and regulations;
- ✓ select proper materials and sealing devices in relation to the circulating fluid;
- ✓ consider using highly reliable control instrumentation and, for critical variables, redundant systems;
- ✓ adopt safety valves and depressurization valves on pipelines and equipment, in accordance with internationally recognized standards and regulations;
- ✓ consider minimizing the flanged connections, to reduce the frequency of occurrence of the loss of containment events.

REFERENCES

[1]. Det Norske Veritas, DNV, Phast DNV Risk Management Software.

[2]. IOGP (International Association of Oil and Gas Producers), Report 434-01, “Risk Assessment Data Directory - Process Release Frequencies”, Ed. 2019.

[3]. IOGP (International Association of Oil and Gas Producers), Report434-14, “Vulnerability of Humans”, 2019

[4]. IP-UKOOA, 2006, “Ignition Probability Review, Model Development and Look-up Correlations”.

[5]. RINA Doc. No. P0044005-2-H1 - Assumptions Sheet Report, December 2024.

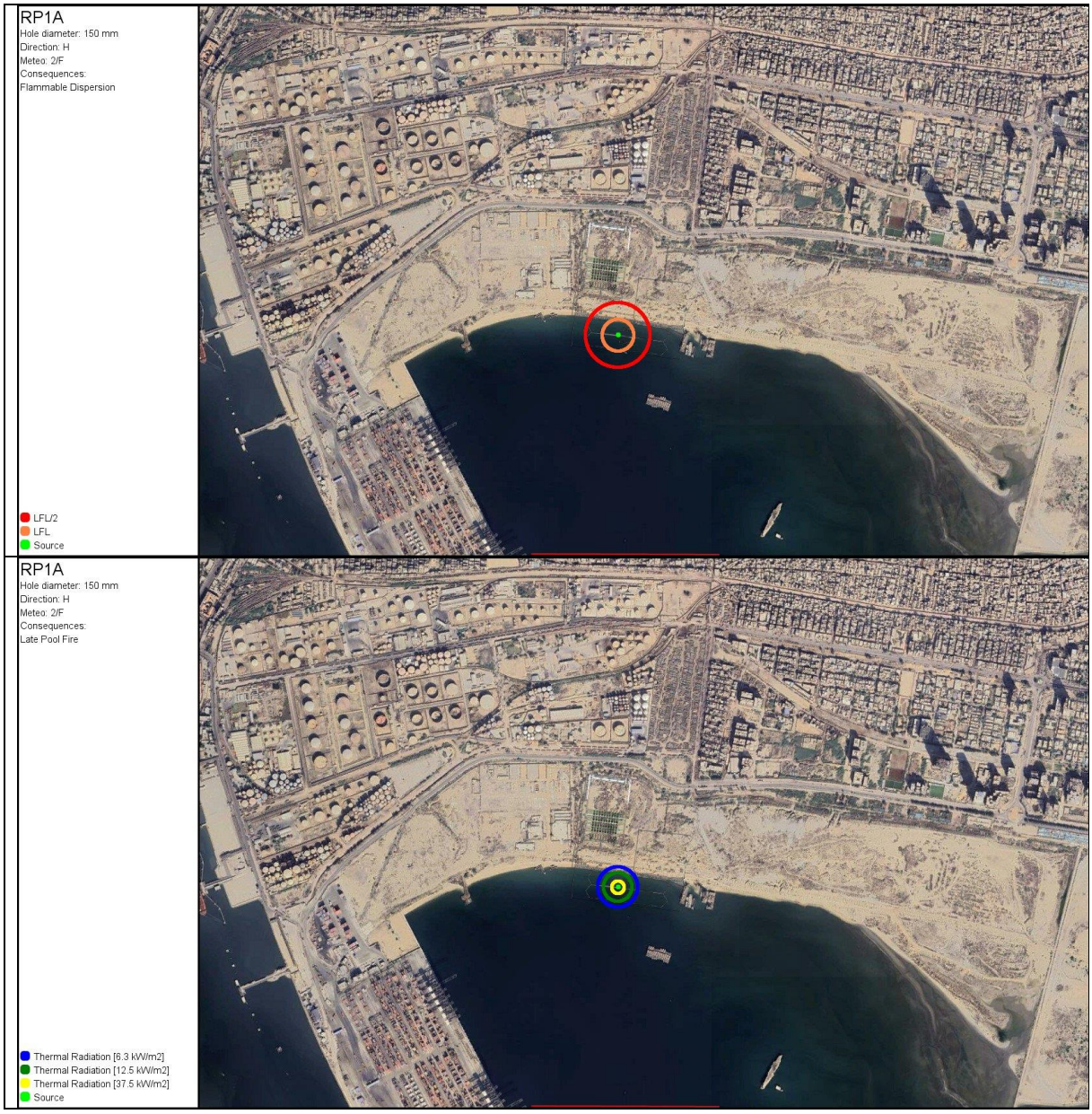
[6]. RINA Doc. No. P0044005-2-H2 – HAZID Report, December 2024.

[7]. TNO guidelines “Purple Book - Guidelines for Quantitative Risk Assessment.”

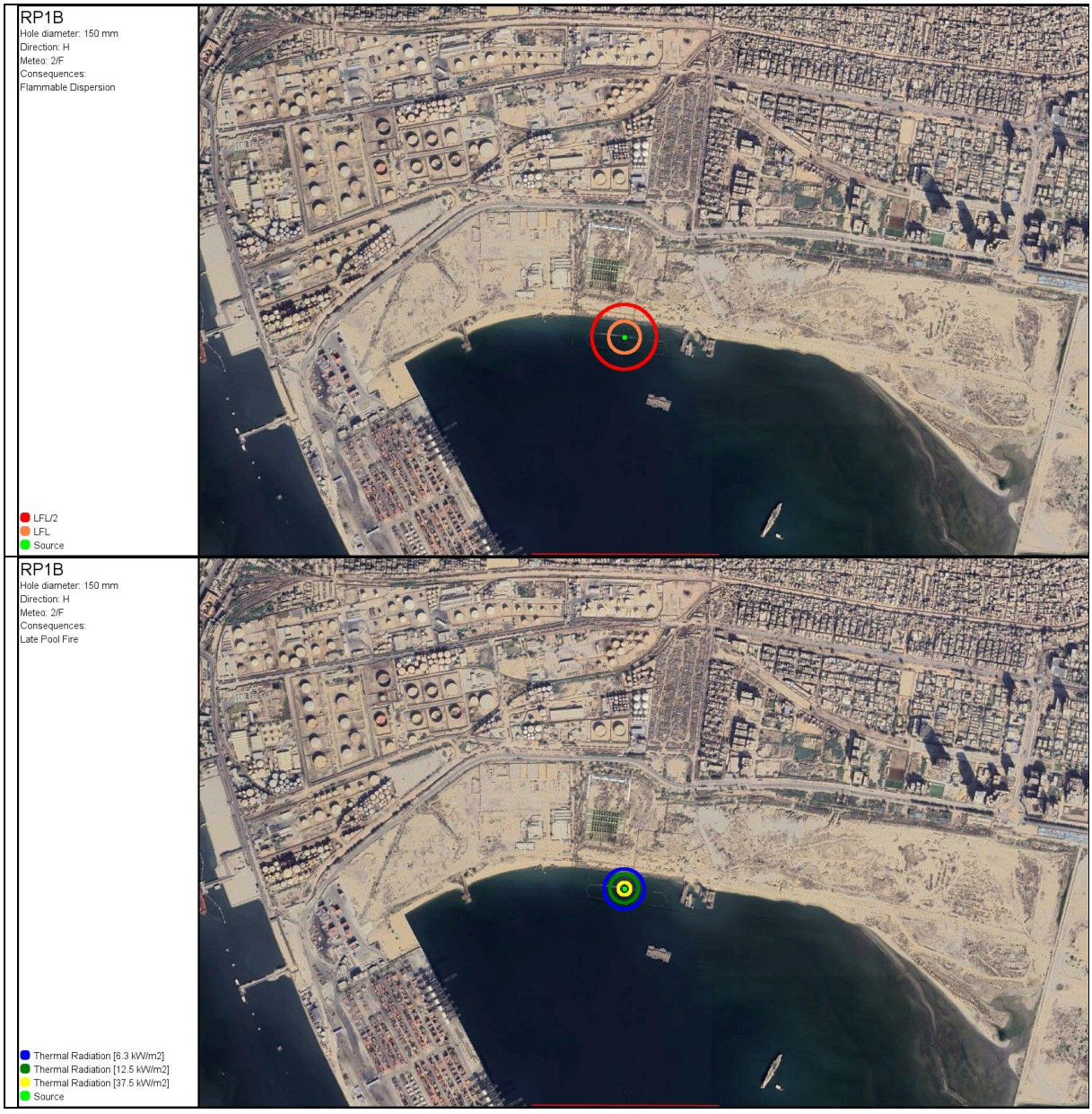
Appendix A

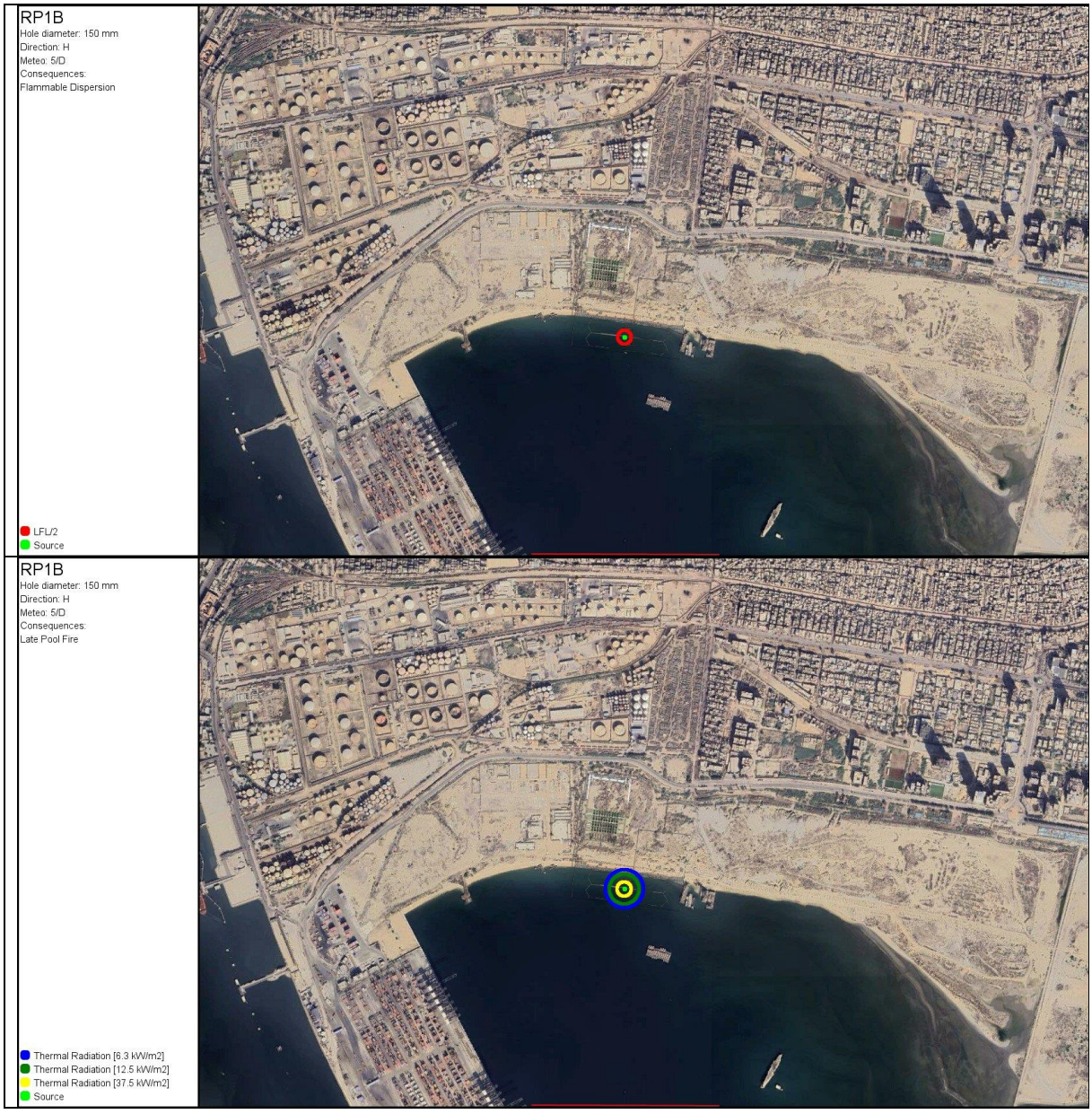
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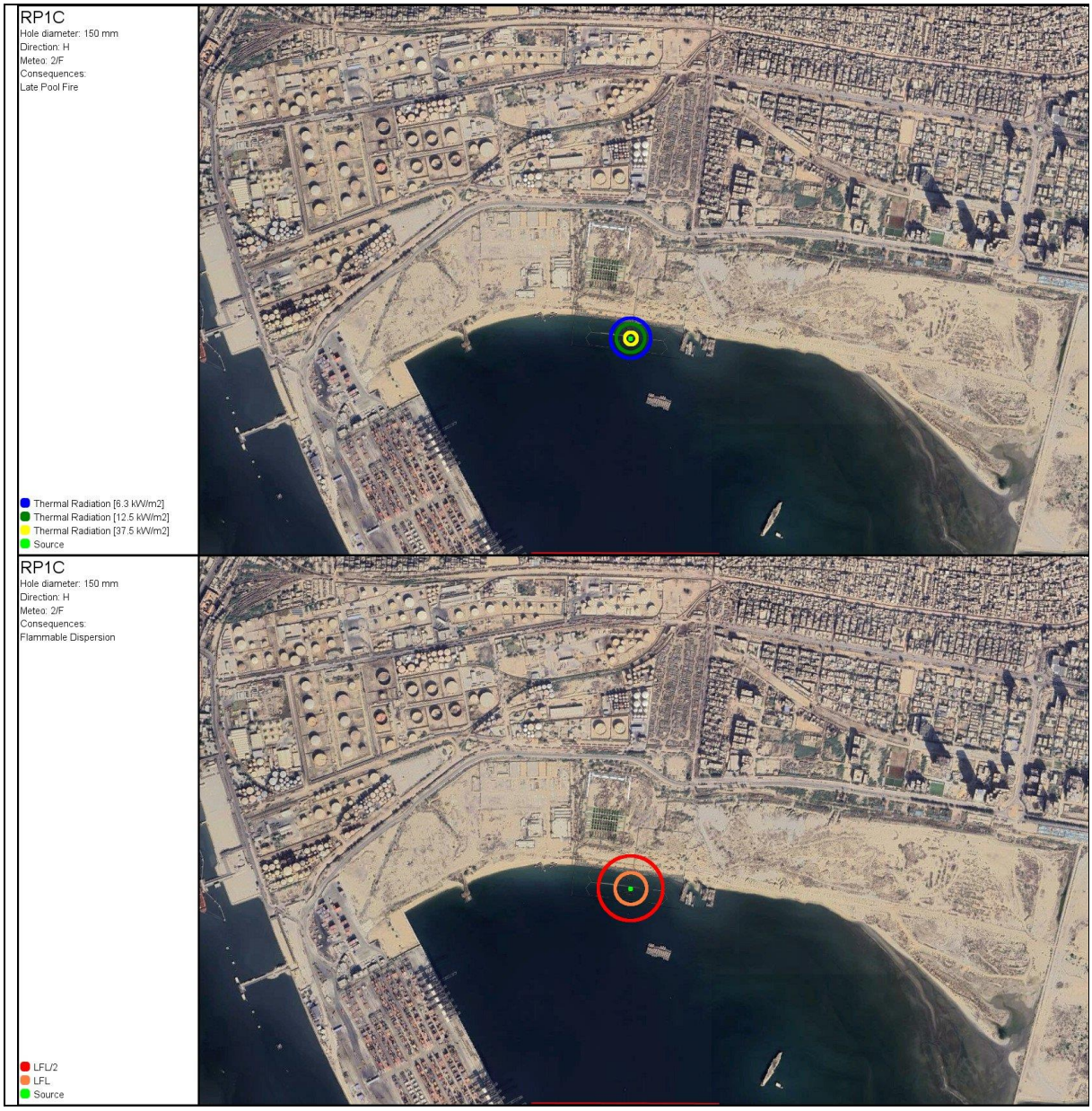
Doc. No. P0044005-2-1-H3 Rev. 1 – December 2024

