Hagler Bailly Pakistan

EVTL Expansion Project

Environmental Impact Assessment

Final Report

HBP Ref.: R7V02EWE A2

February 22, 2007

Engro Vopak Terminal Limited

Karachi

Executive Summary

Engro Vopak Terminal Ltd. (EVTL) owns and operates a liquid / gaseous chemical and liquefied petroleum gas (LPG) storage facility at Bin Qasim near Karachi. The company, formed in 1995, is a joint venture between Engro Chemicals Pakistan Ltd. and the Royal Vopak of the Netherlands. EVTL has planned to construct a 10,000 m^3 ethylene storage and handling facility within its terminal. The new facilities will be dedicated to facilitate Engro Asahi Polymer and Chemicals Ltd. (EAPCL) in their polyvinyl chloride (PVC) manufacturing plant expansion and back integration project to start manufacturing of ethylene dichloride (EDC) and vinyl chloride monomer (VCM) at their site. The project site is located in the South Western Zone of Port Qasim, Karachi (see **Exhibit I**).

Policy, Statutory, and Institutional Framework

The Pakistan Environmental Protection Act, 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The key features of the law that have a direct bearing on the proposed project relate to the environmental assessment for development projects. The Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000 (IEE-EIA Regulations, 2000), prepared by the Pak-EPA under the powers conferred upon it by the PEPA, 1997 categorizes projects for IEE and EIA. Schedules I and II, attached to the IEE-EIA Regulations, 2000, list the projects that require IEE and EIA, respectively. As per the regulations the proposed activities require an IEE.

Project Description

The proposed project has two main parts, the installation of a 10,000 m^3 storage and other process equipment required for safe storage of refrigerated ethylene and a 1.5 km import pipeline from the jetty to the storage tank. The annual throughput of ethylene received by EVTL via ship tankers will be 72,000 metric tons, which is expected to increase to 105,000 tons in five years.

Ethylene will be transported from the ships through an import and chill down pipeline and stored at the site from where vaporized ethylene will be supplied to EAPCL through a 6.5 km export pipeline that will be owned and operated by EAPCL.

Project Location

The proposed project is located in the southwestern zone of Port Qasim in the Bin Qasim town which is located in the southern part of Malir district, Karachi division, in Sindh. Bin Qasim town is one of the eighteen administrative towns of Karachi. Karachi division is divided into five districts—Karachi West, Karachi East, Karachi South, Karachi Central, and Malir. Karachi East, Karachi South, and Karachi Central are entirely urban, whereas Malir and Karachi West have both urban and rural populations. The proposed project site is located near Qasim International container terminal (QICT) in the south

western zone of Port Qasim. The Malir district located in the eastern part of the Karachi Division, covers an area of 2,268 km^2. It is bounded on the north by the Jamshoro district, on the south by the Thatta district and the Arabian Sea, on the east by the Jamshoro and Thatta districts and on the west by the districts Karachi South, Karachi Central, Karachi East, Karachi West, and Lasbela of Balochistan.[1] The project area and its surroundings are shown in **Exhibit II**.

Existing Facilities and Operations

EVTL is spread over a total area of 0.41 km^2 and provides storage and handling services for a variety of chemical products namely Paraxylene, mono ethylene glycol, acetic acid, acrylonitrile, phosphoric acid, vinyl chloride monomer, and liquefied petroleum gas. The facility has 20 storage tanks with a combined storage capacity of 69,000 m^3. Other ancillary facilities include a dedicated chemical jetty accessed via a 1.1 km long trestle, truck loading stations, and office facilities.

Proposed Development Project

The ethylene storage and handling facility at EVTL will comprise of the following main components:

- Marine unloading arm for low temperate application
- 1.5 km long main import and chill down pipeline for refrigerated ethylene
- 10,000 m^3 storage tank (s) for liquefied ethylene
- Boil off gas compressors
- Re-liquefaction unit
- Send out pumps
- Ethylene vaporizers
- Blow down and ground level combustor

Environmental Setting

Port Qasim is located on the northwest edge of the Indus Delta system. The system is characterized by long and narrow creeks, mangrove forests, and mud flats. The site is located on the Gharo creek that runs west to east.

The climate of the project area can be broadly classified as arid, moderate, hot and humid climate typical of subtropical coastal areas under the influence of monsoons. The mild winter is restricted to the December-January period. The summer extends from April to September, which overlaps the short spells of the main rainy season during July-August. The weather tends to be very humid during May-June and September and pleasant during the periods of July to August and November to March.

---

[1] Population Census Organization. 1998. *District Census Report of Malir District*. Islamabad

The two principle sources of industrial emissions in the vicinity of the proposed site are the Pakistan Steel Mill complex and the KESC power station.

There is no freshwater body in the area and the groundwater resources are also not very developed. Papri Badel Nala, a non-perrinieal stream flows through the industrial zone. The stream that rises in the hills of Sindh Kohistan, north of Port Qasim, drains the torrential water from the hills to into the Gharo creek. The seawater quality within the Gharo Creek is comparatively good, except in certain places where effluents are discharged directly from areas such as the *Bhains Colony* (Cattle Colony), Pakistan Steel Mills, and KESC Power Plants, and the other parts of Port Qasim Area. The Korangi Creek located west of Gharo creek, is polluted due to the effluent discharged directly from the fishing villages and industries located further northwards.

The natural setting of creek coastal ecosystem of the project area has been characterized by some common shrubs and grasses. According to Flora of Pakistan (1972) eight species of mangroves have been reported from Pakistan, however, only four continue to thrive. Several species of reptiles, birds, and terrestrial mammals inhabit the project area, wherever suitable habitats are found. No species found in the project area are of concern from the point of view of conservation.

There are no villages or residential colonies in the project area. The nearest human settlement from the proposed site is Goth Lal Mohammad which is more than 5 km north to the site. The *dargah* (shrine) of Noor Hasan Shah is located approximately at 5 km east to the site. Other settlements which lie in the north and northwest of the project area at more than 7 km are Goth Lal Mohammad, Goth Mohammad Keserani and Pipri Colony. The port Qasim residential colony is located approximately 7 km north from the existing facility boundary.

Environmental Impacts and Mitigations

Potential impacts of the proposed project were identified through a formal system of scoping. This included public consultation in two phases. Assessment of potential impact of included defining criteria for determining significance, predicting of the magnitude of the potential impacts, identifying mitigation measures, evaluating of the residual impact, and identifying monitoring requirements.

Impacts Associated with Construction Activities

As the project will be constructed on a site that is already acquired, moreover, the site is in an industrial area and no residential areas are located within 6-km of the site, many of the typical construction related environmental issues will not arise. To minimize the impact, mitigation measures based on sound construction and environmental practices have been proposed. These cover construction noise, dust emission, and vehicle and equipment exhaust emissions.

Impacts Associated with Project Operations

The EVTL facility operation does not result in any process effluent or significant amount of air emissions. A limited number of solid waste, including hazardous waste (chemical containers including partially full containers) will be generated during the project

operation. To mitigate the environmental impacts of waste handling and disposal recyclable material will be separated at source. Separate bins will be placed at the construction site for different type of materials—plastic, paper, metal, glass, wood, and cotton. The recyclable waste will be sold to waste contractors. Waste bins for the operational waste will be constructed inside the storage facility boundary. No waste will be dumped at any location outside the boundary. Depending on the nature and quantity of the hazardous waste, it will either be disposed of by licensed hazardous waste contractors, or will be incinerated at incineration facilities equipped to handle hazardous waste and chemical containers (including partially full containers) will be returned to vendors.

The main potential environmental impacts associated with the operational phase of the project is accidental release of ethylene into the atmosphere, accidental spillage of ethylene into the water and a vapor cloud explosion of ethylene. A summary of these impacts are discussed below.

Accidental Release into the Atmosphere

Project operations will involve use of ethylene in large quantities. Ethylene will be supplied to the site through a 1.5 km pipeline and 10,000 m^3 of it would be stored onsite. These chemicals have a potential to harm human health and the environment around it if released accidentally into the atmosphere. A detailed risk assessment is carried out to assess the risk exposure of the population to hazardous levels of hazardous gases.

In this case, two types of risks are evaluated:

1. *Short-term exposure limit:* Human exposure to concentration exceeding this limit may result in immediate health impact including possibly fatalities as it will act as simple asphyxiant.
2. *Explosivity limits:* A vapor cloud with concentration exceeding this limit can result in explosion.

The accidental scenario for the pipeline and from the storage tank has been carried out separately taking into account the worst case conditions. The rupture in the ethylene storage tank is assumed to have an area equal to 0.20 m^2 (equal to the area of the nozzle on the roof of the tank), the spill source type is vertical jet with the source plane parallel to the ambient wind direction. In case of pipe, rupture is taken as 0.032 m^2 with the spill source type being a horizontal jet with the source plane perpendicular to the ambient wind direction. The emission rate for the storage tank has been taken as 5.23 kg/min. The worst case scenario time has been selected as 12 hours after which the leak is detected and is sealed. The emission rate in case of the pipeline for the worst case scenario has been taken as 3,333 kg/min.

To assess the dispersion of the hazardous vapor cloud after it is released due rupture in the storage tank or the pipeline is United States Environmental Protection Agency's accidental release model AFTOX is used. The results of the dispersion modeling show that in case of release from storage tank, no area will be exposed to concentration exceeding 1,147 mg/m^3. On the other hand, in case of release from the pipeline, the exposed area will vary with respect to the atmospheric conditions.

The consequence of an accidental release may include damage to the EVTL storage facility and the operators, in case of an explosion, fatalities in case of severe short term exposure, and various diseases such as cancer, disruption of the endocrine system, neurotoxicity, and immune system suppression. Of the two cases, the frequency of accidents for ethylene pipeline facility is the greatest. However of all the four cases of plume distribution, maximum distance of the plume is 1,100 m. The distance will be reduced considerably for the Lower explosivity limit (LEL) which will be approximately 130 m.

An emergency response plan is to be prepared to avoid accidental release of gases and to minimize the impacts. The key feature of emergency response plan will include the following.

1. Identification of hazardous chemicals, processes and the operations
2. Release scenarios, consequences in term of heat generation, over pressure and toxic release etc.
3. Preparation of site plan for damage control
4. Identification of the vulnerable zones
5. Classification of unit or units which have the most potential for creating on-site as well as off-site emergency
6. Identification of the important facilities available in the vulnerable zone
7. Identification of the requirements of various departments in-site as well as out-site the process storage facility for coping emergency situation

The monitoring requirements for the mitigation of the potential risk will involve:

- Bolts, nuts and studs, other pipe connections of proper material specification strictly be used where there is chance of leakage.
- A proper system of periodic inspection of all equipment including cocks, valves and pipelines and degassing system should be introduced and followed jointly by the process and maintenance department. Preventive maintenance should be planned in a manner to synchronize gradually with periodic routine shut down of equipment.
- A complete register for recording the periodic testing should be maintained.
- A control room equipped with the instruments for automatic detection of small amount of gas releases and their location.
- Process flow, temperature, instrumentation control, pressure relief, safety and general operating condition should by examined to ensure that the storage operation would not only be conducted safely but should also fail safely if it is going to fail at all.
- Periodic safety audit by both internal and external audit team should be undertaken by the management.

Accidental Spills

Spills from the pipeline, storage tanks and during other transportation, can potentially affect the soil, water resources, flora and human being.

The worst case scenario has been chosen by considering the failure of the import pipeline over the Gharo Creek resulting in discharge of the entire content of the pipeline into the creek water.

As ethylene is a highly volatile gas, the chances are that most of the ethylene will evaporate instantaneously by absorbing heat from the sea water. In this process, a thin layer of ice will be formed on the surface of water. In the initial moment of spill, some of the ethylene will also get dissolved in the seawater. The quantity of ethylene that is dissolved will be limited by two factors solubility of ethylene in water and the volume of water that comes in contact in the brief period. As a worst case scenario, it is assumed that a column of water having a thickness equal to the depth of the creek and an area twice the size of the spill will be saturated with ethylene. Calculation based on this scenario shows that the quantity of ethylene that will be dissolved in water will be less that 1% of the total spill. The remaining ethylene will evaporate during the process. Surface area of 50 m^2 has been taken because an area greater than this value will result in all of the ethylene being evaporated and a value lesser than this will have a lower concentration value of ethylene and since the calculations are based on the worst case scenario therefore this value of 50 m^2 has been chosen. At saturation, the concentration of ethylene in water will be 131 mg/l causing the concentration of ethylene to exceed the significance criteria determined by the United Nations Environmental Program (UNEP).

Under the worst case scenario, less than 0.1% of fish in a very small area (about 100 m^2) will be affected. It is unlikely to have any permanent impact on the aquatic life. The ethylene dissolved in water will gradually disperse and evaporate reaching, 6 mg/l, the background concentration of ethylene in water in a very short time.

A comprehensive contingency plan will be developed for accidental spill management. The development of plan will involve following steps:

1. Identification of potential sources of the event
2. Risk minimization
3. Action plan for spill response
4. Designation of personnel and training
5. Disposal options of contaminated material

No significant residual impact due to operation is expected if above mentioned mitigations implemented. The key monitoring is the regular inspection of the storage facility and import pipeline particularly where high risk to effect on water resources, workers, or any other receptors.

Vapor Cloud Explosion

The risk of vapor cloud explosion has been assessed following the United States Environmental Protection Agency (USEPA) document *Risk Management Program Guidance for offsite Consequence Analysis* (USEPA, 2004). EPA has defined the worst-case scenario as the release of the largest quantity of a regulated substance from a single

vessel or process line failure that results in the greatest damage or largest area being impacted.

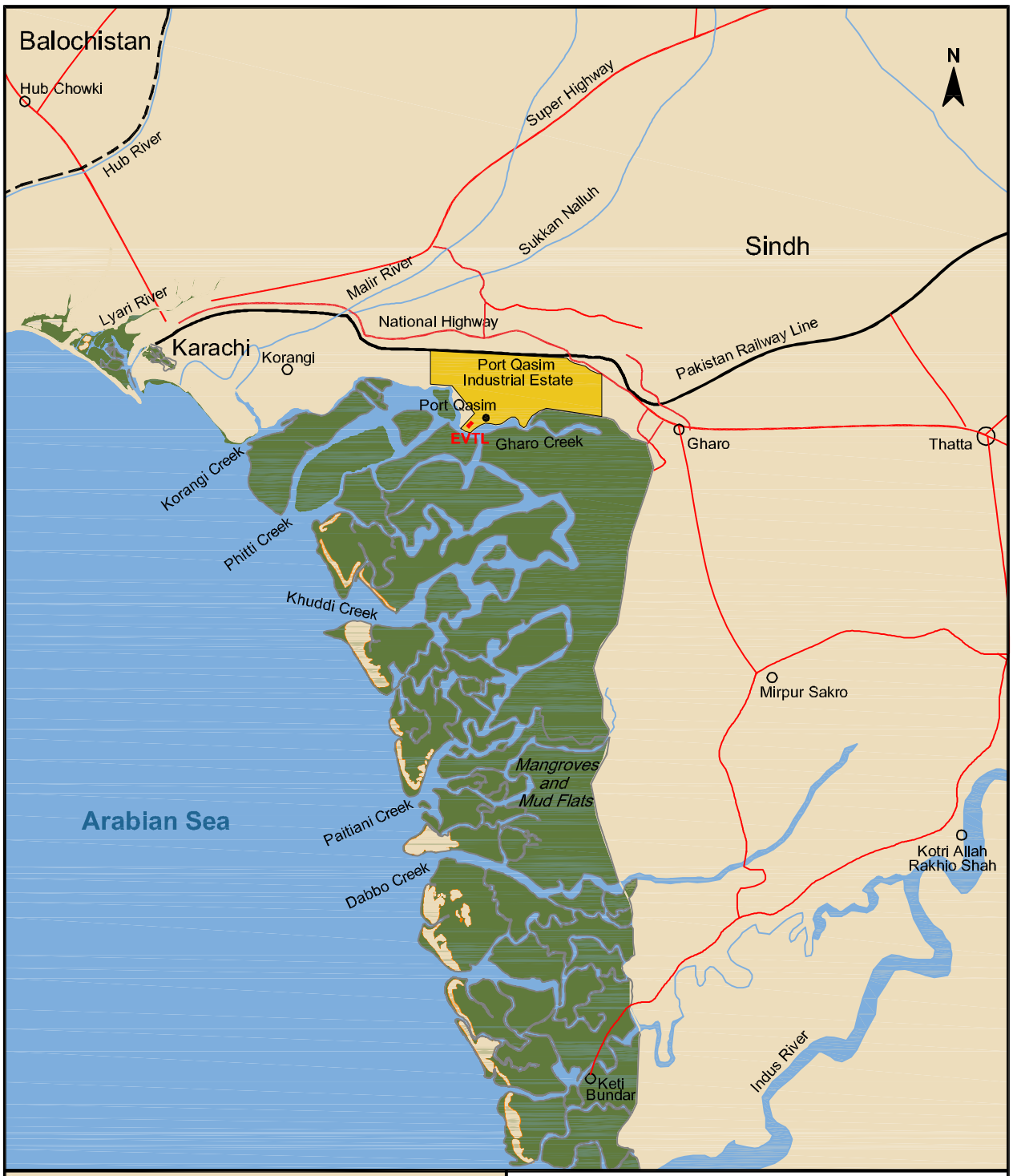
The program calculates the distance to the point beyond which the heat from a fire or blast waves from a vapor cloud explosion will not result in any serious injuries. It is done in terms of estimating the consequence distance to an overpressure level of 1 pound per square inch (psi) from the explosion of the vapor cloud. An overpressure of 1 psi may cause partial demolition of houses and shattering of glass windows, which may cause minor injuries and skin laceration from flying glass. The worst-case scenario is defined as the release of the entire content of the ethylene storage tank or the import pipeline. Results of the vapor cloud explosion calculations for this scenario will affect an area with a radius of approximately 2.9 km of the storage tank. Of the affected area, about 75% is on water and mangroves. Of the 25% on land, only one third (7.5% of the total area) is currently occupied by industrial units. There are no residential areas within this range.

Conclusion

This study was carried out to assess the environmental and socioeconomic impact of the proposed ethylene storage to be installed in the EVTL chemical storage facility. The assessment was carried out in keeping with the Pakistani legislation and the World Bank (WB)/ IFC guidelines.

It is concluded that if the field activities, including the implementation of all mitigation measures, are carried out as described in this report, the anticipated impact of the project on the area's natural and socioeconomic environment will be well within acceptable limits. The project will also comply with all the statutory requirements and standards.

To ensure implementation of the mitigation measures an environmental management plan for the construction phase will be prepared separately.



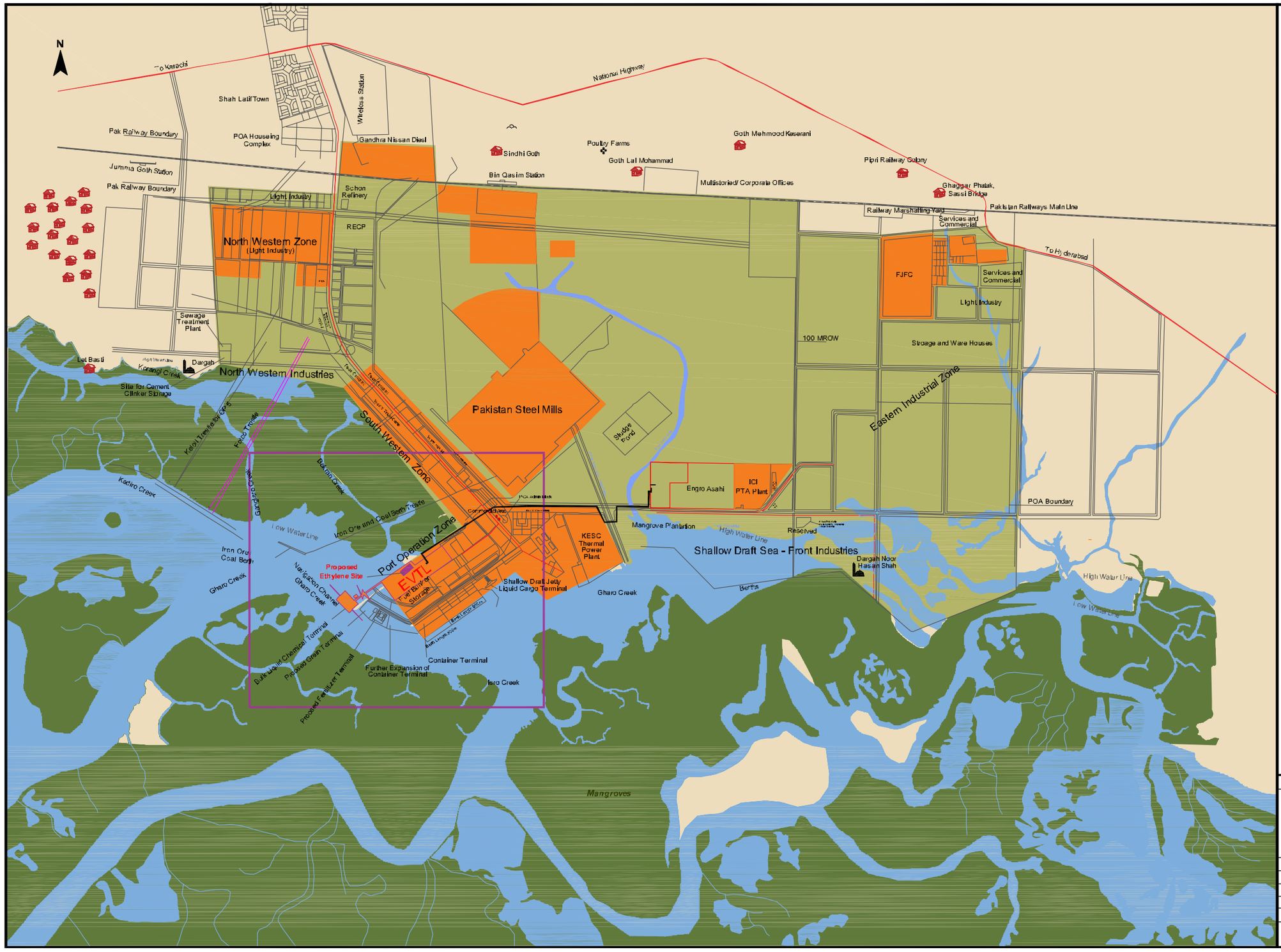
EIA of EVTL Expansion Project

Exhibit I

Project Location

Scale	1 : 650,000
Drawing	W6E01EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan



Legend

- Main Road
- Railway Track
- Pipeline
- Project Area
- Streams
- Mangroves
- Settlements
- Graveyard
- Project Location

Port Qasim Industrial Area

- Occupied
- Unoccupied

0 0.5 1 1.5 2 2.5 3 km

EIA of EVTL Expansion Project

Exhibit II

Project Area and Surroundings

Scale	1 : 75,000
Source	EVTL and HBP Field Survey
Drawing	W6E02EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan

Abbreviations

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DWT	Deadweight tonnage
EAPCL	Engro Asahi Polymer and Chemicals Ltd.
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EVTL	Engro Vopak Terminal Limited
HBP	Hagler Bailly Pakistan (Pvt.) Limited
IEE	Initial Environmental Examination
IUCN	World Conservation Union
NEQS	National Environmental Quality Standards
NGO	Non-Governmental Organizations
Nm^3/h	Normal cubic meter (m^3) per hour
NSC	Pakistan National Conservation Strategy
Pak-EPA	Pakistan Environmental Protection Agency
PEPC	Pakistan Environmental Protection Council
PQA	Port Qasim Authority
PVC	Polyvinyl Chloride
RoW	Right of Way
SEPA	Sindh Environmental Protection Agency
WWF	World Wide Fund for Nature

Contents

Appendices

Exhibits

1. Introduction

Engro Vopak Terminal Limited (EVTL), a chemical storage and handling facility at Port Qasim, Karachi, is the joint venture of Engro Chemicals (Pakistan) Ltd. (50%) and Royal Vopak (50%) of the Netherlands. EVTL intends to build an ethylene storage facility at their terminal. This expansion of EVTL is being undertaken to facilitate Engro Asahi Polymer and Chemical Ltd. (EAPCL) for their EDC/VCM manufacturing project. The new facility at EVTL with an annual throughput of 72,000 tons, expandable to 105,000 tons, will receive refrigerated ethylene via ship tankers, store liquefied ethylene, and feed vaporized ethylene directly into the manufacturing plant of EAPCL through a dedicated 6.5 km long underground pipeline, to be owned and maintained by EAPCL.

EVTL has acquired the services of Hagler Bailly Pakistan (Pvt.) Limited (HBP), to undertake an Environmental and Social Soundness Assessment Study (ESSAS) of the proposed expansion plan. Therefore HBP is conducting the initial environmental examination (IEE) of the proposed activities to meet the regulatory as well as EVTL's internal corporate requirement.

1.1 Project Proponents

Engro Vopak Terminal Ltd. (EVTL), formerly Engro Paktank Terminal Ltd. (EPTL), was incorporated in 1995. EVTL provides its customers in the chemical and petrochemical industry and traders with first class facilities to handle and store their bulk raw material and products at its terminal in Port Qasim on the outskirts of Karachi in a safe, efficient and environmentally friendly manner. The company is ISO 9001, 14001, 18001 and CDI-T certified. EVTL aims at zero incidents by placing safety, health and environment above every other objective.

EVTL is the only state of the art integrated bulk liquid and gaseous chemical handling and storage facility in Pakistan. The company owns and operates a jetty designed to handle ships up to 75,000 dwt (deadweight tonnage). Offloading of liquid chemical products from vessels is carried out through dedicated marine loading arms and hoses and is transferred via pipelines from the jetty to the storage tanks located on a plot measuring about 0.4 km^2. Currently, there are twenty storage tanks having total capacity of 69,000 cubic meters.

The company aims to maintain the world's highest industry standards to ensure safety and reliability. The company meets all requirements of the Pakistan Environmental Protection Agency through audits by local and international firms. EVTL is committed to playing a leading role in the development of standards in the terminal services business in Pakistan. It is expected that the company will see significant growth in its facilities by offering quality services to the chemical and petrochemical industry in the country and the region.

1.2 Project Area

The project area refers to the geographical area in which the activities related to the construction and operation of the plant are proposed to take place and in which the environmental impact of the activities are likely to happen. Unless otherwise specified or implied by context, the term 'project area' will refer to the area within 2 km of the proposed site of the plant. The project area and its surroundings are shown in **Exhibit 1.2**.

1.3 Introduction of the ESSAS

1.3.1 Objectives of the ESSAS

The ESSAS will be conducted to:

- Assess the existing environmental and socioeconomic conditions in the project area (the area where project activities are expected to take place is denoted as the 'project area' in this document), including identification of environmentally sensitive areas, if any
- Identify the likely impacts of the proposed project on the natural and socioeconomic environment, predict and evaluate these quantitatively wherever possible, and determine their significance in light of the technical and regulatory concerns, as well as those related to public perceptions
- Propose appropriate mitigation and monitoring measures that can be incorporated into the design of the project to minimize any damaging effects or lasting negative consequences identified by the assessment
- Assess the proposed project activities and determine whether they comply with the relevant environmental regulations in Pakistan
- Prepare an ESSAS report for submittal to the Sindh Environment Protection Agency (SEPA).

1.3.2 Scope of the EIA

This ESSAS covers assessment of the physical, biological, and socioeconomic impact of the following:

- Construction activities including the setting up of new unit at the proposed site
- Relevant off-site construction and operations related activities
- Operation of the new facility
- Decommissioning of the facility.

1.3.3 Approach and Methodology

The ESSAS was performed in four main phases, which are described below.

Scoping

The key activities of this phase included:

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

Published Literature Review: Secondary data on weather, soil, water resources, wildlife, and vegetation were reviewed and compiled.

Legislative Review: Information on relevant legislation, regulations, guidelines, and standards was reviewed and compiled.

Identification of Potential Impacts: The information collected in the previous steps was reviewed and potential environmental issues identified.

Baseline Data Collection

A considerable amount of baseline information on the project area was available from existing literature and other studies conducted close to the project area. A field visit was conducted to verify and collect primary data on the proposed site alternatives of the expansion plan.

Impact Assessment

The environmental, socioeconomic, and project information collected was used to assess the potential impacts of the proposed activities. The issues studied included potential project impacts on:

- Geomorphology
- Groundwater and surface water quality, with particular reference to the coast
- Ambient air quality and ambient noise levels
- The ecology of the area, including flora and fauna especially the marine ecosystem
- Local communities.

Wherever possible and applicable, the discussion covers the following aspects:

- The present baseline conditions
- The potential change in environmental parameters likely to be effected by project related activities
- The identification of potential impacts
- The evaluation of the likelihood and significance of potential impacts
- The defining of mitigation measures to reduce impacts to as low as practicable
- The prediction of any residual impacts, including all long-term and short-term, direct and indirect, and beneficial and adverse impacts
- The monitoring of residual impacts.

Documentation

This report documenting the ESSAS process and results is prepared according to the relevant guidelines set by the Pakistan Environmental Protection Agency (Pak-EPA) and the IFC.

1.4 Organization of this Report

Section 2 (*Policy, Statutory, and Institutional Framework*) briefly discusses existing national policy and resulting legislation for sustainable development and environmental protection, and then presents the legislative requirements that need to be followed while conducting an ESSAS.

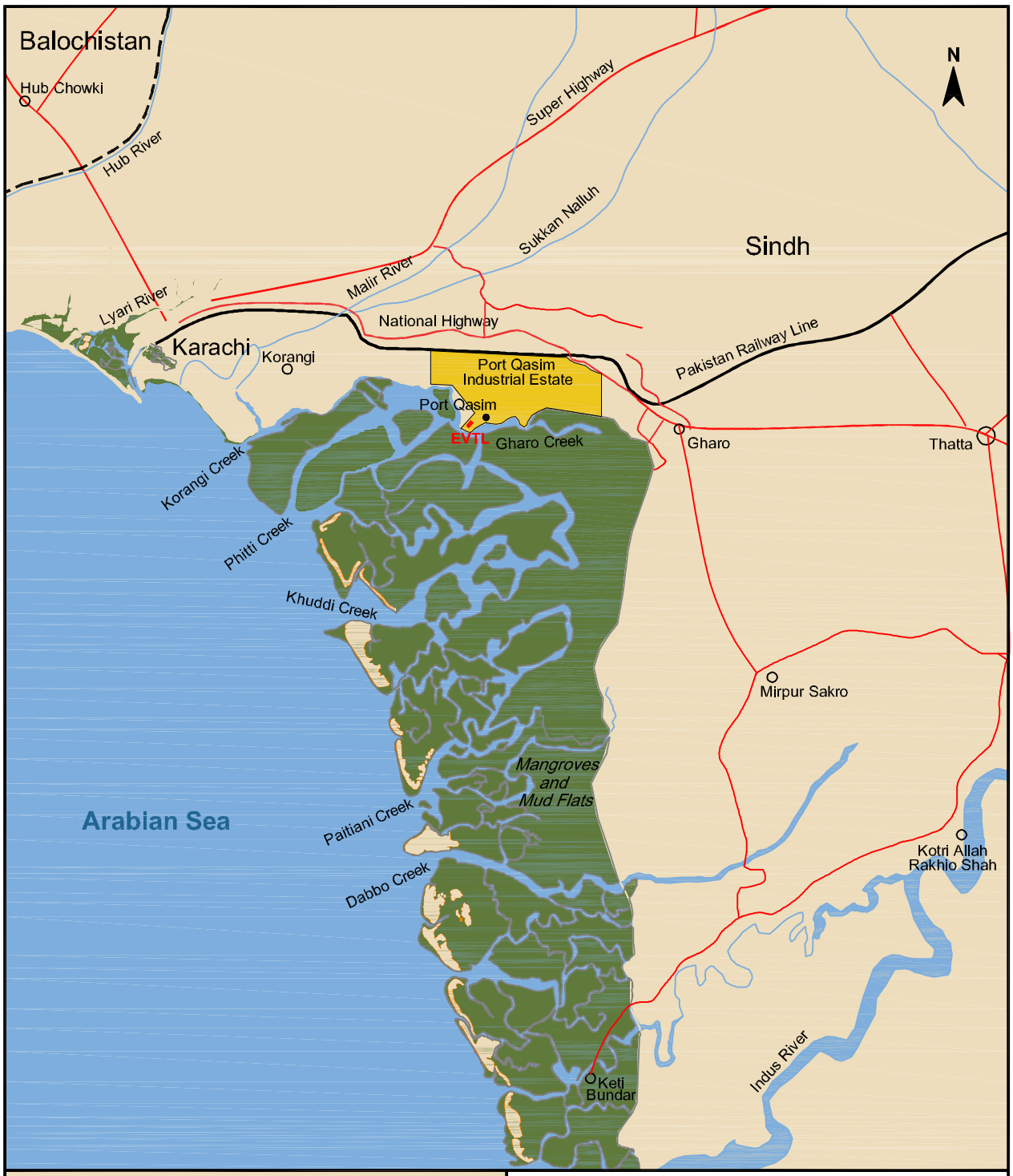
Section 3 (*Project Description*) describes the proposed EVTL Expansion Project.

