Enabling Logistics Solutions

ENVIRONMENTAL ASSESSMENT OF LOGISTICS ASSET - 2002 REVIEW AND UPDATE

PETROLEUM DEVELOPMENT OMAN

SULTANATE OF OMAN

Authorized for release by:

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EXECUTIVE SUMMARY

Introduction

This report updates the environmental assessment of Logistics asset, which is one of the eight service assets within PDO's concession area in the Sultanate of Oman. The first environmental assessment for Logistics asset was carried out in September 1999. Since then, several changes with respect to the facilities, processes and procedures have taken place in the asset. In order to review the impacts on the environment due to these changes, the environmental hazards and effects associated with the activities in the asset are reassessed in this study. This study is conducted, on behalf of PDO by HMR Environmental Consultants during the period of June-December 2002.

Overview of Asset Activities and Facilities

PDO operates over 113,550 km^2 of concession area consisting of about a hundred fields, 2,454 oil producing wells and 72 gas producing wells. Currently, PDO produces 843,490 barrels/day of crude and 44 million Sm^3 of gas on average per day.

Logistics asset is one of the eight service providers in PDO. The areas of operation of the asset cover the entire interior concession area in south and central Oman as well as Mina Al Fahal (MAF) on the coast The main responsibility of the logistics asset is to provide dedicated logistics support to all other assets in PDO for cargo haulage, passenger commuting, fleet management and warehousing.

The facilities where the logistics asset has operational control include airstrips and associated facilities; road vehicles and automobile workshops; fuelling stations; and warehouses and storage yards.

Description of Environment

The topographical features from the southernmost part of the concession area (Marmul) to the northern coast (MAF) show three distinct zones as below:

- Desert plains with very low population within most of the concession area
- Low to medium altitude hills over the southernmost and northernmost parts
- A small coastal plain surrounded with urban population

The natural vegetation is composed of desert plants and grasses, and is restricted to the wadi plains only. Among all the assets, Nimr and Marmul assets have relatively denser vegetation.

Most of the concession area falls under central and south-central Oman and is characterised by flat gravel desert plains with occasional rocky outcrops interspersed with a few wadi channels. The altitude in the plains is mostly in the range of 100-150m above the mean sea level. The desert plains are very thinly populated. Hills of low to medium altitude are encountered over the southernmost and northernmost parts of the concession area.

The MAF terminal area is located within the MAF industrial area on the shore of MAF bay and surrounded by hills, rising to 214 m altitude above the sea level on the eastern boundary. There are large urban settlements adjacent to MAF area to northwest.

The geology of most of the PDO's concession area comprises of mainly limestone with shale, dolomite and sandstone. The central plains mostly consist of flat limestones of oligocene and miocene ages to mid-tertiary. UeR aquifer is the main prolific aquifer in the area.

The mineral content in UeR water increases as it travels from south to north. Within the entire PDO concession area, only Marmul asset has groundwater that is potable without any pre-treatment. In all other assets the UeR water is very saline.

The mean monthly temperatures range from around 20°C in December/ January to about 35°C in July. The maximum absolute temperature will be as high as 50°C and the minimum absolute temperature will be as low as 5°C.

Rainfall in this region is scanty and is highly variable in time and space with an average of 36 mm per annum. Although the annual average rainfall is very low, flash floods are known to have occurred in the area. Wind speeds vary considerably from calm to strong gusts. The dominant wind direction is from the south with an average wind speed of 8 knots.

The natural flora in most of the concession area is composed of desert plants and grasses, and trees are rarely seen. Several fauna groups including mammals, birds and reptiles are seen. Large mammalian species known to inhabit the area include the Arabian Gazelle (*Gazelle gazelle*), the Rhim Gazelle (*Gazella subgutturosa marica*), the Nubian Ibex (*Capra nubiana*). These animals are currently listed on the IUCN World Red List and the Regional Red List threat categories. The Arabian Oryx is seen in Mukhaizna field in Bahja asset.