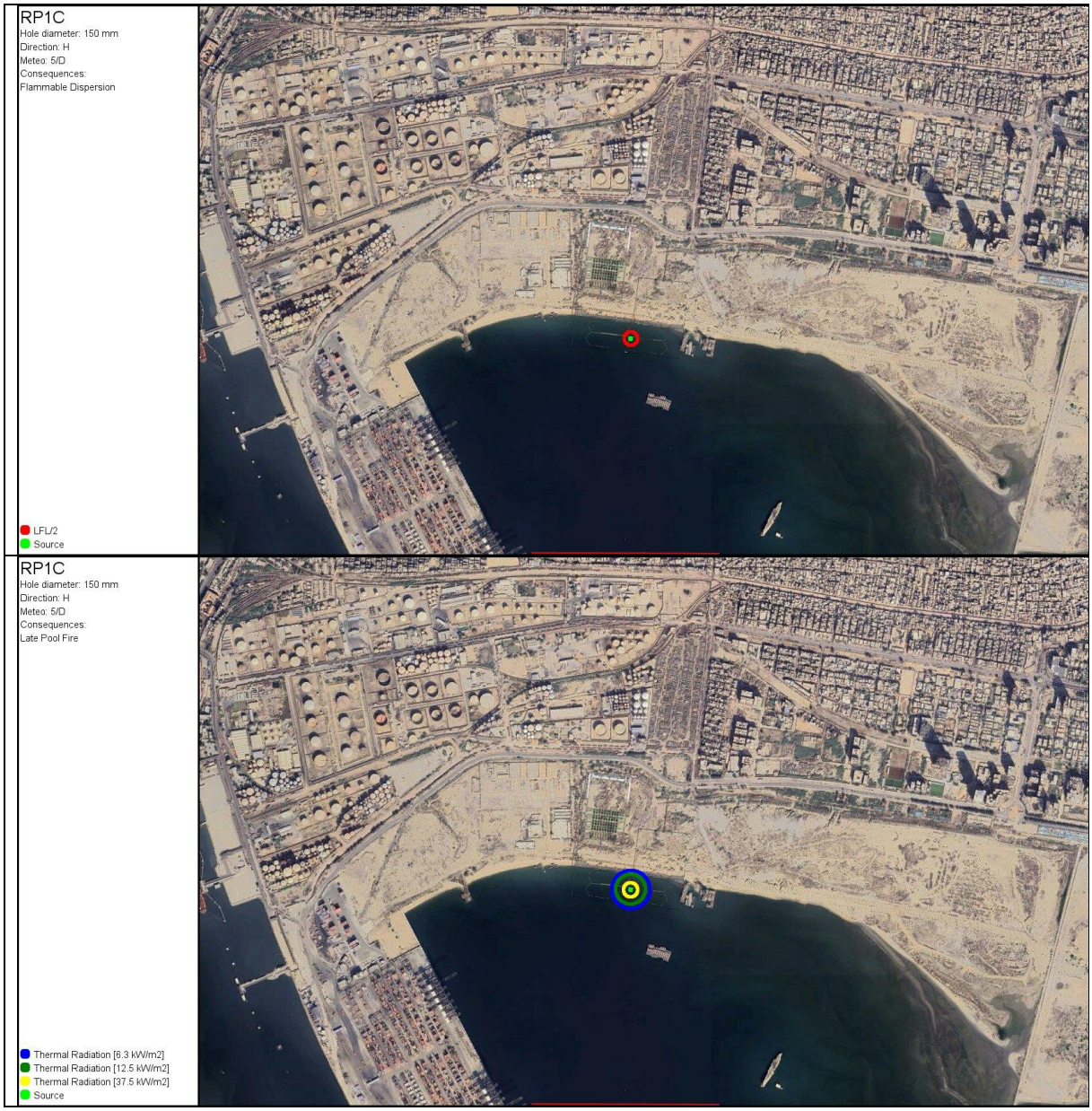

RP1A
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source
RP1A
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

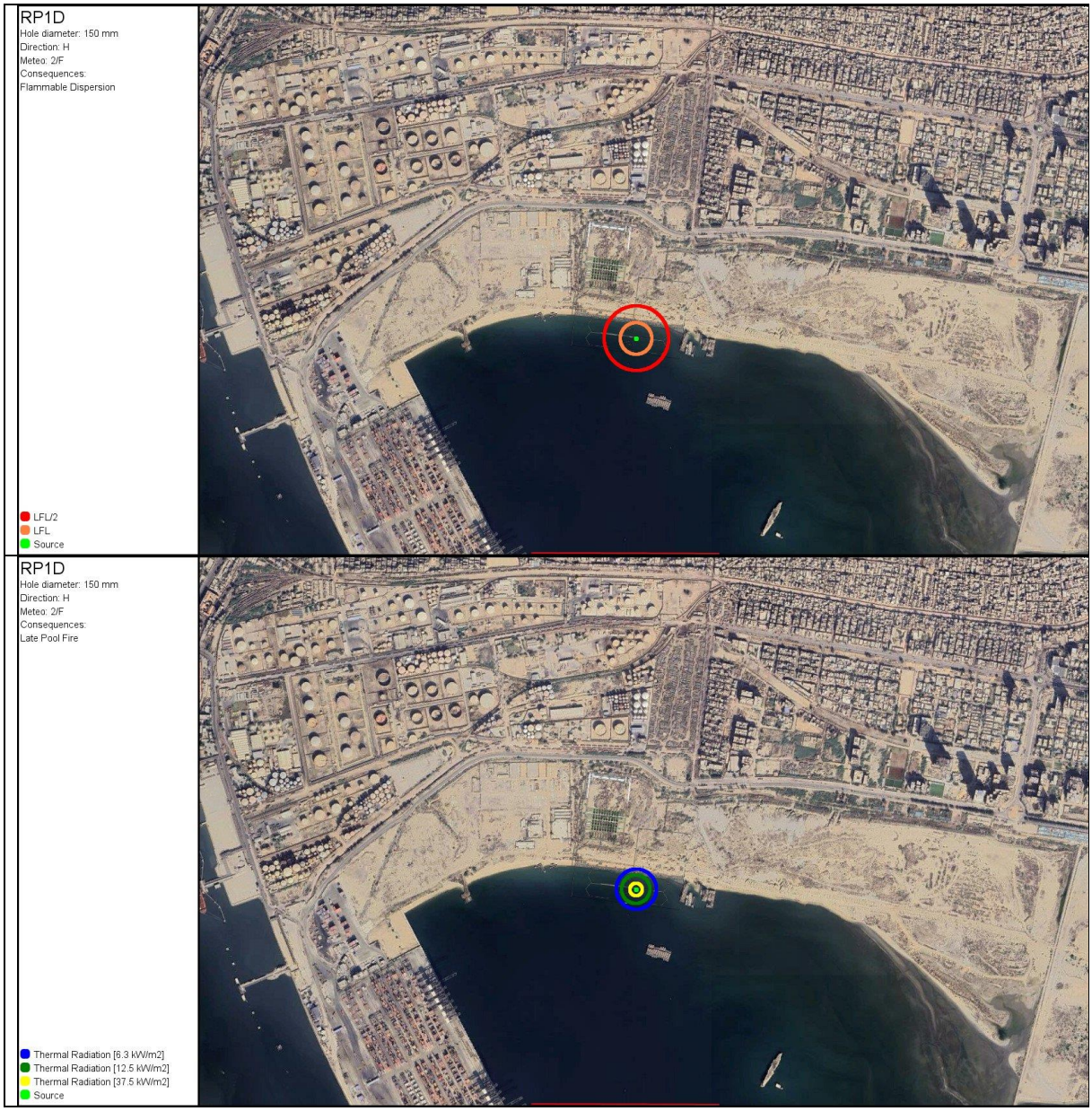

RP1A
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source
RP1A
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

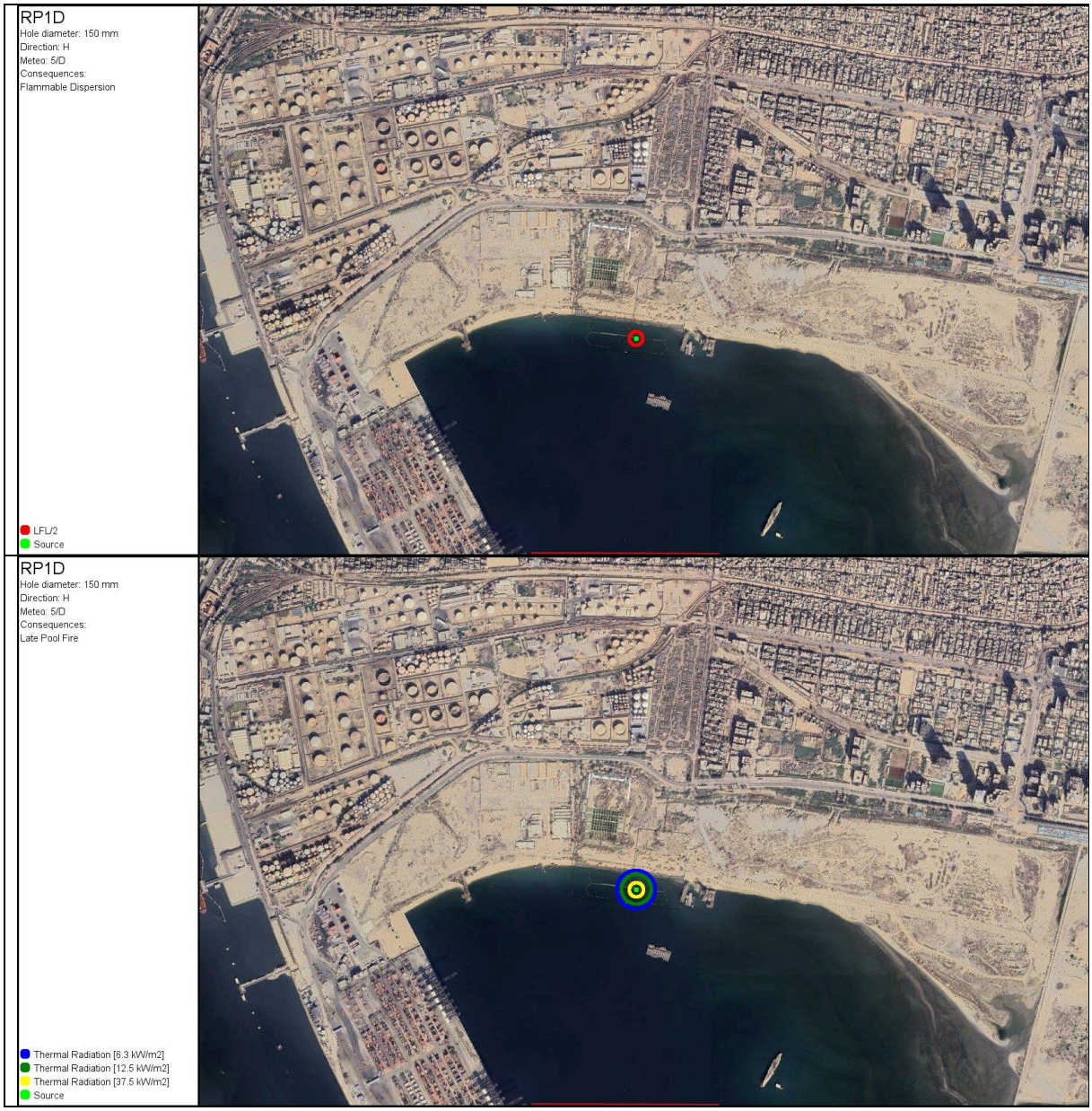

RP1B
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source
RP1B
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

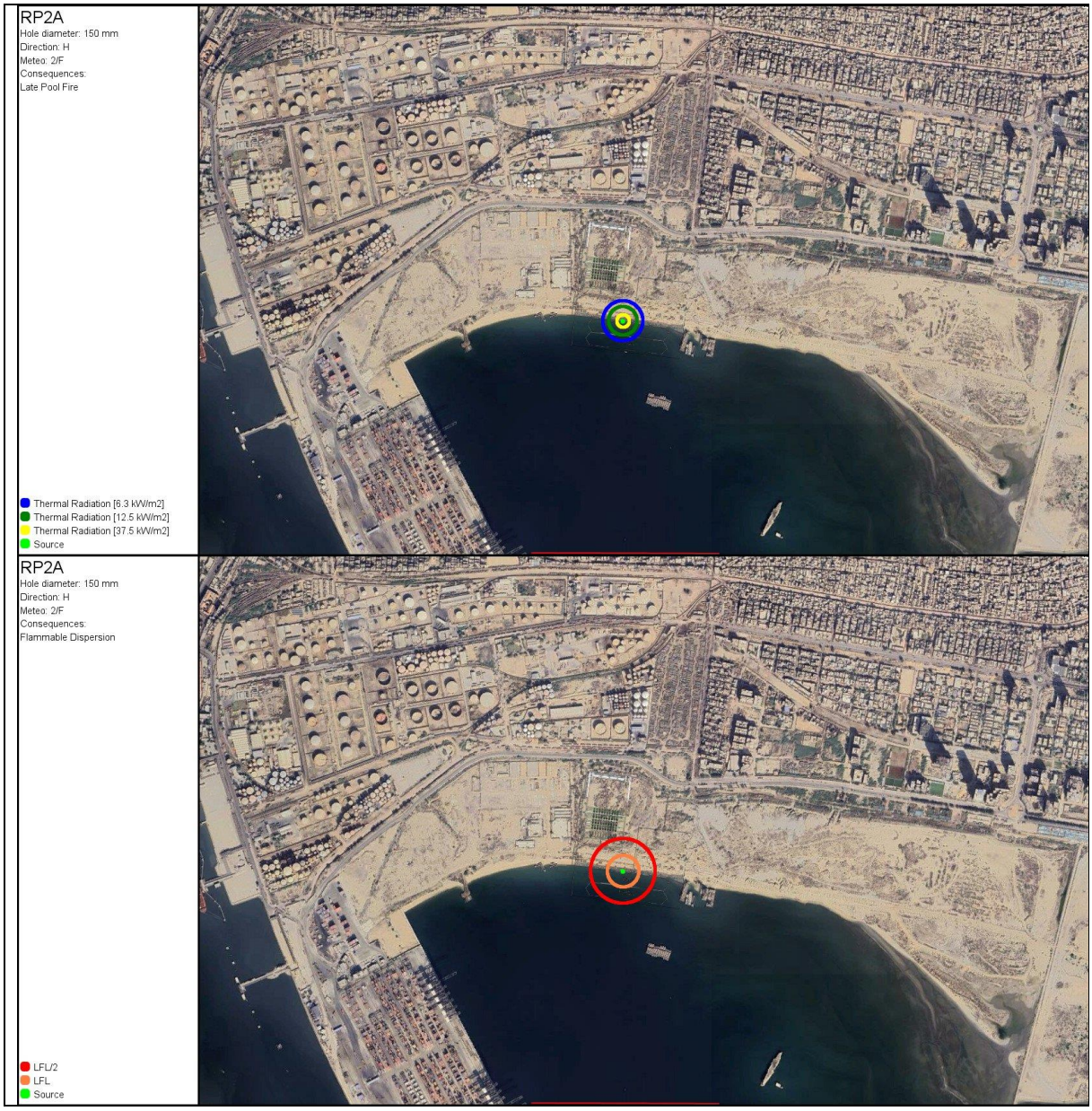

RP1B
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source
RP1B
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