Section 4 (*Description of the Environment*) details the project area's existing physical, biological, and socioeconomic condition, including geomorphology and soils, water resources, and air quality, flora and fauna, and demography.

Section 5 (*Project Impacts and Mitigation*) presents an assessment of the project's impact and their required mitigation measures to the physical, biological, and socioeconomic environment.

Section 6 (*Analyses of Alternatives*) presents the project alternatives that were considered, and the reasons for their rejection.

Finally, in **Section 7** (*Conclusion*) the conclusions of the projects are summarized, followed by **Section 8** (*References*).



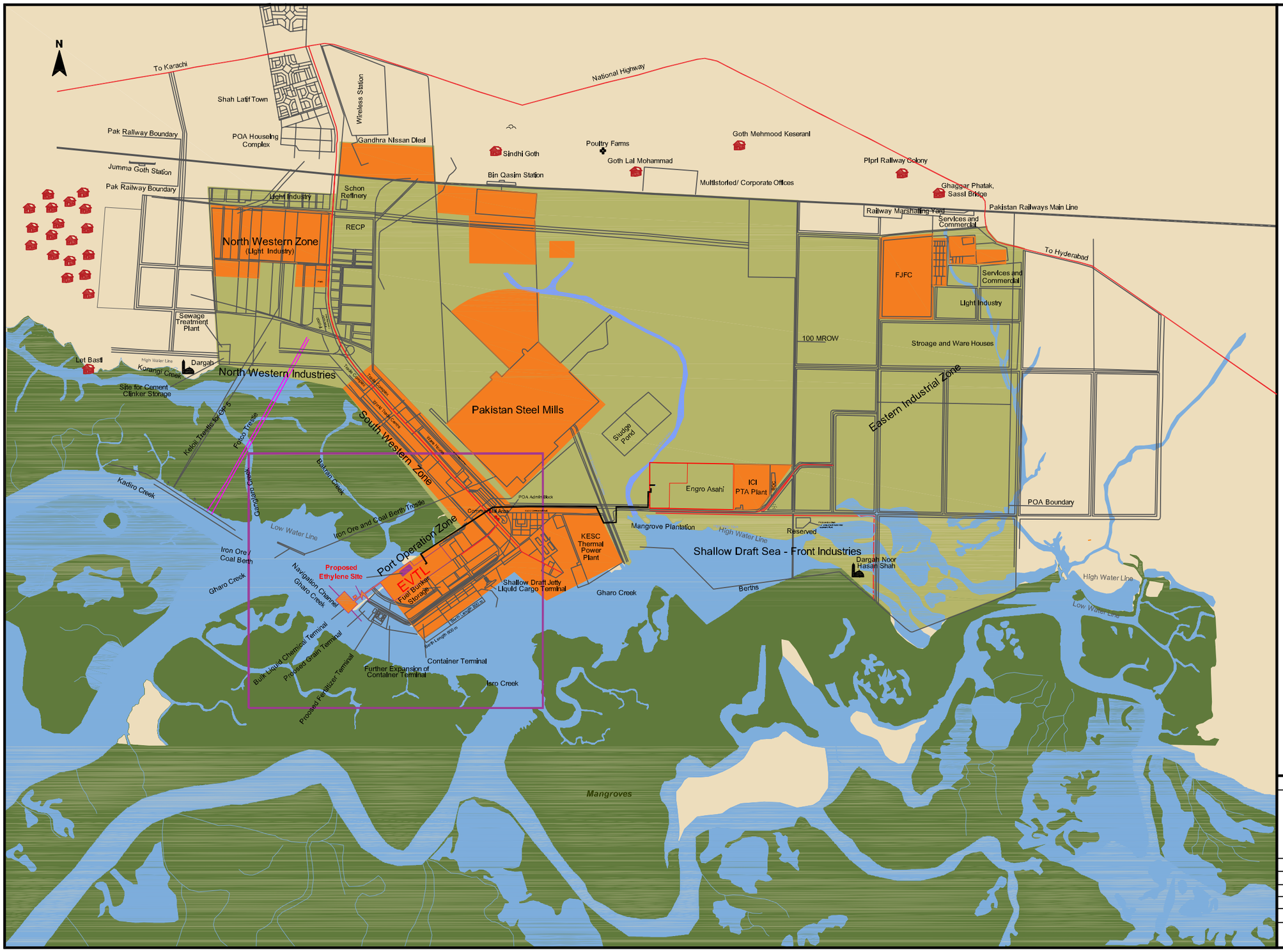
EIA of EVTL Expansion Project

Exhibit 1.1

Project Location

Scale	1 : 650,000
Drawing	W6E01EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan



Legend

- Main Road
- Railway Track
- Pipeline
- Project Area
- Streams
- Mangroves
- Settlements
- Graveyard
- Project Location

Port Qasim Industrial Area

- Occupied
- Unoccupied

0 0.5 1 1.5 2 2.5 3 km

EIA of EVTL Expansion Project

Exhibit 1.2

Project Area and Surroundings

Scale	1 : 75,000
Source	EVTL and HBP Field Survey
Drawing	W6E02EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan

2. Policy, Statutory, and Institutional Framework

The success of environmental and social soundness assessment in ensuring that development projects are environmentally and socially sound depend on the capability of regulatory institutions for environmental management. Sustainable development is a concept that has emerged over the past three decades to describe a new framework aimed at economic and social development whilst maintaining the long-term integrity of the ecological and social system. The principles of sustainable development are in the process of being incorporated into national policies and legislation in Pakistan through various statutory instruments.

As the possibility of financing for the project from IFC is being explored, the assessment has been carried out to comply with both local and IFC guidelines. This chapter describes the current legal framework for assessment of the proposed project in the context of the environment and sustainable development, and the institutions that exist in Pakistan that may influence the environmental management, and the IFC.

2.1 Statutory Requirements of Pakistan

2.1.1 Overview

The development of statutory and other instruments for environmental management has steadily gained priority in Pakistan since the late 1970s. The Pakistan Environmental Protection Ordinance, 1983 was the first piece of legislation designed specifically for the protection of the environment. The promulgation of this ordinance was followed, in 1984 by the establishment of the Pakistan Environmental Protection Agency, the primary government institution dealing with environmental issues. Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the drafting of the Pakistan National Conservation Strategy (NCS) in 1992. Provincial environmental protection agencies were also established at about the same time. The National Environmental Quality Standards (NEQS) were established in 1993. The enactment of the Pakistan Environmental Protection Act, 1997 (PEPA, 1997) conferred broad-based enforcement powers to the environmental protection agencies. The publication of the *Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000* (IEE-EIA Regulations, 2000) provided the necessary details on the preparation, submission, and review of initial environmental examinations and environmental impact assessments.

The Ministry of Environment deals with environment and wildlife issues at the federal level. Within the ministry, the Pakistan NCS unit established in 1992 is responsible for overseeing the implementation of the NCS.

Two organizations, the Pakistan Environmental Protection Council (PEPC) and the Pak-EPA, are primarily responsible for administering the provisions of the PEPA 1997. The

PEPC oversees the functioning of the Pak-EPA. Its members include representatives of the government, industry, non-governmental organizations, and the private sector. The Pak-EPA is required to ensure compliance with the NEQS, establish monitoring and evaluation systems, and both identify the need to, as well as initiate legislation whenever necessary. It is thus the primary implementing agency in the hierarchy. The provincial environmental protection agencies (EPAs) are the provincial arms of the federal EPA, which is authorized to delegate powers to its provincial counterparts. One of the functions delegated by the Pak-EPA to the provincial EPAs is the review and approval of environmental assessment reports.

Each provincial government has its own environmental protection institution responsible for environmental pollution control. The Sindh Environmental Protection Agency is responsible for the approval of the EIA (ESSAS) and IEE of new developments undertaken in Sindh.

2.1.2 National Conservation Strategy

The NCS is a broad-based policy statement aimed at achieving environmentally sustainable economic and social development in Pakistan. The three overriding objectives of the NCS are:

- Conservation of natural resources
- Sustainable development
- Improved efficiency in the use and management of resources.

Three operating principles are identified to achieve these objectives. These are:

- Greater public participation in development and environmental management
- A merging of environment and economics decision-making
- Lasting improvements in the quality of life.

The NCS was developed over a nine-year period (1983-1992) after an extensive consultation process with thousands of experts, interested individuals, communities, non-governmental organizations (NGOs), and government agencies. The Federal Cabinet approved the documents in March 1992, as the principal policy document for environmental management in the country.

The NCS sets out the basic guidelines for an integrated effort aimed at protecting the environment and natural resources of the country. This broad framework provides a comprehensive point of reference for all agencies, departments, private sector companies, financial institutions, and donor agencies for undertaking systematic efforts to bring about an effective change for sustainable development.

The NCS has three main parts. Part 1, *Pakistan and the Environment*, provides the context of the document. Part 2, *Elements of National Conservation Strategy*, contains the basic policy statement. It defines the objectives and principles of the NCS and then discusses issues and opportunities for sustainable development in various sectors and the policy measures required to address these issues. Part 3, *Implementation Arrangements*, provides the action agenda and implementation strategy. It is organized into 14 program

areas for priority implementation. Within the 14 program areas, 68 specific programs have been identified and long-term goals and expected outputs and physical investments have been identified for each. The implementation strategy discusses the role of the various tiers of the government as well as that of the community and private sector.

The NCS proposes policies in 14 primary, secondary, and tertiary sectors. Of these, the policies and measures proposed in nine sectors (agriculture, forest management, rangeland rehabilitation, livestock management, water resources,[1] wildlife, mineral resources, energy, and human settlement) do not have direct relevance to the proposed project. The policies proposed in marine and coastal resource management, fisheries, industrial development, pollution control, and tourism are relevant to the proposed project. The policies for these sectors include the following:

1. *Marine and coastal resource management:* Development of alternate sources of employment for coastal communities to prevent over-exploitation of coastal resources such as mangroves; conducting research on environmental and social impact of traditional resource-use practices
2. *Fisheries:* Development of sea fisheries to the sea's full sustainable yield level; protection and restoration of shrimp fishing habitat
3. *Industrial development:* Development and enforcement of effective pollution controls; promotion of clean industrial processes and recycling; establishment of incentives for environmental beneficial or benign industries; development of a policy for siting of industries in areas of low environmental sensitivity; building awareness within industry
4. *Pollution control:* Promotion of domestic wastewater treatment technologies that provide for recovery and reuse of water, nutrients, and organic matter; focusing on the regulatory approach for industrial discharge; supporting recovery and use of heavy metals from industrial effluents; promoting biological methods of wastewater treatment wherever practicable; giving priority to areas where there is a risk of groundwater contamination; promotion of proper maintenance of motor vehicles, industrial boilers, and furnaces; encouragement of higher fuel efficiency in motor vehicles; undertaking environmental impact of plant siting; promotion of reuse and recycling; encouraging marketing assistance for effective use of scavenging systems
5. *Recreation and tourism:* Supporting the 1991 Tourism Policy's top priority of protecting, conserving, and restoring the basic natural capital and heritage resources

The proposed project is consistent with the stated policies on marine and coastal resource management and on fisheries.

---

[1] As 97% of the fresh water consumption is in the agricultural sector, the policy focuses on increasing irrigation efficiency.

2.1.3 Statutory Framework

The key environmental laws that have implications for the proposed project are discussed as under:

Pakistan Environmental Protection Act, 1997

The PEPA, 1997 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 key features of the law that have a direct bearing on the proposed project relate to the requirement for an initial environmental examination (IEE) and EIA for development projects. Section 12(1) requires that: "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an initial environmental examination or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment, and has obtained from the Federal Agency approval in respect thereof." The Pak-EPA has delegated the power of review and approval of environmental assessments to the provincial environmental protection agencies. As the proposed project will be located near Karachi, it falls under the jurisdiction of the SEPA.

Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000

The PEPA, 1997 provides for two types of environmental assessments: IEEs and EIAs. EIAs are carried out for projects that have a potentially 'significant' environmental impact, and IEEs are conducted for relatively smaller projects with a relatively less significant impact. The IEE-EIA Regulations, 2000, prepared by the Pak-EPA under the powers conferred upon it by the PEPA, 1997 categorizes projects for IEE and EIA. Schedules I and II, attached to the IEE-EIA Regulations, 2000, list the projects that require IEE and EIA, respectively. There are no explicit requirements or procedures for modification of existing plant in the Pakistan Environmental Protection Act, 1997 or the IEE-EIA Regulations 2000. The Act defines the term 'project' as 'any activity, plan, scheme, proposal or undertaking involving any change in the environment and includes … alteration, expansion, repair, decommissioning or abandonment of existing buildings or other works, roads or other transport systems, factories or other installations.' In this sense, whatever regulations are applicable to the construction of a chemical storage facility are also applicable to its alteration.

Under the regulations, chemical projects involving chemical manufacturing and/or processing require an EIA. Secondly, projects that undertake port and harbor development for ships of 500 gross tons and above require and EIA, also projects taking place within environmentally sensitive areas (protected areas ie national parks, wildlife sanctuaries etc) require an EIA.

The proposed project would require an EIA on the grounds that the expected parcel size for ethylene import would be 3,000 metric tons and a new marine loading arm would be added to the existing chemical jetty. Therefore, as per section 12 of the Pakistan Environmental Protection Act, the proposed project requires an EIA.

The IEE-EIA Regulations, 2000 also provide the necessary details on the preparation, submission, and review of IEEs and EIAs. The following is a brief step-wise description of the approval process:

1. A project is categorized as requiring an IEE or EIA using the two schedules attached to the Regulations.
2. An EIA or IEE is conducted as per the requirement and following the Pak-EPA guidelines.
3. The EIA or IEE is submitted to the concerned EPA—provincial EPAs if the project is located in the provinces or the Pak-EPA if it is located in Islamabad.
4. A fee, depending on the cost of the project and the type of the report, is submitted along with the document.
5. The submittal is also accompanied by an application in the format prescribed in Schedule IV of the Regulations.
6. The EPA conducts a preliminary scrutiny and replies within 10 days of the submittal of a report, a) confirming completeness, or b) asking for additional information, if needed, or c) returning the report requiring additional studies, if necessary.
7. The EPA is required to make every effort to complete the IEE and EIA review process within 45 and 90 days, respectively, of the issue of confirmation of completeness.
8. When the EPAs accord their approval subject to certain conditions:
9. Before commencing construction of the project, the proponent is required to submit an undertaking accepting the conditions.
10. Before commencing operation of the project, the proponent is required to obtain from the EPA a written confirmation of compliance with the approval conditions and requirements of the EIA.
11. An Environmental Management Plan (EMP) is to be submitted with a request for obtaining confirmation of compliance.
12. The EPAs are required to issue confirmation of compliance within 15 days of the receipt of request and complete documentation.
13. The EIA approval is valid for three years from the date of accord.

This EIA has been prepared following the guidelines of the Pak-EPA. It will be submitted to the SEPA by the EVTL.

A monitoring report is to be submitted to the EPA after completion of construction, followed by annual monitoring reports during operation

National Environmental Quality Standards

The NEQS were first promulgated in 1993 and have been amended in 1995 and 2000. The NEQS specify the following standards:

1. Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers)
2. Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources.
3. For power plant operating on oil or coal:
    a. Maximum allowable emission of sulfur dioxide from the power plant
    b. Maximum allowable increment in concentration of sulfur dioxide in ambient air due to operation of the plant
    c. Maximum allowable concentration of nitrogen oxides in ambient air when the plant is operating
    d. Maximum allowable emission of nitrogen oxide for steam generators as a function of heat input
    e. Maximum allowable concentration of pollutants (2 parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles.

The complete set of NEQS is given in **Appendix A**.

The Sindh Wildlife Protection Ordinance, 1972

The Sindh Wildlife Protection Ordinance, 1972 empowers the government to declare certain areas reserved for the protection of wildlife and control activities within these areas. It also provides protection to endangered species of wildlife. As no activities are planned in declared protected areas, no provision of this law is applicable to the proposed project.

The Sindh Fisheries Ordinance, 1980

The Sindh Fisheries Ordinance, 1980 regulates fishing in the public waters, including the coastal areas, of Sindh. It empowers the government of Sindh to issue licenses for fishing in public waters, put restriction on the type of equipment that can be used for fishing, restrict fishing in certain areas or of certain species of fish, regulate the onshore trade of fish catch, and regulate the fish processing industry. Article 8 of the Ordinance prohibits the discharge of wastewater to public waters without the consent of the Director Fisheries. A copy of the EIA report will be sent to the Director Fisheries, Government of Sindh for his consent when the report is submitted to the SEPA for environmental approval.

The Forest Act, 1927

The Forest Act, 1927 empowers the government to declare certain areas reserved forest. As no reserved forest exists in the vicinity of the proposed project, the provisions of this law are not applicable to the proposed project.

Hazardous Substance Rules, 2003 (Draft)

Section 14 of the PEPA 1997 requires that "no person shall generate, collect, consign, transport, treat, dispose of, store, handle or import any hazardous substance except (a) under a license issued by the Federal Agency and in such manner as may be prescribed; or (b) in accordance with the provisions of any other law for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement or other instrument to which Pakistan is a party." Pak-EPA has drafted the Hazardous Substance Rules to implement the licensing requirement. The rules are still in their draft form and are pending notification.

The Antiquities Act, 1975 and the Sindh Cultural Heritage (Preservation) Act, 1994

The Antiquities Act of 1975 ensures the protection of Pakistan's cultural resources. The Act defines 'antiquities' as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The Act is designed to protect these antiquities from destruction, theft, negligence, unlawful excavation, trade, and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area that may contain articles of archaeological significance. Under the Act, the project proponents are obligated to ensure that no activity is undertaken within 61 m (200 ft) of a protected antiquity, and to report to the Department of Archaeology, Government of Pakistan any archaeological discovery made during the course of the project.

The Sindh Cultural Heritage (Preservation) Act, 1994 is the provincial law for the protection of cultural heritage. Its objectives are similar to those of the Antiquity Act, 1975. No antiquity protected under these two laws was identified in the vicinity of the proposed project.

2.1.4 Guidelines

Key environmental guidelines are reviewed below.

Pakistan Environmental Assessment Procedures

The Federal EPA has published a set of environmental guidelines for carrying out environmental assessments and the environmental management of different types of development projects. These are general guidelines that are designed to provide information on the various methods that are available for environmental assessments. There are four general guidelines (*Policy and Procedures for Filing, Review and Approval of Environmental Assessments*; *Guidelines for the Preparation and Review of Environmental Reports*; *Guidelines for Public Consultation*; and *Guidelines for Sensitive and Critical Areas*) and nine sectoral guidelines. The relevance of the guidelines to the proposed project is briefly reviewed below.

Policy and Procedures for Filing, Review and Approval of Environmental Assessments

These guidelines define the policy context and the administrative procedures that will govern the environmental assessment process, from the project pre-feasibility stage to the approval of the environmental report. All specific requirements given in this guideline,

except the policy for handling projects with trans-province impact, have been superseded by the requirements in the IEE-EIA Regulations, 2000 (**Section 2.3.2**). As the proposed project is entirely in the province of Sindh and no trans-boundary impact is envisaged, this guideline will not have implications for the proposed project.

Guidelines for the Preparation and Review of Environmental Reports

The *Guidelines on the Preparation and Review of Environmental Reports* is broadly divided into four parts: Chapters 1 to 5 describes the environmental assessment process, and the desired contents of the environmental assessment report; Chapter 6 provides guidelines on reviewing and decision-making; Chapter 7 discusses monitoring and auditing; and guidelines for environmental study project management are provided in the last chapter.

The requirements for environmental assessment as specified in this guideline are consistent with the requirements of the World Bank (see **Section 2.2**). The EIA of the proposed project has been conducted meeting the requirements of this document.

Guidelines for Public Consultation

These guidelines deal with possible approaches to public consultation and techniques for designing an effective program of consultation that reaches out to all major stakeholders and ensures the incorporation of their concerns in any impact assessment study. Public consultation has been conducted as part of the proposed project meeting the basic requirements of these guidelines.

Guidelines for Sensitive and Critical Areas

The purpose of these guidelines is to help project proponents identify sensitive and critical areas in Pakistan. The sensitive and critical areas include protected ecosystems (national parks, wildlife sanctuaries, and game reserves), and protected archeological and cultural sites. The guidelines provide a list of areas that are protected against exploitation under the various wildlife laws of Pakistan and a list of all sites and buildings that are protected under federal and provincial laws related to archeological and cultural heritage. The proposed approach to environmental assessment for development projects in sensitive and critical areas includes the proper identification of such sites and close coordination with the relevant government departments for assessment of potential environmental impact.

As the project is not located in a protected ecosystem or near any protected cultural heritage, the provisions of these guidelines are not applicable to it.

Sectoral Guidelines

There are no guidelines for proposed project related activities available in Pakistan.

2.2 Requirement of IFC and World Bank

The IFC and the World Bank require all projects funded by these agencies to be constructed and operated in an environmentally responsible manner. All projects that receive IFC funding must therefore comply with appropriate World Bank Group environmental policies and guidelines. As the project proponents are likely to seek funding from the IFC for the proposed expansion project, the EIA has been carried out to comply with both national and IFC guidelines. The key documents of the IFC are discussed below.

2.2.1 Social and Environmental Review Procedures

IFC's Environment and Social Review Procedure (ESRP) outlines the process through which IFC staff implement the Corporation's commitment to promoting projects that are environmentally and socially sustainable. This commitment is a fundamental part of IFC's mission and is elaborated on in IFC's Policy and Performance Standards on Social and Environment Sustainability (PPS) as well as in IFC's Policy on Disclosure of Information (the Disclosure Policy). The ESRP applies to the full range of IFC's investment activities: direct lending to private enterprises (including both corporate and project finance); lending to financial intermediaries; minority equity/shareholding in companies, financial institutions, and other entities; structured finance products (guarantees, securitizations); and municipal finance. The ESRP also describes IFC's approach to its technical assistance and advisory activities, including both investment-related work and capacity building to help support private sector development in emerging markets. The ESRP also describes the application methodology that IFC staff must follow in order to implement IFC's institutional disclosure requirements in accordance with the Disclosure Policy. The application of the PPS varies according to the nature of IFC's intervention with the client and the nature of the client's business (for example, industrial companies versus financial institutions). The ESRP covers IFC's review and supervision responsibilities for environmental and social performance throughout the project life cycle.

The timing of an IFC investment in relation to a client's business activities and project implementation process varies from project to project. IFC does not control the timing of its entry into a project; IFC's engagement, more times than not, occurs well after the project is conceived, with the site selected and development started. When considering whether or not to participate in a transaction, IFC's review takes into account any project development work undertaken beforehand. IFC has a range of other tools to help staff assist its clients in improving the environment and social outcomes of their projects. Other sources of information that complement the PPS include the Guidance Notes for the Performance Standards; IFC Environmental Health and Safety Guidelines, which provide specific benchmark criteria in line with good international practice; and a diverse range of best practice material. The ESRP therefore does not provide technical support or guidance for specific environmental and social issues. Instead it is a defined and structured process that helps IFC maintain consistency and quality of its review process and ensure that policy requirements are identified and committed to. It thus helps fulfill the Corporation's commitment to sustainable outcomes in the operations it invests in or supports. Assessing and managing environmental and social impacts in a manner

consistent with the PPS is the responsibility of the client. IFC's responsibility is to review the work of the client, identify opportunities to improve outcomes, and ensure consistency with policy requirements. IFC's approach is to take full advantage of any work undertaken by the client before IFC's own entry into the transaction, thus minimizing additional processing burdens where it is possible to do so while still meeting the Corporation's policy requirements. Of particular importance in the PPS is the adequacy of the client's ESMS. IFC's investment or advisory support is used to influence and improve performance whenever possible.

The ESRP includes an amended categorization methodology, which categorizes projects according to potential adverse impacts after IFC's review rather than during initial screening. Categorization was previously used as a determinant of certain procedural requirements for the client relating to assessment, community engagement and disclosure. The ESRP recognizes that all process requirements of the client have now been captured in the PPS and that categorization is now used only to determine IFC's institutional disclosure requirements. IFC's environmental and social specialists are essential and integral parts of the process the Corporation uses to optimize outcomes. The ESRP is not a substitute for professional judgment and expertise but provides a framework for the consideration and documentation of key issues and decisions that are made during the project cycle. It also provides staff with a process for document preparation.

2.2.2 IFC Performance Standards on Social and Environmental Sustainability

IFC applies the Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing[2]. The Performance Standards may also be applied by other financial institutions electing to apply them to projects in emerging markets. Together, the eight Performance Standards establish standards that the client[3] is to meet throughout the life of an investment by IFC or other relevant financial institution:

Performance Standard 1: Social and Environmental Assessment and Management System

Performance Standard 2: Labor and Working Conditions

Performance Standard 3: Pollution Prevention and Abatement

Performance Standard 4: Community Health, Safety and Security

Performance Standard 5: Land Acquisition and Involuntary Resettlement

Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management

---

[2] IFC will apply the Performance Standards to projects it finances, consistent with the provisions in the accompanying IFC's Policy on Social and Environmental Sustainability. IFC's institutional disclosure of information will be pursuant to IFC's Policy on Disclosure of Information.

[3] The term "client" is used throughout the Performance Standards broadly to refer to the party responsible for implementing and operating the project that is being financed, or the recipient of the financing, depending on the project structure and type of financing. The term "project" is defined in Performance Standard 1.

Performance Standard 7: Indigenous Peoples

Performance Standard 8: Cultural Heritage

Performance Standard 1 establishes the importance of: (i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the client's management of social and environmental performance throughout the life of the project. Performance Standards 2 through 8 establish requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the client is required to manage them through its Social and Environmental Management System consistent with Performance Standard 1.

In addition to meeting the requirements under the Performance Standards, clients must comply with applicable national laws, including those laws implementing host country obligations under international law.

A set of Guidance Notes, corresponding to the Performance Standards, offers helpful guidance on the requirements contained in the Performance Standards, including reference materials, and on good sustainability practices to help clients improve project performance.

2.2.3 World Bank Guidelines on Environment

The Pak-EPA recommends using World Bank (WB) environmental guidelines for areas where there may be a gap in the national guidelines. The principal World Bank publications that contain environmental guidelines are listed below.

- Pollution Prevention and Abatement Handbook 1998: Towards Cleaner Production[4]
- Environmental Assessment Sourcebook, Volume I: Policies, Procedures, and Cross-Sectoral Issues[5]
- Environmental Assessment Sourcebook, Volume II: Sectoral Guidelines[6]

The first two publications listed above provide general guidelines for conducting an EIA, and address the EIA practitioners themselves as well as project designers. While the Sourcebook in particular has been designed with Bank projects in mind, and is especially

---

[4] World Bank, UNIDO, and UNEP. 1999. *Pollution Prevention and Abatement Handbook, Towards Cleaner Production*. Environment Department, The World Bank; UNIDO; UNEP.

[5] World Bank. 1991. *Environmental Assessment Sourcebook*, *Volume I, Policies, Procedures, and Cross-Sectoral Issues*. World Bank Technical Paper No. 139. Environment Department, The World Bank.

[6] World Bank. 1991. *Environmental Assessment Sourcebook,* Volume III, Sectoral Guidelines. World Bank Technical Paper No. 140. Environment Department, The World Bank

relevant to impact assessments of large-scale infrastructure projects, it also contains a wealth of information useful to environmentalists and project proponents.

The Sourcebook identifies a number of areas of concern that should be addressed during impact assessment. It lists activities that may have significant negative consequences for biodiversity, and mentions loss of habitat resulting from mining and mineral exploration as one such activity. It sets out guidelines for determining the project impact in such cases, provides a checklist of tools to identify possible biodiversity issues, and suggests possible mitigation measures. Possible project development effects on wild lands, wetlands, forests, etc., are also identified, and mitigation measures suggested. The Sourcebook also highlights core concerns in social impact assessment and emphasizes the need to incorporate socioeconomic issues into environmental impact assessment exercises.

The Environmental Assessment Sourcebook dealing with sectoral assessment is more specific. It contains sections on dams, reservoirs, watershed development, and flood protection. In addition to these documents, several other World Bank operational policies and directives that provide guidelines for environmental assessment were used during the assessment.

2.3 Non-governmental Organizations

International environmental and conservation organizations, such as the World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF), have been active in Pakistan for some time. Both these organizations have worked closely with the government and have played an advisory role with regard to the formulation of environmental and conservation policies. In the 14 years since the Rio Summit, a number of national environmental NGOs have also been formed that have been engaged in advocacy and, in some cases, research. The most prominent national environmental NGOs, such as the Sustainable Development Policy Institute (SDPI) and Shirkatgah, are members of the IUCN's Pakistan National Committee. ICUN and WWF were consulted during the EIA process (see **Appendix B** for details of the stakeholder consultation).

3. Project Description

EVTL intends to build storage and handling facility for refrigerated ethylene to facilitate the expansion of the EAPCL PVC manufacturing plant in the South Western Zone of Port Qasim, Karachi. The expansion will enhance EVTL's existing chemical storage and handling facility. The expansion project envisages an addition of 10,000 m^3 storage capacity of ethylene and a 1.5 km long import pipeline transporting refrigerated ethylene from the EVTL jetty to the storage site.

A marine loading arm (MLA) will be installed at the EVTL liquid unloading jetty as part of the project activity.

3.1 Project Location

The project will be installed within EVTL's existing storage terminal at the south-western zone of Port Qasim, in the town of Bin Qasim Karachi. Bin Qasim is the easternmost town of the 18 constituent towns of the greater metropolitan Karachi. The Gadap Town borders Bin Qasim to the north, Thatta district and the Indus River to the east, the Arabian Sea to the south, and the Malir River and the towns of Landhi, Malir, and Korangi Cantonment to the west. Port Qasim spreads over an area of 4,500 hectares (11,000 acres). Some of the industrial plants or facilities present in the estate are the Pakistan Steel Mills Complex, the Pakistan PTA plant, BOC Gas, KESC power plant, EAPCL, and the Engro Zarkhez fertilizer blending plant. The project location is shown in **Exhibit 1.1**.