The beaches along the coastline are composed primarily of fine sand derived from the neighbouring land with shallow areas extending up to 2 km offshore. The seawater temperature at MAF ranges from 25°C in winter (February and March) up to 39°C in summer (June and July). The salinity ranges from 35 to 40 parts per thousand.

The human population density within PDO's concession area (interior areas) is extremely low and is to the order of 26 persons per 100 km^2. Within the total concession area of 113,550 km^2, the total current population is of the order of 30,000. The majority are the PDO and contractor staff living in the various accommodation camps located in the assets, and they number about 20,000 currently.

There are no forts, ruins or other archeological declared sites in PDO's concession area. However, abundant marine fossils are present in Jabal Fahud and Natih areas (Fahud asset).

Significant Environmental Effects

Based on the existing activities and the current status of the environment, the environmental hazards and potential effects are identified. The potential environmental effects are assessed based on the HEMP methodology outlined in PDO's document GU-195 "Environmental Assessment Guideline". The effects with a risk rating level of medium or higher are short-listed and the necessary additional mitigation measures are recommended. The following table summarizes the recommended additional mitigation measures against each of the environmental specifications of PDO, *viz.*, SP-1005 to SP-1012 and SP-1170.

Specification	Areas of Non-compliance or Concern	Recommended Additional Mitigation Measures
SP-1005: Specification for Emissions to Atmosphere	• With aging, the emission performance of automobile engine may deteriorate.	• Emission checks shall be routinely done for all vehicles.
SP-1006: Specification for Aqueous Effluents	• In airport passenger buildings, the overflow of raw sewage from soak pits on to land may be hazardous since it may carry pathogenic organism.	• Septic tanks and soak pits shall be checked on annual basis and cleaned if necessary.
SP-1007: Specification for Accidental Releases to Land and Water	• Not all chemicals leaks and spills are reported. • Incident reporting on accidental releases is not comprehensive.	• All chemical leaks and spills, irrespective of the quantity shall be reported and quantified. • Contaminated soils shall be promptly recovered and transferred to the waste management centre.

Specification	Areas of Non-compliance or Concern	Recommended Additional Mitigation Measures
SP-1008: Specification for Use of Energy, Materials and Resources	• Efficient use of fuel in automobiles under the operational control of logistics asset is not demonstrated.	• Fuel conservation measures shall be promoted.
SP-1009: Specification for Waste Management	• It is likely that not all contaminated soils are recovered.	• Contaminated soils shall be promptly recovered and transferred to the waste management centre.
SP-1010: Specification for Environmental Noise and Vibration	• None	• None
SP-1011: Specification for Flora and Fauna	• None	• None
SP-1012: Specification for Land Management	• None	• None
SP-1170: Specification for Management of Naturally Occurring Radioactive	• None	• None

Conclusion

Based on the present study, it is concluded that no change in PDO's existing HSE management system is required. However, it is necessary to modify the HSE plans and programmes in the asset by incorporating the additional mitigation measures recommended above. This will ensure that the potential environmental risks are minimized, non-compliances are eliminated and the overall environmental performance of the asset is significantly improved.