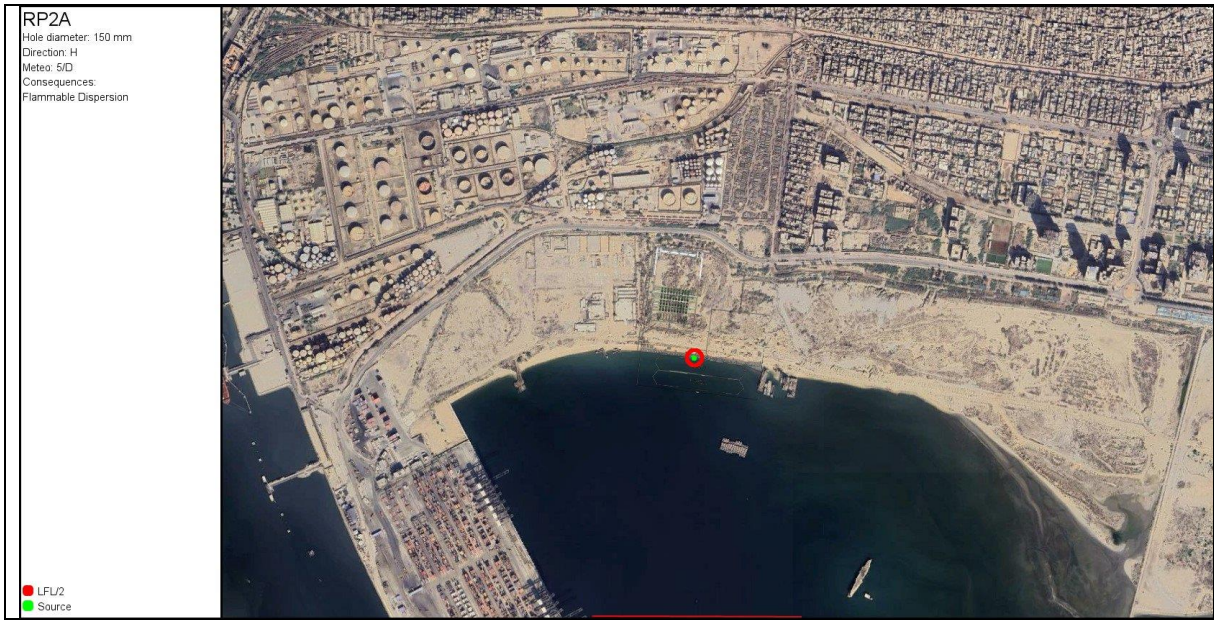

RP1C
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source
RP1C
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source


RP1C
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source
RP1C
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP1D
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source
RP1D
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP1D
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source
RP1D
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP2A
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source
RP2A
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source

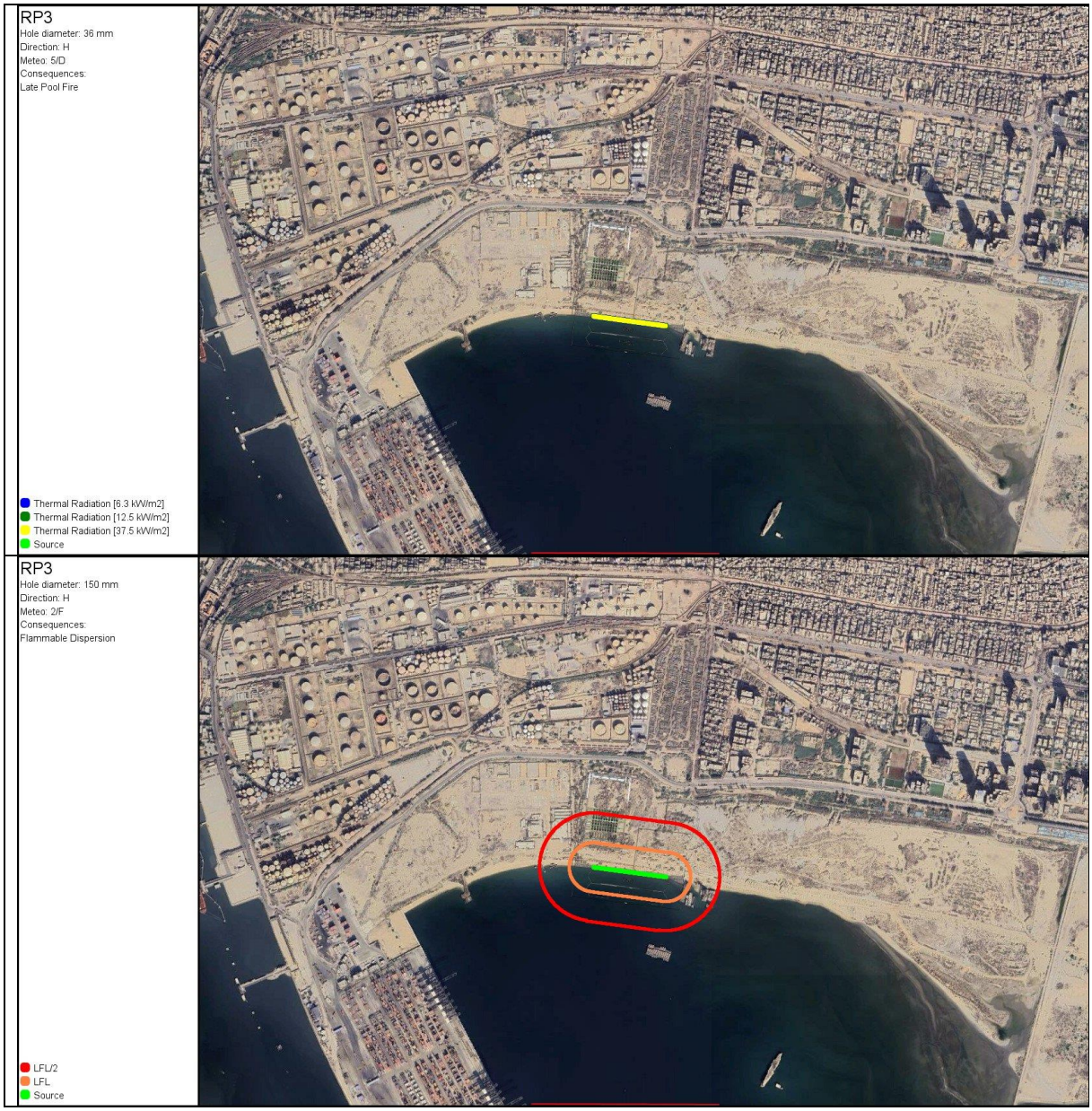

RP2A
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source

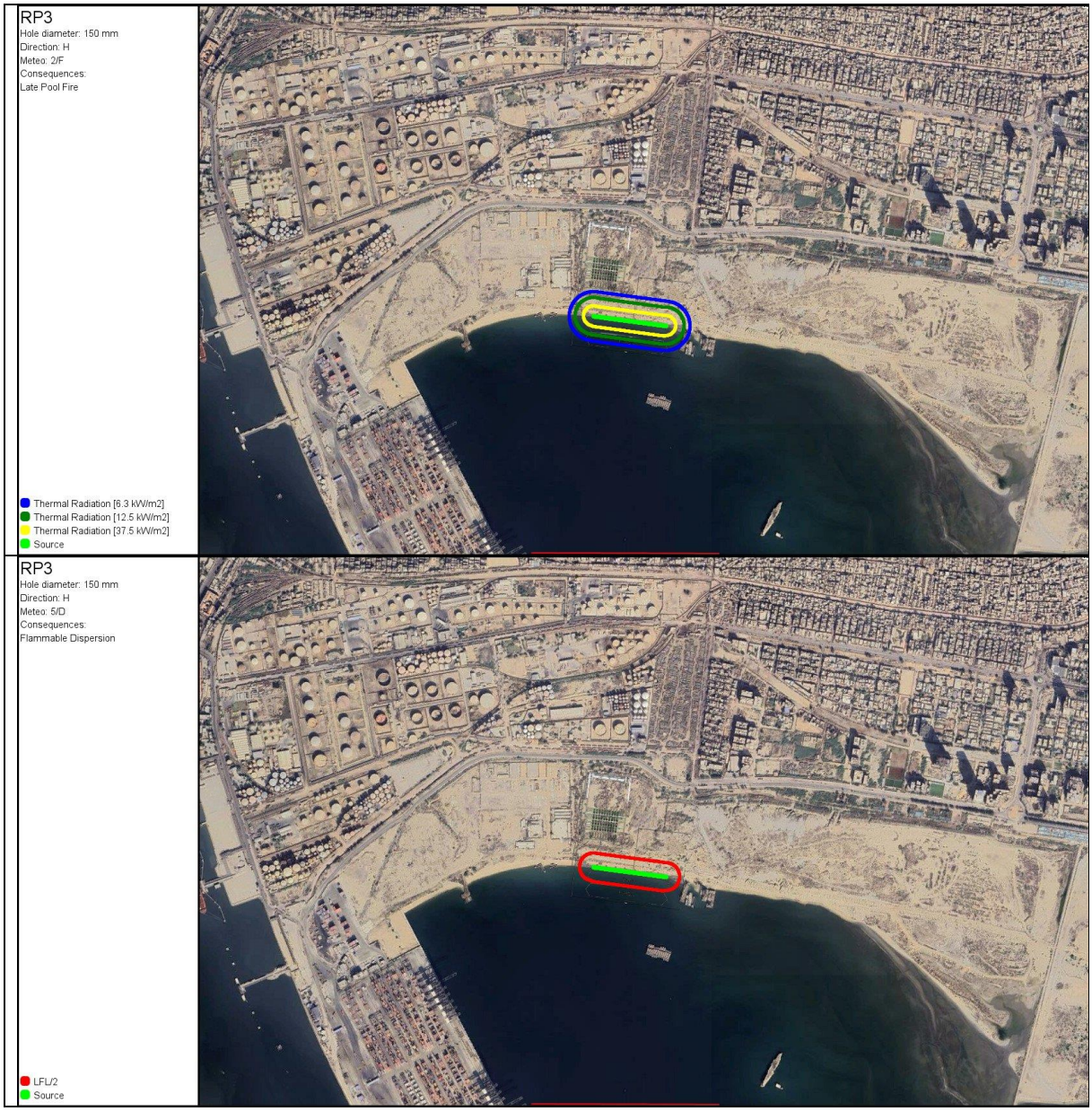

RP2B
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Explosions
Overpressure [0.07 barg]
Overpressure [0.3 barg]
Overpressure [0.5 barg]
Source
RP2A
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP2B
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source
RP2B
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP2B
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source
RP2B
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP3
Hole diameter: 36 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
Source
RP3
Hole diameter: 36 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP3
Hole diameter: 36 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source
RP3
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source


RP3
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source
RP3
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source


RP3
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

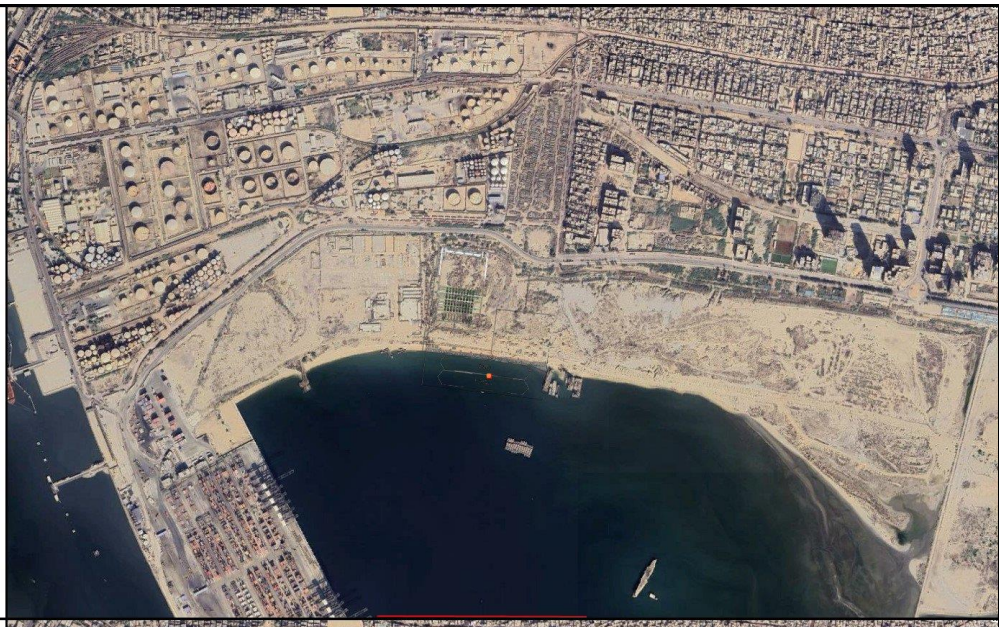

RP4
Hole diameter: 36 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Source
RP4
Hole diameter: 36 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source


RP4
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source
RP4
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source

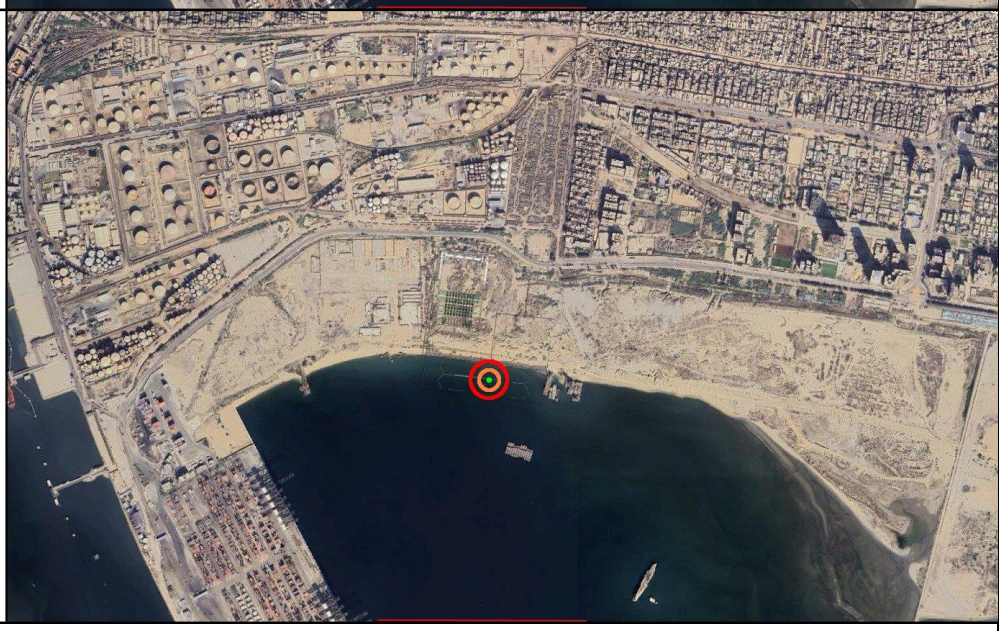

RP4
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
Source


RP5
Hole diameter: 36 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion
LFL/2
LFL
Source
RP4
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Late Pool Fire
Thermal Radiation [6.3 kW/m2]
Thermal Radiation [12.5 kW/m2]
Thermal Radiation [37.5 kW/m2]
Source

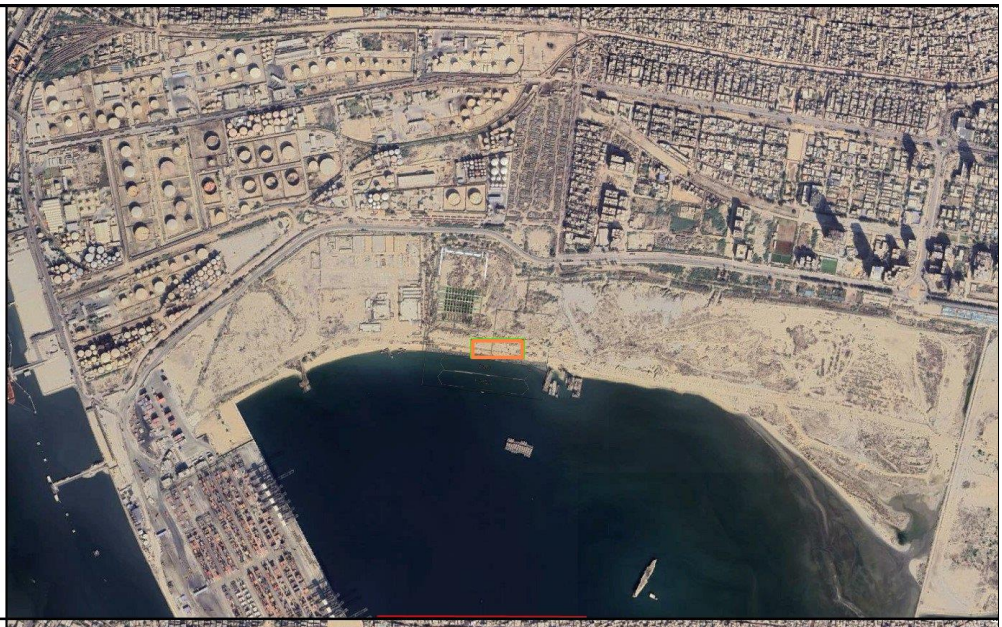
RP5
Hole diameter: 36 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion



RP5
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion

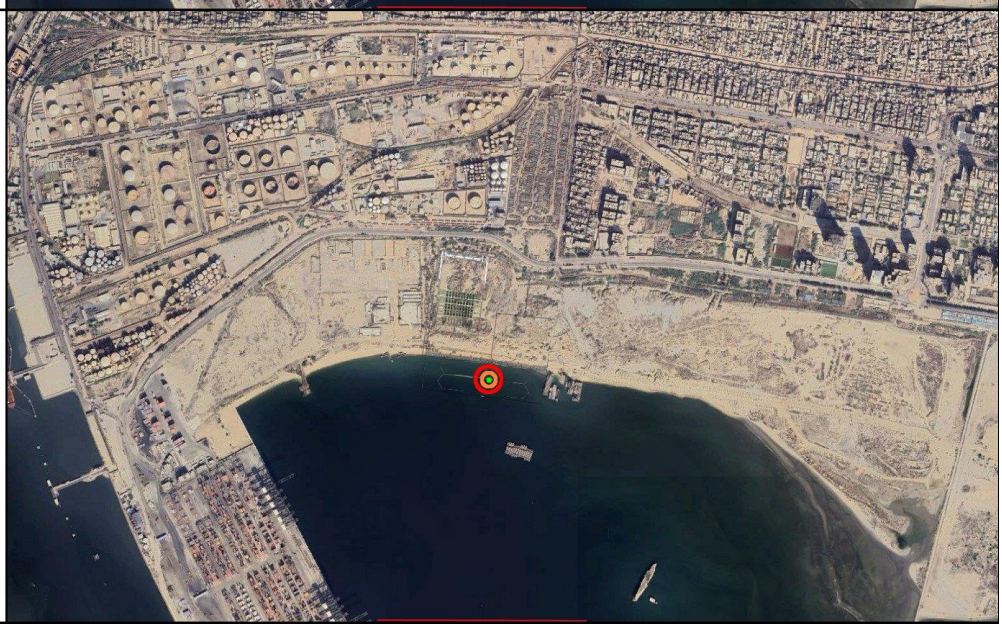


RP6
Hole diameter: 36 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion



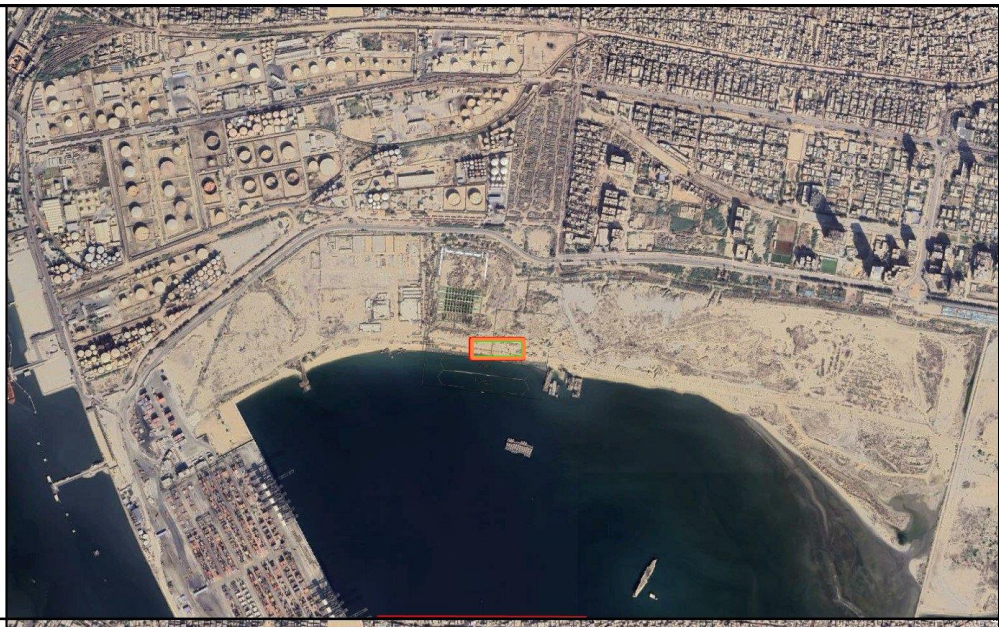
LFL/2
LFL
Source

RP5
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion



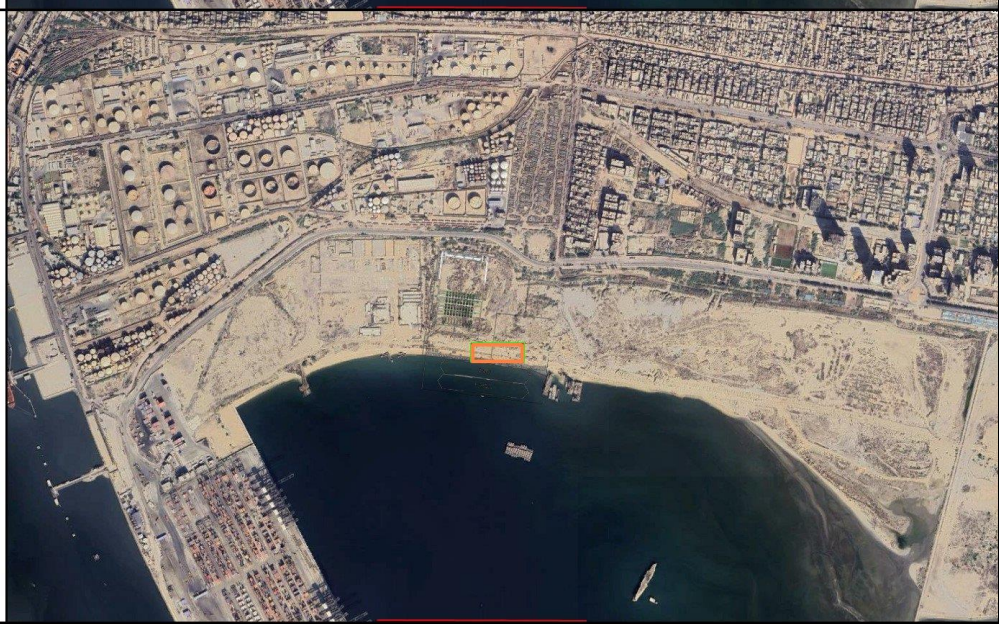
LFL/2
LFL
Source

RP6
Hole diameter: 150 mm
Direction: H
Meteo: 2/F
Consequences:
Flammable Dispersion

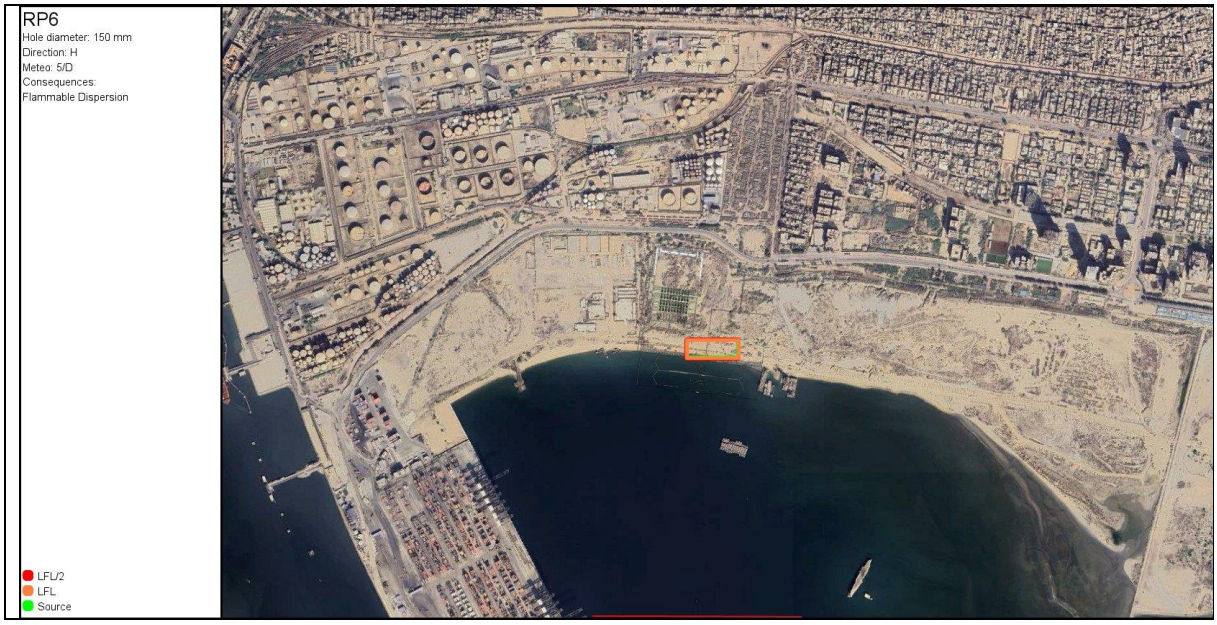


LFL/2
LFL
Source

RP6
Hole diameter: 36 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion



LFL/2
LFL
Source


RP6
Hole diameter: 150 mm
Direction: H
Meteo: 5/D
Consequences:
Flammable Dispersion
LFL/2
LFL
Source

SINDH ENVIRONMENTAL PROTECTION ACT, 2014



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Contents

The Sindh Environmental Protection Act, 2014 1
NOTIFICATION 1
Preamble.- 1
PART – I 2
1. Short title and commencement.- 2
2. Definitions.- 2
PART – II THE SINDH ENVIRONMENTAL PROTECTION COUNCIL 10
3. Establishment of the Sindh Environmental Protection Council.- 10
4. Functions and Powers of the Council.- 11
PART – III THE SINDH ENVIRONMENTAL PROTECTION AGENCY 13
5. Establishment of the Sindh Environmental Protection Agency.- 13
6. Functions of the Agency.- 13
7. Powers of the Agency.- 17
PART – IV SINDH SUSTAINABLE DEVELOPMENT FUND 19
8. Establishment of the Sindh Sustainable Development Fund.- 19
9. Management of the Sindh Sustainable Development Fund.- 19
10. Accounts.- 21
PART – V PROHIBITIONS AND ENFORCEMENT 22
11. Prohibition of certain discharges or emissions and compliance with standards.- 22
12. Prohibition of import of hazardous waste.- 22
13. Handling of hazardous substances.- 22
14. Prohibition of action adversely affecting Environment.- 23
15. Regulation of motor vehicles.- 24

16. Certified Environmental Laboratory.-....24
PART – VI ENVIRONMENTAL EXAMINATIONS AND ASSESSMENTS 25
17. Initial environmental examination and environmental impact assessment.-....25
18. Strategic environmental assessment.- 26
19. Environmental monitoring.-....27
20. Environmental audit and review.- 27
PART – VII ENVIRONMENTAL PROTECTION ORDER....29
21. Environmental Protection Order.- 29
22. Penalties.- 31
23. Offences by body corporate.-....32
24. Offences by Government Agencies, local authorities or local councils.- 33
PART – IX ENVIRONMENTAL PROTECTION TRIBUNALS AND COURTS....34
25. Environmental Protection Tribunals.- 34
26. Jurisdiction and powers of Environmental Protection Tribunals.- 35
27. Appeals to the Environmental Protection Tribunal.- 36
28. Appeals from orders of the Environmental Protection Tribunal.-....36
29. Jurisdiction of Judicial Magistrate.-....37
30. Appeals from orders of the Judicial Magistrate.- 37
PART – X PUBLIC PARTICIPATION....38
31. Public participation.-....38
PART – XI GENERAL....39
32. Power to make and amend schedule.-....39
33. Indemnity.- 39
34. Dues recoverable as arrears of land revenue.-....39
35. Act to override other laws.- 39

36. Power to make rules.- 39
37. Power to make regulations.-.....39

The Sindh Environmental Protection Act, 2014

SINDH ACT NO. VIII OF 2014

Extra ordinary, Published by Authority

Karachi, Thursday March 20, 2014

PART-IV

PROVINCIAL ASSEMBLY OF SINDH

NOTIFICATION

NO. PAS/Legis-B-06/2014- The Sindh Environmental Protection Bill, 2014 having been passed by the Provincial Assembly of Sindh on 24th February, 2014 and assented to by the Governor of Sindh on 19th March, 2014 is hereby published as an Act of the Legislature of Sindh.

AN
ACT

to provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution, and promotion of sustainable development.

Preamble.- WHEREAS it is expedient to provide for the protection, conservation, rehabilitation and improvement of the environment, prevention and control of pollution, promotion of sustainable development, and for matters connected therewith and incidental thereto:

PART – I

It is hereby enacted as follows:-

1. Short title and commencement.- (1) This Act may he called the Sindh Environmental Protection Act.

(2) It extends to the whole of the Province of Sindh.

(3) It shall come into force at once.

2. Definitions.- In this Act, unless there is anything repugnant in the subject or context-

(i) "adverse environmental effect" means impairment of, or damage to, the environment and includes—

(a) impairment of, or damage to, human health and safety or to biodiversity or property;

(b) pollution; and

(c) any adverse environmental effect as may be specified in the rules or regulations made under this Act.

(ii) "Agency" means the Sindh Environmental Protection Agency established under section 5 of this Act;

(iii) "agricultural waste" means waste from farm and agricultural activities including poultry, cattle farming, animal husbandry residues from the use of fertilizers, pesticides and other farm chemicals and agricultural runoff;

(iv) "air pollutant" means any substance that causes pollution of air and includes soot smoke, dust particles, odour, light, electro-magnetic radiation, heat, fumes, combustion exhaust, exhaust gases, noxious gases, hazardous substances and radioactive substances;

(v) "biodiversity" or "biological diversity" means the variability among living organisms from all sources, including inter-alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems;

(vi) "biosafety" means the mechanism developing through policy and procedure to ensure human health and the environmentally safe application of biotechnology;

(vii) "Council" means the Sindh Environmental Protection Council established under section 3 of this Act;

(viii) "discharge" means spilling, leaking, pumping, depositing, seeping, releasing, flowing-out, pouring, emitting, emptying or dumping into the land, water or atmosphere;

(ix) "ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit;

(x) "effluent" means any material in solid, liquid or gaseous form or combination thereof being discharged from industrial activity or any other source and includes a slurry, suspension or vapour;

(xi) "emission standards" means the permissible standards established by the Agency for emission of air pollutants and noise and for discharge of effluent and waste;

(xii) "environment" means-

(a) air, water, land and natural resources;

(b) all layers of the atmosphere;

(c) all organic and inorganic matters and living organisms;

(d) ecosystems and ecological relationships;

(e) buildings, structures, roads, facilities and works:

(f) all social and economic conditions affecting community life; and

(g) the inter-relationship between any of the factors in sub-clause (a) to (f) made under this Act.