3.2 Project Proponents

Engro Vopak is a 50/50 joint venture of Royal Vopak of the Netherlands and Engro Chemical Pakistan Limited (ECPL). Royal Vopak of the Netherlands is the largest independent terminal operator specializing in the storage and handling of liquid and gaseouschemicals. Its worldwide operations include 75 terminals with a total capacity of more than 20 million cubic meters. Its joint venture partner ECPL is Pakistan's second largest producer of urea fertilizer with an annual capacity of 945,000 metric tons per year and is one of the most progressive and diversified local groups in Pakistan.

EVTL was incorporated in 1995 with the objective to serve the chemical, petrochemical, and LPG industries and traders of the country with first class services to store and handle their liquid and gaseous products in a safe, efficient, and environmentally friendly manner. EVTL to date has facilitated investments of more that US$ 1 billion in the chemical industry of Pakistan.

3.3 Existing Facility

EVTL is spread over a total area of 0.41 km^2 and provides storage and handling services for a variety of chemical, petrochemical, and petroleum products namely paraxylene,

mono ethylene glycol, acetic acid, acrylonitrile, phosphoric acid, vinyl chloride monomer, and liquefied petroleum gas. The facility has 20 storage tanks with a combined storage capacity of 69,000 m^3. Other ancillary facilities include a dedicated jetty access via a 1.1 km long trestle, truck loading stations, and office facilities. The layout of the existing plant is shown in **Exhibit 3.1**.

The operation of the facility results in the generation of hazardous and non-hazardous waste (both solid and liquid). Details of the existing facility's waste generation, handling, and disposal are presented as **Exhibit 3.2**. A listing of all the storage tanks, both existing and proposed, at the facility along with their type, storage capacity, and contents is presented in **Exhibit 3.3** whereas throughput details of the existing facility is provided in **Exhibit 3.4**. The existing air emissions resulting from the existing facility's operation include process vapors, combustion products, and venting gases. **Exhibit 3.5** provides a list of the sources and composition of these emissions.

3.4 Proposed Development Project

As per the proposed project the EVTL facility with an annual throughput of 72,000 metric tons (expandable to 105,000 in five years) will receive refrigerated ethylene via ship tankers, store liquefied ethylene, and feed vaporized ethylene directly into the 6.5 km long under ground export pipeline to the EAPCL plant. This pipeline will be owned and maintained by EAPCL.

The ethylene storage and handling facility at EVTL will comprise of the following main components:

- Marine unloading arm for low temperate application
- 1.5 km long main import and chill down pipeline for refrigerated ethylene
- 10,000 m^3 storage tank (s) for liquefied ethylene
- Boil off gas compressor for maintaining liquefied ethylene at acceptable pressure in the tank
- Re-liquefaction unit
- Send out pumps
- Ethylene vaporizers
- Blow down and ground level combustor

The maximum inventory of ethylene at one point in time at EVTL will be about 5,000 tons. Ethylene is a flammable hydrocarbon which forms explosive air-gas mixture, is lighter than air, and is stored at extremely cold temperature (-103 °C). The ethylene terminal operations will involve the following:

- Unloading of liquefied ethylene from ship tanker into the storage tank via 1.5-km-long import line.
- Chilling of import line by recirculation of ethylene from storage tank through the chill down pipeline for several hours before the start of unloading operation.
- Ship unloading of about two parcels per month.

- Sending out vaporized ethylene on a continuous basis into the export line. Send-out operation includes running of in-tank submersible pumps and flowing of liquid ethylene through air/water/steam heated vaporizers.
- The vapors generated as a result of heat ingress (Ethylene is a liquefied gas which gets vaporized with slight change in temperature) into the tank will be collected and compressed either into the export line or condensed back in to the tank

The proposed activities when in operation are not expected to bring any change to facilities existing waste generation (both solid and liquid), air emissions, and staffing. The project is however expected to bring about a variety of accidental release scenarios as a result of the proposed ethylene storage. These scenarios are discussed in detail in **Section 5** (*Project Impact and Mitigations*).

3.5 Construction Activities

The construction and installation activities of the proposed project are described below.

3.5.1 Site Preparation

EVTL has existing land of 0.41 km^2 and no new area for the proposed facility expansion was acquired. All construction and installation work will be carried out within the existing EVTL boundary.

Once the site sub-base has been prepared, the underground infrastructure will be installed and foundations laid for the process equipment and supporting infrastructure.

Typical activities that are conducted during the civil construction are:

- Soil survey to advise specific foundation
- Boring and casting for in-situ reinforced concrete column (RCC)
- Casting of elevated slabs on top of piles for tank foundation
- Other equipment foundations as per the recommendation of the soil survey
- Extension of roads

3.5.2 Ethylene Storage Facility Installation

The new tank and ancillary equipment, brought to the site by road in sections, will be erected on site and hooked-up. Typical activities entailed in this process are:

- Bottom plates laying and welding
- Roof structure and plates fabrication and welding
- Outer shell construction
- Roof blowing and welding
- Inner shell construction
- Nozzles welding on roof

- Insulation
- Piping connections

3.5.3 Installation of Ancillary Equipment

The following ancillary equipment will be installed and erected to ensure the safe and efficient storage and handling of ethylene:

- BOG compressor
- Associated vessels and inter-coolers
- Ethylene reliquification unit
- Ethylene vaporizer
- Ethylene ground level combustor
- Transfer pumps
- Ethylene in-tank

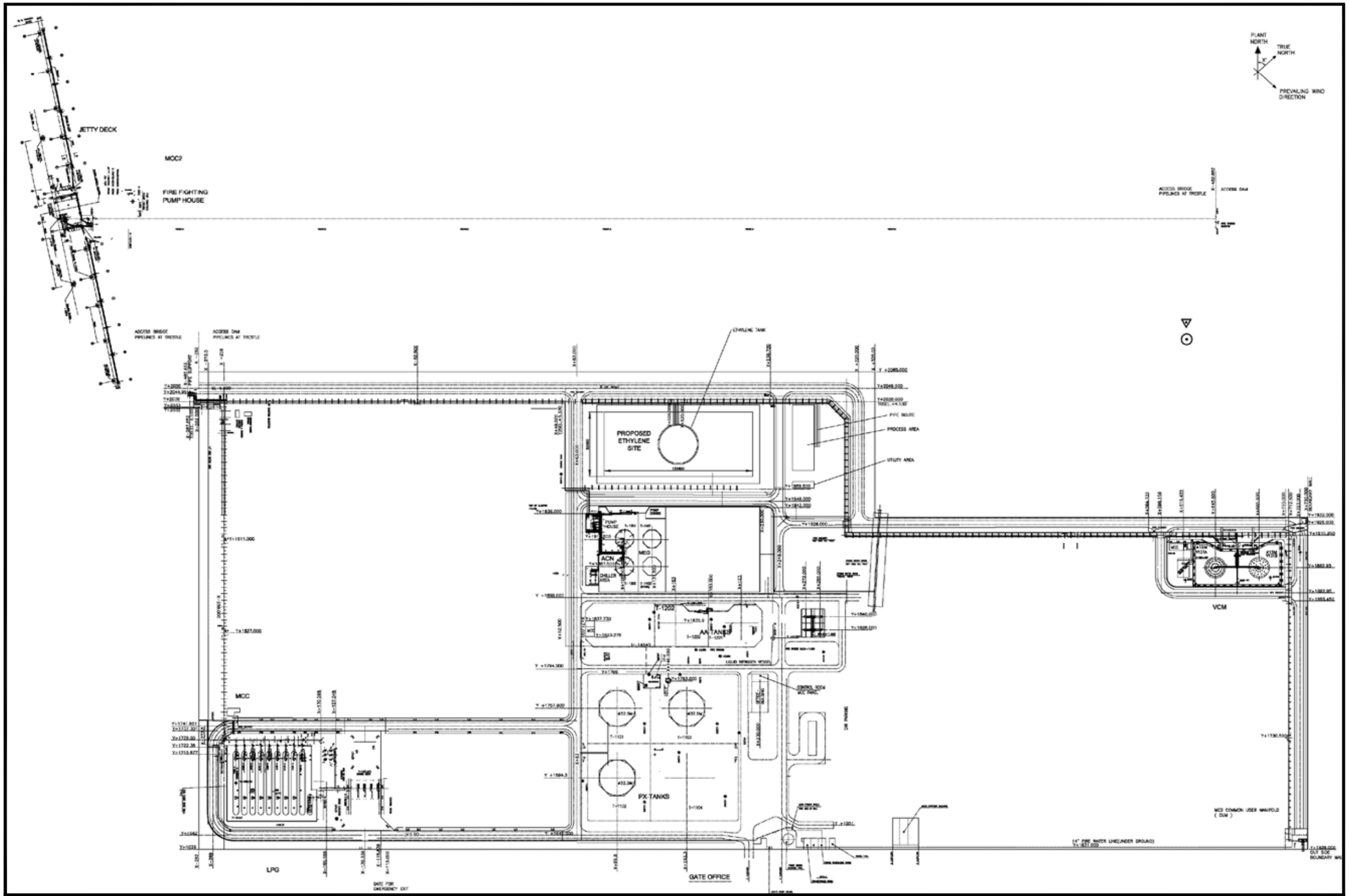
3.5.4 Import Pipeline Laying

The pipeline will be laid on pipe alley parallel to the existing trestle connecting the jetty to the storage facility, along the existing import pipelines. The laying down of the pipeline will include following activities:

- Stringing
- Lineup welding
- NDT weld testing and repairing
- Insulation
- Valves installation
- Flushing, hydrostatic testing, and dewatering

3.5.5 Pipeline Cleaning and Testing

After a section of the pipeline has been installed, a traceable brushing pig will be sent down the section of a line for cleaning as well as removing some of the construction and fitting waste material and water that is likely to be accumulated in the pipeline during construction. The waste (predominantly water with some residue) will be removed from the pipe. Flushing with clean water will then further clean the line. A pig train containing water (comprising a pig, water, pig sandwich) will be sent down the line. The test water will be disposed of along with other liquid effluents at the terminal.



LEGEND

- ⊗ Firewater Hydrant
- Firewater Monitor
- Firewater Line

EIA of EVTL Expansion Project

Exhibit 3.1

Existing and Proposed Layout

Scale	1 : 2,700
Source	EVTL
Drawing	W6E03EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan

Exhibit 3.2: Waste Handling and Disposal

Waste	*Description*	*Type (Solid/Liquid)*	*Quantity*	*Frequency*	*Source*	*Disposal method*	*On-site storage capacity*
Non- Hazardous Waste (Trash and unusable)	Dirty cotton rags, used cotton gloves, trash, kitchen waste, poly bags, liquid effluent (sewage), etc.	Solid	Not defined	Twice a month. (waste bins have been collected and emptied twice a month by the contractors. (Quantity not defined).	Operation, Kitchen, Washrooms, Office activities	Collection through approved contractor.	10 Sets are provided at different location having 3 waste bin/ set. Capacity of one bin is 50 kg.
Non- Hazardous Waste (Recyclable/ Reusable)	Printer and fax toners/ cartridges, empty bottles (glass/ plastic), empty drums/ containers, unserviceable instruments/ equipment, metal pieces, packaging material etc.	Solid	Not defined	Twice a month. (waste bins have been collected and emptied twice a month by the contractors. (Quantity not defined).	Operation, Kitchen, Washrooms, Office activities, Maintenance.	Collection through approved contractor.	10 Sets are provided at different location having 3 waste bins/ set. Capacity of one bin is 50 kg.
Hazardous Waste	Used Lubricants, greases, Empty drums/ packaging of hazardous chemicals, Unserviceable hoses used for product handling, Residual chemicals, Effluent from storage tank pits, pump houses or sump pits, Used gaskets, cartridges, used chemical suits, Waste arising from tank cleaning or other operational activities etc.	Solid/Liquid	Not defined	Twice a month. (waste bins have been collected and emptied twice a month by the contractors. (Quantity not defined).	Operation, Maintenance.	Collection through approved contractor. & slop chemicals are returned to customers.	

Note: Non-hazardous liquid effluent is being recycled and used in horticulture**.**

Exhibit 3.3: Tank Farm Inventory

Tank ID	*Contents*	*Tank Construction Description*	*Type (Atmospheric/ Pressurized/ Refrigerated)*	*Total Capacity (m^3)*
T-1101 – 3 (3 Tanks)	pX	Material: CS; cylindrical & dome roof	Atmospheric	36,000
T-3101	pX	Material: CS; cylindrical & dome roof	Atmospheric	62
T-1201 – 2 (2 Tanks)	AA	Material: SS-316L; cylindrical & dome roof	Atmospheric	5,000
T-1301 – 2 (2 Tanks)	ACN	Material: CS; cylindrical & cone roof	Atmospheric	6,400
V-101A – B (2 Spheres)	VCM	Material: CS; Spherical Vessel	Pressurized	7,500
V-201A – J (9 bullets)	LPG	Material: CS; Earth mounded cylindrical vessel	Pressurized	9,900
V-202A	LPG	Material: CS; Earth mounded cylindrical vessel	Pressurized	200
T-1401	MEG	Material: CS with internal epoxy lining; cylindrical & dome roof	Atmospheric	4,000
T-3201	Fresh Water	Material: CS; cylindrical & cone roof	Atmospheric	1,000
T-1010 – 13 (4 Tanks)	Diesel	Material: CS; cylindrical	Atmospheric	80
V-3180	General Slop (Jetty)	Material: CS; cylindrical vessel	Atmospheric	0.003
V-3181	pX Slop (Jetty)	Material: CS; cylindrical vessel	Atmospheric	0.003
V-3182	AA Slop (Jetty)	Material: CS; cylindrical vessel	Atmospheric	0.003
V-3191	Mobile slop	Material: CS; cylindrical vessel	Atmospheric	0.003
V-3302	Foam Storage (Jetty)	Material: CS; cylindrical vessel	Atmospheric	2
CWT-1301	Chilled Water (ACN)	Material: CS; cylindrical vessel	Atmospheric	10
U-3501	Nitrogen	Material: CS; cylindrical vessel	Atmospheric	3.7
T-1501	Ethylene (Proposed)	Material: CS; cylindrical & dome roof	Refrigerated	10,000

Exhibit 3.4: Throughput Data[1]

Product	*Throughput ('000 metric tons)*	*No. of Ships*	*No. of Road Tankers*
Paraxylene	300	37	11,300
Mono Ethylene Glycol	33	16	833
Acetic Acid	18	10	847
Acrylonitrile	12	6	587
Phosphoric Acid	405	21	nil (exported via pipeline)
Vinyl Chloride Monomer	91	30	nil (exported via pipeline)
Liquefied Petroleum Gas	26	11	1,408
Ethylene	72	24	nil (exported via pipeline)

Exhibit 3.5: Air Emissions of the Existing Facility

Stack/ Vent ID	*Source (Process, Vent, Combustion)*	*Height (mm)*	*Diameter (mm)*	*Composition*	*Temperature*
S-201	Vent	15,000	200	LPG Vapors	-42 to 60 °C
ST-102	Vent	25,000	154	VCM Vapors	-42 to 60 °C
ST-202	Vent	12,000	82	LPG / VCM / ACN Vapors from Jetty	-42 to 60 °C

[1] The data provided in the exhibit is actual terminal data of the year 2005

4. Description of Environment

This section describes the environmental setting of the project area (**Exhibit 1.2**). The project area is defined as the area where the project related activities are to be carried out. The project area refers to the geographical area in which the activities related to the construction and operation of the plant are proposed to take place and in which the environmental impact of the activities are likely to happen. The description provided in this section is based on published information, previous studies conducted in the area, and field survey data that was collected specifically for this study. The field surveys were conducted in July 2006.

4.1 Location

The proposed project is located in the southwestern zone of Port Qasim in the Bin Qasim town which is located in the southern part of Malir district, Karachi division, in Sindh. Bin Qasim town is one of the eighteen administrative towns of Karachi. Karachi division is divided into five districts—Karachi West, Karachi East, Karachi South, Karachi Central, and Malir. Karachi East, Karachi South, and Karachi Central are entirely urban, whereas Malir and Karachi West have both urban and rural populations. The proposed project site is located near Qasim International container terminal (QICT) in the south western zone of Port Qasim. The Malir district located in the eastern part of the Karachi Division, covers an area of 2,268 km^2. It is bounded on the north by the Jamshoro district, on the south by the Thatta district and the Arabian Sea, on the east by the Jamshoro and Thatta districts and on the west by the districts Karachi South, Karachi Central, Karachi East, Karachi West, and Lasbela of Balochistan.[1]

Port Bin Qasim was constructed in the late 1970s to relieve congestion at the Karachi Port. Port Qasim was named after the Muslim general Muhammad bin Qasim who captured the area around 712 AD. The port was developed close to the Pakistan Steel Mills Complex near the Indus River delta. Port Qasim is Pakistan's second busiest port, handling about 35% of nation's cargo (17 million tons per annum). It is located in an old channel of the Indus River at a distance of 35 kilometers east of the Karachi city centre. The total area of the port comprises 1,000 acres (4 km^2) with an adjacent 11,000 acres (45 km^2) of the Qasim industrial estate. The approach to the port is along a 45-kilometre long navigation channel which can provide the safe navigation for vessels of greater than 100,000 Dead Weight Tonnage (DWT) with the channel draft of 13 meters and width of 200 meters. The geographic position of the port places it in close proximity to major shipping routes. One of it's major advantages is its proximity to national transport facilities; it is located 11.3 km from the Pakistan National Highway, 8.7 km from the national railway network through six railway tracks located immediately behind the berths, and 22 km from the Quaid e Azam International Airport.

---

[1] Population Census Organization. 1998. *District Census Report of Malir District*. Islamabad

4.2 Natural Environment

4.1.1 Topography, Geology, and Soils

Ridges, plains, and the coastal belt are the dominant topographic features of the project area. Details of topographical features of the area follow:

- *Ridge and Runnel Upland in Sindh Kohistan*: This is an area of rugged topography in the north. It is an offshoot of the Kirthar mountain range and forks away in a southwest direction from the main range at the mountain knot of Gorag at an altitude of 2,126 m, gradually decreasing in height as it approaches the Gadap plain.
- *Plains and Plateau of Malir-Lyari Interflous*: The vast tract of land lying between the Malir and Lyari rivers forms the interflous of the drainage systems of the two rivers. This area has very little natural drainage scars, which indicate it having a rocky base of alternating layers of consolidated sandstone, intervened by silt and clay beds.
- *Plains and Hills of the Coastal Belt*: The southern part of the Malir District follows the coastal strip of the Gharo and Korangi creeks, demarcating the northern boundary of the old Indus delta. The areas, to the south of the east-west baseline of the triangular outline of the Karachi division subsided and were covered by the sea making a shallow basin. In the course of time the deltaic deposits of the Indus River filled this shallow basin and the northern part of the basin, which coincided with a fault line making the coastal edge. The terrain rises gradually northward from the Arabian Sea, culminating in low, flat-topped, parallel hills. Sub-parallel ridges interrupted by wide intervening plains, categorized as marine denudation plains, sand dunes, and marine terraces, are prominent features of this area.[2]

The existing facilities and proposed project site covers an area of 102 acres. The nearest residential area is the village Let Basti located at 7 km northwest of the proposed location. Other residential areas include the colonies of PQA employees are located in the north and are at over 8 km distance. The proposed site is flat reclaimed land with vegetation outside the boundaries. The topographical and environmental features in the vicinity of the proposed project site are shown in **Exhibit 1.1**. The proposed site is surrounded by QICT in the east, Gharo Creek in the south and south east. Papri Badel Nala flows northwest of the proposed site. This nala ultimately falls into the Gharo creek located in the adjacent south of the proposed site. The land use of the rest of the project area is divided amongst industrial plots; public and civic buildings; roads, railway lines, and drains that are passing through the industrial area.

---

[2] Population Census Organization. 1999. *1998 District Census Report of Malir*. Islamabad

4.1.2 Seismicity of the Project Area

According to one classification Pakistan has 15 seismotectonic regions.[3] The proposed project is located in the seismotectonic region of the Kirthar Ranges, where a moderate level of seismic activity is believed to exist, but large magnitude earthquakes are rare. The Building Code of Pakistan[4] places Karachi in Zone 2 corresponding approximately to Intensity VII of the Modified Mercalli Scale of 1931.[5] The local effect of Scale VII earthquake is described as: 'Everybody runs outdoors'. Damage negligible in buildings of good design and construction, slight to moderate in ordinary structures, and considerable in poorly built or badly designed structures. Felt in moving automobiles.[6] Scale VII corresponds to average peak ground acceleration of 0.10-0.15 g (acceleration due to gravity, which is equal to 9.80 meter per square second), and an average peak velocity of 8-10 centimeter per second. The peak ground acceleration values in the Zone 2 according to the Building Code of Pakistan ranges from 0.08 to 0.16 g. Thus a plant that is designed, for example, on the basis of Uniform Building Code Zone 2B, which corresponds to peak ground acceleration value of 0.2 g, should be able to withstand the seismic load expected in the region.

4.1.3 Climate

Classification

The Indus Delta at present experiences an arid, moderate, hot and humid climate typical of subtropical coastal areas under the influence of monsoonal winds. The mild winter is restricted to the December-January period. The summer extends from April to September, which overlaps the short spells of the main rainy season during July-August. The weather tends to be very humid during May-June and September and pleasant during the periods of July to August and November to March.

The coastal area of the delta including the Karachi coast is largely influenced by the subtropical monsoon regime. The strong southwest monsoon period prevails from May to September while the weak northeast monsoon period is restricted to the period between December to January. The period between the two monsoons is considered to be transitional or calm period with winds of variable speed and direction. The weather during the inter-monsoon periods is uncertain and short spells of dust storms, dry weather, or a humid cool breeze may prevail for short durations

---

3 Quittmeyer, R. C. 1979. The Seismicity of Pakistan and Its Relation to Surface Faults in Geodynamics of Pakistan. Quetta: Geological Survey of Pakistan.

4 Government of Pakistan. 1986. *Building Code of Pakistan.* Islamabad: Ministry of Housing and Works, Environment and Urban Affairs Division.

5 Unlike earthquake magnitude, which indicates the energy a quake expends, the Modified Mercalli Intensity Scale of 1931 is designed to describe the effects of an earthquake, at a given place, on natural features, on installations and on human beings. It has 12 divisions, using Roman numerals from I to XII. I is the mildest—described as: 'Not felt except by a very few under especially favorable circumstances'—and XII is the most severe—'Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

6 United Stated Geological Survey. 1998. <http://neic.usgs.gov/neis/intensity/pym/mmi_abbrev.html> (March 9, 2004).

Further details on the climate of the district are given in **Exhibit 4.1**.

Air Temperature

Thirty years (1961-1990) average temperature data recorded at nearest meteorological station located at Karachi airport is shown in **Exhibit 4.1**.

Wind Speed and Direction

The wind direction during the southwest monsoon period comes predominantly from the west and southwest and during northeast monsoon comes from the northeast and north. The wind speed during the southwest monsoon period is about 14 m/s, while the wind speed during the northeast monsoon rarely exceeds 8 m/s. The wind roses delineate the percentages of winds from different directions and intensity. Strong winds exceeding 12 m/s in speed blow from SW to W direction for about 71 percent of the time. During NE monsoon, the wind blows for about 12 percent with an average intensity of 6 m/s. The NE strong wind of 12 m/s blows for about 1 percent of the time in a year.

Precipitation

Due to the semi-arid climate of the area, the annual rainfall is extremely low. The records kept by the Pakistan Meteorological Department indicate an average annual rainfall of about 162 mm at Karachi and the deltaic region for the years 1981-84. It varies between 150 to 250 mm for the average of two decades. The average number of rainy days per year is less than ten. However, most of the precipitation usually takes place within a short spell of 2-3 days. More than half of the total annual rainfall occurs during the July and August period while more than one-third of the annual rainfall takes place during the winter months of February to March. As the entire region is almost arid and most of the annual rainfall takes place within short spells of 2-3 days, the resulting flash floods find their way to the sea through a large number of storm water drains, and small seasonal rivers. These flash floods cause environmental problems such as erosion of the coastal belt, transport of large quantities of silt and suspended materials into creeks, disruptions of communication and transportation and destruction of coastal road, drinking water supply and electric supply at many places.

Humidity

Humidity levels at the coastal belt are extremely high. The exact humidity figures are not available. However, the data recorded at the Karachi city indicate that the monthly average maximum humidity (recorded at 8.00 A.M.) varies from 74% to 88% during May to September. The monthly minimum average humidity (recorded at 5.00 P.M.) varies from 27 to 52 percent during October through March.

Visibility

Mist sometimes develops on the coast after a calm and clear night, but soon disperses after sunrise. Sometimes along the Indus Deltaic coast, thick fog banks may develop between October and February, drifting seawards with the land winds and returning with the sea breezes, until dispersed by the heat of the day. The deltaic coast has high visibility. Occasionally haze hangs over the land.

4.1.4 Air Quality

Pakistan lacks a comprehensive and effective air quality monitoring system that can be used to track and address specific instances of air pollution and air quality degradation. At present, monitoring of urban air pollution in Pakistan is limited to isolated instances where air pollutants are measured for brief periods at selected locations. Urban locality, city, region, or countrywide continuous or repeated air quality monitoring data does not exist. Similarly, there is no formal system of air quality data storage and reporting. Whatever air quality data is in hand is available with the public and private organizations and agencies that conducted the studies. Apart from the availability of ambient air quality data, its integrity is another important concern. To compare air quality measurements from different cities and locations and from different times at the same location, it is important to systematically record and report, among other things, the analyzer technology, measurement technique, sensor location, instrument detection limit, sampling frequency, averaging time, time of measurement, meteorological conditions, and the anthropogenic activity (traffic, industrial emissions, etc.) corresponding to each observation. This information is not regularly reported with the data, which makes it impossible to interpret the data.

The two principle sources of industrial emissions in the vicinity of the proposed site have been determined and are listed below:

- The Pakistan Steel Mill complex and its ancillary processes
- The KESC power station.

It is important to measure air pollution over an extended period as changes in climatic conditions can significantly alter recorded levels. A period of one year is normally regarded as representative in order to determine the effects of seasonal climatic changes. The general air quality data for the major pollutants was carried out by SUPARCO in 2002 and the concentration of different pollutants is given in **Exhibit 4.2**.

4.1.5 Water Resources

There was a continuous supply of freshwater (150 million acre feet) and silt (400 million tones) into the entire Indus Delta from Indus River up to about 50 to 70 years ago. The Indus River discharge has now been reduced progressively from 35 MAF water and 100 million tones silt about 10 years back to 10 MAF down the Kotri Barrage. In winter months there is virtually no discharge from Indus River.

According to an estimate there is need of minimum 10 Million acre feet (MAF) of water to support the growth of mangrove vegetation and the mangrove system as a whole. The requirement of about 10 MAF water is only met during flash floods due to snow melting and upstream heavy rainfall during the Southwest Monsoon period (June to August).

There is no significant natural freshwater source in the project area. The Indus River about 120 km to the east of Karachi city and the Hub River, a perennial stream that originates in Balochistan and marks the boundary between Karachi Division and Balochistan are the sources of water in Karachi.

The Lyari and Malir Rivers that passes through the city do not have any natural flow, except during the monsoons. Malir River is ephemeral and is constituted from two major tributaries, ie Mol and Khadeji as well as some minor tributaries. Khadeji is a perennial stream that originates at Khadeji falls and gains flow as it travels across the Malir Basin. The Malir and Khadeji River basins include dry hill torrents and flow depends upon precipitation during rains.[7]

Groundwater resources in Karachi area are limited. The aquifers close to the coastal belt are mostly saline and unusable for domestic purposes. The aquifers near the Hub River bed are well developed and are source of water for agriculture and other domestic purposes. The aquifers are estimated to lie at depths of 50-100 m.

The total estimated water supply to Karachi is about 2.27 million m^3/d (500 mgd).[8] Approximately 2.02 million m^3/d (445 mgd), which amounts to 89% of the total supply to Karachi, is transported to the city from the Kotri Barrage on the Indus River through a system of canals and conduits. The second source of surface water to Karachi is the dam on the Hub River located north of Karachi, which supplies about 0.13 million m^3/d (29 mgd) of water to the city. In addition to these surface water sources, an estimated 0.09 million m^3/d (20 mgd) is supplied from private and public groundwater wells in and around Karachi. Except for a few Karachi Water and Sewerage Board's (KWSB) wells, all of which are connected to the piped supply system, the water from the groundwater wells is distributed through water tankers to various parts of the city.

Reduced flow of water downstream and silt from Indus River has an impact on the Indus Estuary and on Indus Delta Mangrove Ecosystem that is dependent on the annual supply of water and silt load. Main impacts of reduced discharge include the following:

- Reduced estuarine conditions due to reduced flow of water and silt from Indus River;
- Increased Seawater intrusion in Indus Delta and salt water intrusion in adjacent lands;
- Meandering and erosion of creeks;
- The mangrove cover in Indus Delta has reduced from estimated 43.3% to 23.8% during a span of 22 years from 1966 to 1998;
- The reduction of freshwater has resulted in increased water salinity (40-50 parts per thousand) and have promoted the salt water intrusion into the land and in the ground water resources;
- Size of Indus Estuary shrunk drastically and reduced to a narrow area along the mouth of discharge points;

---

7 Population Census Organization. 1998. *District Census Report of Malir District*. Islamabad

8 The main source of the information (Karachi City Government. 2003. *Basic Facts 2003-04*. Karachi) gives the water supply as 481.5 mgd that includes 1.5 mgd from seven wells under KWSB. No information is available on the yield of private groundwater wells. A conservative figure of 18.5 mgd is assumed.

- Estuarine characters of the most part of Indus Delta and its estuarine fauna and flora has disappeared in most parts of the delta;
- Decrease in biodiversity in the Mangrove ecosystem in terms of number of species reducing from 8 to 3 during last 40 years;
- Reduction in variety of habitats and niches for marine plants and animals;
- Reduced nutrient supply from silt has considerably reduced overall productivity of the area;
- Reduced silt load to the Arabian Sea has increased erosion of the coastline leading to loss of valuable land to the sea.
- The natural balance in deposition and erosion has been disturbed in favor of erosion forces;
- The frequency of storms and cyclones in the deltaic area has increased

In project area there are no tube wells and dug wells. Ground water is saline. At present the required water for EVTL is supplied by PQA through a fresh water pipeline distribution system

4.1.6 Coastal Water

The situation in Indus Delta is complex containing the four ecosystems i.e. terrestrial, estuarine, inter-tidal and marine ecosystems. The area of Indus Delta extends to three districts of Sindh ie Karachi, Thatta and Badin. It has an area of about 600,000 hectares spread between Karachi in the northeast to Rann of Kutch in the west. It is under the control of four different agencies Sindh Forest Department, Port Qasim Authority, Sindh Board of Revenue and Coastal Development Authority.

The Inter-tidal part of the delta harbors about seventeen major creeks and extensive mudflats. About 160,000 hectares of the delta are covered with mangrove forest, which thrive in the arid climate. The average annual rainfall is very low (200-250 mm) and in some years there is no rainfalls during the monsoon season (April-September). Therefore, the mangroves in the Indus Delta are largely dependent upon the freshwater discharges from the Indus River and a small quantity of freshwater from run-off, agriculture drains, seepage and the discharge from domestic and industrial sources from Karachi.