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ABBREVIATIONS

AP	atmospheric pressure (<0.5 kPa gauge pressure)
API	American Petroleum Institute
bar(g)	unit of gauge pressure (equal to 101.3 kPa gauge)
bbl	barrel (equal to about 159 liters)
bpd	barrels per day
Bq	Bequerel, unit for measurement of radioactivity (One nuclear disintegration/second)
^oC	degree centigrade
^oK	degree Kelvin
$CaCO_3$	calcium carbonate
CFC	chloro-fluoro-carbon
d	day
DGEA	Directorate General of Environmental Affairs
DLN	dry low NO_x
DWD	deep water disposal
ESP	electrical submersible pump
E&P	exploration & production
EPC	engineering, procurement and construction
EU	European Union
h	hour
ha	hectare
HCFC	hydro-chloro-fluoro-carbon
HFC	hydro-fluoro-carbon
HEMP	hazards and effects management process
HMR Consultants	HMR Environmental Engineering Consultants
HP	high pressure (>150 kPa gauge pressure)
kg	kilogram
km	kilometer
km^2	square kilometer
kPa	kilo Pascal, unit of pressure (1 atm = 101.13 kPa)
LP	low pressure (0.5 – 150 kPa gauge pressure)
m^3	cubic meter
mg	milligram
ml	milliliter
MLPS	main line pumping station
MOL	main oil line
MPN	most probable number
mPa.s	milli-Pascal-second (a unit of viscosity equivalent to 1 centipoise or cp)
MD	ministerial decision
MJ	mega-Joule
NOCS plant	North Oman crude stabilization plant
MW	megawatt
MWh	megawatt-hour
MRME&WR	Ministry of Regional Municipalities, Environment and Water Resources
MSDS	material safety data sheet
NAAQ	national ambient air quality
Nm^3	normal cubic meter (at 1atm and 0^oC)
NO	nitric dioxide
NO_2	nitrogen dioxide

NO_x	oxides of nitrogen
NORM	naturally occurring radioactive materials
PDO	Petroleum Development Oman LLC
ppm	parts per million
ppmv	parts per million, volume based
PM_{10}	particulate matter of <10 µm size
$PM_{2.5}$	particulate matter of <2.5 µm size
RD	royal decree
RMS	remote manifold station
RO	reverse osmosis
SHOC	safe handling of chemicals
Sm^3	standard cubic meter (at 1atm and 20^{o}C)
SOGL	south Oman gas line
STOIIP	stock tank of oil initially in place
t	metric tonne (equal to 1000 kg)
TDS	total dissolved solids
tpa	tonnes per annum (year)
tpd	tonnes per day
tph	tonnes per hour
TSP	total suspended particulates
UeR	Umm er Radhuma
UNEP	United Nations Environmental Program
UNESCO	United Nations Scientific and Cultural Organisation
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
µg	micro-gram
µm	micro-meter (also known as micron)
µS/cm	micro-Siemens per centimeter (unit of electrical conductivity)

1 INTRODUCTION

1.1 Petroleum Development Oman

Petroleum Development Oman (PDO) is the largest petroleum exploration and production (E&P) company in the Sultanate of Oman, with 113,550 km^2 of concession area, covering most of the central and southern parts of the Sultanate. The geographical map of PDO's concession area is shown in Figure 1.1. Presently, PDO's concession area is divided into two main administrative assets viz., North Oman and South Oman. The production assets within North Oman include Fahud, Lekhwair, Yibal and Qarn Alam, and those within South Oman include Bahja, Nimr and Marmul. The crude oil export facilities and the administrative head quarters are located on the coast in Mina Al Fahal. The current asset organisation structure in PDO is shown in Figure 1.2.

Currently PDO operates from about a hundred fields and has 2,454 oil producing wells and 72 gas producing wells. The total production of crude oil currently is about 843,490 barrels per day, and that of associated gas is 44 million Sm^3 per day. A network of 9,300 km of pipelines, 28 gathering stations and 18 production stations feed the produced crude oil into the main storage facility located at Mina Al Fahal near Muscat (at Muscat coastal area), from where the oil is loaded into tankers moored offshore. The produced gas is partly utilised within the assets and the rest processed in three gas stabilisation stations (located in Yibal, Saih Rawl and Saih Nihayda) and then exported. The asset-wise break-up for land area, crude oil production, gas production and production water is presented in Table 1.1 below for the current year (2002) and their percentages are given in figure 1.3.