(xiii) "environmental aspect" means an organization's activities or services that can interact with the environment;

(xiv) "environment audit" means a systematic scrutiny of environmental performance of an organization, factory, company or manufacturing and production unit regarding to its operations;

(xv) "environmental impact assessment" means an environmental study comprising collection of data, prediction of qualitative and quantitative impacts comparison of alternatives, evaluation of preventive, mitigation and compensatory measures, formulation of environmental management and training plans and monitoring arrangements, *and* framing of recommendations and such other components as may be prescribed;

(xvi) "Environmental Management Plan" means a site specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with the environmental legislation;

(xvii) "Environmental Protection Order" means an order passed under Section 21 made under this Act;

(xviii) "Environmental Protection Tribunal" means the Environmental Protection Tribunal constituted under section 25 of this Act;

(xxix) "Environmental Review" means a quantitative and qualitative assessment of documents submitted by proponent, comments from public and Government agencies or organizations;

(xx) "factory" means any premises in which industrial activity is being undertaken;

(xxi) "genetically modified organism" means any organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology and which does not occur naturally through mating and or recombination and includes both living and non-living modified organisms;

(xxii) "Government" means the Government of Sindh;

(xxiii) "Government Agency" includes:-

(a) A department, attached department or any other office of Government; and

(b) A development authority, local authority, company, body, corporate established or control by Government;

(xxiv) "Court" means the court of the Judicial Magistrate First Class;

(xxv) "hazardous substance means:-

(a) a substance or mixture of substances, other than a pesticide as defined in the Agricultural Pesticides Ordinance, 1971 (II of 1971), 'which, by reason of its chemical activity or toxic, explosive, flammable, corrosive, radioactive or other characteristics, causes, or is likely to cause, directly or in combination with other matters an adverse environmental effect; and

(b) any substance which may be prescribed as a hazardous substance;

(xxvi) "hazardous waste" means waste which is or which contains a hazardous substance or which may be prescribed as hazardous waste, hospital waste, nuclear waste, obsolete pesticides and persistent organic pollutants;

(xxvii) "hospital waste" means waste medical supplies and materials of all kinds, and waste blood, tissue, organs and other parts of the human and animal bodies, from hospitals, clinics, laboratories and veterinary facilities;

(xxviii) "industrial activity" means any operation or process for manufacturing, making, formulating, synthesising, altering, repairing, ornamenting, finishing, packing or otherwise treating any article or substance with a view to its use, sale, transport, delivery or disposal, or for mining, for oil and gas exploration and development, or for pumping water or sewage, or for generating, transforming or transmitting power or for any other industrial or commercial purposes;

(xxix) "industrial waste" waste means waste resulting from an industrial activity;

(xxx) "initial environmental examination" means a preliminary environmental review of the reasonably foreseeable qualitative and quantitative impacts on the environment of a proposed project to determine whether it is likely to cause an adverse environmental effect for requiring preparation of an environmental impact assessment;

(xxxi) "local authority" means any agency set up or designated by Government, by notification in the official Gazette to be a local authority for the purposes of this Act;

(xxxii) "local council" means a local council constituted or established under a law relating to local government;

(xxxiii) "motor vehicle" means any mechanically propelled vehicle adapted for use upon land whether its power of propulsion is transmitted thereto from an external or internal source, and includes a chassis to which a body has not been attached, and a trailer, but does not include a vehicle running upon fixed rails;

(xxxiv) "municipal waste" includes sewage, refuse, garbage, waste from abattoirs, sludge and human excreta and the like;

(xxxv) "noise" means the intensity, duration and character of sounds from all sources, and includes vibration;

(xxvi) "non degradable plastic products" means a plastic product which are made from the non-biodegradable substances;

(xxxvii) "nuclear waste" means waste from any nuclear reactor or nuclear plant or other nuclear energy system, whether or not such waste is radioactive;

(xxxviii) "Oxo-biodegradable Plastic Products" means a plastic product made of a polymer by adding a pro-degrading additive containing a transition metal salt, except cobalt, which cause the plastic to degrade and bio-grade from oxidative and cell mediated phenomena either simultaneously or successfully;

(xxxix) "person" means any natural person or legal entity and includes an individual, firm, association, partnership, society, group, company, corporation,. co-

operative society, Government Agency, non-governmental organization, community-based organization, village organization, local council or local authority and, in the case of a vessel, the master or other person having for the time being the charge or control of the vessel;

(xl) "pollution" means the contamination of air, land or water by the discharge or emission of effluent or wastes or air pollutants or noise or other matter which either directly or indirectly or in combination with other discharges or substances alters unfavourably the chemical, physical, biological, radiational, thermal or radiological or aesthetic properties of the air, land or water or which may, or is likely to make the air, land or water unclean, noxious or impure or injurious, disagreeable or detrimental to the health, safety, welfare, or property of persons or harmful to biodiversity;

(xli) "prescribed" means prescribed by rules made under this Act;

(xlii) "project" means any activity, plan, scheme, proposal or undertaking involving any change in the environment and includes-

(a) construction or use of buildings or other works;

(b) construction or use of roads or other transport systems;

(c) construction or operation of factories or other installations;

(d) mineral prospecting, mining, quarrying, stone-crushing, drilling and the like;

(e) any change of land use or water use; and

(f) alteration, expansion, repair, decommissioning or abandonment of existing buildings or other works, roads or other transport systems, factories or other installations;

(xliii) "proponent" means the person who proposes or intends to undertake a project;

(xliv) "regulations" means regulations made under this Act;

(xlv) "rules" means rules made under this Act;

(xlvi) "sewage" means liquid or semi-solid wastes and sludge from sanitary conveniences, kitchens, laundries, washing and similar activities and from any sewerage system or sewage disposal works;

(xlvii) "Schedule Plastic Products" means all types of flexible plastic packaging and disposable plastic products made of Polythene, Polypropylene, Polystyrene and Poly-ethylene Terephthalate (PET), used for food and non-food items, like shopping bags, garbage bags, snacks packs, water and milk packaging, shrink wraps, bubble pellet wraps, films, liners, woven or non-woven bags, mulch films;

(xlviii) "Sindh Environmental Quantity Standards" means standards established by the Agency under clause (e) of sub-section (1) of section 6 and approved by the Council under clause (C) of sub-section (1) of section 4 made under this Act;

(xlix) "standards" means qualitative and quantitative standards for discharge of effluent and wastes and for emission of air pollutants and noise either for general applicability or for a particular area, or from a particular production process, or for a particular product, and includes the Sindh Environmental Quality Standards, emission standards and other standards established under this Act and the rules and regulations;

(l) "strategic environmental assessment" mean an analysis of a proposed policy, legislation, plan or programme to determine whether the principles of sustainable development have been integrated therein and to identify its likely environmental effects and such components as require an initial environmental examination or environmental impact assessment;

(li) "sustainable development" means development that meets the needs of the present generation without compromising the ability of future generations to meet their needs;

(lii) "trans-boundary environmental impacts" means environmental impact arising from beyond the boundaries or limits of Sindh province and causing any adverse environmental impact or pollution in the air, land, water and coaster water of Sindh province;

(liii) "waste" means any substance or object which has been, is being or is intended to be, discarded or disposed-of, and includes liquid waste, solid waste, waste gases, suspended waste, industrial waste, agricultural waste, nuclear waste, municipal waste, hospital waste, used polyethylene bags and residues from the incineration of all types of waste;

(liv) "waters (coastal waters, internal waters, territorial waters and historical waters)" means such limits of the waters adjacent to the land territory as may be specified in the Territorial Waters and Maritime Zones Act, 1976 (LXXXII of 1976).

PART – II THE SINDH ENVIRONMENTAL PROTECTION COUNCIL

3. Establishment of the Sindh Environmental Protection Council.- (1) The Government of Sindh shall, by notification in the official Gazette, establish a Council to be known as the Sindh Environmental Protection Council consisting of-

(i)	Chief Minister or such other person as the Chief Minister may nominate in this behalf.	Chairperson
(ii)	Minister-in-charge of the Environment Protection Department.	Vice chairperson
(iii)	Additional Chief Secretary, Planning and Development Department, Government of Sindh.	Ex-officio Member
(iv)	Secretaries of the Environment, Finance, Public Health Engineering, Irrigation, Health, Agriculture, Local Government, Industries, Live Stock and Fisheries, Forest and Wildlife, Energy, Education, Departments of Government of Sindh and the divisional commissioners of Sindh.	Ex-officio Members
(v)	Such other persons not exceeding twenty- five as Government may appoint from representatives of the Chambers of Commerce and Industry and industrial associations, representatives of the Chambers of Agriculture, the medical and legal professions, trade unions, non-governmental organizations concerned with the environment and sustainable development, and scientists, technical experts and educationists.	Non-official Members
(vi)	Director General, Sindh Environment Protection Agency.	Member / Secretary

(vii)	Two Members of the Provincial Assembly of Sindh amongst the eleven Members of the Standing Committee on Environment nominated by the Speaker.	Members

(2) The Members of the Council, other than ex-officio members, shall be appointed in accordance with the prescribed procedure.

(3) A non-official member, unless he sooner resigns or is removed, shall hold office for a term of three years and shall be eligible for re-appointment but shall not hold office for more than two terms.

(4) The Council shall frame its own Rules of Procedure.

(5) The Council shall hold meetings, as and when necessary, but not less than two meetings, shall be held in a year.

(6) The Council may constitute committees of its members and entrust them with such functions as it may deem fit, and the recommendations of the committees shall be submitted to the Council for approval.

(7) The Council, or any of its committees, may invite any technical expert or representative of any Government Agency or non-governmental organization or other person possessing specialized knowledge of any subject for assistance in performance of its functions.

4. Functions and Powers of the Council.- (1) The Council shall-

(a) co-ordinate and supervise the enforcement of the provisions of this Act and other laws relating to the environment in the Province;

(b) approve comprehensive provincial environmental and sustainable development policies and ensure their implementation within the framework of a conservation strategy and sustainable development plan as may be approved by Government from time to time;

(c) approve the Sindh Environmental Quality Standards;

(d) provide guidelines for the protection and conservation of species, habitats, and biodiversity in general, and for the conservation of renewable and non-renewable resources.

(e) coordinate integration of the principles and concerns of sustainable development into socio-economic and development policies, plans and programmes at the provincial, district and local levels;

(f) consider the annual Sindh Environment report and give appropriate directions thereon and cause it to be laid before the Provincial Assembly;

(g) deal with inter-provincial and federal-provincial issues, and liaise and coordinate with other Provinces through appropriate inter-provincial forums regarding formulation and implementation of standards and policies relating to environmental matters with an inter-provincial impact;

(h) provide guidelines for biosafety and for the use of genetically modified organisms; and

(i) assist the Federal Government or Federal Agency in implementation and or administration of various provision of United Nation Convention on Laws on Seas, 1980 (UNCLOS) in coastal waters of the province;

(2) The Council may, either itself or on the request of any person or organization, direct the Agency or any Government Agency to prepare, submit, promote or implement projects for the protection, conservation, rehabilitation and improvement of the environment, the prevention and control of pollution, and the sustainable development of resources or to undertake research in any specified aspect of environment.

PART – III THE SINDH ENVIRONMENTAL PROTECTION AGENCY

5. Establishment of the Sindh Environmental Protection Agency.- (1) Government shall, by notification in the Official Gazette, establish the Sindh Environmental Protection Agency, to exercise the powers and perform the functions assigned to it under the provisions of this Act and the rules and regulations made thereunder.

(2) The Agency shall be headed by a Director General who shall be appointed by Government on such terms and conditions as it may determine.

(3) The Agency shall have such administrative, technical and legal staff as Government may specify, to be appointed in accordance with such procedure as may be prescribed.

(4) The powers and functions of the Agency shall be exercised and performed by the Director General.

(5) The Director General may, by general or special order, delegate any of these powers and functions to staff appointed under sub-section (3).

(6) For assisting the Agency in the discharge of its functions Government shall establish Advisory Committees for various sectors and appoint as members thereof eminent representatives of the relevant sector, educational institutions, research institutes and non- governmental organizations.

6. Functions of the Agency.- (1) The Agency shall–

(a) administer and implement the provisions of this Act and the rules and regulations;

(b) prepare, in co-ordination with the appropriate Government Agency or local council and, in consultation with the concerned Advisory Committees where established, environmental policies for the approval of the Council;

(c) take all necessary measures for the implementation of the environmental policies approved by the Council;

(d) prepare and publish an annual Sindh Environment Report on the state of the environment in the province;

(e) prepare or revise and establish the Sindh Environmental Quality Standards with approval of the Council:

Provided that before seeking approval of the Council, the Agency shall publish the proposed Sindh Environmental Quality Standards for public opinion in accordance with the prescribed procedure;

(f) ensure enforcement of the Sindh Environmental Quality Standards;

(g) where the quality of ambient air, water, land or noise so requires, the Agency may, by notification in the Official Gazette establish different standards for discharge or emission from different sources and for different areas and conditions as may be necessary:

Provided that where these standards are less stringent than the Sindh Environmental Quality Standards; prior approval of the Council shall be obtained;

(h) establish systems and procedures for surveys, surveillance, monitoring, measurement, examination, investigation, research, inspection and audit to prevent and control pollution, and to estimate the costs of cleaning up pollution and rehabilitating the environment in various sectors;

(i) take measures to promote research and the development of science and technology which may contribute to the prevention of pollution, protection of the environment, and sustainable development;

(j) issue licences, approval for the consignment, handling, transport, treatment, disposal of, storage, handling or otherwise dealing with hazardous substances;

(k) certify laboratories as approved laboratories for conducting tests and analysis and one or more research institutes as environmental research institutes for conducting research and investigation for the purposes of this Act;

(l) identify the needs for and initiate legislation in various sectors of the environment;

(m) Provide assistance to relevant Federal and Provincial Government Agencies in the management of environment accidents and natural and environmental disasters, including conduct of inquiry thereto;

(n) render advice and assistance in environmental matters including such information and data available with it as may be required for carrying out the purposes of this Act:

Provided that the disclosure of such information shall be subject to the restrictions specified in Part XI (Access to Information);

(o) assist Government Agencies, local councils, local authorities and other persons to implement schemes for the proper disposal of wastes so as to ensure compliance with the Sindh Environmental Quality Standards:

(p) Provide information and guidance to the public on environmental matters;

(q) recommend environmental courses, topics, literature and books for incorporation in the curricula and syllabi of educational institutions;

(r) promote public education and awareness of environmental issues through mass media and other means including seminars and workshops;

(s) establish and maintain mechanisms, including its own website, to disseminate information, subject to the provisions of this Act, regarding policies, plans and decisions of the Government, the Council and the Agency, relating to the environment;

(t) specify safeguards for the prevention of accidents and disasters which may cause pollution, collaborate with the concerned persons in the preparation of contingency plans for control of such accidents and disasters, and co-ordinate implementation of such plans;

(u) review and approve mitigation plans and give guidance and directions, where necessary, relating to clean up operations ordered under this Act;

(v) encourage the formation and working of nongovernmental organizations, community organizations and village organizations to prevent and control pollution and promote sustainable development;

(w) take or cause to be taken all necessary measures for the protection, conservation, rehabilitation and improvement of the environment, prevention and control of pollution and promotion of sustainable development; and

(x) Perform any function that the Council may assign to it.

(2) The Agency may-

(a) undertake inquiries or investigation into environmental issues, either of its own accord or upon complaint from any person or organization;

(b) request any person to furnish any information or data relevant to its functions;

(c) initiate, with the approval of Government, requests for foreign assistance in support of the purposes of this Act and enter into arrangements with foreign agencies or organizations for the exchange of material or information and participate in international seminars or meetings;

(d) recommend to Government and the Council the adoption of financial and fiscal programmes, schemes or measures for achieving environmental objectives and goals and the purposes of this Act, including –

(i) taxes, duties, cesses and other levies; and

(ii) incentives, prizes, awards, rewards, subsidies, tax exemptions, rebates and depreciation allowances;

(e) establish and maintain laboratories to help in the performance of its functions under this Act and to conduct research in various aspects of the environment and provide or arrange necessary assistance for the establishment of similar laboratories in the private sector;

(f) arrange, in accordance with such procedure as may be prescribed, financial assistance for projects designed to facilitate in discharge of its functions; and

(g) acquire assistance of concerned authorities of district administration and other relevant agencies, departments and police assistance for enforcement of this Act.

7. Powers of the Agency.- Subject to the provisions of this Act, the Agency may-

(a) lease, purchase, acquire, own, hold, improve, use or otherwise deal in and with any property both moveable and immovable;

(b) sell, convey, mortgage, pledge, exchange or otherwise dispose of its property and assets;

(c) fix and realize fees, rates and charges for rendering any service or providing any facility, information or data under this Act or its rules and regulations;

(d) enter into contracts, execute instruments, incur liabilities and do all acts or things necessary for proper management and conduct of its business;

(e) appoint, with the approval of Government and in accordance with such procedures as may be prescribed, such advisers, experts and consultants as it considers necessary for the efficient performance of its functions on such terms and conditions as it may deem fit;

(f) summon and enforce the attendance of any person and require him to supply any information or document needed for the conduct of any enquiry or investigation into any environmental issue;

(g) Director General may authorize any officer or official to enter and inspect or under a search warrant issued by Environmental Protection Tribunal or a Court, search at any time, any land, building, premises, vehicle or vessel or other place where or in which there are reasonable grounds to believe that an offence under this Act has been, or is being, or likely to be committed;

(h) take samples of any materials, products, articles or substances or of the effluent, wastes or air pollutants being discharged or emitted or of air, water or land in the vicinity of the discharge or emission;

(i) arrange for the testing and analysis of samples at a certified laboratory;

(j) confiscate any article used in the commission of the offence where the offender is not known or cannot be found within a reasonable time:

Provided that the powers under clauses (f), (g), (h) (i), and (j) shall be exercised in accordance with the provisions of the Code of Criminal Procedure, 1898 (Act V of 1898) or the rules and regulations and under the direction of the Environmental Protection Tribunal or a Court; and

(k) establish the Sindh Environmental Co-ordination Committee comprising the Director-General as its Chairman and such other persons as Government shall appoint as its members to exercise such powers and perform such functions as shall be delegated or assigned to it by Government for carrying out the purposes of this Act and for ensuring coordination among Government Agencies in implementation of environmental policies.