The coastal belt has been used to dispose off sewage from adjacent coastal areas and industries located in Korangi Industrial Area, Landhi Industrial Trading Estate and Bin Qasim Industrial Area. There are several open drains carrying untreated raw sewage discharge in to the Korangi and Gharo Creek. According to an estimate about 50 MGD[9] of sewage and waste waters are discharged into the creeks in the area.

[9] S Amjad1, S H N Rizvi and A Inam, National Institute of Oceanography, 'Impact of Reduced River Discharge on the Mangrove Ecosystem and Socio-economy of Indus Delta'

The coastal waters of Karachi receive wastewater from many sources other than the Malir and the Lyari rivers. It has been estimated that nearly 15% of the city effluent discharges directly to the sea. Other sources of pollution include discharges from coastal power plants, steel mill, oil refineries, the fish harbor and the ships docked in the harbor.

The constant inflow of untreated effluent into the Karachi coastal waters has led to marine pollution which, by various accounts,[10] has reduced the quality of water and led to loss of habitat for flora and fauna, reduced species diversity, smothering by high suspended solids and oils, accumulation of toxins in marine organisms especially in the larval stages of commercial species, tar balls on beaches, and reduction in amenities, and the eventual loss of marine living resources in the polluted areas. Very little study on chemical accumulation of and its harmful effects has been done in Pakistan but a survey show that plankton in the Arabian Sea has Dichlorodiphenyltrichloroethane (DDT) concentration of 0.005 to 3.21 ppm which shows an alarming trend of pollution.

The 3,500 km^2 area covered by the creeks off the coast of Karachi were once a spawning ground for a large number of commercial species of marine organisms. Pollution from the land has reduced the fishing potential of Gharo, Gizri and Korangi Creeks. Consequently, due to excessive pollution in the creeks there has also been a significant decrease in fish catch.[11]

The seawater quality within the Gharo Creek is comparatively good, except in certain localized places where effluents are discharged directly from areas such as the *Bhains Colony* (Cattle Colony), Pakistan Steel Mills, and KESC Power Plants, and the other parts of Port Qasim Area. The Korangi Creek is polluted due to the effluent discharged directly from the fishing villages and industries located further northwards. The Kadiro Creek appears to be relatively pollution free except for small quantities of oil that flows in from the adjacent Phitti Creek. The Phitti Creek is the main channel leading to Port Qasim, and has seen an increase in sea traffic over the last two decades, since the Port became operational. Thus, the biggest contributors to the pollution load in this creek are the ships going to and fro from Port Qasim. The ships and boats contribute to the pollution by releasing oils, ship refuse, cargo refuse, and garbage.

The industrial and municipal discharges contribute different types of pollutants to the creeks. These include acids, heavy metals, organo-chlorines, organo-phosphorous, alum, arsenic, benzene, calcium, chlorides, magnesium, potassium, sodium, sulfates, toluene and suspended matter. The water that enters the creeks at high tide and leaves at low tide is the only source flushing the pollutants to the open sea.

---

[10] National Engineering Services Pakistan (Pvt) Ltd. Date of Publishing Unknown. Environmental Impact Studies for Karachi Port Modernisation Project V. Draft Final Report. Volume I. Karachi.

[11] Pollution is not the only source of reduction in fish catch. Over-fishing and use of gill net fishing by local and foreign trawlers have contributed to the reduced fish catch.

4.2 Sea Conditions

Seawater Temperature

The sea surface temperature in the Project Area ranges from between 18 °C to 32 °C. **Exhibit 4.3** shows the sea water temperature at various depths, seasons and locations in the Arabian Sea. The important features of the sea temperature variations are the following:

1. The sea water temperature in the Arabian Sea is strongly influenced by the monsoons.
2. The highest temperature occurs around May, shortly before the southwest monsoon sets in.
3. On the contrary, in mid-summer it drops, because at this time cold water from the deeper sea circulates near the coast.
4. When the southwest monsoon subsides in October, the influx of the cold deep-zone water also recedes. Coupled with a simultaneous decline of the air temperatures, the water surface temperature along the entire coast is quite balanced
5. In the course of the winter cooling, a temperature drop sets in from south to north.
6. The water is coldest in February
7. The sea water temperatures of the water column from the surface to about 10 m depth in the area between Churna Island and the Goth Bunglow near Cape Monze have an annual range of between 20 °C to 30 °C, which is suitable for the growth of corals in the area. This temperature range appears to be specific to this shallow rocky area in the nearshore coastal waters of Karachi.

Seawater Salinities

Due to a high evaporation of the surface water in the Arabian Sea, resulting in a relatively high salt content of the seawater causing the salinity near the coastal areas to be relatively high. On the average, the salinity ranges between 35 and 37‰ (parts per thousand) in the coastal water during most part of the year. An exceptional period is the short spell after rains in July-September when the salinity drops to about 25-28‰ for a few days to a week.

The sea water salinity in most of the inter tidal creeks of the Indus Delta remain between 37-41‰ during the greater part of the year. It drops to about 30‰ in certain creeks during the period of August to October, due to the rain. The influx of floodwater from the Indus River lowers seawater salinity in the creeks adjacent to the river. For example, in the Turshian Creek, near Keti Bunder, the salinity falls to about 10‰.

The seawater salinity plays an important role in the geomorphological changes taking place in the Indus Delta. The erosion and accretion patterns are very much influenced by the salinity gradient between fresh water runoff from the land and the open seawater. The rate at which flocculation and sedimentation of suspended materials takes place is accelerated along the salt wedges formed between two water masses of different salinity.

Suspended Load

Suspended load off Sonmiani Bay indicates clear water in the offshore area beyond 5 m depths where the values are around 70 parts per million (ppm). During monsoons the suspended load increases to about 120 ppm. In the near coast area the suspended load at 3m depth during the monsoon is about 170 ppm at the head of the bay.

The suspended matter in the nearshore seawater on the open West Coast of Karachi varies from between 3 to 120 ppm over the year. The suspended matter value ranges from between 90 ppm and 120 ppm during the period from April through to September, and ranges from between 3 to 15 ppm during the period of October through to January. An average value of 100 to 400 ppm of suspended matter in seawater was observed during the period of October through March, while during the southwest monsoon period it ranges from 400 to 900 ppm.

The suspended matter in the creek areas has an annual range of 25-170 ppm. The higher values were observed during the southwest monsoon period (usually May-August). The average suspended load during June-July was between 80-115 ppm. However, higher values (115-170 ppm) were also recorded at some places in the Gharo/Korangi Creek system. Lower suspended matter (25-50 ppm) was recorded during March and the September-November period. The suspended load in these creeks also exhibits variations with the degree of turbulence during a tidal cycle. During the flood season in the Indus River (September) the suspended load rises to about 4,000 ppm in Khobar Creek and to about 1,500 to 2,000 ppm in the adjacent creeks.

4.2.1 Storms and Cyclones

Severe storms and cyclones seldom cross the coast of Pakistan. **Exhibit 4.4** shows the monthly intensity and location of cyclonic activities. The main cyclonic activity in the Project Area takes place in the month of June. All the cyclonic storms that emerge in the Arabian Sea either curve sharply into the Gulf of Kutch or cross the Arabian Sea from East to West and end up at the coast of the Arabian Peninsula. When the cyclones cross the coast they are accompanied by storm surges, generally known as storm tides. The cyclones that cross the coast in the month of June generate winds of approximately 15-18 m/s.

4.2.2 Waves

The wave regime on the coast varies with seasons. During the winter season, when winds are around 5 m/s, the coastal waters are almost calm and the wave height is less than 1 meter. During the southwest monsoons of the summer months, the winds are around 13 m/s and the waves on the coast are more than 3 m high and vary according to the nearshore depths and locations. In other months the waves are between 1.5 to 2.5 m.

The Deep Seas Wave Climate: Pakistan lies to the northern end of the Arabian Sea that extends southwards into the Indian Ocean for thousands of kilometers. The coast is exposed to waves from the south, southwest and west. The distances involved mean that the wave generation times, and consequently the wave periods may be very long.

During the severe weather in the summer due to the monsoons, the majority of the wind, and hence the waves come from the southwest. During the winter months, however, the

weather conditions are very different, with the wind no longer coming predominantly from one direction. Therefore, in the winter both swell waves and locally wind generated waves influence the coast.

For the swell waves, voluntary observations of weather data by ships of passage are considered to give the most realistic offshore wave data. However, for the locally generated waves, wind data from nearby coastal stations are considered to be more accurate.

Deep sea wave data, for the SW monsoon months (May to September) applicable to Pakistan coast is given in **Exhibit 4.5**.

4.2.3 Wave Induced Currents

Apart from the currents generated by the orbital motion in waves, there are two important currents which influence the erosion and the movement of eroded material. These currents are described below.

The longshore current is the littoral current in the breaker zone which moves essentially parallel to the shore. The current is usually generated by waves breaking at an angle to the shoreline. The value of longshore current in the Indus Deltaic region is about 1.0 meter per second and at Gadani is 1.3 meter per second.

The rip currents are characterized by the under currents and eroding sand which swiftly move towards the open sea from the nearshore areas on the open sea beaches. The rip currents, therefore, pose a danger of drowning to the bathers and swimmers on the beaches in addition to the scouring effects on the artificial coastal structures built within the area of their influence. The rip currents have been observed in a few places along the coast of Karachi. The most probable places where the rip currents occur are in Hawkes Bay, Gadani Bay, Khalifa Bay, Phuari Bay and off the islands at the entrances of the creeks.

4.3 Biological Environment

4.3.1 Flora

Pakistan is divided into four phytogeographical regions based on similarity of natural flora. Karachi falls in the Saharo-Sindian region. Floristically this region is considered very poor as despite its size, only 9.1% of the known 4,940 floral species of Pakistan are found in this region.[12] However the project is located close to the coast therefore, marine phytoplankton and mangrove forests are in relative abundance in the coastal areas (see **Exhibit 1.2**). A list of plants found in the project area, their local and scientific names, distribution, and status are given in **Appendix B**.

---

[12] Nasir, Y. J. and A.R. Rubina. 1995. *Wild Flowers of Pakistan*. Karachi: Oxford University Press.

Coastal Belt

The natural setting of creek coastal ecosystem of the project area has been characterized as (Saifullah *et al.*)[13]:

- *Dwarf common plants:* Prosopis juliflora, Salvadora persica, Cressa cretica.
- *Grasses:* Suaeda nudiflora, Cenchrus bliflora, Sporobolus tremulus and Juncellus laerigatis.
- *Mangrove plants:* Avicennia. marina and Rhizophora sp. are dominant species. Rhizophora is being planted in the coastal areas by various organizations under different mangrove rehabilitation programs.
- *Mangrove associated microorganisms:* Phaeocystis (phytoplankton) algae occur exclusively in areas rich in organic matters along the detritus of mangroves and sewage pollutants from residential settlements, discharged into the sea.

According to Flora of Pakistan (1972) eight species of mangroves have been reported from Pakistan (see **Exhibit 4.6**). Though of these species, only four continue to thrive. These are *Avicennia marina*, *Aegiceras corniculatum*, *Ceriops tagal* and *Rhizophora mucronata*.

Bacterial and fungus populations observed along with the mangrove community in creek area belong to species *Entrophospo* sp., *Acailospora gadanskensis*, *A. mellea* and *A. gadanskis*.

Data on the Phytoplankton along the shelf and coastal waters of Pakistan is scarce. According to IUCN, more than 200 species of diatoms, more than 59 species of cocolithophorids, and more than 120 species of dinoflagellates are known to occur in the Arabian Sea[14].

Indus Delta mangrove ecosystem provide protection to the coastline from wind, waves and water currents, reduce sedimentation of navigational channels, reduce impacts of storm surges and cyclones and promote eco-tourism. The direct economic importance of the mangroves is attached to its capacity as a fisheries production area, sustenance and support for coastal and offshore fisheries, and nursery areas for young fish species and shrimps. The second most significant indirect economic activity supported by the study area is providing nutrient regeneration to support fishery production.

Mangrove forest: has vast environmental value for their capacity to clean air, assimilate water pollution except oil, and regulate carbon cycle in the atmosphere. Their well-developed root system holds the shore sands tight and prevents soil erosion and desertification. The evergreen forests of mangrove trees provide a habitat for many waterfowl and a variety of marine organisms including edible species of fish, crustaceans and mollusks. In winter, a large number of migrating waterfowl use the area for feeding and breeding. The mangroves are also home to a variety of reptiles including snakes, fiddler crabs, shrimps, prawns and mudskippers. Mangroves also provide a variety of

---

[13] Saifullah, S.M.; M. Nizamuddin. 1977. Studies on the marine algae from Pakistan: Ulvales. Botanica Marina, 20: 521-535.

[14] IUCN. 2003. Biodiversity, Status and Management for Creek. Karachi

marketable products. Mangrove forest provides fodder for domestic cattle, camels, fire wood; Jhugis, timmer, low cost housing; fishing poles; pulp, honey and has some medicinal uses as well.

4.3.2 Fauna

Several species of reptiles, birds, and terrestrial mammals inhabit the project area, wherever suitable habitats are found. The beaches and coast of Karachi are home to an abundance of marine fauna, such as birds, reptiles, fish, and marine mammals. The project area also falls in the Indus Flyway, one of the major migration routes for birds. The coast becomes winter home and even breeding grounds for many species of birds. A detailed list of wildlife of the project area, their status, occurrence, and distribution is given in **Appendix B**.

Coastal Belt

The distinguishing characteristics of the mangrove community are the great variety of land and water organisms that live together there because the habitats of land and sea overlap. Probably no other habitat in the marine environment is associated with such a variety of fauna as the mangrove swamps. They provide food and shelter to fish and waterfowl. The mangrove swaps act as nurseries and nutrients suppliers for economically important fish species on which many coastal communities in developing countries depend. Many marine animals live on the trunks and roots of the mangrove attached in the same way as they are on rocks elsewhere.

51 species of fish have so far been recorded from the mangroves and crest area of the Karachi (Jaleel and Khaliluddin 1981). Among the fish fauna of the swamps, mudskippers (Periophthalmidae) are the best adapted for this peculiar type of habitat[15].

Two species of dolphin have been observed locally known as Tabi and Malar (*Sousa plumbea*) are relatively abundant. These are bottle nosed dolphins and are very often observed towards the eastern side of Port Qasim. They are seen in schools of four or five. It is often seen following sardine shoals when it enters the creek, however its favorite food is shrimp. The population of this species is declining considerably although it is noted to occur throughout the year but not very often sighted. Pollution in the creeks area might be a reason for the decline in this species (pollution is so heavy in this region that it is difficult for animals such as dolphins to survive).[16]

Indian Ocean green turtle and pacific turtle are the two turtle species that are reported from the coastal area of Karachi (Hafiz ur Rehman and Fehmida 1997).

The crustaceans form a major component of the fauna with highest density and biomass. The fauna includes shrimps 6 species, crabs 10 species and lobsters 3 species (Jaleel and Khaliluddin 1981).

Among the sea snakes, the following have been known to occurred in the swamps area: *Hydrophis cyanocinctus* (Daudin) (annolated sea snake); *H caerulescens* (George Shaw)

---

[15] IUCN. 2003. Biodiversity, Status and Management for Creek. Karachi

[16] IUCN. 2003. Biodiversity, Status and Management for Korangi Creek. Karachi

(many toothed sea make); *H mamillaris*; (Daudin) (Beaked sea snake); *Microcephalophis gracilis gracilis* (Shaw) (common small headed sea snake); *Pelamis platurns* (Himaens) (pelagic sea snake); and *Ephydrina schistose* (beaked sea snake). Ten species of lizard have been reported.

The coastal area attracts a number of migratory birds, particularly waterfowl. In all, 285 species of birds belonging to 23 orders and 60 families are known to exist in the Sindh coastal waters. Among these 147 birds are residents, 5 summer visitor, 85-winter visitor, and others are migratory in nature (HBP 2001-02-02). The Green Turtle and Olive Ridley Turtles frequent the shores of the Karachi coast, where they come to nest (Hafiz ur Rehman and Fehmida 1997, Minton 1966)).

Far towards the sea in the mangrove forest the jackal (*Canis aureus aureus*) population is known to live in the mangrove forest.

4.4 Socioeconomic Environment

The proposed project site is located inside the EVTL's existing facility's boundary. The proposed site is bordered by empty land leading to the Qasim International Container Terminal (QICT) in the east and and Gharo Creek in the east and south. Papri Badel Nala (stream) flows northwest of the proposed site. This nala ultimately fall into the Gharo creek located to the south of the proposed site. There are no villages or residential colonies in the project area. The nearest human settlement from the proposed site is village Let Basti which is 7 km west to the site. The *dargah* (shrine) of Noor Hasan Shah is located approximately at 9 km east to the site. Other settlements which lie in the north and northwest of the project area at more than 9 km are Goth Lal Mohammad, Goth Mohammad Keserani and Pipri Colony. The port Qasim residential colony is located approximately 8 km northwest from the existing boundary. .

Coastal Communities

During the 18th and 19th centuries the Indus Delta was flourishing well with plenty of freshwater and sediment discharge from the Indus River all the year round. There were two river-sea ports: Keti Bandar and Shah Bandar that used to handle all imports and exports from Sindh and Bombay, Gawadar, and Middle East. Similarly the coastal agriculture areas of Keti Bandar, Kharo-chan and Shah Bandar were producing Rice as the main crop for export. The sea-borne goods in transit to upper Sindh area used to be transported to river boats. The socio-economy of these areas was very good and people were prosperous[17]. River Ports Shah Bandar – a river port established in 1759 by Kalhoro Regime was a viable port till the earthquake of 1819 that altered the flow of river to the port and reduced it to the level of a fishing village.

Rehri (a coastal fishing village in the east of the project location is about 4,060 years old), after the Kotri Barrage in 1958, the freshwater disappeared from many parts of Indus Delta and many people from the affected parts settled in and around Rehri Village.

---

[17] Sindh Gazetteer6 1876

These coastal communities have long been dependent on the coastal resources to meet their demands of food, fodder, fuel wood, sea-salt, timber for their temporary hutments (Jhuggi) and generation of income and for economic activities. Almost all of the populations of the coastal areas are engaged in fishing, fishing trade and as laborers in fishing industries, forest products, fishing boats, boat engine mechanics and camel raising, etc. Within these coastal communities, the drinking water supply is inadequate or absent. Public health care is minimum and sanitation is poor.

There are a number of coastal communities including permanent fishing villages along the coast, especially the fishing villages of Ibrahim Hyderi, Rehri and Lat Basti. The Coastal zone of Sindh is inhabited by communities such as Moros, Khaskhelis, Jats and Machees engaged in fishing. The main communities in the coastal areas along mangrove ecosystem are:

- Southeastern coast, Karachi: Jamote, Dhori, Mir Baher, Rabwai, Phullai, Khaskelli, Syeds, Jats, Bangali and Burmees, Baloch, Brohi, Larak. Musani, Panjwani, Waryani, Qasimani, Malkai and Shah;
- Port Qasim area: Mirbaher, Jat, Khaskheli, Syed, Baloch, Shaikh, Bangali, Burmees;
- East Karachi: Mirbahar, Baloch, Syed, Khaskheli;

Housing facilities are inadequate, mostly kutcha, semi-pucca and hutments (*Jhugis*). Basic public utilities are not available to most of the households except in the coastal zone adjacent to Karachi. The poor socio-economic situation is clearly reflected in the low illiteracy, high un-employment, and low income. Poverty and lack of essential civic necessities have increased the dependence of coastal communities on the available natural resources that ensure their livelihood security under the prevailing socioeconomic situation. Most of the population lives in hutments (*Jhugis*) made up of local indigenous materials ie, local vegetation, wood from mangrove trees, straw, etc. Most of the coastal communities live within or close to mangrove forests. Almost all the population in the coastal villages are fishermen or involved in fisheries related activities. A small percentage is involved in raising camels, buffaloes and goats, woodcutting or dry wood collecting from mangrove forests. The rate literacy is very low. Very few primary schools, dispensaries and mosques exist in the coastal areas. Skin diseases are common and Goiter cases are absent due to fish consumption. They have increased stamina, particularly in women, due to regular fish diets. The coastal villages lack all basic civic facilities including supply of drinking water roads and sewerage.

The mangrove ecosystem is of economic and ecological significance to the entire coastal area and for the dependent human settlements. Coastal communities of the area are heavily dependent on the coastal fisheries resources for their daily income generation and daily food. The rate of consumption of fish in the daily food (0.2 to 0.5 kg/head/day) of fishermen in the coastal communities has not changed much. Communities prefer to eat fish over mutton or beef and use vegetable or pulses only once a week.

The traditional fishing communities used to engage in sustainable harvesting. They knew how to fish, without depleting the fish stocks or harming the mangroves. The new entrants (Burmees, Bangladeshi, Afghans) in fishing business activities in Indus Delta are

blamed for their main interest in making good profits and do not follow the age-old fishing practices and traditions of local communities for sustainable use of coastal resources. The reduction of wild stocks of fish and shrimp in the Indus delta area, appears to be mainly due to:

- Reduction in the availability of freshwater and sediment supply to Indus Delta and,
- Unsustainable fishing by local and foreign fishing boats.

The following factors also contributed to the depletion of fish stocks:

- . The use of non-judicious fishing techniques (use of Jari, Boola and Katra nets (small mesh size bag set net);
- . The local Jat community changing to fishing business from camel breeding;
- . Influx of foreign fishing communities (i.e. Bangladesh, Burma) increasing pressure on local and coastal fisheries;
- . Increase in fishing effort by mechanized fish trawlers along the coast that are based in Karachi;
- . Increased fishing effort by foreign and Pakistani fishing vessels under Joint fishing Ventures within the territorial waters;
- . Increased levels of marine pollution from industrial and domestic sources.

Most of the local population of the coastal communities is directly or indirectly involved in fishing business. The livelihood main stay of the village folk is coastal fishing using small sized nets to catch mullets, small size fishes, juvenile shrimp and crabs etc. The coastal fishermen catch about 3,000 metric tons of fish, 2,000 metric tons shrimp and about 2,500 metric tons of crabs to earn their livelihood. Most of the small size fish is also used for making fish meals and manure. The fish constitute the main diet of all coastal communities in the area. The increase in the number of fishermen population and the fishing labour force in the area has been mainly due to a large number of local communities that have migrated from Keti Bundar and adjacent parts of Indus Delta and have permanently moved to Korangi-Gharo Creek system due to loss of the agriculture activity and for better economic opportunities. Most of them opted for fishing and fisheries related professions. These migrations have increased the existing pressures of coastal resources.

The coastal areas at the end of Gharo Creek are being used to produce sea-salt for the last 50 years. An estimated 480,000 kg sea-salt/year is being produced from the two main sea-salt producing factories in the area.

The mangrove forest has been providing good potential sites for honey production. Both the villagers and the fishermen collect it from the mangrove forest. It is estimated that about 1,000 kg of honey per year can be produced from the Korangi-Gharo Creek system. The quantity produced per year is negligible because it is based on beehives in the wild. On the average about less than 2% of the mangrove wood collectors from the coastal villages are engaged in honey collection (1-2 kg per head) as part time business mostly during March to April period, the flowering period of mangroves.

4.4.1 Historical Background

Before the construction of Port Qasim, the area of Bin Qasim was seasonally occupied by nomads. The nomads constructed temporary dwellings in the area and cultivate food crops using rain water. In the early 1970s the Port Authority acquired the entire area for industrial development. Agriculture was stopped and all temporary and permanent villages in the vicinity of project site were shifted to the interior of Sindh province.

4.4.2 Demography of Bin Qasim Town

The town had a population of about 315,000 at the 1998 census, of which 97% are Muslim and include several ethnic groups. Urdu speakers, Punjabis, Sindhis, Pakhtuns, and Balochs are main ethnic groups. The Bin Qasim town is consisted of 7 union councils names cattle colony, Gaghr, gulshan-e-Hadeed, Ibrahim Hyderi, Landhi Colony, Qaidabad, and Rehri.

The cattle colony is the center of cattle and meat trade in Karachi. The Cattle Colony is the dairy products shopping and supply center of Karachi.

4.4.3 Livelihood

A large proportion of the residents of Pipri Colony and coastal area are employed as unskilled industrial labor at Port Qasim Industrial Area, and Pakistan Steel Mills. According to a survey (HBP, 2003) conducted in the coastal area, the unskilled labor with irregular jobs earn between Rs 2,500 and 4,500 (US$ 43-78) per month, depending on the industry and the level of activity involved. These figures are estimated to be increased by 20% during last three years. A small number of people work in various government departments such as the education and police departments, where they earn a similar amount.

4.4.4 Gender

Most women form a part of the informal labor market, working to supplement inadequate household incomes. Female ‘invisibility’ and segregation are therefore comparatively rare and largely confined to the more conservative migrants from Sindh, Balochistan and the NWFP.

4.4.5 Community Life

In the ethnic mix of the colonies, each community strives to maintain its identity—regional languages are still commonly spoken, endogamous marriages are a continuing tradition, and specific ethnic groups dominate many occupations. The majority of labor and transport sector workers, for instance, tend to be Pukhtuns while Bengalis form a large part of the fishing industry and Christians are generally employed as sanitation workers. Despite such ethnic groupings, a degree of cohesion exists when it comes to a collective external threat from public sector officials. The residents of the colony are perpetually harassed by officials; in particular, the police. The colony’s vision for a better future focuses on good governance, access to health care, and better educational facilities.

4.4.6 Cultural and Archeological Resources

There are two *dargahs* (shrines) in the surroundings of the project area. Dargah Noor Hasan Shah is located at southeast of the project area approximately at 8.6 km from the boundary of EVTL and another shrine in the northwest at 5.88 kms close to village Let Basti.

At Rehri, along the coast east of Karachi, Karachi University archaeological team discovered a few Mesolithic and Late Palaeolithic sites. Most of these sites have vanished during the last twenty years. Nevertheless their discovery shed new light on the prehistory of the coastal area of Lower Sindh. Scatters of flint were found in different spots, some of which were associated with Terebralia palustris mangrove shells.

Exhibit 4.1: Climate of the Project Area

Month	*Relative Humidity (%)*	*Average Daily Maximum Temperature (°C)*	*Daily Mean Minimum Temperature (°C)*	*Average Daily Precipitation (mm)*	*Mean No of Rainy Days*	*Average Wind (Kts)*		*Maximum Wind Speed (Kts)*
						Speed	*Direction*	*Speed*
JAN	64	25.8	10.4	6.0	0.5	2.5	NE	17
FEB	68	27.7	12.7	9.8	0.6	3.1	Variable	21
MAR	73	31.5	17.6	11.7	0.4	3.9	W	26
APR	76	34.3	22.3	4.4	0.3	5.9	W	19
MAY	75	35.2	25.9	0.0	0.0	8.6	W	28
JUN	76	34.8	27.9	5.5	0.7	8.2	W	19
JUL	80	33.1	27.4	85.5	2.6	7.8	W	17
AUG	82	31.7	26.1	67.4	2.5	8.3	W	17
SEP	81	32.6	25.2	19.9	0.7	6.9	W	17
OCT	84	34.7	21.0	10.0	0.1	3.2	W	14
NOV	65	31.9	15.9	1.8	0.2	2.7	NE	16
DEC	62	27.4	11.6	4.4	0.7	2.2	NE	17

Source: Pakistan Metrological Department

Exhibit 4.2: Ambient Air Quality Measured by SUPARCO in Port Qasim Industrial Area

Pollutant	*Concentration*
Sulpher dioxide	20 ppb
Nitrogen Oxide	18 ppb
Carbon dioxide	310 ppm
Ozone	11 ppb
Carbon monoxide	3.8 ppm

Exhibit 4.3: Arabian Sea Temperature

Location	*Depth*	*Season*	*Temperature*	
Deep Sea Northern Indian Ocean	Surface	Pre-monsoon (Feb-May)	Avg.	25.35
		SW Monsoon (Jun-Sep)	Avg.	26.18
		NE Monsoon (Oct-Jan)	Avg.	25.06
	100 m	Pre-monsoon (Feb-May)	Avg.	22.61
		SW Monsoon (Jun-Sep)	Avg.	21.13
		NE Monsoon (Oct-Jan)	Avg.	20.83
Off Mekran and Las Bela Coasts	Surface	Pre-Monsoon (May)	Avg.	~ 29
		Mid-summer	Avg.	~ 27
		Post SW Monsoon (October)	Range	26 to 27
		February	Range	< 22
Karachi Nearshore	Surface	Annual	Range	19 to 31
		Winter	Range	19 to 24
		Summer	Range	28 to 31
	5 m	Annual	Range	18 to 30
Karachi Offshore	Surface	Annual	Range	20 to 30
	5 m	Annual	Range	19 to 29
	10 m	Annual	Range	18 to 28
Inside the Indus Deltaic Creeks	Surface	Annual	Range	18 to 32
Seaward Side of the Creek	Surface	Annual	Range	18 to 31
Indus Deltaic Coast Nearshore	Surface	Annual	Range	19 to 31
		Winter	Range	19 to 24
		Summer	Range	28 to 31

Exhibit 4.4: Month-wise intensity and Location of Storms in Arabian Sea

Month	*Intensity of Storms On an arbitrary scale of 0-4*	*Primary Area of Activity*
January	0 (No Storms)	–
February	0 (No Storms)	–
March	0 (No Storms)	–
April	2	Southern Arabian Sea
May	3	Southern Arabian Sea
June	3	Northern Arabian Sea
July	1orms	Northern Arabian Sea
August	1	Northern Arabian Sea
September	2	Northern and Central Arabian Sea
October	4 (Severe)	Southern and Eastern Arabian Sea
November	4 (Severe)	Southern and Eastern Arabian Sea
December	1	Southern and Eastern Arabian Sea

Marine Investigators, 1998

Exhibit 4.5: Deep Sea Wave Frequency Distribution Statistics

Resultant Wave Height (m)	*Wave Period (Seconds) for Higher of Sea/Swell Height*									
	0-3	*4-5*	*6-7*	*8-9*	*10-11*	*12-13*	*14-15*	*16-17*	*18-*	*Total*
0 to 0.5	2.6%	4.1%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%
0.6 to 1.0	1.1%	5.3%	1.8%	0.4%	0.1%	0.0%	0.0%	0.0%		8.9%
1.1 to 1.5	1.2%	6.7%	6.3%	2.2%	0.6%	0.1%	0.1%	0.0%	0.0%	17.3%
1.6 to 2.0	0.1%	3.8%	4.9%	2.9%	0.9%	0.2%	0.1%	0.0%	0.0%	12.8%
2.1 to 2.5	0.0%	2.8%	5.0%	3.6%	1.4%	0.4%	0.1%	0.0%		13.2%
2.6 to 3.0		1.3%	3.4%	3.2%	1.5%	0.5%	0.1%	0.0%	0.0%	10.0%
3.1 to 4.0		1.1%	4.9%	6.1%	2.9%	1.0%	0.3%	0.1%	0.0%	16.4%
4.1 to 5.0		0.2%	1.8%	3.3%	1.9%	0.8%	0.2%	0.0%	0.0%	8.3%
5.1 to 6.0		0.0%	0.5%	1.4%	1.1%	0.4%	0.1%	0.0%	0.0%	3.6%
6.1 to 7.0			0.2%	0.5%	0.4%	0.2%	0.1%	0.0%	0.0%	1.5%
7.1 to 8.0			0.0%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.5%
8.1 to 9.0			0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.1%
9.1 to 10.0			0.0%	0.0%	0.0%	0.0%				0.0%
10.1 to 12.0				0.0%	0.0%		0.0%			0.0%
12.1 or more							0.0%			0.0%
Total	5.1%	25.3%	29.4%	23.9%	11.0%	3.7%	1.3%	0.3%	0.1%	100.0%

Notes:

1. Sea Area Coverage: 15-25 N, 60-70 E
2. Seasonal Coverage: May to September
3. Period of data: January 1949-October 1995
4. Blank indicates zero frequency whilst 0.0% indicates less than 0.05%
5. Total number of observations were 38143

Exhibit 4.6: List and Distribution of Mangrove Species in Pakistan

Species	*Distribution*
Rhizophoraceae	
Bruguiera gymnorhiza (L) Lamk.	Karachi and Indus delta (Hassan) Estuary of Indus (Murray); no specimen in Kew, Edinburgh and Pakistan
Ceriops tagal (Perr.) C.B.	Robin Karachi and Coast of Sindh (stocks) Mouth of Indus and "Salt water creek" (Murray)
Ceriops decandra (G.) Ding Hou	Sindh tidal zone; existence considered doubtful
Rhizophora apiculata Blume	Tidal marshes at the mouth of Indus: Miani Hor, Las Bella (T & S)
Rhizophora mucronata Lamk.	Mouth of Indus on muddy shores and tidal creeks (Henslow; Las Bella and Makran Coast (Burkill)
Myrsinaceae	
Aegiceras corniculatum (L.) Blco.	Mangrove swamps at mouth of the Indus (Stocks, Ritchie) Karachi (Jafri): Miani Hor
Avicenniaceae	
Avicennia marine (Forsk.) Vierh	Tidal mangrove swamps; Sand spit (stern) China creek, etc. (Jafri), Kalmat Hor
Sonneratiaceae	
Sonneratia caseolaris (L.)	Engler Mouth of Indus and Tidal Zone (Common, fide Murray); Indus delta no specimen seen.