PART – IV SINDH SUSTAINABLE DEVELOPMENT FUND

8. Establishment of the Sindh Sustainable Development Fund.- (1) There shall be established a Sindh Sustainable Development Fund.

(2) The Sindh Sustainable Development Fund shall be derived from the following sources, namely—

(a) allocations and grants made or loans advanced by the Government of Sindh or by the Federal Government;

(b) aid and assistance, grants, advances, donations and other non-obligatory funds received from foreign governments, national or international agencies, and nongovernmental organizations; and

(c) Voluntary contributions from private, corporate, multinational organizations and other persons.

(d) Any fees generated under the provision of this act including the fines imposed against contraventions including penalties.

(3)The Sindh Sustainable Development Fund shall be utilized, in accordance with such procedures as may be prescribed for –

(a) providing financial assistance to projects designed for the protection, conservation, rehabilitation and improvement of the environment, the prevention and control of pollution, the sustainable development of resources and for research in any specified aspect of the environment; and

(b) any other purposes which, in the opinion of the Board, will help achieve environment objectives and the purposes of this Act.

9. Management of the Sindh Sustainable Development Fund.- (1)The Sindh Sustainable Development Fund shall be managed by a Board known as the Provincial Sustainable Development Fund Board consisting of—

(i)	Additional Chief Secretary, Planning and Development Department, Government of Sindh	Chairperson
(ii)	Such officers of Government, not exceeding five (05), as Government may appoint including Secretaries of the Environment, Finance, Industries and Local Government Departments, Government of Sindh.	Ex-officio Members
(iii)	Such non-official persons, not exceeding five (05), as Government may appoint, including representatives of the Chambers of Commerce and Industry, non-governmental organizations and major donors.	Non-official Members
(iv)	Director General, Sindh, Environmental Protection Agency.	Secretary / Member

(2) The members of the Board, other than ex-officio members, shall be appointed in accordance with the prescribed procedure.

(3) A non-official member of the Board, unless he sooner resigns or is removed, shall hold office for a term of three years and shall be eligible for re-nomination, but shall not hold office for more than two terms.

(4) The Board shall frame its own rules of procedure with the approval of Government.

(5) In accordance with such procedures and such criteria as may be prescribed, the Board shall have the power to —

(a) sanction financial assistance for eligible projects;

(b) invest moneys held in the Sindh Sustainable Development Fund in such profit-bearing Government bonds, saving schemes and securities as it may deem suitable; and

(c) take such measures and exercise such powers as may be necessary for utilization of the Sindh Sustainable Development Fund for the purposes specified in subsection (3) of section 8.

(6) The Board shall constitute committees of its members to undertake regular monitoring of projects financed from the Sindh Sustainable Development Fund and to submit progress reports to the Board which shall publish an Annual Report incorporating its annual audited accounts and performance evaluation based on the progress reports.

10. Accounts.- (1) The Agency shall maintain proper accounts of the Sindh Sustainable Development Fund and other relevant records and prepare annual statement of accounts in such form as may be prescribed.

(2) The accounts of the Sindh Sustainable Development Fund shall be audited annually by the Auditor General of Pakistan.

PART – V PROHIBITIONS AND ENFORCEMENT

11. Prohibition of certain discharges or emissions and compliance with standards.- (1) Subject to the provisions of this Act and the rules and regulations, no person shall discharge or emit or allow the discharge or emission of any effluent, waste, pollutant, noise or any other matter that may cause or likely to cause pollution or adverse environmental effects, as defined in section 2 of this Act, in an amount, concentration or level which is in excess to that specified in Sindh Environmental Quality Standards; or, where applicable, the standards established under Section 6(1)(g)(i); or direction issued under Section 17, 19, 20 and 21 of this Act; or any other direction issued, in general or particular, by the Agency.

(2) All persons, in industrial or commercial or other operations, shall ensure compliance with the Environmental Quality Standards for ambient air, drinking water, noise or any other Standards established under section 6(1)(g)(i); shall maintain monitoring records for such compliances; shall make available these records to the authorized person for inspection; and shall report or communicate the record to the Agency as required under any directions issued, notified or required under any rules and regulations.

(3) Monitoring and analysis under sub-section (1) and (2), shall be acceptable only when carried out by the Environmental Laboratory certified by the Agency as prescribed in the rules.

12. Prohibition of import of hazardous waste.- No person shall import hazardous waste into Sindh province or its coastal, internal, territorial or historical waters, except acquiring prior approval of the Agency.

13. Handling of hazardous substances.- Subject to the provisions of this Act, no person shall import, generate, collect, consign, transport, treat, dispose of, store, handle or otherwise use or deal with any hazardous substance except-

(a) under a licence issued by the Agency; or

(b) in accordance with the provisions of any other law, rule, regulation or notification for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement or other instrument to which Government is a party.

14. Prohibition of action adversely affecting Environment.- (1) Subject to the provisions of this Act and the rules and regulations, no person shall cause any act, deed or any activity, including-

(a) recycling or reuse of hospital waste and infectious waste;

(b) disposal of solid and hazardous wastes at unauthorized places as prescribed;

(c) dumping of wastes or hazardous substances into coastal waters and inland water bodies;

(d) release of emissions or discharges from industrial or commercial operations as prescribed;

(e) recycling or reuse or recovery of hazardous wastes or industrial by-products in an unauthorized or non-prescribed manner or procedure; and

(f) any activity which may cause adverse environmental affect due to trans boundary projects of Province of Sindh.

which lead to pollution or impairment of or damage to biodiversity, ecosystem, aesthetics or any damage to environment and natural resources as defined in section 2 (xxxvi) of this Act.

(2) No person shall generate, handle, transport, dispose of or handle the hospital waste and infections waste except in accordance with the Hospital Waste Management Rules and in such manner as may be prescribed.

(3) No person shall import, manufacture, stockpile, trade, supply, distribute or sell any scheduled plastic product which is non-degradable. The scheduled plastic products

must be oxo-biodegradable and the pro-degradant used must be approved by the Agency or any other department or agency and in such manner as prescribed.

15. Regulation of motor vehicles.- (1) Subject to the provisions of this Act, no person shall operate or manufacture a motor vehicle or class of vehicles from which air pollutants or noise are being emitted in an amount, concentration or level which is in excess of the Sindh Environmental Quality Standards or, where applicable, the standards established under sub-clause (i) of clause (g) of sub-section (1) of section 6.

(2) For ensuring compliance with the standards mentioned in sub-section (1), the Agency may direct that any motor vehicle or class of vehicles shall install such pollution control devices or other equipment or use such fuels or undergo such maintenance or testing as prescribed.

(3) For ensuring compliance with the standards mentioned in sub-section (1), the Agency may direct that any manufacturer of motor vehicle or class of vehicles shall use such manufacturing standard or design or pollution control devices or other equipment or undergo such testing as may be prescribed.

(4) Where a direction has been issued by the Agency under sub-section (2) and (3) in respect of any motor vehicles or class of motor vehicles, no person shall operate or manufacture any such vehicle till such direction has been complied with.

16. Certified Environmental Laboratory.- (1) The monitoring, testing and analysis carried out in compliance or for the enforcement of any provisions of this Act.

(2) The laboratory or organization having any facility for environmental monitoring, testing and analysis and intend to perform under sub-section (1) shall register with the Agency in accordance with the Environmental Laboratory Certification Rules as prescribed.

PART – VI ENVIRONMENTAL EXAMINATIONS AND ASSESSMENTS

17. Initial environmental examination and environmental impact assessment.- (1) No proponent of a project shall commence construction or operation unless he has filed with the Agency an initial environmental examination or environmental impact assessment, and has obtained from the Agency approval in respect thereof.

(2) The Agency shall –

(a) review the initial environmental examination and accord its approval, subject to such terms and conditions as it may prescribe, or require submission of an environmental impact assessment by the proponent; or

(b) review the environmental impact assessment and accord its approval subject to such terms and conditions as it may deem fit to impose or require that the environmental impact assessment be re-submitted after such modifications as may be stipulated or decline approval of the environmental impact assessment as being contrary to environmental objectives.

(3) Every review of an environment impact assessment shall be carried out with public participation and, subject to the provisions of this Act, after full disclosure of the particulars of the project.

(4) The Agency shall communicate its approval or otherwise within a period of two months from the date that the initial environmental examination is filed, and within a period of four months from the date that the environmental impact assessment is filed complete in all respects in accordance with the regulations, failing which the initial environmental examination or, as the case may be, the environmental impact assessment shall be deemed to have been approved, to the extent to which it does not contravene the provisions of this Act and the rules and regulations.

(5) The provisions of sub-sections (1), (2), (3) and (4) shall apply to such categories of projects and in such manner as prescribed.

(6) The Agency shall maintain separate registers for initial environmental examination and environmental impact assessment projects, which shall contain brief particulars of each project and a summary of decisions taken thereon, and which shall be open for inspection to the public during office hours.

18. Strategic environmental assessment.- (1) All provincial government agencies, departments, authorities, local councils and local authorities responsible for formulating policies, legislation, plans and programmes to be implemented in Sindh province which may cause any environmental impact in the jurisdiction of the province shall, before submitting the same to the competent authority for approval, forward to the Sindh Environmental Protection Agency a strategic environment assessment containing —

(a) description of the objectives and features of the proposed policy, legislation, plan or programme that are in consonance with the principles of sustainable development;

(b) assessment of the adverse environmental effects, if any, likely to be caused during implementation of the policy, legislation, plan or programme alongwith proposed preventive, mitigation and compensatory measures;

(c) analysis of possible alternatives; and

(d) Identification of those components of the policy, legislation, plan or programme, if any, in respect of which specific environmental impact assessment need to be carried out in due course.

(2) The Agency shall, in consultation with the concerned Government Agencies and Advisory Committees where established, review the strategic environment assessment, within sixty (60) days of its filing, and prepare a report containing its comments and recommendations in respect thereof which shall be forwarded to the initiating Government Agency, authority, local council or local authority and duly considered by it and the competent authority before approval or otherwise of the proposed policy, legislation, plan or programme.

(3) The provisions of sub-sections (1), and (2) shall apply to such categories of policies, plans and programmes and in such manner as may be prescribed.

19. Environmental monitoring.- (1) The Agency shall carry out or arrange environmental monitoring of all projects in respect of which it has approved an initial environmental examination or environmental impact assessment to determine whether the actual environmental impact exceeds the level predicted in the assessment and whether the conditions of the approval are being complied with.

(2) For purposes of sub-section (1), the Agency may require the person in charge of a project to furnish such information as it may specify pertaining to the environmental impact of the project, including quantitative and qualitative analysis of –

(a) discharge of effluents, wastes, emissions of air pollutants, noise and any other matter or action that may be found offensive under section 14 from the project on daily, weekly, monthly or annual basis;

(b) ambient quality of the air, water, noise and soil before, during and after construction and during operation of the project.

(3) On review of the data collected by it and information provided, the Agency may issue such directions to the person in charge as it may consider necessary to ensure compliance with the conditions of the approval.

20. Environmental Audit and Review.- (1) The Agency shall from time to time require the person in charge of a project to furnish, within such period as may be specified, an environmental audit or environmental review report or environmental management plan containing a comprehensive appraisal of the environmental aspects of the project.

(2) The report of a project prepared under sub-section (1) shall include –

(a) analysis of the predicted qualitative and quantitative impact of the project as compared to the actual impact;

(b) evaluation of the efficacy of the preventive, mitigation and compensatory measures taken with respect to the project; and

(c) recommendations for further minimizing or mitigating the adverse environmental impact of the project.

(3) Based on its review of the environmental audit report, the Agency may, after giving the person in charge of the project an opportunity of being heard, direct that specified mitigation and compensatory measures be adopted within a specified time period and may also, where necessary, modify the approval granted by it under section 17.

PART – VII ENVIRONMENTAL PROTECTION ORDER

21. Environmental Protection Order.- (1) Where the Agency is satisfied that the discharge or emission of any effluent, waste, air pollutant or noise, or the disposal of waste, or the handling of hazardous substances, or any other act or omission is likely to occur, or is occurring, or has occurred, in violation of any provision of this Act, the rules or regulations or of the conditions of a licence, or is likely to cause, or is causing or has caused an adverse environmental effect, the Agency may, after giving the person responsible for such discharge, emission, disposal, handling, act or omission an opportunity of being heard, by order direct such person to take such measures as the Agency may consider necessary within such period as may be specified in the order.

(2) In particular and without prejudice to the generality of the foregoing power, such measures may include —

(a) immediate stoppage, preventing, lessening or controlling the discharge, emission, disposal, handling, act or omission, or to minimize or remedy the adverse environmental effect;

(b) installation, replacement or alteration of any equipment or thing to eliminate, control or abate on a permanent or temporary basis, such discharge, emission, disposal, handling, act or omission;

(c) action to remove or otherwise dispose of the effluent, waste, air pollutant, noise, or hazardous substances;

(d) action to restore the environment to the condition existing prior to such discharge, disposal, handling, act or omission, or as close to such condition as may be reasonable in the circumstances, to the satisfaction of the Agency; and

(e) impose a penalty as prescribed.

(3) Notwithstanding the provisions of sub-section (1), in an emergency situation where, for reasons to be recorded, the Agency is satisfied that the discharge or emission of any effluent, waste, air pollutant or noise, or the disposal of waste, or the handling of

hazardous substances, or any other act or omission is likely to occur, or is occurring, or has occurred, in violation of the provisions of this Act and that circumstances of the case warrant immediate action in the public interest, it may pass an ad-interim order of the nature described in sub-sections (1) and (2) by providing reasonable opportunity of hearing.

PART – VIII OFFENCES AND PENALTIES

22. Penalties.- (1) Whoever contravenes or fails to comply with the provisions of sections 11, 17, 18 and 21 or any order issued there under shall be punishable with a fine which may extend to five million rupees, to the damage caused to environment and in the case of a continuing contravention or failure, with an additional fine which may extend to one hundred thousand rupees for every day during which such contravention or failure continues:

Provided that if the contravention of the provisions of section 11 also constitutes a contravention of the provisions of section 15, such contravention shall be punishable under sub-section (2).

(2) Whoever contravenes or fails to comply with the provisions of sections 13, 14, 15 and 16 or any rule or regulation or conditions of any license, any order or direction, issued by the Agency, shall be punished with a fine, and in case of continuing contravention or failure with an additional fine which may extend to ten thousand rupees for every day during which such contravention continues.

(3) Where an accused has been convicted of an offence under sub-sections (1) and (2), the Environmental Protection Tribunal and Court shall, as the case may be, in passing sentence, take into account the extent and duration of the contravention or failure constituting the offence and the attendant circumstances.

(4) Where an accused has been convicted of an offence under sub-sections (1) or (2), the Environmental Protection Tribunal or Court, as the case may be, shall endorse a copy of the order of conviction to the concerned trade or industrial association, if any, or the concerned Provincial Chamber of Commerce and Industry or the Federation of Pakistan Chambers of Commerce and Industry.

(5) Where a person convicted under sub-sections (1) and (2) had been previously convicted for any contravention of this Act and its rules or regulations, the Environmental Protection Tribunal, as the case may be, may, in addition to the punishment awarded thereunder-

(a) sentence him to imprisonment for a term that may extend up to three years;

(b) order the closure of the factory;

(c) order confiscation of the facility, machinery and equipment, vehicle or substance, record, document or other object used or involved in contravention of the provisions of this Act;

(d) order such person to restore the environment at his own cost, to conditions existing prior to the contravention or as close to such conditions as may be reasonable in the circumstances to the satisfaction of the Agency; and

(e) order that compensation be paid to any person or persons for any loss, or damage to their health or property suffered by such contravention.

(6) The Director General or an officer generally or specially authorised by him in this behalf may, on the application of the accused, compound an offence under this Act with the permission of the Environmental Protection Tribunal or Court in accordance with such procedure as prescribed.

(7) Where the Director General is of the opinion that a person had contravened any provision of this Act, he may, subject to the rules, by notice in writing to that person require him to pay to the Agency a penalty in the amount set out in the notice for each day the contravention continues.