5. Project Impacts and Mitigation

This section discusses the potential environmental and social impacts of the proposed activities, predicts the magnitude of the impact, assesses significance, identifies mitigation measures to minimize adverse impacts, and evaluates the residual impacts of the project. The discussion starts with a description of the methodology used for the impact assessment (see **Section 5.1**).

5.1 Impact Assessment Methodology

Once potential impacts have been identified, the assessment of each potential impact follows these steps:

1. Definition of the Criteria for Determining Significance

   The consequence of the proposed activity is evaluated by comparing it against a recognized Significance Criteria. The criteria are of the following types:

   a. Institutional recognition—laws, standards, government policies, or plans.

   b. Technical recognition—guidelines, scientific or technical knowledge, or judgment of recognized resource persons

   c. Public recognition—social or cultural values or opinion of a segment of the public, especially the community directly affected by the project

   d. Professional interpretation of the evaluator

2. Prediction of the magnitude of the potential impacts

   This step refers to the description, quantitatively (where possible) or qualitatively, of the anticipated impacts of the proposed project. This may be achieved through the use of models or comparison with other similar activities.

3. Identification of the mitigation measures

   If it is determined that the predicted impact is significant when compared with the Criteria for Determining Significance, suitable mitigation measures are identified. There is a range of mitigation measures that can be applied to reduce impacts. Broadly, these measures can be classified into following categories:

   a. Avoiding the impact altogether by not taking a certain proposed activity or parts of an activity, for example, using CFC-free equipment to avoid impact on ozone layer

   b. Minimizing impacts by limiting the degree or magnitude of the activity, for example, minimizing dust emission by reducing vehicular traffic

   c. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment

   d. Compensating for the impact by replacing or providing substitute resources or environments.

4. Evaluation of the residual impact

   Incorporation of the suggested mitigation measures reduces the adverse impact of the project and brings it within the acceptable limit. This step refers to the identification of the anticipated remaining impacts after mitigation measures have been applied—the residual impacts.

5. Identification of the monitoring requirements

   The last step in the assessment process is the identification of the minimum monitoring requirements. The scope and frequency of the monitoring depends on the residual impacts. The purpose of monitoring is to confirm that the impact is within the predicted limits and to provide timely information if unacceptable impact is taking place.

5.2 Environmental Impacts Associated with Construction Activities

The environmental and socioeconomic impacts associated with the construction activities of the storage facility are discussed in this section. The impacts that are discussed are the following:

- Construction Noise
- Dust Emission During Construction
- Vegetation and Wildlife Impact
- Impact on Water Resources
- Vehicle and Equipment Exhaust

The project construction is not expected to result in any socioeconomic impacts as no communities are present within 2 km of the project site and the proposed construction activity would not result in any land acquisition, change to land-use, also since it the construction work would be carried out through contractors it is not expected to generate any employment. Furthermore, project activities would not affect any archeological or cultural resources of the area.

5.2.1 Construction Noise

Depending on the construction equipment used and its distance, the receptors may typically be exposed to intermittent and variable noise levels. During the day such noise results in general annoyance and can interfere with sleep during the night. In general, human sound perception is such that a change in sound level of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and a change of 10 dB is perceived as a doubling or halving of sound level.

Potential Issues

The potential noise related issues during construction is the disturbance caused outside the EVTL boundary due to construction machinery operation on the project site. Since the construction site is located well within the terminal boundary and since no other plant

neighbors the terminal, the construction noise generated is not expected to affect any nearby plant.

Existing Conditions

The exiting significant sources of noise in the project area include the industrial units and the road traffic. Interviews with people in the project area suggest that the existing noise due to exiting activities is not considered significant.

Criteria for Determining Significance

The World Bank guidelines for noise (**Exhibit 5.1**) require that the sound level in industrial areas should not exceed 70 dB(A) at anytime during the day.[1] An alternate criterion is the World Health Organization (WHO) guidelines.[2] The WHO guidelines (**Exhibit 5.2**), in addition to specifying the energy-average sound level L_{eq}, also prescribe the maximum noise level L_{max}. The maximum noise level is important when there are distinct events to the noise.

Impact Analysis

The potential sources of significant noise during the construction period include the construction machinery, generators at camps and construction related traffic. Precise prediction of noise due to construction activity at given location at a given time requires the list of all equipment that is operational at the time and the following information regarding each piece of equipment:

- The maximum and minimum noise levels, measured at a reference distance from the equipment, during a work cycle
- The fraction of time it operates at maximum level during a work cycle
- The usage factor, i.e., the number of hours during the day when the equipment is operational
- The distance of the equipment from the receptor
- Potential noise barriers and other topographic features that attenuate the sound.
- Atmospheric conditions—the wind speed and direction, humidity and barometric pressure—also affect the propagation of sound, however, for short distances the effect of these is insignificant compared to other variables.

No community is present in the project area, the EVTL management will ensure that the noise levels outside their boundary wall do not exceed the guideline values. Since the size of the proposed ethylene storage facility and its corresponding construction work is not very large, it is not expected that the guideline values stated in the preceding section would be exceeded

---

[1] World Bank, UNIDO and UNEP. 1999. *Pollution Prevention and Abatement Handbook 1998: Towards Cleaner Production*. Environment Department, The World Bank; UNIDO; UNEP.

[2] World Health Organization. 1999. *Guidelines for Community Noise.*

Mitigation

Given the predicted impact, the strategy to minimize the noise beyond the facility boundary to within acceptable limits will be based on the following:

- Reduce equipment noise at source
- Before the start of the operations conduct a noise survey of the equipment and prepare a noise control plan
- Minimize vehicular noise

The proposed strategy will be implemented through the following specific measures if required:

- Noise Survey

  Noise survey of all construction equipment will be conducted prior to their deployment. For this purpose each piece will be tagged and the following data will be recorded:

  - Survey date, surveyor, and noise meter ID
  - Equipment ID, type, and make
  - Noise levels at reference distance(s) in idling conditions, in all four directions
  - Noise levels at reference distance(s) in full throttle conditions, in all four directions

  The survey will be repeated periodically.

- Reduce equipment noise at source

  Based on the above survey, equipment emitting excessive noise in comparison with other similar equipment will not be allowed to operate. Equipment under use will be regularly maintained, tuned, and provided with mufflers to minimize noise levels. Equipment in poor state of maintenance, particularly without effective noise control will be checked to determine if it can be improved, and replaced with less noisy equipment as soon as practicable.

- Traffic noise

  - The construction related traffic would enter the project site from the entrance gate and thereafter use the road inside the storage facility to reach the construction site.
  - Blowing of horn will be prohibited on the access road to the project site and inside the site.

Residual Impacts

No irreversible noise impact is expected from the construction activities at the project site. It is possible that occasionally there will be exceedances of the significance criteria during construction. This may happen if, for example, a number of construction machineries are deployed close to the boundary. This will cause a nuisance to the

bystanders outside the storage facility boundary, although it is likely to last for short period.

Monitoring Requirements

Given the residual impacts, a noise monitoring plan will be developed that will cover regular monitoring of noise at source and at the storage facility boundary on a regular basis.

5.2.2 Dust Emission During Construction

Dust emission from construction sites is a concern particularly for the settlements that are found near the construction sites. However, that is not the case with this project due to no community settlements being present within 2 km of the proposed storage facility.

Dust generated during construction activities can be substantial. Dust or the equivalent technical term 'particulate matter,' is generally defined as any airborne finely divided solid or liquid material up to the size of about 100 microns (micrometers or one-millionth of a meter). The main health hazards are the particles smaller than 10 microns (designated as 'PM_{10}') as they are respirable. Larger particles also tend to settle rapidly and often do not reach receptors. In cases where they reach the receptors, the dust is considered a nuisance as it may soil property and affect visibility.

Potential Issues

Particulate matter emitted during construction activities can result in deterioration of ambient air quality in the vicinity of the source, and be a nuisance to anyone exposed to it. However, since the roads surrounding the construction site are concrete roads, it not expected that construction related traffic will cause significant amount of dust emissions. However, dust emissions may occur during the road widening and onsite construction activities.

Existing Conditions

The main sources of particulate matter emissions are the KESC power plant and Pakistan Steel Mills. There is limited particulate matter emission from vehicular traffic as all roads in the Port Qasim area are paved.

Criteria for Determining Significance

For the construction activity at the project site, a significant effect on the environment will be interpreted if there is an increase in visible dust beyond the boundaries of the project site due to activities undertaken onsite.

Impact Analysis

Potential sources of particulate matter emission during construction activities include earthworks (dirt or debris pushing and grading), exposed surfaces, exposed storage piles, truck dumping, hauling, vehicle movement on unpaved roads, combustion of liquid fuel in equipment and vehicles, land excavation, and concrete mixing and batching.

The quantity of dust that will be generated on a particular day will depend on the magnitude and nature of activity and the atmospheric conditions prevailing on the day. Due to the uncertainty in values of these parameters, it is not possible to calculate the quantity from a 'bottom-up' approach, that is, from adding PM_{10} emissions from every activity on the construction site separately. Typical and worst-case PM_{10} emission from construction sites has been estimated[3] as 0.27 megagram per hectare per month of activity (Mg/ha-month) and 1.04 Mg/ha-month, respectively.

The project activities will not involve a significant amount of civil and groundwork and therefore it is expected that they would not result in a significant amount of dust emissions beyond the boundaries. Incase there are significant dust emissions a wide variety of options exist to control emissions from construction sites. The most effective means of reducing the dust emission is wet suppression. Watering exposed surfaces and soil with adequate frequency to keep soil moist at all times can reduce the total dust emission from the project by as much as 75%.[4] Specific measures that can be employed for the proposed construction are discussed in the following section.

Mitigation

The following mitigation measures will be implemented at the storage facility construction site during construction to control emission of particulate matter:

- Water will be sprinkled daily or when there is an obvious dust problem on all exposed surfaces to suppress emission of dust. Frequency of sprinkling will be kept such that the dust remains under control, particularly when wind is blowing towards the community.
- Dust emission from soil piles and aggregate storage stockpiles will be reduced by appropriate measures. These may include:
  - Keeping the material moist by sprinkling of water at appropriate frequency
  - Erecting windshield walls on three sides of the piles such that the wall project 0.5 m above the pile, or
  - Covering the pile, for example with tarpaulin or thick plastic sheets, to prevent emission.
- All roads within the project site that are paved, any new unpaved roads that would need to be used during construction will be sprinkled regularly to prevent dust emission. Other temporary tracks within the site boundary will be compacted and sprinkled with water during the construction work.
- Construction materials that are susceptible to dust formation will be transported only in securely covered trucks to prevent dust emission during transportation.

---

[3] Gaffney, G. and Shimp, D. 1997. *Improving PM_{10} Fugitive Dust Emission Inventories*. Sacramento, CA. California Air Resource Board. <www.arb.ca.gov/emisinv/pubs/pm10tmp.pdf>

[4] El Dorado County Air Pollution Control District. 2002. Guide to Air Quality Assessment: Determining Significance of Air Quality Impacts Under the California Environmental Quality Act. First Edition. <http://co.el-dorado.ca.us/emd/apcd>

- Aggregate material will be delivered to the batching plant in a damp condition, and water sprays will be applied, if needed, to reduce dust emissions.
- Conveyors will be enclosed where possible.

Residual Impacts

The dust emission during construction activities will affect the ambient air quality, however, within the acceptable limits. The effects of the dust nuisance are temporary with no lasting impact expected after the completion of the construction.

Monitoring Requirements

In view of the residual impacts, dust emission from the construction activity will be visually monitored, particularly when activity is undertaken close to the neighboring facilities, to prevent visible dust beyond the storage facility property lines.

5.2.3 Vegetation and Wildlife Loss

Since no vegetation is present at the proposed site and no widening or development of access road is required for the proposed activities, no vegetation would be lost and no impact would occur on vegetation. Also the proposed site is not located on the natural habitat of any faunal species and so the project activities would not result in any impacts on the wildlife resources of the area.

5.2.4 Water Resources

The water requirements for the proposed construction activities will be sourced by the water supplied to the EVTL facility through the PQA dedicated water supply. The supplied water would not result in any kind of water shortage. Therefore, no mitigation measures are required for impacts on water resources.

5.2.5 Vehicle and Construction Equipment Exhaust Emissions

Potential Issues

Combustion exhaust emissions from vehicles and construction can affect the ambient air quality of the project area.

Existing Conditions

The project area is located within an industrial zone and therefore a variety of air emission sources exist in the vicinity of the project. The two principal sources of air emission in the area are the KESC power plant and the Pakistan Steel Mills. An air emissions monitoring of the Port Qasim area was conducted in the year 2002 and that revealed the following concentration of pollutants in the ambient air:

- Sulfur Dioxide: 20 ppb
- Oxides of Nitrogen: 18 ppb
- Carbon dioxide: 310 ppm
- Ozone: 11 ppb

- Carbon monoxide: 3.8 ppm

Criteria for Determining Significance

A significant impact on ambient air quality will be interpreted if the vehicles or equipment emits visible smoke or there are persistent complaints from daily commuters and neighboring plant personnel.

Impact Analysis

Combustion processes in generators and other construction equipment result in exhaust gases that can effects the ambient air quality locally. However, the environmental issue can be avoided by using properly maintained equipment.

Mitigation

The following mitigation measures will be incorporated to prevent any adverse impact on the ambient air quality:

- All vehicles, generators and other equipment used during the construction will be properly tuned and maintained in good working condition in order to minimize emission of pollutants
- The stack height of the generators will be at least 3 m above the ground

Residual Impacts

Implementation of the proposed mitigation measures is likely to leave no long-term residual impact on the ambient air.

Monitoring Requirements

To ensure compliance regular inspection of equipment and vehicles will be undertaken.

5.3 Environmental Impacts Associated with Facility Operation

The environmental and socioeconomic impacts associated with the operation phase of the expanded storage facility are discussed in this section. The impacts that are discussed are the following:

- Accidental Releases into the Atmosphere
- Accidental Spillage of Ethylene
- Waste Management

5.3.1 Accidental Releases into the Atmosphere

Potential Issues

Project operations will involve use of hazardous material ethylene, which is unloaded from ship through1.5 km long import pipeline to the facility and then is stored in the storage tank with a storage capacity of 10,000 m^3. This chemical has a potential to harm human health and the environment around it if released accidentally into the atmosphere.

The Ethylene Storage and Handling facility will be constructed in accordance with the international standards. During normal operations, it will be a "No Emission" site as the following safety features are being built.

1. Whenever there is a rise in pressure inside the tank because of heat ingress or any other reason, the boil-off gas compressor will cut in automatically to take the vapors and reduce the pressure inside the tank. The compressed ethylene vapors will either be sent into the export pipeline for onward delivery to Engro Asahi's site or re-liquefied and returned to the tank.
2. If pressure continues to rise beyond a pre-set limit irrespective of compressor operation, a pressure control valve (located on the pipeline routed to ground level flare) will open and release the pressure by safely disposing ethylene after burning in the flare system.
3. There is a third level of safety (or the last line of defense) in the form of a Pressure Safety Valve which will release the pressure inside the tank, if it continues to increase beyond a pre-set limit, and will protect the tank from failure.

Criteria for Determining Significance

The exposure limits for ethylene, are shown in **Exhibit 5.3**. In this case, two types of risks are evaluated:

1. *Short-term exposure limit:* Human exposure to concentration exceeding this limit may result in immediate health impact including possibly fatalities as it will act as simple asphyxiant.
2. *Explosivity limits:* A vapor cloud with concentration exceeding this limit can result in explosion.

Impact Analysis

Assessment of risk associated with hazardous material generally follows these steps:

Step 1: Identifying the hazardous conditions and the associated hazardous event

Step 2: Assessing the consequences of the hazardous event

Step 3: Assessing the likelihood of the hazardous event

Combination of the likelihood and consequences of a specified hazardous event occurring is referred to as risk.

Identification of Hazard

Ethylene is the main gas which can affect the neighboring receptors in case of heavy leaks.

Ethylene will be supplied through an 8 inches diameter, 1.5 km long pipeline and then will be stored under atmospheric pressure in the storage tank with the storage capacity of 10,000 m^3. The accidental scenario for the pipeline and from the storage tank has been carried out separately taking into account the worst case conditions. The rupture in the ethylene storage tank is assumed to have an area equal to 0.20 m^2 (equal to the area of the

nozzle on the roof of the tank), the spill source type is vertical jet with the source plane parallel to the ambient wind direction. In case of pipe, rupture is taken as 0.032 m^2 with the spill source type being a horizontal jet with the source plane perpendicular to the ambient wind direction. The emission rate for the storage tank has been taken as 5.23 kg/min. The worst case scenario time has been selected as 12 hours after which the leak is detected and is sealed. The emission rate in case of the pipeline for the worst case scenario has been taken as 3,333 kg/min.

Assessing the Consequences

To assess the dispersion of the hazardous vapor cloud after it is released due rupture in the storage tank or the pipeline is United States Environmental Protection Agency's accidental release model AFTOX is used. The model simulates the atmospheric dispersion of buoyant as well as lighter than air gases.

The model input parameters are as described in **Exhibit 5.4**. Each emission scenario is simulated for four typical climatic conditions (two daytime and two nighttime) and one averaging time corresponding to the short-term (15-minutes) exposure limits.

The results of the dispersion modeling are presented in **Exhibit 5.5.** It shows that in case of release from storage tank, no area will be exposed to concentration exceeding 1,147 mg/m^3. On the other hand, in case of release from the pipeline, the exposed area will vary with respect to the atmospheric conditions.

Frequency of Accident

Based on the US statistics, the frequency of industrial accidents related to ethylene is shown in **Exhibit 5.6**.

Assessment of Risk

The consequence of an accidental release may include damage to the EVTL storage facility and the operators, in case of an explosion, fatalities in case of severe short term exposure, and various diseases such as cancer, disruption of the endocrine system, neurotoxicity, and immune system suppression. Of the two cases, the frequency of accidents for ethylene pipeline facility is the greatest. The area influenced under the plume in case of a pipe rupture is mostly occupied and is used for port operations as shown in **Exhibit 5.7**. However of all the four cases of plume distribution, maximum distance of the plume is 1,100 m. The distance will be reduced considerably for the Lower explosivity limit (LEL) which will be approximately 130 m.

Mitigation

A detailed risk assessment will be carried out for the release of potentially hazardous gases from the storage facility.

An emergency response plan is to be prepared to avoid accidental release of gases and to minimize the impacts. The key feature of emergency response plan will include the following.

1. Identification of hazardous chemicals, processes and the operations

2. Release scenarios, consequences in term of heat generation, over pressure and toxic release etc.
3. Preparation of site plan for damage control
4. Identification of the vulnerable zones
5. Classification of unit or units which have the most potential for creating on-site as well as off-site emergency
6. Identification of the important facilities available in the vulnerable zone
7. Identification of the requirements of various departments in-site as well as out-site the process storage facility for coping emergency situation

Monitoring Requirements

The monitoring will involve:

- Bolts, nuts and studs, other pipe connections of proper material specification strictly be used where there is chance of leakage.
- A proper system of periodic inspection of all equipment including cocks, valves and pipelines and degassing system should be introduced and followed jointly by the process and maintenance department. Preventive maintenance should be planned in a manner to synchronize gradually with periodic routine shut down of equipment.
- A complete register for recording the periodic testing should be maintained.
- A control room equipped with the instruments for automatic detection of small amount of gas releases and their location.
- Process flow, temperature, instrumentation control, pressure relief, safety and general operating condition should by examined to ensure that the storage operation would not only be conducted safely but should also fail safely if it is going to fail at all.
- Periodic safety audit by both internal and external audit team should be undertaken by the management.

5.3.2 Accidental Spills

Potential Issues

Spills from the pipeline, storage tanks and during other transportation, can potentially affect the soil, water resources, flora and human being.

Existing Conditions

The quality of the coastal waters is discussed in detail in **Section 4**.

Criteria for Determining Significance

A significant impact will be interpreted, if there is any discharge of ethylene from the storage tanks, import pipeline, accidents, and any equipment breakdown that affects any

aquatic life. The different parameters governing the concentration of ethylene in water which are harmful to the aquatic environment are presented in **Exhibit 5.8**.

Impact Analysis

The worst case scenario has been chosen by considering the failure of the import pipeline over the Gharo Creek resulting in discharge of the entire content of the pipeline into the creek water.

As ethylene is a highly volatile gas, the chances are that most of the ethylene will evaporate instantaneously by absorbing heat from the sea water. In this process, a thin layer of ice will be formed on the surface of water. In the initial moment of spill, some of the ethylene will also get dissolved in the seawater. The quantity of ethylene that is dissolved will be limited by two factors solubility of ethylene in water and the volume of water that comes in contact in the brief period. As a worst case scenario, it is assumed that a column of water having a thickness equal to the depth of the creek and an area twice the size of the spill will be saturated with ethylene. Calculation based on this scenario (see **Exhibit 5.9**), shows that the quantity of ethylene that will be dissolved in water will be less that 1% of the total spill. The remaining ethylene will evaporate during the process. Surface area of 50 m^2 has been taken because an area greater than this value will result in all of the ethylene being evaporated and a value lesser than this will have a lower concentration value of ethylene and since the calculations are based on the worst case scenario therefore this value of 50 m^2 has been chosen. A sensitivity analysis has also been performed by changing the value of different parameters and then calculating the value of percentage death in fish as shown in **Exhibit 5.10**.

At saturation, the concentration of ethylene in water will be 131 mg/l. Thus the concentration of ethylene will exceed the significance criteria shown in **Exhibit 5.8**. However, the concentration will rapidly fall below the significance criteria. To estimate the time in which the ethylene will disperse, the average velocity of tidal current in the creek at the point of spill is estimated as shown in **Exhibit 5.9**. As the speed is approximately 0.08 m/s, it will take a column of water about 12 m wide will take about 2.5 minutes to move. As the dispersion depends, on lateral movement of water as well as molecular diffusion, the actual time is likely to be longer than 2.5 minutes but of the same order. Thus within a period of less than 10 minutes the concentration is likely to reduce to half of the upper limits of the significance criteria and reduce below the lower limit of the significance criteria within less than 20 minutes. Assuming linear decrease in concentration, the average exposure during the first 20 minutes will be approximately 50 mg/l. The significance criterion is that if the fish are exposed for four days to a dose of 50-119 mg/l, about 50% fatality is expected. As the exposure above this limit is expected for less than 20 minutes, the fish fatalities are likely to be insignificant (less than 0.1%). A sensitivity analysis on the above calculation, where the assumed parameters are changes by 25% indicates that the expected impact on fish fatalities will remain of the same order.

Residual Impact

Under the worst case scenario, less than 0.1% of fish in a very small area (about 100 m^2) will be affected. It is unlikely to have any permanent impact on the aquatic life. The

ethylene dissolved in water will gradually disperse and evaporate reaching, 6 mg/l, the background concentration of ethylene in water in a very short time.

Mitigation

A comprehensive contingency plan will be developed for accidental spill management. The development of plan will involve following steps:

1. Identification of potential sources of the event
2. Risk minimization
3. Action plan for spill response
4. Designation of personnel and training
5. Disposal options of contaminated material

Residual Impacts

No significant residual impact due to operation is expected if above mentioned mitigations implemented.

Monitoring Requirements

The key monitoring is the regular inspection of the storage facility and import pipeline particularly where high risk to effect on water resources, workers, or any other receptors.

5.3.3 Vapor Colud Explosion

The risk of vapor cloud explosion has been assessed following the United States Environmental Protection Agency (USEPA) document *Risk Management Program Guidance for offsite Consequence Analysis* (USEPA, 2004). US laws requires that facilities with large quantities of very hazardous chemicals should prepare and implement programs to prevent accidental release of those chemicals and to mitigate the consequences of any releases that do occur. These guidelines have been developed to support the regulatory requirement. The guideline calculates the impact for worst-case scenario. EPA has defined the worst-case scenario as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest damage or largest area being impacted.

The program calculates the distance to the point beyond which the heat from a fire or blast waves from a vapor cloud explosion will not result in any serious injuries. It is done in terms of estimating the consequence distance to an overpressure level of 1 pound per square inch (psi) from the explosion of the vapor cloud. An overpressure of 1 psi may cause partial demolition of houses and shattering of glass windows, which may cause minor injuries and skin laceration from flying glass.

The worst-case scenario is defined as the release of the entire content of the ethylene storage tank or the import pipeline. The entire content of the cloud is assumed to be within the flammability limits, and the cloud is assumed to explode. As recommended by the guidelines, TNT-equivalent method is used with a 10% yield factor.

The spill parameters, properties of ethylene and the results are presented in **Exhibit 5.11**. It can be seen from the results that in case of a vapor cloud explosion from the storage tank, an area with a radius of approximately 2.9 km is likely to be affected, as shown in **Exhibit 5.12**. Of the affected area, about 75% is on water and mangroves. Of the 25% on land, only one third (7.5% of the total area) is currently occupied by industrial units. There are no residential areas within this range.

5.3.4 Waste Management

Potential Issues

The waste generated due to the operation of the storage facility can potentially affect the environment.

Existing Conditions

The surrounding areas have a variety of sources that generate industrial wastes.

Criteria for Determining Significance

As no regulations for waste handling and disposal exists, an adverse impact on the environment will be interpreted if,

- Any person is exposed to potentially hazardous waste generated by the project
- Project generates waste that can be avoided through practicable means (waste minimization)
- Reusable waste generated by the project is discarded
- Recyclable waste instead of separation at the source is dumped at the trash bins
- Any waste generated by the project is scattered at any place outside the designated bins, or
- Non-recyclable and non-reusable waste ends up at any place other than the designated landfill site.

Impact Analysis

In the absence of national or domestic regulations and a waste management system in the project area, waste disposal can potentially become a serious environmental issue, particularly with the local contractors. To avoid any potential issue, the EVTL project management will impose internal controls for the storage facility.

Mitigation

The specific mitigation measures that, in most cases, are already in place are listed below:

- On-site handling
  - Recyclable material will be separated at source. Separate bins will be placed at the construction site for different type of materials—plastic, paper, metal, glass, wood, and cotton. The recyclable waste will be sold to waste contractors.

- ▷ Waste bins for the operational waste will be constructed inside the storage facility boundary. No waste will be dumped at any location outside the boundary.
- ▷ All hazardous waste will be separated from other wastes.
- ▷ Hazardous waste that cannot be disposed of through acceptable means will be stored in on-site storage facility until an off-site hazardous waste disposal facility is available.

- ▶ Audits
  - ▷ On-site audits of the waste management will be undertaken on a regular basis.
  - ▷ Audits of the waste disposal contractors and waste disposal facilities will be undertaken on a regular basis to check that procedures are being followed.
- ▶ Records
  - ▷ Records of all waste generated will be maintained. Quantities of waste disposed, recycled, or reused will be logged on a Waste Tracking Register.
- ▶ Disposal
  - ▷ All non-hazardous waste material that cannot be recycled or reused will be disposed of at appropriate landfill site.
  - ▷ Depending on the nature and quantity of the hazardous waste, it will either be disposed of by licensed hazardous waste contractors, or will be incinerated at incineration facilities equipped to handle hazardous waste.
  - ▷ The possibility of returning the packaging to the manufacturers for reuse will be explored.
  - ▷ Recyclable waste will be disposed of via approved waste contractors
  - ▷ Chemical containers (including partially full containers) will be returned to vendors
- ▶ Other management measures
  - ▷ An emergency response plan will be developed for the hazardous waste (and substances)
  - ▷ Training will be provided to personnel for identification, segregation, and management of waste
  - ▷ All containers of hazardous waste will be appropriate labeled.
  - ▷ Equipment and material containing asbestos, poly-chlorinated biphenyls (PCBs), and ozone depleting substances (ODSs) will not be used.

Residual Impacts

Even after implementation of the above measures, it is possible that some littering may take place. Monitoring and inspections will be undertaken to minimize the residual impact.

Monitoring Requirements

The monitoring measures will include:

- Records of all waste generated will be maintained. Quantities of waste disposed, recycled, or reused will be logged on a Waste Tracking Register.
- On-site audits of the waste management will be undertaken on a regular basis.
- Audits of the waste disposal contractors and waste disposal facilities will be undertaken on a regular basis to check that procedures are being followed.
- The areas around the storage facility boundary and access will be periodically inspected to verify that no project related waste is scattered in these areas.

5.4 Stakeholders Consultation

Initiating the stakeholder consultation process at an early stage in the project cycle ensures that feedback from communities and other stakeholders directly or indirectly affected by the project can be used to adjust and improve project design, planning, and implementation from an environmental and social perspective.

The stakeholder consultation was conducted with respect to the EVTL expansion project as well as the EAPCL expansion and back integration project. The reason for this was that the primary and secondary stakeholders for both these projects were the same as the EVTL project is being done to facilitate the expansion and back integration project of EAPCL.

5.4.1 Objectives of Stakeholder Consultation

The main objective of the stakeholder consultation process was to disseminate information on the project and its expected long- and short-term impact among primary and secondary stakeholders, as well as to document feedback that could be used to address potential issues at an early stage. A second objective was to determine the extent of the potential positive and negative impacts of different project activities and recommend appropriate mitigation measures.