23. Offences by body corporate.- Where any contravention of this Act has been committed by a body corporate, and it is proved that such offence has been committed with the consent or connivance of, or is attributed to any negligence on the part of, any director, partner, manager, secretary or other officer of the body corporate, such director, partner, manager, secretary or other officer of the body corporate, shall be deemed guilty of such contravention along with the body corporate and shall be punished accordingly:

Provided that in the case of a company as defined under the Companies Ordinance, 1984 (XLVII of 1984), only the Chief Executive as defined in the said Ordinance shall be liable under this section.

Explanation.- For the purposes of this Section, "body corporate" includes a firm, association of persons and a society registered under the Societies Registration Act, 1860 (XXI of 1860), or under the Co-operative Societies Act, 1925 (VII of 1925).

24. Offences by Government Agencies, local authorities or local councils.- Where any contravention of this Act has been committed by any Government Agency, local authority or local council, and it is proved that such contravention has been committed with the consent or connivance of, or is attributable to any negligence on the part of, the Head or any other officer of Government Agency, local authority or local council, such Head or other officer shall also be deemed guilty of such contravention along with the Government Agency, local authority or local council and shall be liable to be proceeded against and punished accordingly.

PART – IX ENVIRONMENTAL PROTECTION TRIBUNALS AND COURTS

25. Environmental Protection Tribunals.- (1) Government may, by Notification in the Official Gazette, establish as many Environmental Protection Tribunals as it considers necessary and, where it establishes more than one Environmental Protection Tribunal, it shall specify territorial limits within which, or the class of cases in respect of which, each one of them shall exercise jurisdiction under this Act.

(2) An Environmental Protection Tribunal shall consist of a Chairperson who is, or has been, or is qualified for appointment as a Judge of the High Court to be appointed after consultation with the Chief Justice of the High Court and two members to be appointed by Government, of which at least one shall be a technical member nominated from amongst the officers of the Agency with suitable professional qualifications and experience in the environmental field.

(3) For every sitting of the Environmental Protection Tribunal, the presence of the Chairperson and not less than one Member shall be necessary.

(4) A decision of an Environmental Protection Tribunal shall be expressed in terms of the opinion of the majority of its members, including the Chairperson, or if the case has been decided by the Chairperson and only one of the members and there is a difference of opinion between them, the decision of the Environmental Protection Tribunal shall be expressed in terms of the opinion of the Chairperson.

(5) An Environmental Protection Tribunal shall not, merely by reason of a change in its composition, or the absence of any member from any sitting, be bound to recall and rehear any witness who has given evidence, and may act on the evidence already recorded by, or produced, before it.

(6) An Environmental Protection Tribunal may hold its sittings at such places within its territorial jurisdiction as the Chairperson may decide.

(7) No act or proceeding of an Environmental Protection Tribunal shall be invalid by reason only of the existence of a vacancy in, or defect in the constitution, of, the Environmental Protection Tribunal.

(8) The terms and conditions of service of the Chairperson and members of the Environmental Protection Tribunal shall be such as may be prescribed.

26. Jurisdiction and powers of Environmental Protection Tribunals.- (1) An Environmental Protection Tribunal shall exercise such powers and perform such functions as are, or may be, conferred upon or assigned to it by or under this Act or the rules and regulations.

(2) All contraventions punishable under sub-section (1) of section 22 shall exclusively be triable by an Environmental Protection Tribunal.

(3) An Environmental Protection Tribunal shall not take cognizance of any offence triable under sub-section (2) except on a complaint in writing by—

(a) the Agency or any Government Agency or Local Council; and

(b) any aggrieved person, who has given notice of not less than thirty days to the Agency, of the alleged contravention and of his intention to make a complaint to the Environment Protection Tribunal.

(4) In exercise of its criminal jurisdiction, the Environmental Protection Tribunal shall have the same powers as are vested under the Code of Criminal Procedure, 1898 (Act V of 1898).

(5) In exercise of the appellate jurisdiction under section 27 the Environmental Protection Tribunal shall have the same powers and shall follow the same procedure as an appellate court in the Code of Civil Procedure, 1908 (Act V of 1908).

(6) In all matters with respect to which no procedure has been provided for in this Act, the Environmental Protection Tribunal shall follow the procedure laid down in the Code of Civil Procedure, 1908 (Act V of 1908).

(7) An Environmental Protection Tribunal may, on application filed by any officer duly authorised in this behalf by the Director General, issue bailable warrant for the arrest of any person against whom reasonable suspicion exists, of his having been involved in contravention punishable under sub-section (1) of section 22:

Provided that such warrant shall be applied for, issued and executed in accordance with the provisions of the Code of Criminal Procedure, 1898 (Act V of 1898):

Provided further that if the person arrested executes a bond with sufficient sureties in accordance with the endorsement on the warrant he shall be released from custody, failing which he shall be taken or sent without delay to the officer in-charge of the nearest jurisdiction police station.

(8) All proceedings before the Environmental Protection Tribunal shall be deemed to be judicial proceedings within the meaning of sections 193 and 228 of the Pakistan Penal Code (Act XLV of 1860), and the Environmental Protection Tribunal shall be deemed to be a court for the purpose of sections 480 and 482 of the Code of Criminal Procedure, 1898 (Act V of 1898).

(9) No court other than an Environmental Protection Tribunal shall have or exercise any jurisdiction with respect to any matter to which the jurisdiction of an Environmental Protection Tribunal extends under this Act and the rules and regulations.

(10) Where the Environmental Protection Tribunal is satisfied that a complaint made to it under sub-section (3) is false and vexatious to the knowledge of the complainant, it may, by an order, direct the complainant to pay to the person complained against such compensatory costs which may extend to one hundred thousand rupees.

27. Appeals to the Environmental Protection Tribunal.- (1) Any person aggrieved by any order or direction of the Agency under any provision of this Act or the rules or regulations may prefer an appeal with the Environmental Protection Tribunal within thirty days of the date of communication of the impugned order or direction to such person.

(2) An appeal to the Environmental Protection Tribunal shall be in such form, contain such particulars and be accompanied by such fees as prescribed.

28. Appeals from orders of the Environmental Protection Tribunal.- (1) Any person aggrieved by any final order or by any sentence of the Environmental Protection Tribunal passed under this Act may, within thirty days of communication of such order or sentence, prefer an appeal to the High Court.

(2) An appeal under sub-section (1) shall lie before the High Court of Sindh.

29. Jurisdiction of Judicial Magistrate.- (1) Notwithstanding anything contained in the Code of Criminal Procedure, 1898 (Act V of 1898), or any other law for the time being in force, but subject to the provisions of this Act, all contraventions punishable under sub-section (2) of section 22 shall exclusively be triable by the Court of Judicial Magistrate of First Class having jurisdiction.

(2) A Judicial Magistrate shall be competent to impose any punishment specified in sub-sections (2) and (4) of section 22.

(3) A Judicial Magistrate shall not take cognizance of an offence triable under sub-section (1) except on a complaint in writing by-

(a) the agency; and

(b) any aggrieved person

30. Appeals from orders of the Judicial Magistrate.- Any person aggrieved by any final order or sentence passed by a Judicial Magistrate under section 28 may, within thirty days from the date of the communication of such order or sentence, appeal to the Court of the District and Sessions Judge defined as Green Court under this Act, whose decision thereon shall be final.

PART – X PUBLIC PARTICIPATION

31. Public participation.- (1)The Agency shall cause relevant details of any proposed project regarding which an Environmental Impact Assessment has been received to be published, alongwith an invitation to the public to furnish their comments thereon within a specified period.

(2) In accordance with such procedure as may be prescribed, the Agency shall hold public hearings to receive additional comments and hear oral submissions.

(3) All comments received under sub-sections (1) and (2) shall be duly considered by the Agency while reviewing the environmental impact assessment or strategic impact assessment, and decision or action taken thereon shall be communicated to the persons who have furnished the said comments.

PART – XI GENERAL

32. Power to make and amend schedule.- The Agency may, by notification in the official Gazette, make and amend the schedule.

33. Indemnity.- No suit, prosecution or other legal proceedings shall lie against Government, the Council, the Agency, the Director General of the Agency, members, officers, employees, experts, advisors, committees or consultants of the Agency or Environmental Protection Tribunal or Court or any other person for anything which is done or intended to be done in good faith under this Act or rules or regulations.

34. Dues recoverable as arrears of land revenue.- Any dues recoverable by the Agency under this Act and rules or regulations shall be recoverable as arrears of land revenue.

35. Act to override other laws.- The provisions of this Act shall have effect notwithstanding anything inconsistent therewith contained in any other law for the time being in force.

36. Power to make rules.- The Sindh Environment Protection Agency may, by notification in the Official Gazette, make rules for carrying out the purposes not in consistence of this Act with the approval of Government.

37. Power to make regulations.- (1) For carrying out the purposes of this Act, the Agency may, by Notification in the Official Gazette and with the approval of Government, make regulations not inconsistent with the provisions of this Act or the rules.

(2) In particular and without prejudice to the generality of the foregoing power, such regulations may provide for-

(a) submission of periodical reports, data or information by any Government Agency, local authority or local council in respect of environmental matters;

(b) preparation of emergency contingency plans for coping with environmental hazards and pollution caused by accidents, natural disasters and calamities;

(c) appointment of officers, advisors, experts, consultants and employees as per prescribed rules;

(d) levy of fees, rates and charges in respect of services rendered, actions taken and schemes implemented;

(e) monitoring and measurement of discharges and emissions;

(f) categorization of projects to which, and the manner in which sections 17, 18 and 20 applies;

(g) laying down of guidelines for preparation of initial environmental examination, environmental impact assessment and strategic environmental assessment, and development of procedures of their filing, reviews and approval.

(h) laying down standard operating procedures for environmental sampling, examination of water, waste water, gaseous emissions, solid waste and noise;

(i) providing procedures for handling hazardous substances; and

(j) installation of devices in, use of fuels by, and maintenance and testing of motor vehicles for control of air and noise pollution.

BY ORDER OF THE SPEAKER
PROVINCIAL ASSEMBLY OF SINDH
G.M.UMAR FAROOQ
SECRETARY
PROVINCIAL ASSEMBLY OF SINDH

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Sindh Environmental Protection Act, 2014

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KARACHI

The Sindh Environmental Protection Agency (Environmental Assessment) Regulations, 2021

GOVERNMENT OF SINDH

SINDH ENVIRONMENTAL PROTECTION AGENCY

[Karachi dated, the 3rd September, 2021]

*Notification No. EPA/TECH/739/2021. – In exercise of the powers conferred by section 37 of the Sindh Environmental Protection Act, 2014, the Sindh Environmental Protection Agency, with the approval of Government, is pleased to make the following regulations, namely : –

1. **Short title and commencement.** – (1) These regulations may be called the Sindh Environmental Protection Agency (Environmental Assessment) Regulations, 2021.

(2) They shall come into force at once.

2. **Definitions.** – (1) In these regulations, unless there is anything repugnant in the subject or context –

(a) "**Act**" means the Sindh Environmental Protection Act, 2014 (VIII of 2014);

(b) "**Agency**" means the Sindh Environmental Protection Agency as defined under section 2(ii);

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*Published in the Sindh Govt. Gaz., Extr., Pt. I, P. No. 879, dt. Sept. 9, 2021.

(c) **"Director General"** means the Director General of the Agency;

(d) **"Environmental Checklist"** means rapid environmental assessment or environmental screening through a prescribed checklist in respect of projects having least/minimal impacts on the environment;

(e) **"Firm"** means the Environmental Consulting Firm registered by the Agency;

(f) **"Environmentally sensitive area"** means a location, large or small, that has significant environmental values that contribute to maintaining biological diversity and integrity, have intrinsic or attributed scientific, historical or cultural heritage value, or are important in providing amenity, harmony or sense of community, ecosystem as declared by Agency;

(g) **"Protected area"** means any area which safeguards the earths precious bio-diversity, protected areas of natural beauty and conservation of cultural significance as declared by relevant authority;

(h) **"Schedule"** means the Schedules provided in these regulations;

(i) **"Urban area"** means an area within the limits of a town, municipality or city as determined by the Agency on the basis of population and environmental issues.

(2) All other words and expressions used but not defined in these regulations shall have the same meaning as are assigned to them in the Act.

3. Projects requiring Environmental Checklist (EC). – A proponent of a project falling in any category listed in Schedule-I shall file environmental checklist with the Agency and the provisions of section 17 shall apply to such projects.

4. Projects requiring an Initial Environmental Examination (IEE). – A proponent of a project falling in any category listed in Schedule-II shall file an IEE with the Agency, and the provisions of section 17 shall apply to such projects.

5. Projects requiring an Environmental Impact Assessment (EIA). – A proponent of a project falling in any category listed in Schedule-III shall file an EIA with the Agency, and the provisions of section 17 shall apply to such projects.

6. Projects not requiring an Environmental Assessment. – (1) A project not falling in any category listed in Schedules-I, II and III shall not be required to file an EC, IEE or EIA.

(2) Notwithstanding anything contained in sub-regulation (1), the Agency may direct the proponent of a project, whether or not listed in Schedule I or II or III, to file an EC or IEE or EIA, for reasons to be recorded in such direction :

Provided that no such direction shall be issued without the recommendations in writing of the Advisory Committee constituted under regulations 21.

7. Preparation of environmental assessment report. – (1) The Agency may issue guidelines for preparation of an EC or IEE or EIA reports including guidelines of general applicability, and sectoral guidelines indicating specific assessment requirements for planning, construction and operation of projects relating to particular sector.

(2) The Agency may issue guidelines for preparation

scope of an Environmental Management Plan (EMP) or Environmental Audit (EA).

(3) Where guidelines have been issued under sub-regulation (1) & (2), an EC, IEE or EIA or EMP or EA shall be prepared, to the extent practicable, in accordance therewith and the proponent shall justify any departure therefrom.

8. **Review Fees.** – The proponent shall pay, at the time of submission of an EC, IEE or EIA or EMP or BTS tower a non-refundable review fee to the Agency as prescribe in Schedule-IV.

9. **Filing of report.** – (1) Two hard copies and two electronic copies for an EC or IEE or EIA report shall be filed with the Agency by the proponent. The Agency may require the proponent to submit additional copies, as and when required during the review process.

(2) Every EC, IEE and EIA shall be accompanied by –

(a) an application, in the form prescribed in Schedule-V;

(b) Copy of receipt showing payment of review fee as prescribed in Schedule-IV.

10. **Preliminary Scrutiny.** – (1) Any report filed by the proponent or applicant shall be returned, if found incomplete in terms of Regulation 9.

(2) Notwithstanding anything contained in sub-regulation (1) of regulation 12, the Agency may require the proponent to submit an additional information at any stage during the review process.

11. **Public participation.** – (1) In the case in an EIA, the

Agency shall issue a public notice to be published in widely circulated English or Urdu or Sindhi national newspaper and in a local newspaper of general circulation in the area affected by the project, mentioning the type of project, its exact location, the name and address of the proponent and the date, time and place of public hearing for inviting comments from primary stakeholders.

(2) The date fixed under sub-regulation (1) shall not be earlier than ten days from the date of publication of the notice.

(3) The Agency shall also ensure the circulation of the EIA, where necessary, to the concerned Government Agencies and solicit their comments thereon.

(4) All comments received by the Agency from the public or any Government Agency shall be duly considered before issuance of decision.

(5) The Agency may issue guidelines indicating the basic techniques and measures to be adopted to ensure effective public consultation, involvement and participation in EIA assessment.

12. Review process. – (1) Notwithstanding anything contained in sub section (4) of Section 17, the Agency shall make every effort to conclude its review process of the EA, EMP or environmental checklist within fifteen days, of the IEE within thirty days, and of the EIA within sixty days after receiving of complete case.

(2) In reviewing an EIA, the Agency shall consult such Committee of Experts be constituted for the purpose by the Director General, and may also solicit views of concerned Advisory Committee, if any, constituted by the Agency.

(3) The Director General may, where considers it necessary, constitute a committee to inspect the site of the project and submit its report on such matters as may be specified.

(4) In reviewing the IEE, the Director General may constitute a committee of the officers from within the Agency, on case to case basis, in view of the jurisdiction and location of the project for the purpose to extend final recommendation about the approval or rejection of the IEE.

(5) The review of the IEE or EIA by the Agency shall be based on quantitative and qualitative assessment of the documents and data furnished by the proponent, comments from the public and Government Agencies received under regulation 12, and views of the committees mentioned in sub-regulations (2) and (3) above.

(6) EMP, EA, EC shall be reviewed as per guidelines issued by SEPA.