5.4.2 Identification of Stakeholders

Stakeholders are people, groups, or institutions that may be affected by, can significantly influence, or are important to the achievement of the stated purpose of a proposed intervention. The Primary and secondary stakeholders were identified based on standard following definitions:

1. *Primary Stakeholders:* People, groups or institutions affected positively (beneficiaries) or negatively by the project
2. *Secondary Stakeholders:* People, groups, or institutions that are important intermediaries in the project delivery process (eg, the government line agencies, or NGOs).

For the purpose of this project, the primary stakeholders do not exist. The closest community settlements are located at more than six kilometers from the project location.

However a survey for the identification of the primary stakeholders was conducted in the surroundings of the project area. Secondary stakeholders included national as well as international NGOs, government representatives, and other organizations concerned with the project. The consultation and involvement process was determined based on the stakeholders identified.

5.4.3 Stakeholder Consultation Process

Stakeholder consultation consisted of meetings held with relevant organizations and government departments, which are in some way linked to the project and therefore considered stakeholders. The purpose of these meetings was to apprise stakeholders of the project, assess how it may affect their activities, and document their concerns, whether real or perceived. The results of this exercise are described below, where mitigation measures have been suggested to address key stakeholder concerns.

5.4.4 Results

As mentioned earlier, there are no houses located near the project location, and, therefore, the only discussion held with secondary stakeholders. A list of the individuals and organizations consulted during the course of the study is given in **Exhibit 5.13**. Concerns expressed by the stakeholders are presented in **Exhibit 5.14**. In general no specific concern was expressed by any persons consulted. However, most of them expressed a general concern about the degradation of mangrove forests and the need of a collective effort to rehabilitate them, however no impacts are expected on the mangrove plantation as a result of this project and EVTL already takes care of the mangrove plantation in its surroundings. Another concern raised was by the Pakistan Fisher Folk forum regarding the discharge of untreated effluent into the sea. Since EVTL is a zero effluent facility and would remain so even after the expansion, this particular concern is not relevant to the project.

5.5 Environmental Impact of Facility Decommissioning

At the end of the useful life of the storage tank, decommissioning of the tank may take place. If decommissioning takes place it may require:

- An environmental site assessment to verify that no quantities of ethylene have seeped into the ground
- Scraping of metal
- Disposal of debris
- Decontamination of piping and equipment

All wastes will be removed from the site. The site will be contoured to allow surface water flow without erosion.

At this stage, it is not possible to discuss the aspects pertaining to the said decommissioning in detail. A Decommissioning Plan will be prepared prior to closure and submitted to regulatory authorities as required.

Exhibit 5.1: World Bank Recommended Noise Levels

Specific Environment	*Maximum Allowable Log Equivalent (Hourly Measurements), in dB(A)*	
	Day (7:00-22:00)	*Night (22:00-7:00)*
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Exhibit 5.2: WHO Guideline Values for Community Noise in Specific Environments

Specific Environment	*LA_{eq} (dB)*	*Averaging Time (hours)*	*LA_{max}, Fast (dB)*
Outdoor living area	55	16	–
Dwelling (indoors)	35	16	
School classrooms (indoors)	35	During class	
Hospital, ward rooms, nighttime (indoors)	30	8	40
Industrial, commercial, shopping and traffic areas (indoors and outdoors)	70	24	110

Exhibit 5.3: Acceptable Limits for Ethylene

Gas	*Limit Type*	*Value (mg/m^3)*	*Explaination*	*Notes*
Ethylene	Short-term	115	The concentration of a substance to which most workers can be exposed without adverse effects	1
	Explosiivity	2.3-32.3%	At 77 °F and 1 atm pressure	2

Notes:

1. American Conference of Governmental and Industrial Hygienists' threshold limit ACGIH TLV
2. *Safety (MSDS) Data for Ethylene*, The Physical and Theoretical Chemistry Laboratory Oxford University, http://physchem.ox.ac.uk/MSDS/ET/ethylene.html, accessed Aug 2, 2006.

Exhibit 5.4: AFTOX model Input Parameters

Chemical Properties of Source Material	*Ethylene*		
	Storage Tank	*Pipeline*	
Spill Site roughness length	10	10	cm
Height of leak above ground	18	1.22	m
Emission rate	5.23	3333.33	Kg/min
Elapsed time of Spill	720	8.23	min
Concentration averaging time	15	15	min
Height of Concentration calculation	2	2	m

	Case 1	*Case 2*	*Case 3*	*Case 4*	
Meteorological Parameters[a]					
Month	March	May	March	June	
Time	Day	Day	Night	Night	
Ambient measurement height	7.0	7.0	7.0	7.0	m
Ambient wind speed	4.0	6.0	0.7	3.3	m/s
Ambient wind direction	263	256	263	249	degrees
Ambient temperature	31.52	35.22	17.62	27.92	^{O}C

Notes:

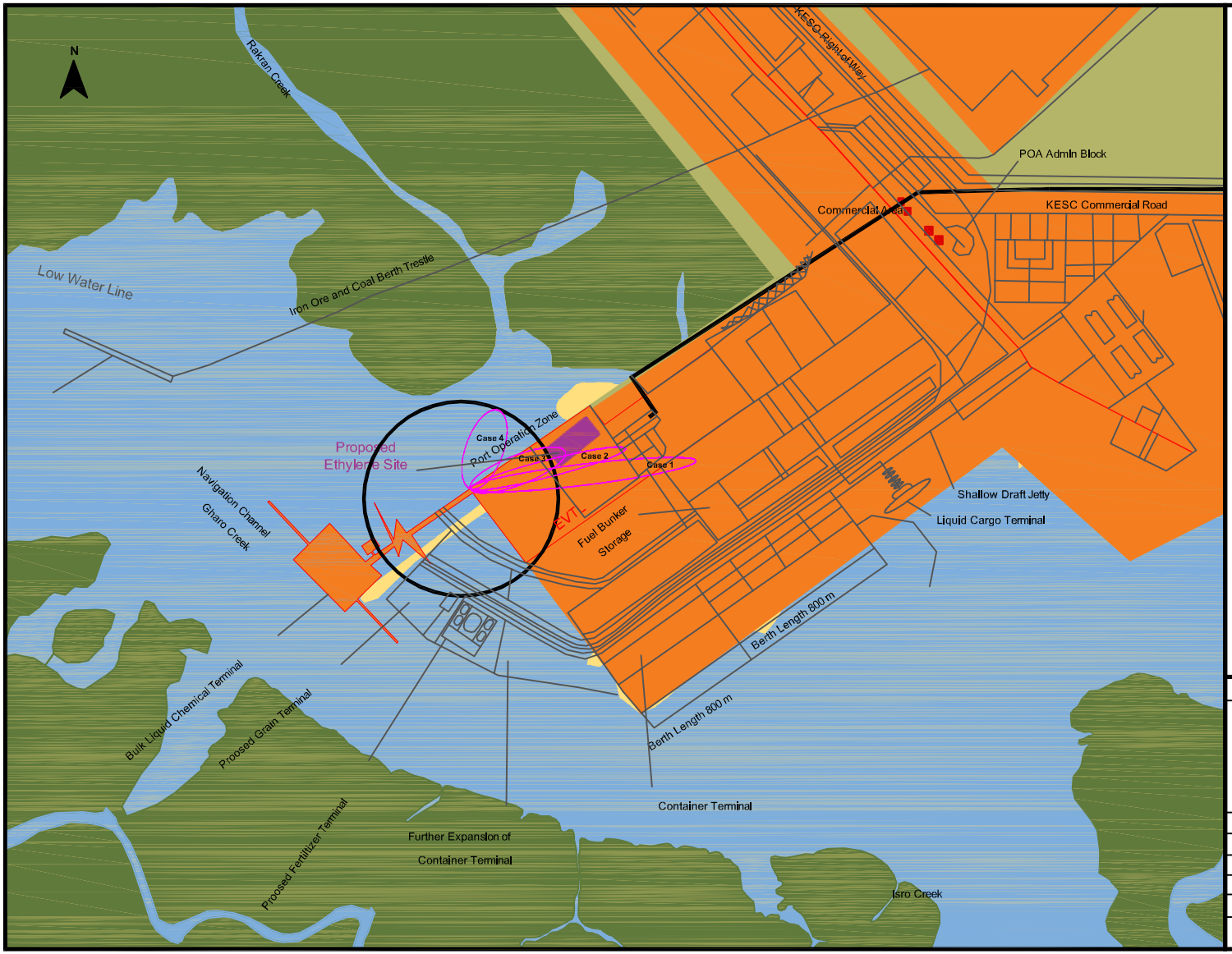
a. Source: Meteorological Department Karachi.

Exhibit 5.5: AFTOX Results of Accidental Releases

Meteorological Case No.	*Exposure Concentration (mg/m^3)*	*Distance (m)*
Ethylene in Storage Tank		
1	3	340
2	2	584
3	4	3,320
4	5	652
Ethylene In pipe line		
1	1,147	1,096
2	1,147	771
3	1,147	398
4	1,147	492

Exhibit 5.6: Normalized Accident Rates for United States, 1994-1999

Chemical	*Accidents/process/year*		*Accidents/million lbs/year*	
	Number	*Rank*	*Number*	*Rank*
Ethylene	0.014	19	0.00089	22



Legend

- Main Road
- Pipeline
- Accidental Release Plume of Ethylene
- Streams
- Mangroves
- Port Qasim Industrial Area
  - Occupied
  - Unoccupied

0 250 500 750 1000 m

EIA of EVTL Expansion Project

Exhibit 5.7

Accidental Plume for Ethylene from Pipeline

Scale	1 : 30,000
Source	EVTL, HBP Field Survey
Drawing	W6E08EEP
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan

Exhibit 5.8: Significance Criteria for Ethylene in Water

	Aquatic Species	*Parameter*	*Range*
Acute/Prolonged toxicity	Fish	LC_{50} [a] (4 days)	50 – 119 mg/l
	Aquatic Invertebrates	EC_{50} [2] (48 hours)	53 – 153 mg/l
	Aquatic plants	EC_{50} (72 hours)	40 mg/l
	Terrestial plants	EC_{50} (24 hours)	8 – 700 µg/l
Baseline Concnetration in Water		Average[c]	6 mg/l
		Heavily[c] Exposed Area	44 mg/l

Notes:

a Lethal concentration to kill 50% of the population through inhalation, source: UNEP Publications

b Concentration of a compound where 50% of its maximal effect is observed, source: UNEP Publications

c Source: UNEP Publications

Exhibit 5.9: Calculation of Ethylene Evaporation

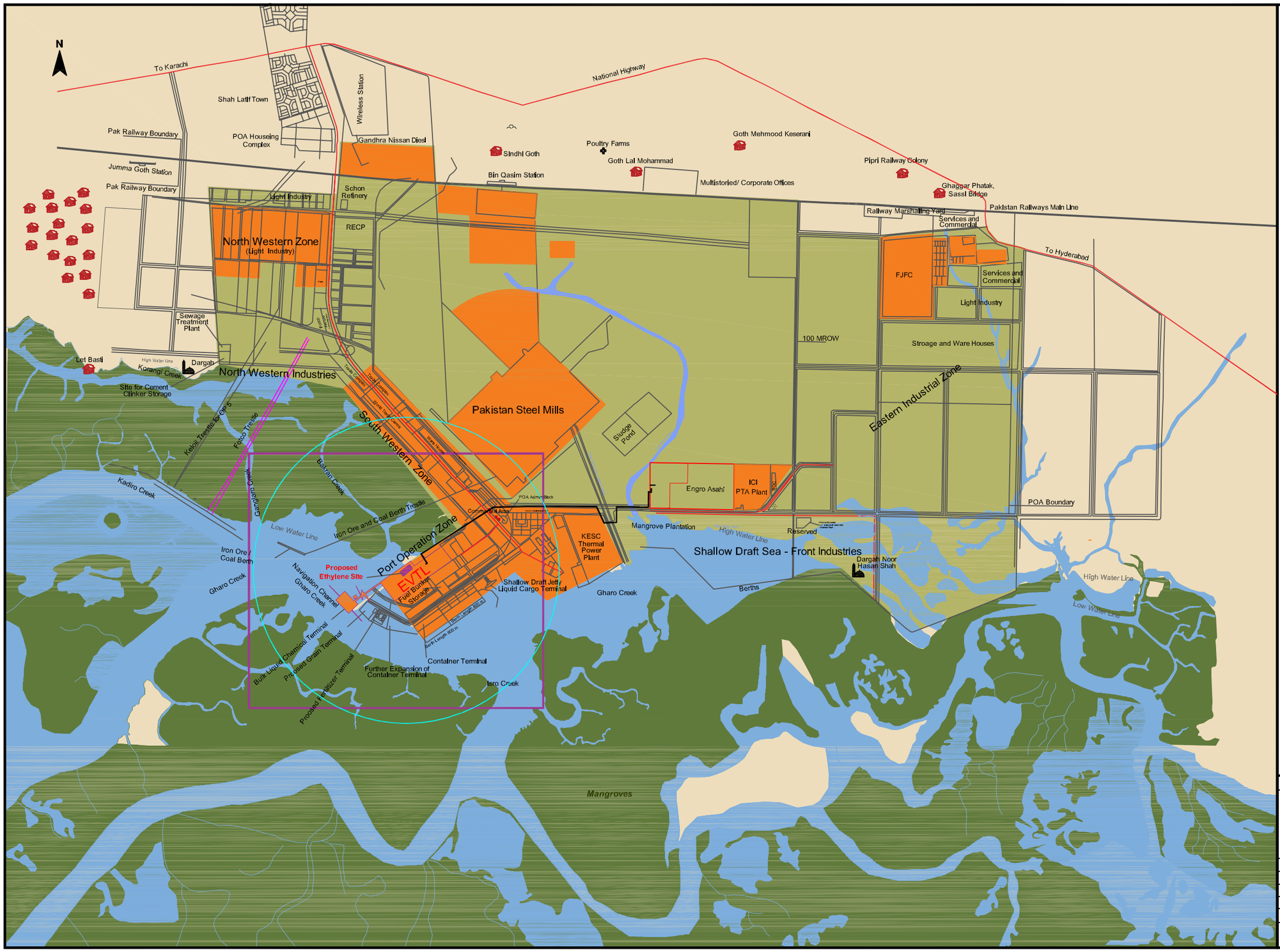
Quantity of Ethylene Spilled	20,224	kg
Solubility of Ethylene in water at 25ºC	131	mg/l
Assumed thickness of to layer	0.1	m
Area of spill	50	m^2
Volume of water that turned to ice	5	m^3
Initial temperature of water	25	^oC
Specific heat capacity of water	4.177	kJ/kgK
Heat of fusion of water	335.5	kJ/kg
Heat loss of water	2,193,026	kJ
Heat of fusion of ethylene	119.50	kJ/kg
Mass of ethylene instantaneously evaporated	18,352	kg
	91%	
Water depth below ice	13.00	m
Approximate area of water below the ice layer in which ethylene has dissolved	100	m^2
Volume of water	1,300	m^3
Mass of ethylene dissolved in water	170.3	kg
	0.8%	
Concentration of ethylene at saturation	131	mg/l
Estimated volume of tidal water upstream of Port Qasim that is discharged during 6 hours	7,875,000	m^3
Cross-sectional area of creek at Engro Vopak Terminal	4,500	m^2
Estimated speed of tidal current	0.08	m/sec

Exhibit 5.10: Sensitivity Analysis

Parameter changed	*Value increased by (percentage)*	*Percentage death in fish*
Surface area of frozen water	10%	2.11%
Depth of water below ice	100%	2.01%
Area of water below ice in shich ethylene has dissolved	100%	2.47%

Exhibit 5.11: Ethylene Spill Parameters, Properties and Results

	Storage Tank	*Pipeline*	
Spill Parameters			
Quantity of ethylene spilled	5,019,600	20,224	kg
Ethylene Properties			
Heat of combustion of ethylene	4,175	4,175	kJ/kg
Results			
Distance to 1 psi overpressure	2,918	464	m



Legend

- Main Road
- Railway Track
- Pipeline
- Project Area
- Streams
- Mangroves
- Vapor Cloud Explosion of Ethylene for Storage Tank
- Settlements
- Graveyard
- Project Location

Port Qasim Industrial Area

- Occupied
- Unoccupied

0 0.5 1 1.5 2 2.5 3 km

EIA of EVTL Expansion Project

Exhibit 5.12

Vapor Cloud Explosion of Ethylene for Storage Tank

Scale	1 : 75,000
Source	EVTL and HBP Field Survey
Drawing	W6E02EWE
Date	January 2007
Client	Engro Vopak Terminal Limited

Hagler Bailly Pakistan

Exhibit 5.13: People and Organizations Consulted

Organization Consulted	*Organization Type*	*Person Consulted*
WWF-Pakistan	Non-governmental organization	Dr Ejaz Ahmad
World Conservation Union (IUCN)	Non-governmental organization	Dr Tahir Qureshi
University of Karachi	Public university	Dr Noureen Qureshi (Center of Excellence in Marine Biology)
Pakistan Fisheries Department	Government	Mr Shoukat Hussain (Director F & T, Marine Fisheries Department)
Pakistan Fisher folk Forum (PFF)	Non-governmental organization	Muhammad Ali Shah (Chairman)
Health and Nutrition Developments Society (HANDS)	Non-governmental organization	Dr M Sarwat Mirza (Deputy Executive Coordinator)
The Citizens Foundation	Non-governmental organizations	Lt Col (R) Khalid Hashmi, Area Manager, Citizens Foundation School Ms Najia Amin, Head of Resource Mobilization

Exhibit 5.14: Stakeholder Concerns and Mitigation Measures

Organization	*Discussion and Concerns*
WWF-Pakistan	There is no major fishing activity close to the area due to no availability of fishing jetty. The main wildlife of the area includes lizards, snakes and birds. No endangered species reported in the area. A study of Gharo Creek can help in quantification of any changes or impacts to habitat and biodiversity.
World Conservation Union (IUCN)	No specific concern about the effluent. Using of industrial effluent for mangrove plantation is possible if salinity levels of about 25 parts per thousand can be maintained.
Karachi University	Dr Noureen informed that she cannot raise any specific concern because she is not much familiar with the processes to be used in the proposed project. She said that the treated wastewater for mangroves is used worldwide. She suggested that the measurement of plants growth can be used as impact monitoring parameter after the project operation starts.
Pakistan Fisheries Department	One of the functional jurisdictions of marine fisheries department is to coordinate between provincial fisheries department and other governmental agencies including Environmental Protection Agencies (EPAs) in promotion and development of fisheries including culture of fish in brackish and estuarine and freshwater. As the quality of fish is directly related to quality of water therefore the effluent disposal into water is main concern of the department. Meeting NEQS of the effluents is primary requirement.
Pakistan Fisher folk Forum (PFF)	Each industry should treat its effluents and the treated water should be reused for the plantation in the city and coastal areas. Discharge of untreated wastewater not only pollutes the seawater and destroys the natural beauty of the coastal areas but also damages properties of the fisherman like decreasing the life of boats when used in polluted water.
Health and Nutrition Developments Society (HANDS)	Health hazards to the communities should be addressed. Services like in health and education should be given to communities in the area. Closest communities should be involved in the employment processes. Currently there is no encouraging support from most the industries in the Port Qasim area. HANDS is providing services in health, education and poverty alleviation of the communities in Port Qasim area. Industries of the area should join us in this cause.
The Citizens Foundation	The TCF explained that they have never been involved in such consultation process in the past. They did not express any specific concerns with regards to the project. They explained that the overall educational status of the people in the Bin Qasim area is relatively poor and any assistance from the industries of the area will help in improving the conditions.

6. Analysis of Alternatives

This section describes the various project management and design alternatives that were examined during the preparation of the feasibility report and the environmental and social impact assessment reports and compares the alternatives in terms of their potential environmental impacts.

6.1 Management Options

The management alternatives examine the no-action option that means not installing the proposed storage facility and bringing no change to the baseline scenario. This option is discussed below:

6.1.1 No-Action

The 'no-action' option by EVTL would result in two scenarios:

- A separate facility is developed to develop the ethylene storage and transportation for EAPCL
- EAPCL does not undertake the proposed expansion project that required EVTL to develop the ethylene storage facility.

The first scenario would require that a new chemical storage facility and dedicated jetty is developed, either by EAPCL or some other organization, to facilitate the PVC production at EAPCL. This will be much more costly and time consuming option compared to proposed project.

The second scenario results in a loss of opportunity for Pakistan to increase its indigenous production of PVC, decrease its reliance on imported PVC, and improve its trade deficit thereby improving the country's economy. This option would also be a loss of possible employment resulting from the construction and operation of the production facilities at EAPCL.

6.2 Project Alternatives

The alternative options discussed in the following sections are of possible storage location alternatives and possible ethylene transportation alternatives.

6.2.1 Alternative Storage Location Option

The alternative storage option to storage at EVTL could be that ethylene is transferred from the EVTL jetty and stored within the EAPCL premises. Ethylene is a hazardous flammable hydrocarbon which forms explosive air-gas mixture. The storage and handling of ethylene is a vastly technical operation (as ethylene cannot be stored in atmospheric conditions) and requires high standards of safety. Therefore the personnel entrusted with the job have to have the required training and experience. EAPCL at the

moment is not handling or storing hazardous chemicals and does not have the expertise and the manpower to facilitate such an operation.

Selected Option

The storage of ethylene would be at EVTL as it is an organization specializing in chemical storage and handling and has the necessary expertise and manpower to ensure safe and efficient storage and transportation to EAPCL.

6.2.2 Alternative Transportation Option

In order to transport ethylene to EAPCL for its PVC production two options have being considered in the ESSAS:

- Transporting the vaporized ethylene to EAPCL through cargo trucks
- Transportation of ethylene through export pipeline.

Cargo Tank refers to the liquid container, insulation, supports and outer jacket that are attached to a trailer used to transport cryogenic liquids over the road. Transportation through cargo trucks equipped with the necessary insulation would not be as efficient as the pipeline as in pipeline transportation ethylene would be fed directly from the storage tank to the EAPCL production plant. Cargo truck transportation would add another step in the transportation of ethylene and would increase the risk of accident during the loading and unloading operation as well as during the road transportation.

Selected Option

The selected option is transportation of ethylene via the export pipeline. This is the most efficient method of transportation as the refrigerated ethylene would be converted to ethylene vapor at the EVTL site and then transported directly to the production plant via the pipeline not involving any kind of intermediate chemical handling.

7. Conclusion

This study was carried out to assess the environmental and socioeconomic soundness of the proposed development of ethylene storage at the EVTL chemical storage facility at Bin Qasim. The assessment was carried out in keeping with the Pakistani legislation, as well as national and international guidelines.

Baseline environmental and socioeconomic information was collected from a variety of sources, including reports of previous studies, published literature, and field surveys. The information collected was used to compose profiles of the natural, socioeconomic, and cultural environments likely to be affected by the project.

As the facility is located in an industrial zone, where the nearest residential community is at least six kilometers away, no serious environmental or social impact is envisaged during the construction phase of the project. The only environmental concern of significance is the accidental release of potentially hazardous material from the plant. Through dispersion modeling it has been demonstrated that no community is likely to get seriously affected even under the worst case emission scenario.

It is therefore concluded that if the field activities, including the implementation of all mitigation measures, are carried out as described in this report, the anticipated impact of the project on the area's natural and socioeconomic environment will be well within acceptable limits. The project will also comply with all the statutory requirements and standards listed in **Section 2** of this report.

To ensure implementation of the mitigation measures an environmental management plan (EMP) for the construction phase will be prepared separately.

8. References

Jaleel S. A. and Khaliluddin M. 1981. A Check List of Marine Fishes of Pakistan. Directorate of Marine Fisheries, Karachi, Govt. of Pakistan.

El Dorado County Air Pollution Control District. 2002. Guide to Air Quality Assessment: Determining Significance of Air Quality Impacts Under the California Environmental Quality Act. First Edition. <http://co.el-dorado.ca.us/emd/apcd>

Government of Pakistan. 1986. Building Code of Pakistan. Islamabad: Ministry of Housing and Works, Environment and Urban Affairs Division.

Hafiz Ur Rehman and I. Fehmida. 1997. A Revised checklist of Reptiles of Pakistan. Records Zool. Sur. of Pak. Vol. XIII. Zoological Survey Department of Pakistan.

Hagler Bailly Pakistan. 2004. Social Impact Assessment of Common Effluent Treatment Plant, Karachi. Prepared for the Asian Development Bank.

IUCN. 2003. *Biodiversity, Status and Management for Creek.* Karachi
Minton, S A, Jr. 1966. 'A Contribution to Herpetology of West Pakistan.' Bulletin of American Museum of Natural History 134(2): 27-184.

Nasir, Y. J. and A.R. Rubina. 1995. *Wild Flowers of Pakistan*. Karachi: Oxford University Press.

National Engineering Services Pakistan (Pvt) Ltd. Date of Publishing Unknown. *Environmental Impact Studies for Karachi Port Modernisation Project V. Draft Final Report. Volume I.* Karachi.

Population Census Organization. 1998. District Census Report of Malir District. Islamabad

Quittmeyer, R. C. 1979. The Seismicity of Pakistan and Its Relation to Surface Faults in Geodynamics of Pakistan. Quetta: Geological Survey of Pakistan.

Reagan, J. A. and C. A. Grant. *Highway Construction Noise: Measurement, Prediction, and Mitigation. Special Report.* US. Department of Transportation, Federal Highway Administration. Available from <http://www.fhwa.dot.gov/environment/noise/highway/index.htm>

Saifullah, S.M.; M. Nizamuddin. 1977. Studies on the marine algae from Pakistan: Ulvales. Botanica Marina, 20: 521-535.

Shamshad, K.M. 1988. The Meteorology of Pakistan. Karachi: Royal Book Company.
Roberts, T J. 1997. *Mammals of Pakistan*. Karachi: Oxford University Press.

United Stated Geological Survey. 1998. <http://neic.usgs.gov/neis/intensity/pym/mmi_abbrev.html> (March 9, 2004).

World Bank, UNIDO and UNEP. 1999. *Pollution Prevention and Abatement Handbook 1998, Towards Cleaner Production*. Environment Department, The World Bank; UNIDO; UNEP.

World Bank, UNIDO and UNEP. 1997. *Pollution Prevention and Abatement Handbook, Towards Cleaner Production*. Environment Department, The World Bank; UNIDO; UNEP.

World Bank. 1991. *Environmental Assessment Sourcebook, Volume I, Policies, Procedures, and Cross-Sectoral Issues*. World Bank Technical Paper No. 139. Environment Department, The World Bank.

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.

World Health Organization. 1999. *Guidelines for Community Noise.*

Appendix A: National Environmental Quality Standards

Exhibit A.1: NEQS for Municipal and Liquid Industrial Effluents[1, 2]
(mg/l, unless otherwise defined)

No.	*Parameter*	*Standards*		
		Into Inland Waters	*Into Sewage Treatment*[3]	*Into Sea*[4]
1.	Temperature increase[5]	=<3 °C	=<3 °C	=<3 °C
2.	pH value	6 to 9	6 to 9	6 to 9
3.	Five-day bio-chemical oxygen demand $(BOD)_5$ at 20 °C[6]	80	250	80[7]
4.	Chemical oxygen demand (COD)	150	400	400
5.	Total suspended solids (TSS)	200	400	200
6.	Total dissolved solids (TDS)	3,500	3,500	3,500
7.	Grease and oil	10	10	10
8.	Phenolic compounds (as phenol)	0.1	0.3	0.3
9.	Chlorides (as Cl')	1,000	1,000	SC[8]
10.	Fluorides (as F')	10	10	10
11.	Cyanide total (as CN')	1.0	1.0	1.0
12.	Anionic detergents (as MBAS)[9]	20	20	20
13.	Sulphates (SO_4)	600	1,000	SC[8]
14.	Sulphides (s')	1.0	1.0	1.0
15.	Ammonia (NH_3)	40	40	40
16.	Pesticides[10]	0.15	0.15	0.15
17.	Cadmium[11]	0.1	0.1	0.1
18.	Chromium (trivalent and hexavalent)	1.0	1.0	1.0
19.	Copper[4]	1.0	1.0	1.0
20.	Lead[4]	0.5	0.5	0.5
21.	Mercury[4]	0.01	0.01	0.01
22.	Selenium[4]	0.5	0.5	0.5
23.	Nickel[4]	1.0	1.0	1.0

Continues …

… Continued

No.	*Parameter*	*Standards*		
		Into Inland Waters	*Into Sewage Treatment*[3]	*Into Sea*[4]
24.	Silver[4]	1.0	1.0	1.0
25.	Total toxic metals	2.0	2.0	2.0
26.	Zinc	5.0	5.0	5.0
27	Arsenic[4]	1.0	1.0	1.0
28.	Barium[4]	1.5	1.5	1.5
29.	Iron	8.0	8.0	8.0
30.	Manganese	1.5	1.5	1.5
31.	Boron[4]	6.0	6.0	6.0
32.	Chlorine	1.0	1.0	1.0

Explanations:

1. Dilution of liquid effluents to bring them to the NEQS limiting values is not permissible through fresh water mixing with the effluent before discharging into the environment.
2. The concentration of pollutants in water being used will be substracted from the effluent for calculating the NEQS limits.
3. Applicable only when and where sewage treatment is operational and BOD = 80 mg/l is achieved by the sewage treatment system.
4. Provided discharge is not at shore and not within 10 miles of mangrove or other important estuaries.
5. The effluent should not result in temperature increase of more than 3°C at the edge of the zone where initial mixing and dilution take place in the receiving body. In case zone is not define, use 100m from the point of discharge
6. Assuming minimum dilution 1:10 discharge, lower ratio would attract progressively stringent standards to be determined by the Federal Environmental Protection Agency. By 1:10 dilution means, for example that for each one cubic meter of treated effluent, the recipient water body should have 10 cubic meter of water for dilution of this effluent.
7. The value for industry is 200 mg/l
8. Discharge concentration at or below sea concentration (SC)
9. Modified Benzene Alkyl Sulphate assuming surfacetant as biodegradable.
10. Pesticides include herbicides, fungicides, and insecticides
11. Subject to total toxic metals discharge should not exceed level given at S. No. 25.

Exhibit A.2: National Environmental Quality Standards for Gaseous Emissions

No.	*Parameter*	*Source of Emission*	*Standards*
1.	Smoke	Smoke opacity not to exceed	40% or 2 on Ringlemann Scale or equivalent smoke number
2.	Particulate matter[1]	(a) Boilers and furnaces:	
		i) Oil-fired	300
		ii) Coal-fired	500
		iii) Cement kilns	300
		(b) Grinding, crushing, clinker coolers and related processes, metallurgical processes, converters, blast furnaces and cupolas	500
3.	Hydrogen chloride	Any	400
4.	Chlorine	Any	150
5.	Hydrogen fluoride	Any	150
6.	Hydrogen sulphide	Any	10
7.	Sulphur oxides[2, 3]	Sulfuric acid/sulphonic acid plants	5,000
		Other plants except power plants operating on oil and coal	1,700
8.	Carbon monoxide	Any	800
9.	Lead	Any	50
10.	Mercury	Any	10
11.	Cadmium	Any	20
12.	Arsenic	Any	20
13.	Copper	Any	50
14.	Antimony	Any	20
15.	Zinc	Any	200
16.	Oxides of nitrogen[3]	Nitric acid manufacturing unit	3,000
		Gas-fired	400
		Oil-fired	600
		Coal-fired	1,200

1. Based on the assumption that the size of the particulate is 10 micron or more.
2. Based on 1 per cent sulphur content in fuel oil. Higher content of sulphur, will cause standards to be pro-rated.
3. In respect of emissions of sulphur dioxide and nitrogen oxides, the power plants operating on oil and coal as fuel shall in addition to National Environmental Quality Standards (NEQS) special above, comply with the following standards.

Exhibit A.3: Pakistan Standards for Sulfur Dioxide and Nitrogen Oxides for Power Plants Operating on Oil and Coal

A. Sulfur Dioxide

Sulfur Dioxide Background Levels (mg/m^3)			*Standards*	
			Criterion I	*Criterion II*
Background Air Quality (SO_2 basis)	*Annual Average*	*Maximum 24-Hour Interval*	*Max. SO_2 Emissions (TPD)*	*Max. Allowable 1-Year Average Ground Level Increment to Ambient (mg/m^3)*
Unpolluted	< 50	< 200	500	50
Moderately polluted[1]				
Low	50	200	500	50
High	100	400	100	10
Very polluted[2]	> 100	> 400	100	10

1. For intermediate values between 50 and 100 $\mu g/m^3$ linear interpretation should be used.
2. No project with sulfur dioxide emissions will be recommended.

B. Nitrogen Oxides

Annual arithmetic mean of ambient air concentrations of nitrogen oxides (expressed as NO_2) should not exceed		100 $\mu g/m^3$ (0.05 ppm)
Maximum emission levels for stationary source discharges, before mixing with the atmosphere: For fuel fired steam generators		
	Liquid fossil fuel	130 ng/J of heat input
	Solid fossil fuel	300 ng/J of heat input
	Lignite fossil fuel	260 ng/J of heat input

Exhibit A.4: National Environmental Quality Standards for Motor Vehicle Exhaust and Noise

No.	*Parameter*	*Standards (Maximum Permissible Limit)*		*Measuring Method*
1.	Smoke	40% or 2 on the Ringelmann Scale during engine acceleration mode.		To compared with Ringlemann chart at a distance of 6 meters or more.
2.	Carbon Monoxide	Emission Standards:		
		New Vehicles	Used Vehicles	
		4.5%	6%	Under idling conditions: Nondispersive infrared detection through gas analyzer.
3.	Noise	85 db (A)		Sound-meter at 7.5 meters from the source.

Appendix B: Flora and Fauna of the Port Qasim and Surrounding Areas

This appendix provides the information on the flora and fauna of the project area.

Exhibit B.1: Vegetation of the Port Qasim and Project Area

No.	*Local Name*	*Scientific name*	*Local Status*	*Local Distribution*	*From Project Area*
Trees					
1.	Mangrove Tree, Timar	*Avicennia marina*	Common	Coastal Area, Layari,	C[1]
2.	Mangrove Tree, Timar	*Aegiceras corniculatus*	Rare	Coastal, Layari and Estuaries	C
3.	Mangrove Tree, Timar	*Bruguiera gymnorhiza*		Karachi and Indus delta	P[2]
4.	Mangrove Tree, Timar	*Ceriops tagal*		Coast of Sindh	C
5.	Mangrove Tree, Timar	*Ceriops decandra*		Sindh tidal zone	P
6.	Mangrove Tree, Timar	*Rhizophora apiculata*		Tidal marshes of Indus:	P
7.	Mangrove Tree, Timar	*Rhizophora mucronata*		Mouth of Indus and tidal creeks	C
8.	Mangrove Tree, Timar	*Sonneratia caseolaris*		Engler Mouth of Indus and Tidal	P
9.	Jal, Peelu Tree	*Salvadora oleoides*	Common	Coastal area	C
10.	Babool, Kikar	*Acacia nilotica*	Common	Coastal area	C
11.	Masquit Tree	*Prosopis juliflora*	Common	Karachi region	C
12.	Kandi Kheji	*Prosopis cineraria*	Common	Lyari, and Gond Pass	C
13.	Neem	*Azadirachta indica*	Common	Around the settlement in Karachi	C
14.	Barr	*Ficus bengalensis*	Common	Around the settlement in Karachi	C
15.	Sireh	*Albezia lebbek*	Common	Around the settlement in Karachi	C
16.	Jungali Ber	*Zyziphus nummularia*	Common	Coastal area	C
17.	Khajoor	*Phoenix dactylifera*	Scarce	Coastal area	C

Continues…

[1] Confirmed: Species collected from the project area or reported from the reliable resource

[2] Possible: Literature reported from the same type of habitat or the ecosystem of the area in general

…Continued

No.	*Local Name*	*Scientific name*	*Local Status*	*Local Distribution*	*From Project Area*
Shrubs					
1.	Akro Plant	*Calotropis procera*	Scarce	Waste land	C
2.	Kaneer	*Nerium oleander*	Scarce	Waste land	C
3.		*Salsola foetida*	Common	Saline and Coastal Area	C
4.		*Salsola bryosoma*	Common	Saline and Coastal Area	C
5.		*Haloxylon recurvum*	Common	Saline and Coastal Area	C
6.		*Suaeda nudiflora*	Common	Saline and Coastal Area	C
7.		*Suaeda fruticosa*	Scarce	Saline and Coastal Area	C
8.		*Salicornia indicum*	Common	Saline and Coastal Area	C
Grass and Sedges					
1.	Cane Grass-Munj	*Phragmites karka*	Common	Fresh water and along the Sea coast	C
2.	Grass-Deer	*Typha angustata*	Common	Fresh water and along the Sea coast	C
3.	Saccharum Grass	*Saccharum sponteneum*	Common	Fresh water and along the Sea coast	C

Exhibit B.2: Mammals of the Port Qasim and Project Area

No.	*Common Name*	*Scientific Name*	*Status*	*Occurrence*	*Local Distribution*	*From Project Area*
1.	Musk Shrew	*Suncus murinus*	Common	Resident	Settlements	P[3]
2.	Pigmy Shrew	*Suncus etroscus*	Rare	Resident	Settlements	P
3.	Egyptian Fruit Bat	*Rousettus egyptiacus*	Rare	Resident	Sea Cliffs	P
4.	Golden Jackal	*Canis aureus*	Scarce	Resident	Hawkes Bay	C[4]
5.	Small Indian Mongoose	*Herpestes javanicus*	Less Common	Resident	Coastal and Inland	P
6.	Indian Grey Mongoose	*Herpestes javanicus*	Less Common	Resident	Coastal and Inland	P
7.	Five Striped Palm Squirrel	*Funambulus pennanti*	Common	Resident	Whole Karachi	C
8.	House Rat	*Rattus rattus*	Common	Resident	Whole Karachi	C
9.	Norway or Sewer Rat	*Rattus norvegicus*	Common	Resident	Whole Karachi	C
10.	House Mouse	*Mus musculus*	Common	Resident	Whole Karachi	C
11.	Indian Desert Jird	*Meriones hurrianae*	Scarce	Resident	Coastal Sand Dune	P
12.	Little Indian Porpoise	*Neophocaena phocaenoides*	Scarce	Local Migrant	Mangrove Creeks	P
13.	Bryde's Whale	*Balaenoptera edeni*	Scarce	Migrant	Karachi coast	P
14.	Dwarf Sperm Whale	*Kogia simus*	Scarce	Migrant	Karachi coast	P
15.	Indian Hump-backed Dolphin	*Sousa plumbea*	Scarce	Migrant	Mangrove, coastal creeks	P

Source: Roberts (1997)

[3] Possible: Literature reported from the same type of habitat or the ecosystem of the area in general

[4] Confirmed: Species collected from the project area or reported from the reliable resource

Exhibit B.3: Birds reported from the Port Qasim and Project Area

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
1.	Black-headed Gull	*Larus ridibundus*	Abundant	Abundant	3
2.	Redshank	*Tringa totanus*	Common	Common	3
3.	Red-wattled Lapwing	*Hoplopterus indicus*	Abundant	Abundant	1
4.	Ashy-crowned Finch-lark	*Eremopterix grisea*	Common	Common	1
5.	Bar Tailed Godwit	*Limosa lapponica*	Common	Rare	3
6.	Barbary Falcon	*Falco peregrinus babylonicus*	Scarce	Rare	3
7.	Barn Owl	*Tyto alba*	Scarce	Rare	1
8.	Bay-backed Shrike	*Lanius vittatus*	Common	Common	1
9.	Billon's Crake	*Porzana pusilla*	Scarce	Rare	3
10.	Black/Eurasian Coot	*Fulica atra*	Abundant	Abundant	3
11.	Black Drongo	*Dicrurus macrocercus*	Common	Common	
12.	Black Headed Bunting	*Emberiza melanocephala*	Common	Common	6
13.	Black Kite	*Milvus migrans migrans*	Abundant	Abundant	1
14.	Black Partridge	*Francolinus francolinus*	Common	Rare	1
15.	Black Redstart	*Phoenicurus ochruros*	Common	Common	1
16.	Black Shaheen	*Falco perigrinus peregrinator*	Rare	Rare	3
17.	Black Shouldered Kite	*Elanus caeruleus*	Common	Scarce	1
18.	Black Stork	*Ciconia nigra*	Scarce	Rare	1
19.	Black Tailed Godwit	*Limosa limosa*	Abundant	Abundant	3
20.	Black Winged Stilt	*Himantopus himantopus*	Abundent	Abundent	1,2,5
21.	Black-bellied Plover	*Pluvialis squatarola*	Abundaant	Common	3
22.	Black-crowned Finch-Lark	*Eremopterix nigriceps*	Common	Scarce	1
23.	Black-headed Ibis	*Threskiornis melanocephalus*	Scarce	Rare	1
24.	Black-necked grebe	*Podiceps nigricollis*	Frequent	Scarce	1
25.	Blue Rock Pigeon	*Columba livia*	Abundant	Abundant	1

Continues…

Resident: 1 Summer visitor: 2 Winter visitor: 3 Irregular year round visitor: 4
Breeding: 5 Double passage: 6 Autumn migrant: 7 Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
26.	Blue Rock Thrush	*Monticola solitarius*	Common	Scarce	3
27.	Blue Throat	*Luscinia svecica*	Common	Common	3
28.	Blue-cheeked Bee-eater	*Merops superciliosus*	Abundant	Scarce	7
29.	Blyth's Reed Warbler	*Acrocephalus dumetorum*	Common	Common	6
30.	Bonnelli's Eagle	*Hieraaetus fasciatus*	Scarce	Scarce	1,3
31.	Booted Eagle	*Hieraaetus pennatus*	Frequent	Frequent	3
32.	Booted Warbler	*Hippolais caligata*	Common	Common	3
33.	Brahminy Duck	*Tadorna ferruginea*	Common	Rare	1
34.	Brahminy Kite	*Haliaster indus*	Common	Scarce	1
35.	Broad-billed Sandpiper	*limicola falcinellus*	Rare	Rare	3
36.	Brown-headed Gull	*Larus brunnicephalus*	Abundant	Scarce	3
37.	Button Quail	*Turnix tanki*	Frequent	Scarce	2,5
38.	Buzzard Eagle	*Butastur teesa*	Common	Common	1
39.	Caspian Tern	*Sterna caspia*	Common	Scarce	4,5
40.	Cattle Egret	*Bulbulcus ibis*	Common	Common	1
41.	Cetti's Warbler	*Cettia cetti*	Frequent	Scarce	1
42.	Chestnut Bittern	*Ixyobrychus cinnamomeus*	Frequent	Frequent	1
44.	Chiffchaff	*Phylloscopos collybita*	Abundant	Abundant	3
45.	Chinese/Yellow Bittern	*Ixyobrychus sinensis*	Frequent	Frequent	1
47.	Collared Dove	*Streptopelia decaocto*	Abundant	Abundant	1,2,5
48.	Collared Pratincole	*Glareola pratincola*	Common	Common	2,5
49.	Common / Grey Quail	*Coturnix coturnix*	Common	Common	2,5
50.	Common Babbler	*Turdoides caudatus*	Abundant	Abundant	1
51.	Common Crane	*Grus grus*	Rare	Rare	6
52.	Common Crow Pheasant	*Centropus sinensis*	Common	Common	1
53.	Common Eurasian Kingfisher	*Alcedo atthis*	Common	Common	1
54.	Common Heron	*Ardea cinerea*	Common	Common	1

Continues…

Resident: 1 Summer visitor: 2 Winter visitor: 3 Irregular year round visitor: 4
Breeding: 5 Double passage: 6 Autumn migrant: 7 Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
55.	Common Poachard	*Aytha ferina*	Abundant	Common	1
56.	Common Ringed Plover	*Charadrius hiaticula*	Scarce	Rare	3
57.	Common Sandpiper	*Actitis hypoleucos*	Common	Common	3
58.	Common Shelduck	*Tadorna tadorna*	Scarce	Scarce	1
59.	Common Skylark	*Alauda Arvensis*	Less Common	Less Common	1
60.	Common Snipe	*Gallinago gallinage*	Common	Common	3
61.	Common Swallow	*Hirundo rustica*	Abundant	Abundant	3
62.	Common Tern	*Sterna hirundo hirundo*	Scarce	Rare	2
63.	Common White-throat	*Sylvia communis*	Uncommon	Uncommon	7
64.	Common Wood Shrike	*Tephrodornis pondicerianus*	Common	Common	1
65.	Cotton Teal	*Nettapus coromandelianus*	Common	Rare	1
66.	Crab Plover	*Dromas ardeola*	Rare	Rare	6
67.	Cream Colored Courser	*Cursorius cursor*	Scarce	Scarce	1,3
68.	Crested Lark	*Galeridae cristata*	Abundant	Common	1
69.	Cuckoo	*Taccocua leschenaultii*	Rare	Rare	1
70.	Curlew Sandpiper	*Calidris ferruginea*	Abundant	Abundant	3
71.	Dalmaltian Pelican	*Pelecanus crispus*	Common	Rare	1
72.	Desert Finch-lark	*Ammomanes deserti*	Common	Common	1
73.	Desert Warbler	*Sylvia nana*	Common	Common	3
74.	Desert Wheatear	*Oenanthe deserti*	Common	Common	3
75.	Dunlin	*Calidris alpina*	Abundant	Common	3
76.	Dusky Horned Owl	*Bubo coromandus*	Frequent	Rare	1
77.	Eared/Large Indian Kite	*Milvus migrans lineatus*	Abundant	Abundant	1
78.	Eastern Calandra Lark	*Melanocorypha bimaculata*	Scarce	Rare	1
79.	Eastern Golden Plover	*Pluvialis apricaria*	Scarce	Rare	3

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
80.	Eastern Knot	*Calidris tenuirostris*	Rare	Rare	3
81.	Eastren Pied Wheatear	*Oenanthe picata*	Common	Common	1
82.	Eurasian Bittern	*Botaurus stellaris*	Scarce	Scarce	1
83.	Eurasian Cormorant	*Phanacrocorax carbo*	Abundant	Common	1
84.	Eurasian Curlew	*Numenius arquata*	Abundant	Common	3
85.	Eurasian Griffon vulture	*Gyps fulvus*	Frequent	Frequent	3
86.	Eurasian Kestrel	*Falco tinnunculus*	Scarce	Scarce	3
87.	Eurasian Oystercatcher	*Haematopus ostralegus*	Abundant	Scarce	3
88.	Eurasian Roller	*Coracias garrulus*	Frequent	Scarce	7
89.	Eurasian Scops Owl	*Otus scops*	Common	Common	3
90.	Eurasian Sparrow Hawk	*Accipiter nisus melaschistos*	Frequent	Frequent	4
91.	Eurasian Wigeon	*Anas penelope*	Abundant	Common	1
92.	Eurasian Wryneck	*Jynx torquilla*	Frequent	Scarce	6
93.	Eurasin Black vulture	*Aegypius monachus*	Scarce	Rare	3
94.	European Nightjar	*Caprimulgus europaeus*	Common	Frequent	3
95.	Garganey Teal	*Anas querquedula*	Abundant	Rare	1
96.	Glossy Ibis	*Plegadis falcinellus*	Common	Scarce	5
97.	Golden Oriole	*Oriolus oriolus*	Common	Rare	6
98.	Golden-backed Woodpecker	*Dinopium benghalense*	Common	Common	1
99.	Great Creasted Grebe	*Podiceps cristatus*	Scarce	Rare	1
100.	Great Grey Shrike	*Lanius Excuvitor*	Common	Common	2,5
101.	Great Stone Curlew	*Esacus magnirostris*	Rare	Rare	1
103.	Greater Black-headed Gull	*Larus ichthyaetus*	Frequent	Frequent	3
104.	Greater Flamingo	*Phoenicopterus ruber*	Common	Scarce	2
105.	Greater Spotted Eagle	*Aquila pomarina*	Common	Scarce	3
106.	Green Plover	*Vanellus vanellus*	Common	Scarce	3
107.	Green Sandpiper	*Trimga ochropus*	Common	Common	3

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
108.	Green Warbler	*Phylloscopos nitidus*	Frequent	Frequent	3
109.	Greenshank	*Tringa nebularia*	Common	Common	3
110.	Grey Necked Bunting	*Emberiza buchanani*	Scarce	Rare	3
111.	Grey Wagtail	*Motacilla cinerea*	Common	Common	3
112.	Greylag Goose	*Anser anser*	Rare	Rare	6
113.	Gull-billed Tern	*Gelochelidon nilotica*	Common	Common	3
114.	Herring Gull	*Larus argentatus*	Common	Common	3
115.	Honey Buzzard	*Penis ptilorhynchus*	Rare	Rare	1
116.	Hooded Wheatear	*Oenanthe monacha*	Rare	Rare	1
117.	Hoopoe	*Upupa epops*	Common	Common	3
118.	Hoopoe Lark	*Alaemon alaudipes*	Scarce	Scarce	1
119.	Houbara Bustard	*Chlamydotis undulata*	Rare	Rare	3
120.	House Bunting	*Emberiza Striolata*	Frequent	Frequent	1
121.	Hume's Wheatear	*Oenanthe alboniger*	Scarce	Rare	3
122.	Imperial Eagle	*Aquila heliaca*	Scarce	Rare	1,3
124.	Indian Courser	*Cursorius coromandelicus*	Scarce	Scarce	1,3
125.	Indian Bush Lark	*Mirafra erythroptera*	Frequent	Frequent	1
126.	Indian Cormorant	*Phanacrocorax fusicollis*	Common	Scarce	4
128.	Indian House Crow	*corvus splendens*	Abundant	Abundant	1
129.	Indian House Sparrow	*Passer domesticus indicus*	Abundant	Abundant	1
130.	Indian Myna	*Acridotheres tristis*	Abundant	Abundant	1
131.	Indian Nightjar	*Caprimulgus asiaticus*	Common	Frequent	1
132.	Indian Pond Heron	*Ardeola grayii*	Frequent	Frequent	1
133.	Indian reef Heron	*Egretta gularis*	Abundaant	Common	1
134.	Indian River Tern	*Sterna aurantia*	Common	Common	3
135.	Indian Robin	*Saxicoloides fulicata*	Common	Common	1
136.	Indian Roller	*Coracias benghalensis*	Common	Common	1
137.	Indian Sand Lark	*Calandrella Raytal*	Common	Common	1
138.	Indian Sand Martin	*Riparia paludicola*	Abundant	Abundant	1

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
139.	Indian Scops Owl	*Otus bakkamoena*	Common	Common	1
140.	Indian Silver-bill	*Eodice malabarica*	Common	Common	4
141.	Indian Skimmer	*Rynchops albicollis*	Rare	Rare	2
142.	Indian Tree-pie	*Dendrocitta vegebunda*	Common	Common	1
143.	Isabelline Wheatear	*Oenanthe isabellina*	Common	Common	3
144.	Jack Snipe	*Lynmocryptes minimus*	Scarce	Scarce	3
145.	Koel	*Eudynamys scolopacea*	Common	Common	1,2,5
146.	Lagger Falcon	*Falco jugger*	Rare	Rare	1
147.	Large Egret	*Egretta alba*	Common	Common	1
148.	Large Sand Plover	*Charadrius leschenaultii*	Abundant	Common	3
149.	Lesser Crested Tern	*Sterna bengalensis*	Common	Common	4,5
150.	Lesser Florican	*Sypheotides indica*	Vargrant	Rare	1
151.	Lesser Sand Plover	*Charadrius mongolus*	Abundant	Abundant	3
152.	Lesser Whisling Teal	*Denrocygna javanica*	Common	Rare	2
153.	Lesser Whitethroat	*Sylvia curruca*	Abundant	Abundant	3
154.	Little Bittern	*Ixyobrychus minutus*	Rare	Rare	1
155.	Little Brown Dove	*Streptopelia senegalensis*	Abundant	Abundant	1
156.	Little Bustard Quail	*Turnix sylvatica*	Frequent	Rare	1
157.	Little Cormorant	*Phanacrocorax niger*	Abundent	Abundent	1
158.	Little Egret	*Egretta garzetta*	Common	Common	1
159.	Little Grebe/Dabchick	*Tachybaptus ruficollis*	Common	Common	1
160.	Little Green Bee-eater	*Merops orientalis*	Common	Common	2
161.	Little Green Heron	*Butorides striatus*	Scarce	Scarce	1
162.	Little Ringed Plover	*Charadrius dubius*	Common	Common	3
163.	Little Stint	*Calidris minuta*	Abundant	Abundant	3
164.	Little Swift	*Apus affinus*	Abundant	Abundant	1
165.	Little Tern	*Sterna albifrons*	Frequent	Frequent	1
166.	Long Eared Owl	*Asio otus*	Scarce	Rare	3

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
167.	Long-legged Buzzard	*Buteo rufinus*	Common	Common	2
168.	Long-tailed Grass Warbler	*Prinia burnesii*	Frequent	Rare	1
169.	Long-tailed Shrike	*Lanius schach*	Common	Common	1
170.	Mallarded Teal	*Marmaronetta angustirostris*	Rare	Rare	1
171.	Marsh Harrier	*Circus aeruginosus*	Common	Common	3
172.	Marsh Sandpiper	*Tringa Stagnatilis*	Common	Common	6
173.	Merlin	*Falco columbarius*	Rare	Rare	3
174.	Montagu's Harrier	*Circus mlanoleucus*	Scarce	Rare	3
175.	Moorhen	*Gallinula chloropus*	Abundant	Abundant	1
176.	Night Heron	*Nycticorax nycticorax*	Common	Frequent	1
177.	Northern Eagle Owl	*Bubo bubo*	Frequent	Rare	1
178.	Orthean Warbler	*Sylvia hortensis*	Frequent	Frequent	6
179.	Paddy-fied Warbler	*Acrocephalus agricola*	Common	Common	3
180.	Painted Snipe	*Rostratula benghalensis*	Frequent	Rare	1
181.	Painted Stork	*Mycteria ieucocephala*	Scarce	Rare	1
182.	Pale Brown Shrike	*Lanius isabellinus*	Frequent	Frequent	3
183.	Pale Crag Martin	*Ptyonoprogne Fuligula*	Scarce	Scarce	1
184.	Pallid Harrier	*Circus macrourus*	Common	Common	4
185.	Pallid Scops Owl	*Otus brucei*	Scarce	Scarce	3
186.	Parish/Indian Kite	*Milvus migrans govinda*	Abundant	Abundant	1
187.	Peregrine	*Falco perigrinus*	Scarce	Scarce	3
188.	Persian Rock Pipit	*Anthus similis*	Common	Common	3
189.	Pheasant Tailed Jacana	*hadrophasianus chirurgus*	Common	Scarce	1
190.	Piad Avocet	*Recurvirostra avosetta*	Frequent	Frequent	3
191.	Pied Crested Cuckoo	*Climator jacobinus*	Common	Frequent	2,5
192.	Pied Kingfisher	*Ceryle rudis*	Abundant	Common	1

Continues…

Resident: 1 Summer visitor: 2 Winter visitor: 3 Irregular year round visitor: 4
Breeding: 5 Double passage: 6 Autumn migrant: 7 Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
193.	Pied Stonechat	*Saxicola caprata*	Common	Common	1
194.	Pintail Snipe	*Gallinago stenura*	Unknown	Rare	6
195.	Plain Willow Warbler	*Phylloscopos neglectus*	Common	Common	3
196.	Pomatorhine Jaeger	*Stercorarius pomarinus*	Scarce	Rare	3
197.	Purple Heron	*Ardea purpurea*	Common	Scarce	1
198.	Purple Sunbird	*Nectarinia asiatica*	Common	Common	1
199.	Purple Swamp Hen	*Porphyrio porphyrio*	Common	Frequent	1
200.	Rain Quail	*Coturnix coromandelica*	Frequent	Rare	2,5
201.	Red Capped Falcon	*Falco pelegrinoides*	Scarce	Scarce	3
202.	Red headed Merlin	*Falco chicquera*	Common	Scarce	1
203.	Red Shaheen	*Falco pelegrinoides babylonicus*	Scarce	Scarce	3
204.	Red Turtle Dove	*Streptopelia tranquebarica*	Abundant	Scarce	1
205.	Red-breasted Flycatcher	*Ficedula parva*	Common	Scarce	1
206.	Red-breasted Merganser	*Mergus serrator*	Rare	Rare	1
207.	Red-Crested Poachard	*Netta rufina*	Scarce	Rare	1
208.	Red-necked Phalarope	*Phalaropus lobatus*	Common	Rare	3
209.	Red-tailed Wheatear	*Oenanthe Xanthoprymna*	Common	Scarce	3
210.	Red-vented Bulbul	*Pycnonotus cafer*	Abundant	Common	1
211.	Richard's Pipit	*Anthus novaeseelandiae*	Common	Common	1
212.	Ring-tailed Fish Eagle	*Haliaeetus leucoryphus*	Scarce	Rare	1
213.	Rock Thrush	*Monticola saxatilis*	Rare	Rare	6
214.	Rose Ringed Parakeet	*Psittacula krameri*	Abundant	Abundant	1
215.	Rosy Pelican	*Pelecanus onocrotalus*	Common	Scarce	1

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
216.	Rosy Starling	*Sturnus roseus*	Abundant	Common	6
217.	Ruddy Turnstone	*Arenaria interpres*	Frequent	Scarce	3
218.	Ruff	*Philomachus pugnax*	Abundant	Abundant	6
219.	Rufous-fronted Wren Warbler	*Prinia buchanani*	Abundant	Abundant	1
220.	Sanderling	*Calidris alba*	Scarce	Scarce	3
221.	Sandwich Tern	*Sterna sandvicensis*	Common	Common	4
222.	Scavanger vulture	*Neophron percnopterus*	Common	Scarce	1
224.	Shikra	*Accipiter badius cenchroides*	Common	Common	1
225.	Short Toed Eagle	*Circaetus gallicus*	Frequent	Scarce	1,4
226.	Sind Nightjar	*Caprimulgus mahrattensis*	Common	Common	1
227.	Sind Pied Woodpecker	*Dendrocopos assimilis*	Frequent	Scarce	1
228.	Singing Bush Lark	*Mirafra cantillans*	Scarce	Scarce	1
229.	Slender-billed Gull	*Larus genei*	Abundant	Common	1
230.	Small Minivet	*Pericrocotus cinnamomeus*	Common	Frequent	1
231.	Small Skylark	*Alauda gulgula*	Abundant	Abundant	1
232.	Smaller Egret	*Egretta intermedia*	Frequent	Frequent	1
233.	Snake Bird	*Anhinga melanogaster*	Less common	Rare	1
234.	Snowy Plover	*Charadrius alexandrinus*	Abundant	Abundant	2,3,5
235.	Sooty Gull	*Larus hemprichii*	Common	Rare	2,5
236.	Southern Great Reed Warbler	*Acrocephalus stentoreus*	Common	Common	3,5
237.	Spoonbill	*Platalea leucorodia*	Frequent	Scarce	1
238.	Spotbill Duck	*Anas poecilorhyncha*	Common	Rare	1
239.	Spotted Crake	*Porzana porzana*	Scarce	Rare	3
240.	Spotted Flycatcher	*Muscicapa striata*	Common	Common	7
241.	Spotted or Dusky Redshank	*Tringa erythropus*	Frequent	Rare	3

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
242.	Spotted Owlet	*Athene brama*	Common	Common	1
244.	Steppe Eagle	*Aquila rapax nipalensis*	Common	Common	1
245.	Stone Curlew	*Burhinus oedicnemus*	Scarce	Rare	1
246.	Stonechat	*Saxicola torquata*	Common	Common	6
247.	Streaked Fantail Warbler	*Cistisola juncidis*	Common	Scarce	1
248.	Streaked Longtail Warbler	*Prinia gracilis*	Common	Common	1
249.	Striated Babbler	*Turdoides earleri*	Common	Common	1
250.	Swallow Plover	*Glareola lactea*	Abundant	Common	2,3,5
251.	Swift or Great Crested Tern	*Sterna bergii*	Common	Frequent	4,5
252.	Tailor Bird	*Orthotomus sutorius*	Common	Common	1
253.	Tawny/Plain Coloured Prinia	*Prinia Inoranata*	Common	Common	1
254.	Tawny Eagle	*Aquila rapax vindhiana*	Common	Scarce	1
255.	Tawny Pipit	*Anthus campestris*	Common	Common	1
256.	Temminck's Stint	*Clidris temminckii*	Abundant	Common	3
257.	Terek Sandpiper	*Xenus cinereus*	Scarce	Scarce	3
258.	Tibetan River Tern	*Sterna hirundo tibetana*	Scarce	Rare	2
259.	Tree Pipit	*Anthus trivialis*	Frequent	Frequent	2,5
260.	Trumpeter Finch	*Bucanetes githagineus*	Common	Rare	1
261.	Tufted Duck	*Aytha fuligula*	Common	Scarce	1
262.	Water Pipti	*Anthus Spinoletta*	Common	Scarce	3
263.	Watercock or Kora	*Gallicrex cinerea*	Common	Rare	2,5
264.	Whimbrel	*Numenius phaeopus*	Scarce	Scarce	3
265.	Whiskered Tern	*Chlidonias hybridus*	Abundant	Abundant	4
266.	White Backed vulture	*Gyps bengalensis*	Rare	Rare	1
267.	White Breasted Water Hen	*Amaurornis phoenicurus*	Common	Common	1

Continues…

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

…Continued

No.	*Common Name*	*Scientific name*	*Status (T J. Robert)*	*Status (Field observation)*	*Distribution*
268.	White Cheeked Bulbul	*Pycnonotus leucogenys*	Abundant	Abundant	1
269.	White Cheeked Tern	*Sterna represse*	Common	Common	2
270.	White Eyed Poachard	*Anthya nyroca*	Frequent	Rare	1
271.	White Stork	*Ciconia ciconia*	Scarce	Rare	1
272.	White Tailed Lapwing	*Chettusia leucura*	Common	Common	3
273.	White wagtail	*Motacilla alba*	Abundant	Abundant	3
274.	White-browed Fantail Flycatcher	*Rhipidura aureola*	Common	Scarce	1
275.	White-necked Stork	*Ciconia episcopus*	Unknown	Very rare	1
276.	White-throated Kingfisher	*Halcyon smyrnensis*	Common	Common	1
277.	Wilson's Storm Petrel	*Ocaenites oceanicus*	Common	Scarce	1
278.	Wood Sandpiper	*Tringa glareola*	Common	Common	3
279.	Yellow Bellied Wren-warbler	*Prinia flaviventris*	Common	Common	1
280.	Yellow throated Bittern	*Ixyobrychus flavicollis*	Common	Scarce	1
281.	Yellow Wagtail	*Motacilla flava*	Common	Common	1
282.	Yellow-eyed Babbler	*Chrysonna sinense*	Common	Rare	1
283.	Yellow-fronted Woodpecker	*Dendrocopos mahrattensis*	Frequent	Scarce	1
284.	Yellow-headed Wagtail	*Motacilla citreola*	Common	Common	3
285.	Yellow-wattled Lapwing	*Hoplopterus malabaricus*	Frequent	Rare	3