13. Decision. – (1) The documentary evidence in the form of videos (soft copies) of public hearing shall be submitted by the proponent within three days after conclusion of public hearing to the Agency.

(2) On completion of the review process, the decision of the Agency shall be communicated to the proponent in the form prescribed in Schedule-VI or in case of an IEE or EMP or environmental checklist or environmental audit in the form prescribed in Schedule-VII in case of an EIA.

14. Conditions of approval. – (1) Every approval of an EC or IEE or EIA or EMP or EA shall, in addition to such conditions as may be imposed by the Agency, be subject to the condition that the project shall be designed, constructed or operated and mitigatory and other measures adopted, strictly in accordance with the EC or IEE or EIA or EMP or EA, unless

any variations thereto have been specified in the approval by the Agency.

(2) Where the Agency accords its approval subject to certain conditions, the proponent shall submit an undertaking to the Agency, before commencing operation of the project, in the form prescribed in Schedule-VIII that the conditions of approval, and the requirements in the IEE or EIA relating to design and construction, adoption of mitigation and other measures have been duly complied with.

15. Validity period of Approval. – (1) The approval accorded by the Agency under section 17 read with sub-regulation (2) of regulation 15 shall be valid, for commencement of construction, for a period of three years from the date of issue.

(2) If construction is commenced during the initial three years validity period, the validity of the approval shall stand extended for a further period of three year.

(3) The proponent may apply to the Agency for extension in the validity periods mentioned in sub-regulations (1), (2), which may be granted by the Agency in its discretion for such period not exceeding three years at a time, if the conditions of the approval do not require significant change :

Provided that the Agency may require the proponent to submit a fresh IEE or EIA, if in its opinion changes in location, design, construction and operation of the project so warrant.

16. Entry and inspection. – (1) For the purpose of verification of any matter relating to the review or to the conditions of approval of an EC or IEE or EIA or EMP or EA list prior to, before or during and after commencement of construction or operation of a project, duly authorized staff of the Agency shall be entitled to enter and inspect the project site, factory building and plant and equipment installed therein.

(2) The proponent shall ensure full cooperation of the project staff at site to facilitate the inspection, and shall provide such information as may be required by the Agency for this purpose and pursuant thereto..

17. Cancellation of approval. – (1) Notwithstanding anything contained in these regulations, if, at any time, on the basis of information or report received or inspection carried out, the Agency is of the opinion that the conditions of an approval have not been complied with, or that the information supplied by a proponent in the approved EC or IEE or EIA or EMP or EA list is incorrect, it shall issue notice to the proponent for show cause within two weeks of receipt thereof as to why the approval should not be cancelled.

(2) In case no reply is received or if the reply is considered unsatisfactory, the Agency may, after giving the proponent an opportunity of being heard –

(i) require the proponent to take such measures and to comply with such conditions within such period as it may specify, failing which the approval shall stand cancelled; or

(ii) cancel the approval.

(3) On cancellation of the approval, the proponent shall cease construction or operation of the project forthwith.

(4) Any action taken under this regulation shall be without prejudice to any other action that may be taken against the proponent under the Act or rules or regulations or any other law for the time being in force.

18. Registers of EC or IEE and EIA projects. – Separate Registers to be maintained by the Agency for EC or IEE and EIA projects shall be in the form prescribed in Schedule-IX.

19. Environmentally sensitive areas. – (1) The Agency may designate an area to be an environmentally sensitive area.

(2) Notwithstanding anything contained in regulations 3 and 5, the proponent of a project situated in an environmentally sensitive area shall be required to file an EIA with the Agency.

20. Environmental assessment guidelines. – (1) The Agency may from time to time issue guidelines to assist proponents and other persons involved in the preparation of environmental assessment.

(2) Where guidelines have been issued under sub-regulation (1), the projects shall be planned and prepared, to the extent practicable, in accordance therewith and any departure therefrom justified in the IEE/EIA pertaining to the project.

21. Environmental Assessment Advisory Committee. – The agency may constitute one or more Committees for the purpose of rendering advice on implementation and enforcement of Section 17, which may include experts of relevant field, civil society, academia, environmental experts, representative of Administrative Department, legal expert and experts from natural resources.

22. Repeal and Savings. – (1) The Sindh Environmental Protection Agency (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2014, shall, on commencement of these regulations, stand repealed.

(2) All orders made, notification issued, actions taken under the repealed Regulations shall remain in force until amended, altered or repealed by the provisions of these regulations.

SCHEDULE – I

(*See* Regulation 3)

List of projects requiring Environmental Screening (through check list)

a. Subject to the compliance with concerned zoning laws :

   i. Construction of residential and commercial buildings having total covered area from 60,000 sq.feet to 100,000 sq.feet.

   ii. Housing Schemes covering an area from 05 acres to 15 acres.

   iii. Ware Houses for Non-Hazardous substances having total area from 1000 sq.yards to 5,000 sq.yards.

   iv. Warehouse for Fertilizers.

   v. Marriage Halls/Banquet/Restaurants/Baking facilities having total area more than 500 sq.yards.

   vi. Motor vehicle workshops/Service Stations having total area of more than 500 sq.yards.

b. Construction/Reconstruction/Rehabilitation of roads in urban area from 500 meters to 01 kilometres and in rural area from 500 meters to 05 kilometres.

c. Construction of Flyover, underpasses and bridges of length from 100 meters to 500 meters.

d. On-farm dams and fish farms.

e. Pulses mills.

f. Flour Mills.

g. Lining of existing minor canals and/or water courses.

h. Canal cleaning.

i. Forest harvesting operations.

j. Rain harvesting projects.

k. Health care units of less than 50 beds.

l. BTS Tower.

m. Lime Kilns.

n. Ice factories and cold storage.

o. Cotton oil mill.

p. Construction of LPG, CNG, LNG filling station and petrol pumps.

q. Carpet manufacturing units.

r. Rain harvesting projects.

s. Industrial Effluent Treatment Plant.

t. Sanitary Landfill site up to 500 tons/day.

SCHEDULE – II

(*See* Regulation 4)

List of projects requiring an Initial Environmental Examination

A. Agriculture, Livestock and Fisheries

1. Poultry, livestock and fish farms.
2. Warehousing for pesticides and pharmaceuticals.
3. Projects involving packaging, formulation, cold storage and warehouse of agricultural, livestock and fish products.
4. Construction & Operation of Slaughter houses.

B. Energy

1. Hydroelectric power generation up to 25 MW.
2. Thermal power generation up to 100 MW.
3. Coal fired power plants with capacity up to 50 MW.
4. Transmission lines up to 132 KV, and grid stations.
5. Waste-to-energy generation projects including bio-mass up to 25 MW.
6. Construction of Coal Handling and storage facilities.
7. Handling, Transportation & Storage of Biofuel Facility.
8. Handling and storage of edible grains and seeds.
9. All Renewable energy Projects (excluding Protected/ Sensitive area under any law).

C. Oil and Gas projects

1. Oil and gas 2D/3D Seismic survey and drilling activities (on and off shore).
2. Oil and gas extraction projects including exploration and production located outside the environmentally sensitive/protected areas.
3. Oil & Gas transmission gathering, storage, separation & transportation system.
4. Construction of CNG, LPG Petroleum and LNG bulk storage facility.
5. Oil blending and recycling units.

D. Manufacturing and processing

1. Ceramics and glass units.
2. Food processing units.
3. Pharmaceutical units.
4. Rice mills, ghee/oil mills, Cotton ginning.

5. Man-made fibers and resin projects.
6. Tanning and leather finishing projects.
7. Manufacturing of apparel, textile garments units, including weaving, spinning, dyeing, bleaching and printing.
8. Woodwork units manufacturing products.
9. Steel re-rolling mills.
10. Waste recycling plants.
11. Battery manufacturing plant.
12. Brick Kilns.
13. Marble processing units.
14. Stone Crushing units.

E. Mining and mineral processing

1. Commercial extraction of sand, gravel, limestone, clay, Sulphur and other minerals not included in Schedule I.
2. Crushing, grinding and separation processes.
3. Metal Smelting plant production capacity up to 20 tons/day.

F. Transport

1. Construction of flyovers, underpasses and bridges having length more than 500 meters to 1000 meters in urban areas and more than 5 km in rural areas.
2. Bus terminals/railway station/metro stops and construction & operation of transport related terminals.
3. Rehabilitation or rebuilding or reconstruction of existing roads more than one kilometers in urban areas and more than 5 km from rural areas.

G. Water management, dams, irrigation and flood protection

1. Dams and reservoirs with storage volume of less than 25 million cubic meters of surface area less than 4 square kilometers.
2. Irrigation systems and drainage system with the area of less than 15,000 hactors.
3. Flood protection bunds.

H. Water supply and filtration

Water supply schemes and filtration plants.

I. Waste disposal and wastewater treatment

1. Solid and Non-hazardous waste with annual capacity up to 10,000 tonnes (excluding municipal landfill sites and commercial facilities) including Garbage Transfer station/composting plant.
2. Wastewater treatment for sewerage treatment facility less than 100 mgd.
3. Hospital waste disposal facilities including incineration units owned by Hospitals for own use excluding commercial facility.

J. Urban development

1. Housing schemes more than 15 acres to 50 acres.
2. Residential, Commercial multistory High rise construction projects having covered area more than 100,000 sq.feet to 500,000 sq.feet.
3. Laboratories.
4. Hospitals, health care unit of more than 50 beds.
5. Construction of Educational and Academic institutions.

K. Other projects

Any other project for which filing of an IEE is required by the Agency under sub-regulation (2) of Regulation 6.

SCHEDULE – III

(*See* Regulation 5)

List of projects requiring an EIA

A. Energy

1. Hydroelectric power generation more than 50 MW.
2. Thermal power generation more than 100 MW.
3. Coal power projects more than 50 MW.
4. Transmission lines above 132 KVA and distribution projects.
5. Nuclear power plants.
6. Wind, Solar or renewable energy projects if falls under any environmental sensitive and protected area.

B. Oil and Gas projects

1. Oil Petroleum refineries.
2. LPG and LNG Terminals Projects.
3. Coal Handling Terminals Projects.

C. Manufacturing and processing

1. Cement plants.
2. Chemical manufacturing industries.
3. Fertilizer plants.
4. Steel Mills.
5. Sugar Mills and Distilleries.
6. Establishment of Industrial estates & Export processing zones.
7. Petrochemicals complex.

8. Synthetic resins, plastics and man-made fibers, paper and paperboard, paper pulping, plastic products, printing and publishing, paints and dyes.

D. Mining and mineral processing

1. Mining and processing of coal, gold, copper, sulphur and precious stones.
2. Mining and processing of major non-ferrous metals, iron and steel rolling.
3. Metal Smelting plant production capacity more than 20 tons/day.

E. Transport

1. Airports.
2. Construction of highway, motor ways, major roads (Intercity roads) more than one km and above.
3. Ports and harbor development.
4. Mass transit projects.
5. Railway works.
6. Construction of Flyover, underpass and bridges having total length more than one km.

F. Water management, dams, irrigation and flood protection

1. Dams and reservoirs with storage volume of 25 million cubic meters and above having surface area of 4 square kilometers and above.
2. Irrigation and drainage projects serving more than 15,000 hectares and above.

G. Water supply and filtration

Public water supply schemes and filtration plants.

H. Waste Disposal and treatment

1. Facilities for handling, storage or disposal of hazardous or toxic wastes or radioactive waste (including landfill sites, incineration units, etc.).
2. Solid waste municipal landfill sites.
3. Combine Effluent Treatment Plant.
4. Domestic wastewater treatment plant more than 100 mgd.

I. Urban development and tourism

1. Housing schemes above 50 acres.
2. Residential, Commercial High rise buildings subject to compliance of building bylaws of relevant organizations more than 500,000 sq.feet.
3. All Projects located in High Density Zones notified by Government and relevant land controlling organization, irrespective of their size.
4. Commercialization of major corridors/roads in urban centers.
5. Large Scale public facilities.
6. Large-scale tourism development projects.

J. Environmentally Sensitive Areas

All projects situated in environmentally sensitive areas being identified by the Agency.

K. Other projects

1. Any other project for which filing of an EIA is required by the Agency under sub-regulation (2) of Regulation 5.
2. Any other project likely to cause an adverse environmental effect.

SCHEDULE – IV

(*See* Regulation 8)

Project Cost (in million)	Review Fee
Up to 20	Rs. 50,000
Above 20 up to 100	Rs. 100,000
Above 100 up to 200	Rs. 200,000
Above 200 up to 500	Rs. 400,000
Above 500	Rs. 600,000
Review fee for Environmental Checklist or EMP shall be Rs. 40,000/=	
Review fee for BTS Tower shall be 20,000/=	

Note : –

The fee shall be payable into the "Sindh Sustainable Development Fund" account Details are as under :

A/C Title : Sindh Sustainable Development Fund

Account Number : 03084572626100

Bank : Sindh Bank

Branch Code : 0308-Korangi Industrial Area

SCHEDULE – V

[*See* Regulation 9(2)(a)]

Application Form

1.	Name and address of Proponent		Phone : Email :
2.	CNIC No. of proponent		
3.	Brief description of project		
4.	Location of project		
5.	Cost of the Project		
6.	Objectives of project		
7.	IEE/EIA attached?	IEE/EIA :	Yes/No
8.	Have alternative sites/options been considered/reported in IEE/EIA?		Yes/No
9.	Title document of the project		
10.	Existing land use		Land requirement

11.	Is basic site data available, or has it been measured?	(only tick yes if the data is reported in the IEE/EIA)	Available	Measured
		Meterology (including rainfall)	Yes/No	Yes/No
		Ambient air quality	Yes/No	Yes/No
			Yes/No	Yes/No
12.	Have estimates of the following been reported, especially Quantitative Analysis?	Water balance	Estimated	Reported
		Solid waste	Yes/No	Yes/No
		disposal	Yes/No	Yes/No
		Liquid waste	Yes/No	Yes/No
13.	Source of power		Power requirement	
14.	Labour force (number)	Construction : Operation :		
15.	Environmental Consulting Firm			

Verification. – I do solemnly affirm and declare that the information given above and contained in the attached EC/IEE/EIA is true and correct to the best of my knowledge and belief.

Date

Signature, name _____
of proponent (with
official stamp/seal)

SCHEDULE – VI

[*See* Regulation 13(2)]

Decision on IEE/Environmental Check List

1. Name and address of proponent _____

   _____

2. Description of project _____

3. Location of project _____

4. Date of filing of IEE _____

5. After careful review of the IEE, the Agency has decided –

   (a) to accord its approval, subject to the following conditions :

   _____

   _____

or (b) that the proponent should submit an EIA of the project, for the following reasons –

   _____

Dated _____

Tracking No. _____

Director-General
Sindh Environmental Protection Agency
(with official stamp/seal)

SCHEDULE – VII

[*See* Regulation 13(2)]

Decision on EIA

1. Name and address of proponent _____

   _____

2. Description of project _____

3. Location of project _____

4. Date of filing of EIA _____

5. After careful review of the EIA, and all comments thereon, the Federation Agency has decided –

   (a) to accord its approval, subject to the following conditions :

   _____

or (b) that the proponent should submit an EIA with the following modifications –

   _____

or (c) to reject the project, being contrary to environmental objectives, for the following reasons :

   _____

Dated _____

Tracking No. _____

Director-General
Sindh Environmental Protection Agency
(with official stamp/seal)

SCHEDULE – VIII

[*See* Regulation 14(2)]

UNDERTAKING

I, (full name and address) as proponent for (name, description and location of project) do hereby solemnly affirm and declare that the conditions of approval and the requirements in the IEE or EIA relating to design and construction, adoption of mitigation and other measures and other relevant matters have been duly complied with in the design and construction of the project.

Signature, name and designation of proponent
(with official stamp/seal)

Witnesses (full names and addresses)

_____

_____

SCHEDULE – IX

[*See* Regulation 18]

Form of Registers for EC, IEE and EIA projects

S. No.	Description	Relevant Provisions
1	2	3
1.	Tracking number	
2.	Category type (as per Schedules I or II)	
3.	Name of proponent	
4.	Name and designation of contact person	
5.	Name of consultant	
6.	Description of project	
7.	Location of project	
8.	Date of submission of IEE/EIA	
9.	Date of public hearing/ technical presentation	
10.	Date of committee of experts for schedule-II projects	
11.	Approval granted (Yes/No)	
12.	Date of approval granted or refused	