Resident: 1	Summer visitor: 2	Winter visitor: 3	Irregular year round visitor: 4
Breeding: 5	Double passage: 6	Autumn migrant: 7	Spring migrant: 8

Exhibit B.4: Fishes Found off the Coast of Karachi

No.	*English Name*	*Local Name*	*Scientific name*	*Status*	*Local Distribution*
1.	Mangrove Jack/Red Snapper	Hira	*Lutjanus argentimaculatus*	Common	Creeks and Coastal Water
2.	Finger mark Sea Perch/Moses Perch	Mayyo	*Lutjanus johnii*	Common	Creeks and Coastal Water
3.	Oil Sardine	Tarli, Lugger Palli	*Sardinella Longiceps*	Common	Creeks and Coastal Water
4.	Grey Mullet, Springer	Boi, Minghach	*Mugil cephalus*	Common	Creeks and Coastal Water
5.	Blue Spot Grey Mullet	Boi	*Mugil seheli*	Common	Creeks and Coastal Water
6.	Large Scaled Grey Mullet	Boi, Chhodi	*Liza oligolepis*	Common	Creeks and Coastal Water
7.	Common Tassel Fish	Ranwas, Seeri	*Polynemus plebeius*	Common	Creeks and Coastal Water
8.	Grouper	Bhol, Gisser	*Epinephelus lanceoatus*	Common	Creeks and Coastal Water
9.	Kuwehs	Mori	*Atropus atropus*	Common	Creeks and Coastal Water
10.	Olive Grunter	Dhotar, Kumpo	*Pomadasys olivacens*	Common	Creeks and Coastal Water
11.	Spotted Grunter	Dhotar, Kumpo	*Pomadasys maculatus*	Common	Creeks and Coastal Water
12.	Dussemerl's	Mushka	*Sciaena dussumaeri*	Common	Creeks and Coastal Water
13.	Black Spot Jew Fish	Mushka	*Johnius axillaris*	Common	Creeks and Coastal Water
14.	Two Spine Jew Fish, Spoted Croaker	Ghol, Sua	*Johnius diacanthus*	Common	Creeks and Coastal Water
15.	Small Salmon, Drab Jew Fish	Sua	*Johnius sina*	Common	Creeks and Coastal Water
16.	Rosy Jew Fish	Mushka	*Otolithus ruber*	Common	Creeks and Coastal Water
17.	Belanger's Croaker	Mushka, Goli	*Johnins belangeri*	Common	Creeks and Coastal Water
18.	Black Bream, Picnic Seaq Bream	Dandya Dateri	*Acanthopagrus berda*	Common	Creeks and Coastal Water

Continues…

…Continued

No.	*English Name*	*Local Name*	*Scientific name*	*Status*	*Local Distribution*
19.	Two Barred Beam	Dandya Dateri	*Acanthopagrus bifasciatus*	Common	Creeks and Coastal Water
20.	Cobia	Sangra, Sanglore	*Rachycentron canadum*	Common	Creeks and Coastal Water
21.	Russell's Jew Fish	Mushka	*Sciaena russelli*		Creeks and Coastal Water
22.	Tassel Fish	Mushka	*Sciaena sinuata*		Creeks and Coastal Water
23.	Grey Fine Jew Fish	Mushka	*Johnius aneus*		Creeks and Coastal Water
24.	Jew Fish	Mushka	*Johnius semiluctuosus*		Creeks and Coastal Water
25.	Purple Jew Fish	Mushka	*Johnius carutta*		Creeks and Coastal Water
26.	Black Banded Jew Fish	Mushka	*Johnius maculatus*		Creeks and Coastal Water
27.	Silver Banded Jew Fish	Mushka	*Otolithus argenteus*		Creeks and Coastal Water
28.	Green Back Jew Fish	Mushka	*Johnius soldado*		Creeks and Coastal Water
29.	Silver Bream	Dandya	*Rhodosaryus sarba*		Creeks and Coastal Water
30.	Japanese Silver Beam	Dandya	*Acanthopagrus latus*		Creeks and Coastal Water
31.	Surmai	Wahoo	*Acanthopagrus solandri*		Creeks and Coastal Water
32.	Spanish Mackerel	Surmai, Ghore	*Scomberomorus commerson*		Creeks and Coastal Water
33.	Spanish Mackerel	Surmai, Kalgund	*Scomberomorus commerson*		Creeks and Coastal Water
34.	Oil Sardine	Tarli	*Sardinella gibbosa*		Creeks and Coastal Water
35.	Fringe Scale Sardine	Tarli	*Sardinella fumbricata*		Creeks and Coastal Water
36.	Toothed Shad	Tarli	*Pellana ditchella*		Creeks and Coastal Water
37.	Round Headed Grey Mullet	Pharra	*Mugil strongylocephalus*		Creeks and Coastal Water

Continues…

…Continued

No.	*English Name*	*Local Name*	*Scientific name*	*Status*	*Local Distribution*
38.	Armed Trevally	Bhangra	*Carangoides ormatus*		Creeks and Coastal Water
39.	Two Thread Travelly	Bhangra	*Carangoides dinema*		Creeks and Coastal Water
40.	Ferdua's Trevally	Bhangra	*Carangoides ferdau*		Creeks and Coastal Water
41.	Six banded Trevally	Bhangra	*Carangoides sexfasciatus*		Creeks and Coastal Water
42.	Dusky Trevally	Bhangra	*Carangoides chrysopygus*		Creeks and Coastal Water
43.	Black Tipped Trevally	Bhangra	*Caranx melampygus*		Creeks and Coastal Water
44.	Yellow Fin Trevally	Bhangra	*Caranx ignobilis*		Creeks and Coastal Water
45.	Golden Tooless Trevally	Bhangra	*Gnathanodon specious*		Creeks and Coastal Water
46.	Silver Pomfret	Sufed Paplet	*Pampus argeneus*		Creeks and Coastal Water
47.	Brown Pomfret	Kala Paplet	*Parastromateus niger*		Creeks and Coastal Water
48.	Leseer Devil Ray	Karng	*Mobula diabius*		Creeks and Coastal Water
49.	Black See Bream	Kara Dandy	*Crenidens crenidens*		Creeks and Coastal Water
50.	River Shad	Palla	*Hilsa ilisha*	Rare	Creeks and Coastal Water
51.	Lined Silver Grunter	Dhotar	*Pomadasys hasta*		Creeks and Coastal Water

Source: Jaleel and Khaliluddin (1981)

Exhibit B.5: Shrimps, Crabs and Lobsters off the Coast of Karachi

No.	*English Name*	*Local Name*	*Scientific name*	*Status*	*Local Distribution*
Shrimps					
1.	Shrimps	Jhinga	*Penaus meguiensis*	Common	Mangrove creeks and Coastal Water
2.	Shrimps	Jhinga	*Penaus japonicus*	Common	Mangrove creeks and Coastal Water
3.	Shrimps	Jhinga	*Penalus semisulcantus*	Common	Mangrove creeks and Coastal Water
4.	Shrimps	Jhinga	*Metapenaeus stebbingi*	Common	Mangrove creeks and Coastal Water
5.	Shrimps	Jhinga	*Penaus indicus*	Common	Mangrove creeks and Coastal Water
6.	Shrimps	Jhinga	*Penaus penicillatus*	Common	Mangrove creeks and Coastal Water
Marine Crabs					
1.	Ghost Crab	Kekra	*Ocypoda ceratophthalma*	Common	Mangrove creeks and Coastal Water
2.	Ghost Crab	Kekra	*Ocypoda rotundata*	Common	Mangrove creeks and Coastal Water
3.	Fiddler Crab	Kekra	*Uca annulipeslatreille*	Common	Mangrove creeks and Coastal Water
4.	Fiddler Crab	Kekra	*Macrophthalmus pectinipes*	Common	Mangrove creeks and Coastal Water
5.	Swimming Crab	Kekra	*Scylla serrata*	Common	Mangrove creeks and Coastal Water
6.	Swimming Crab	Kekra	*Netunus sanguinoln*	Common	Mangrove creeks and Coastal Water
7.	Swimming Crab	Kekra	*Charybdis hoplites*	Common	Mangrove creeks and Coastal Water
8.	Swimming Crab	Kekra	*Eriphia lancvimana*	Common	Mangrove creeks and Coastal Water
9.	Rock Crab	Kekra	*Atergatis roseus*	Common	Mangrove creeks and Coastal Water
10.	Rock Crab	Kekra	*Graspus strigosuss*	Common	Mangrove creeks and Coastal Water
Lobster					
1.	Spiny Lobster	Lobster	*Panulirus polyphagons*	Common	Mangrove creeks and Coastal Water
2.	Spiny Lobster	Lobster	*Panulirus homarus*	Common	Mangrove creeks and Coastal Water
3.	Spiny Lobster	Lobster	*Panulirus versicolor*	Common	Mangrove creeks and Coastal Water

Source: Jaleel and Khaliluddin (1981)

Exhibit B.6: Reptiles of Port Qasim and Project Area

No.	*Common Name*	*Occurrence*	*Scientific name*	*Status*	*Local Distribution*	*From Project Area*
1.	Indian Ocean Green Turtle	Migratory	*Chelonia mtdas*	Rare	Hawkes Bay,Sands Pit and Coastal Water	P[5]
2.	Pacific/Olive Ridley Turtle	Migratory	*Lepidochelys olivacea*	Rare	Hawkes Bay,Sands Pit and Coastal Water	P
Lizards						
1.	Sindh Sand Gecko	Resident	*Crossobamon orientalis*	Scarce	Coastal Sandy Area	P
2.	Fat Tailled/ Leopard Gecko	Resident	*Eublepharis macularius*	Rare	Coastal Sandy Area	P
3.	Keeled Rock Gecko	Resident	*Cyrtodactylus scaber*	Common	Coastal Sandy Area	C[6]
4.	Warty Rock Gecko	Resident	*Cyrtodactylus kachhensis*	Common	Coastal Sandy Area	P
5.	Banded Dwarf Gecko	Resident	*Microgekko persica*	Scarce	Coastal Sandy Area	P
6.	Blotched Gecko	Resident	*Hemidactylus triedrus*	Common	Coastal Sandy Area	C
7.	Bronze Grass Skink	Resident	*Mabuya macularia*	Common	Gardens and Open Area of Karachi City	C
8.	Striped Grass Skink	Resident	*Mabuya dissimilis*	Common	Gardens and Open Area of Karachi City	
9.	Indian Monitor lizard	Resident	*Varanus bengalensis*	Scarce	Coastal Estuaries	P
10.	Indian Desert Monitor Lizard	Resident	*Varanus grisens*	Scarce	Coastal Estuaries	C
Land Snakes						
1.	Brahnriny Blind Snake	Resident	*Typhlops braminus*	Common	Karachi city,Coast and Lyari	C
2.	Slender Blind Snake	Resident	*Typhlops porectus*	Common	Karachi city,Coast and Lyari	C
3.	Checkered Keelback	Resident	*Xenochrophis piscator*	Scarce	Lyari River, and Estuaries	P

Continues…

[5] Possible: Literature reported from the same type of habitat or the ecosystem of the area in general

[6] Confirmed: Species collected from the project area or reported from the reliable resource

…Continued

No.	*Common Name*	*Occurrence*	*Scientific name*	*Status*	*Local Distribution*	*From Project Area*
4.	Dark Headed Gamma Snake	Resident	*Boiga trigonata*	Scarce	Lyari River, and Estuaries	P
Marine Snakes						
1.	Mangrove/Annulated Sea Snake	Resident	*Hydrophis cyanocinctus*	Common	Mangrove creeks and shallow water	P
2.	Yellow Sea Snake	Resident	*Hydrophis spiralisyanocinctus*	Less Common	Mangrove creeks and shallow water	P
3.	Many toothed Sea Snake	Resident	*Hydrophis caerculescens*	Rare	Mangrove creeks and shallow water	P
4.	Bombay Sea Snake	Resident	*Hydrophis mamillaris*	Rare	Mangrove creeks and shallow water	P
5.	Small Headed Sea Snake	Resident	*Hydrophis faciatus*	Common	Mangrove creeks and shallow water	P
6.	Viperine Sea Snake	Resident	*Praescutata viperina*	Less Common	Mangrove creeks and shallow water	P
7.	Common Small Headed Sea Snake	Resident	*Microcephalophis gracilis*	Rare	Mangrove creeks and shallow water	P
8.	Cantor's Small Headed Sea Snake	Resident	*Microcephalophis cantorisracilis*	Rare	Mangrove creeks and shallow water	P
Amphibians (Toads and Frogs)						
1.	Indus Tood	Resident	*Bufo andersom*	Common	Whole Karachi	C
2.	Marbled Tood	Resident	*Bufo stomaticus*	Common	Whole Karachi	C
3.	Tiger Frog	Resident	*Rana tigerina*	Common	Whole Karachi	C
4.	Skittering Frog	Resident	*Rana cyanophyctis*	Common	Whole Karachi	C
5.	Indian Burrowing Frog	Resident	*Rana breviceps*	Common	Whole Karachi	C

Source: Hafiz ur Rehman and Fehmida (1997); Minton (1966)

Appendix C: Accidental Release of Gases

C.1 Brief Description of the Model

1	**Abstract of Model Capabilities**	AFTOX is a Gaussian dispersion model that is used by the Air Force to calculate toxic corridors in case of accidental releases. It is limited to non-dense gases. It can directly calculate the evaporation rate from liquid spills. AFTOX treats instantaneous or continuous releases from any elevation, and can calculate the rise of buoyant plumes. It is intended to be consistent with the ADAM model for passive (neutrally buoyant) gas releases.
2	**Sponsor and/or Developing Organization**	Phillips Laboratory Directorate of Geophysics Air Force Systems Command Hanscom AFB, MA 01731-5000
3	**Last Custodian/ Point of Contact**	Steven Sambol 30 WS/WES Vandenberg AFB, CA 93437-5000 805-734-8232
4	**Life-Cycle**	AFTOX was developed by the U.S. Air Force in the late 1980s in order to estimate toxic corridors in the case of accidental releases of hazardous chemicals to the atmosphere. AFTOX is intended to be a replacement for the empirical OB/DG model, which was used by the Air Force for similar purposes since the 1960s.
5	**Model Description Summary**	AFTOX requires input of gas or liquid release amount (for instantaneous sources) or release rate (for continuous sources). It can calculate the evaporation of liquid spills. If the release is positively buoyant, it can calculate the buoyant plume rise. Dense gas effects are not accounted for. Dispersion calculations are carried out with standard Gaussian formulas. Stability class is treated as a continuous variable. Averaging time is accounted for. Outputs include maps of toxic corridors, estimates of concentration at specific positions, and estimates of the magnitude and location of the maximum concentration occurring a certain time after release.
6	**Application Limitation**	The code calculates evaporative emissions from liquid spills, but has no other capabilities for determining source emissions. Dense gases are not accounted for. Batch runs are difficult to make. Outputs are limited to contour plots and simplified tables.
7	**Strengths/ Limitations**	**Strengths:** A strength of AFTOX is that it has undergone extensive testing and troubleshooting. The developer, Bruce Kunkel, has made sure that AFTOX and ADAM (valid for dense gases) approach each other in the limit of passive (non-dense) releases. The meteorological processor/stability class estimator represents the state of the art in boundary layer theory. AFTOX allows 90% confidence bounds to be printed out for toxic corridors and concentrations at a point. **Limitation:** The major weakness of AFTOX is that it does not treat dense gases, which are frequently encountered in accidental release scenarios. Also, it would help the user if an algorithm were added to calculate the emission rate from pressurized tank or pipe ruptures. AFTOX could be made more useful by modifying the input and output modules so that batch runs could be made and so that more extensive output files could be printed or plotted.

8	**Model References**	! Kunkel, B. A., 1991: AFTOX 4.0 — The Air Force Toxic Chemical Dispersion Model — A User's Guide. PL-TR-91-2119, Environmental Research Papers No. 1083, Phillips Laboratory, Directorate of Geophysics, Air Force Systems Command, Hanscom AFB, MA 01731-5000, 62 pages. ! Kunkel, B.A., 1985: Development of an Atmospheric Diffusion Model for Toxic Chemical Releases. AFGL-TR-85-0338, AFGL/AFSC, USAF, Hanscom AFB, MA 01731-5000. ! Kunkel, B.A., 1988: User's Guide for the Air Force Toxic Chemical Dispersion Model (AFTOX). AFGL-TR-88-0009, AFGL/AFSC, USAF, Hanscom AFB, MA 01731-5000.
9	**Input Data/Parameter Requirements**	The user must specify the site and time information, chemical information, release information, ground conditions, atmospheric conditions, and output options in order to make a model run. The chemical database for AFTOX contains properties for roughly 80 chemicals. The specification of the source strength is mandatory for all releases, except for a continuous liquid spill where the evaporation rate can be estimated by the model. By default, AFTOX determines atmospheric stability using Golder's nomogram, based on the surface roughness specified by the user and the Monin-Obukhov length internally calculated by the model. If the standard deviation of wind direction is known and is provided as an input, AFTOX will use it to determine atmospheric stability. (The same procedure is also used in the ADAM model to determine atmospheric stability.) One deficiency with the input structure for AFTOX is that the user cannot save the input data for a case so that it can be rerun later on.
10	**Output Summary**	The output generated by the AFTOX model includes three options: (1) concentration contours on the computer screen for up to three user-defined concentration values, (2) concentration at a specified location and time, and (3) maximum concentration at a specified elevation and time. For option (2), the user must specify the receptor locations one at a time. That is, AFTOX does not automatically generate a distribution (or table) of predicted concentrations with downwind distance. For option (3), AFTOX will calculate the location of the maximum concentration for a given elevation and elapsed time.
11	**Applications**	See item 8 above. Also, Hanna et al. (1993) included AFTOX in their comprehensive exercise in which 15 models were evaluated using field data from eight sites (see number 19 below).
12	**User-Friendliness**	The AFTOX model has a text-based interactive user interface, where the user is prompted with a series of questions in order to define a scenario. The user needs to further decide an output option (see number 10 above) before the model performs any calculations. Due to the interactive nature of its input structure, AFTOX can be considered as user friendly in that the user seldom needs to consult the user's manual. However, it is a tedious task to obtain predicted concentrations at a series of downwind distances, since, as mentioned in number 10 above, the user can specify receptor locations only one at a time. Furthermore, AFTOX does not allow the user to save the input data for one case for later use for other cases. Therefore, if it is necessary to run the same case again, all information will have to be entered again.

13	**Hardware-Software Interface Constraints/ Requirements**	Computer operating system:The AFTOX model runs in the MS-DOS environment. Computer platform: Disk space requirements: A minimum of less than 1 MB. Run execution time (for a typical problem):The model takes only a few seconds to run on a Pentium PC for a typical scenario. Programming language:Both the computational and graphical output portions of the code are written in Zenith BASIC (ZBASIC), which is specific to PCS. Other computer peripheral information:AFTOX cannot be directly ported to other computer platforms. The model does not interface with other codes; however, the ADAM dense gas code has been designed to reduce to AFTOX in the passive gas limit (both models were developed for the U.S. Air Force).
14	**Operational Parameters**	Identify whether the code has any error diagnostic messages to assist the user in troubleshooting operational problems:The AFTOX model validates some, but not all, input parameters that the user specifies from the keyboard. The user will be asked to reenter the value for a variable if that value is found to be out of range. The model has no runtime error diagnostics. However, since simple Gaussian-type dispersion algorithms are used, the code is quite robust and rarely encounters numerical difficulties. Set up time for:Requires minimal initial setup. After the model files are copied onto a computer's hard disk, the user simply types "AFTOX" to run the model.
15	**Surety Considerations**	All quality assurance documentation: No information provided. Benchmark runs:No information provided. Validation calculations:No information provided. Verification with field experiments that has been performed with respect to this code: AFTOX was included in the comprehensive model evaluation exercise reported by Hanna et al. (1993). Since AFTOX does not treat the dispersion of denser-than-air gases, the model was mainly evaluated using the Prairie Grass and Hanford field experiments where the releases were neutrally buoyant. In general, AFTOX overpredicted the observed concentrations by a small amount (less than a factor of 2).
16	**Runtime Characteristics**	The AFTOX model is intended to be run in interactive mode, where the user is prompted with a series of questions during the runtime. However, if the user is very familiar with the input requirements for AFTOX, it is possible to run the model in batch mode using the feature of input-redirection, i.e., redirecting the keyboard input to a file, available in MS-DOS.

Meteorology Conditions

Condition No.	*Month*	*Time*	*Surface Roughness height (m)*	*Ambient measurement height (m)*	*Ambient wind speed (m/s)*	*Ambient Temperature (K)*	*Relative Humidity (%)*	*Stability Class*
1	March	Day	0.04	7.0	4.0	304.65	44.0	2.0
2	May	Day	0.04	7.0	6.0	308.35	60.0	3.0
3	March	Night	0.04	7.0	0.7	290.75	78.0	0.0
4	June	Night	0.04	7.0	3.3	301.05	83.0	4.0

C.2 Case Defination

Case No.	*Gas*	*Location*	*Meteorological Condition*
1.	Ethylene	Storage tank	1
2.	Ethylene	Storage tank	2
3.	Ethylene	Storage tank	3
4.	Ethylene	Storage tank	4
5.	Ethylene	Pipeline	1
6.	Ethylene	Pipeline	2
7.	Ethylene	Pipeline	3
8.	Ethylene	Pipeline	4

C.3 Results

C.3.1 Case 1

```
CONTINUOUS RELEASE

ETHYLENE
NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 31.52 C
WIND DIRECTION = 263
WIND SPEED = 7 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 3.55
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 18 M
EMISSION RATE IS 5.23 KG/MIN
ELAPSED TIME OF SPILL IS 720 MIN
TOTAL AMOUNT SPILLED IS 3765 KG
CONCENTRATION AVERAGING TIME IS 15 MIN
ELAPSED TIME SINCE START OF SPILL IS 720 MIN
HEIGHT OF INTEREST IS 2 M

 5 MG/M3 IS TOO HIGH
----------------------------------------------------
AT 720 MIN, THE MAXIMUM DISTANCE FOR 2 MG/M3 IS 509 M
MAXIMUM TOXIC CORRIDOR LENGTH = 1.07 KM  AT 720 MIN
 DIRECTION & WIDTH  83 +/- 22 DEG

AT 720 MIN, THE MAXIMUM DISTANCE FOR 3 MG/M3 IS 340 M
 10 MG/M3 IS TOO HIGH
```

C.3.2 Case 2

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 35.22 C
WIND DIRECTION = 256
WIND SPEED = 6 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 3.59
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 18 M
EMISSION RATE IS 5.23 KG/MIN
ELAPSED TIME OF SPILL IS 720 MIN
TOTAL AMOUNT SPILLED IS 3765 KG
CONCENTRATION AVERAGING TIME IS 15 MIN
ELAPSED TIME SINCE START OF SPILL IS 720 MIN
HEIGHT OF INTEREST IS 2 M


----------------------------------------------------
AT 720 MIN, THE MAXIMUM DISTANCE FOR 2 MG/M3 IS 584 M
MAXIMUM TOXIC CORRIDOR LENGTH = 1.23 KM  AT 720 MIN
 DIRECTION & WIDTH  76 +/- 22 DEG
```

```
 4 MG/M3 IS TOO HIGH
```

C.3.3 Case 3

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 17.62 C
WIND DIRECTION = 263
WIND SPEED = .7 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 6
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 18 M
EMISSION RATE IS 5.23 KG/MIN
ELAPSED TIME OF SPILL IS 720 MIN
TOTAL AMOUNT SPILLED IS 3765 KG
CONCENTRATION AVERAGING TIME IS 15 MIN
ELAPSED TIME SINCE START OF SPILL IS 720 MIN
HEIGHT OF INTEREST IS 2 M
----------------------------------------------------
AT 720 MIN, THE MAXIMUM DISTANCE FOR 2 MG/M3 IS 4.65 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 9.84 KM  AT 720 MIN
 DIRECTION & WIDTH  83 +/- 180 DEG

AT 720 MIN, THE MAXIMUM DISTANCE FOR 3 MG/M3 IS 3.32 KM
AT 720 MIN, THE MAXIMUM DISTANCE FOR 4 MG/M3 IS 2.6 KM
----------------------------------------------------
 20 MG/M3 IS TOO HIGH
----------------------------------------------------
AT 720 MIN, THE MAXIMUM DISTANCE FOR 1 MG/M3 IS 8.15 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 17.16 KM  AT 720 MIN
 DIRECTION & WIDTH  83 +/- 180 DEG

AT 720 MIN, THE MAXIMUM DISTANCE FOR 15 MG/M3 IS 658 M
 20 MG/M3 IS TOO HIGH
```

C.3.4 Case 4

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 27.92 C
WIND DIRECTION = 249
WIND SPEED = 3.3 M/S
NIGHTTIME SPILL
CLOUD COVER IS 0 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 4.58
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 18 M
EMISSION RATE IS 5.23 KG/MIN
ELAPSED TIME OF SPILL IS 720 MIN
TOTAL AMOUNT SPILLED IS 3765 KG
CONCENTRATION AVERAGING TIME IS 15 MIN
ELAPSED TIME SINCE START OF SPILL IS 720 MIN
HEIGHT OF INTEREST IS 2 M

 10 MG/M3 IS TOO HIGH
```

```
----------------------------------------------------
AT 720 MIN, THE MAXIMUM DISTANCE FOR 5 MG/M3 IS 652 M
MAXIMUM TOXIC CORRIDOR LENGTH = 1.38 KM  AT 720 MIN
 DIRECTION & WIDTH  69 +/- 45 DEG

 10 MG/M3 IS TOO HIGH
```

C.3.5 Case 5

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 31.52 C
WIND DIRECTION = 263
WIND SPEED = 4 M/S
NIGHTTIME SPILL
CLOUD COVER IS 0 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 4.08
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
ELAPSED TIME OF SPILL IS 8 MIN
TOTAL AMOUNT SPILLED IS 27433 KG
CONCENTRATION AVERAGING TIME IS 8.22 MIN
ELAPSED TIME SINCE START OF SPILL IS 8 MIN
HEIGHT OF INTEREST IS 2 M
----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 10 MG/M3 IS 2.02 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 48.03 KM  AT 89 MIN
 DIRECTION & WIDTH  83 +/- 45 DEG

AT 8 MIN, THE MAXIMUM DISTANCE FOR 40 MG/M3 IS 2.02 KM
AT 8 MIN, THE MAXIMUM DISTANCE FOR 100 MG/M3 IS 2.02 KM
----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 1000 MG/M3 IS 1.31 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 2.77 KM  AT 8 MIN
 DIRECTION & WIDTH  83 +/- 45 DEG

AT 8 MIN, THE MAXIMUM DISTANCE FOR 2000 MG/M3 IS 865 M
AT 8 MIN, THE MAXIMUM DISTANCE FOR 3000 MG/M3 IS 681 M
----------------------------------------------------
        USAF TOXIC CHEMICAL DISPERSION MODEL

CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 31.52 C
WIND DIRECTION = 263
WIND SPEED = 4 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 3.89
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
ELAPSED TIME OF SPILL IS 8 MIN
TOTAL AMOUNT SPILLED IS 27433 KG
CONCENTRATION AVERAGING TIME IS 8 MIN
ELAPSED TIME SINCE START OF SPILL IS 8 MIN
```

```
HEIGHT OF INTEREST IS 2 M
----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 1.09 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 2.31 KM  AT 8 MIN
 DIRECTION & WIDTH  83 +/- 45 DEG

AT 8 MIN, THE MAXIMUM DISTANCE FOR 3000 MG/M3 IS 631 M
AT 8 MIN, THE MAXIMUM DISTANCE FOR 4000 MG/M3 IS 535 M
----------------------------------------------------
```

C.3.6 Case 6

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 35.22 C
WIND DIRECTION = 256
WIND SPEED = 6 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 3.59
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
ELAPSED TIME OF SPILL IS 8 MIN
TOTAL AMOUNT SPILLED IS 27433 KG
CONCENTRATION AVERAGING TIME IS 8 MIN
ELAPSED TIME SINCE START OF SPILL IS 8 MIN
HEIGHT OF INTEREST IS 2 M

----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 771 M
MAXIMUM TOXIC CORRIDOR LENGTH = 1.62 KM  AT 8 MIN
 DIRECTION & WIDTH  76 +/- 22 DEG
----------------------------------------------------
```

C.3.7 Case 7

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 17.62 C
WIND DIRECTION = 263
WIND SPEED = .7 M/S
SUN ELEVATION ANGLE IS 40 DEGREES
CLOUD COVER IS 2 EIGHTHS
CLOUD TYPE IS HIGH (Ci, Cc, Cs)
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS .5
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
CHEMICAL IS STILL LEAKING
CONCENTRATION AVERAGING TIME IS 8 MIN
HEIGHT OF INTEREST IS 2 M
----------------------------------------------------
THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 465 M
MAXIMUM TOXIC CORRIDOR LENGTH = 977 M
 DIRECTION & WIDTH  83 +/- 180 DEG
----------------------------------------------------
```

```
CONCENTRATION AVERAGING TIME IS 8 MIN
----------------------------------------------------
THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 465 M
MAXIMUM TOXIC CORRIDOR LENGTH = 977 M
 DIRECTION & WIDTH  83 +/- 180 DEG
----------------------------------------------------

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
ELAPSED TIME OF SPILL IS 8 MIN
TOTAL AMOUNT SPILLED IS 27433 KG
CONCENTRATION AVERAGING TIME IS 8 MIN
ELAPSED TIME SINCE START OF SPILL IS 8 MIN
HEIGHT OF INTEREST IS 2 M
----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 283 M
MAXIMUM TOXIC CORRIDOR LENGTH = 902 M  AT 12 MIN
 DIRECTION & WIDTH  83 +/- 180 DEG
----------------------------------------------------
```

C.3.8 Case 8

```
CONTINUOUS RELEASE

ETHYLENE
 NO EXPOSURE LIMITS AVAILABLE AT THIS TIME

TEMPERATURE = 27.92 C
WIND DIRECTION = 249
WIND SPEED = 3.3 M/S
NIGHTTIME SPILL
CLOUD COVER IS 2 EIGHTHS
GROUND IS DRY
THERE IS NO INVERSION
ATMOSPHERIC STABILITY PARAMETER IS 4.35
SPILL SITE ROUGHNESS LENGTH IS 10 CM

THIS IS A GAS RELEASE
HEIGHT OF LEAK ABOVE GROUND IS 1.22 M
EMISSION RATE IS 3333.33 KG/MIN
ELAPSED TIME OF SPILL IS 8 MIN
TOTAL AMOUNT SPILLED IS 27433 KG
CONCENTRATION AVERAGING TIME IS 8 MIN
ELAPSED TIME SINCE START OF SPILL IS 8 MIN
HEIGHT OF INTEREST IS 2 M

----------------------------------------------------
AT 8 MIN, THE MAXIMUM DISTANCE FOR 1147 MG/M3 IS 1.56 KM
MAXIMUM TOXIC CORRIDOR LENGTH = 3.31 KM  AT 8 MIN
 DIRECTION & WIDTH  69 +/- 45 DEG
----------------------------------------------------
```