Table 1.1: Description of Production Assets in PDO

Production Asset	**Land Area (km^2)**	**Crude Oil Production (m^3/d average)**	**Gas Production (10^3 x Sm3/d average)**	**Produced Water (m^3/d average)**
Fahud	11,580	14,670	5,007	11,239
Lekhwair Asset	3,560	14,601	1,550	21,977
Yibal Asset (including Gas Asset)	5,830	31,134	31,995	154,970
Qarn Alam Asset	18,900	14,462	3,084	67,255
Bahja Asset	30,560	12,347	550	27,050
Nimr Asset (Including Rima and Al Noor)	16,160	35,669	780	313,105
Marmul Asset	26,960	11,221	900	41,937
Total for PDO's Concession Area	**113,550**	**134,104**	**43,866**	**637,533**

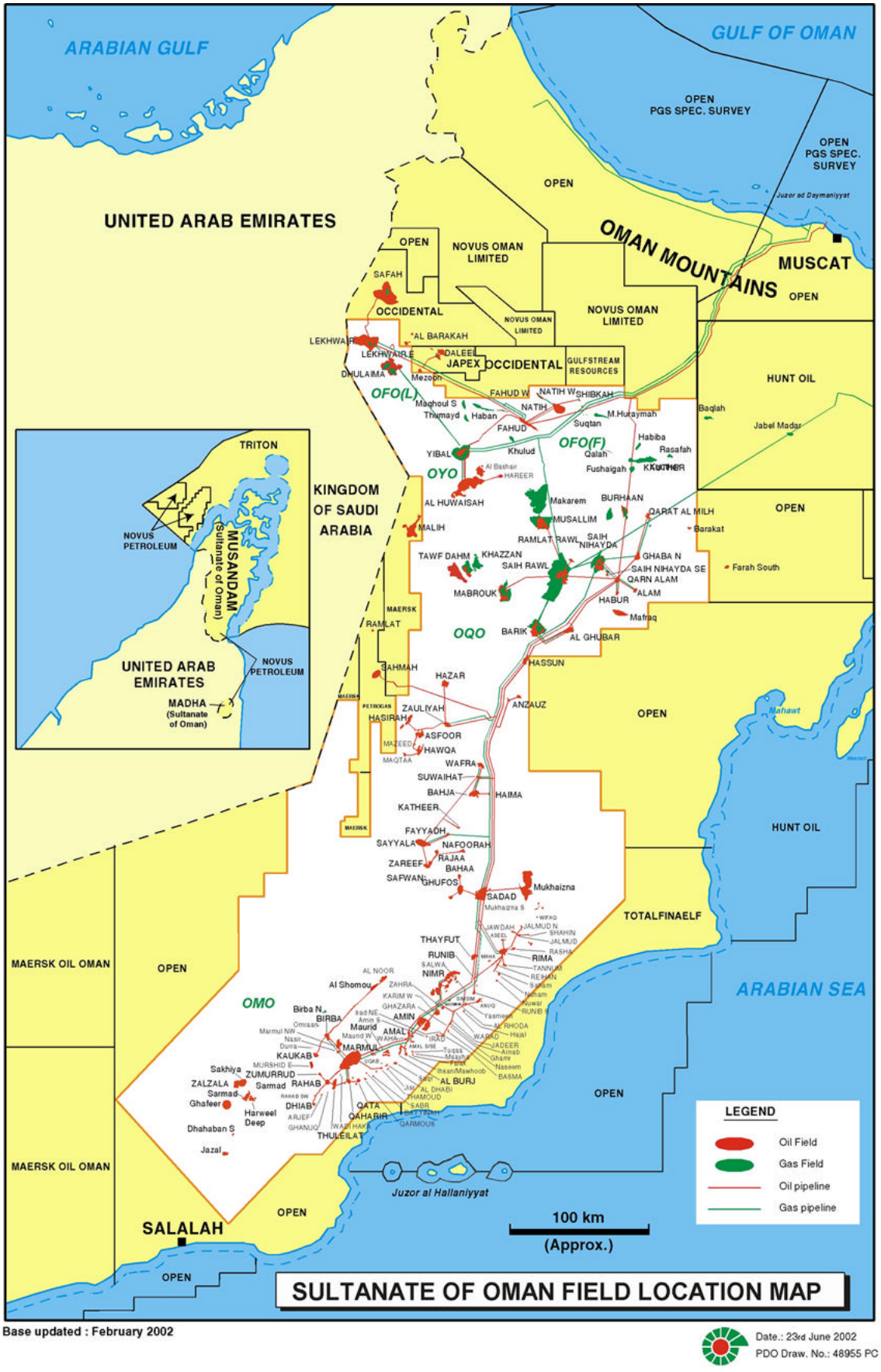


Figure 1.1: Geographical Map of PDO's Concession Area

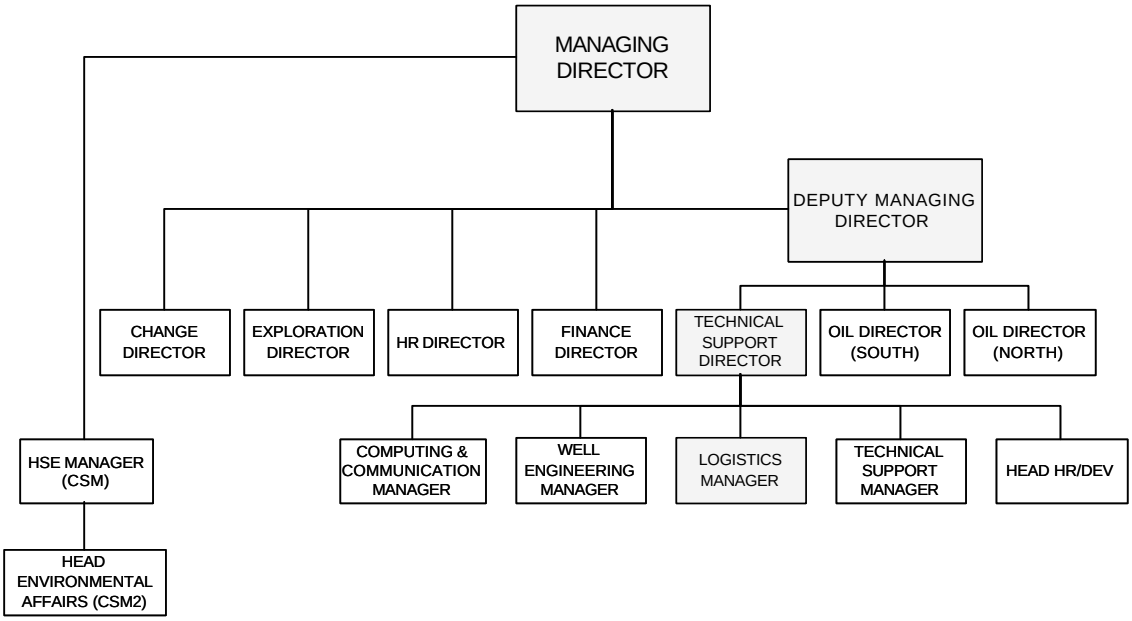
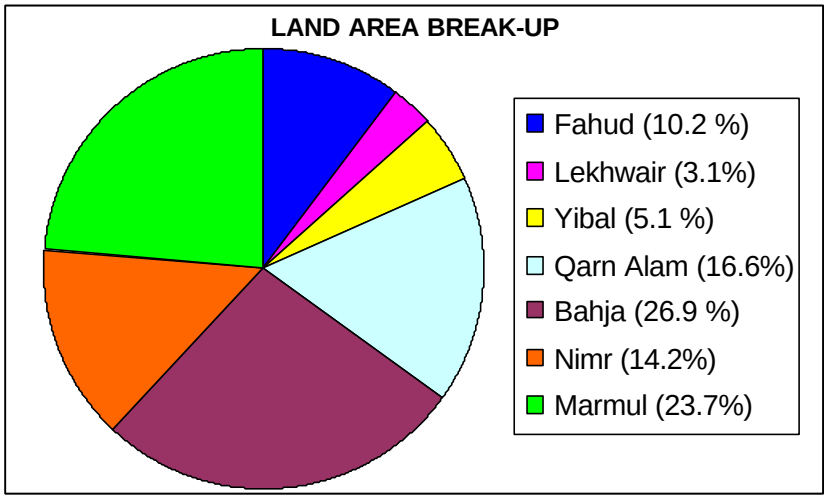
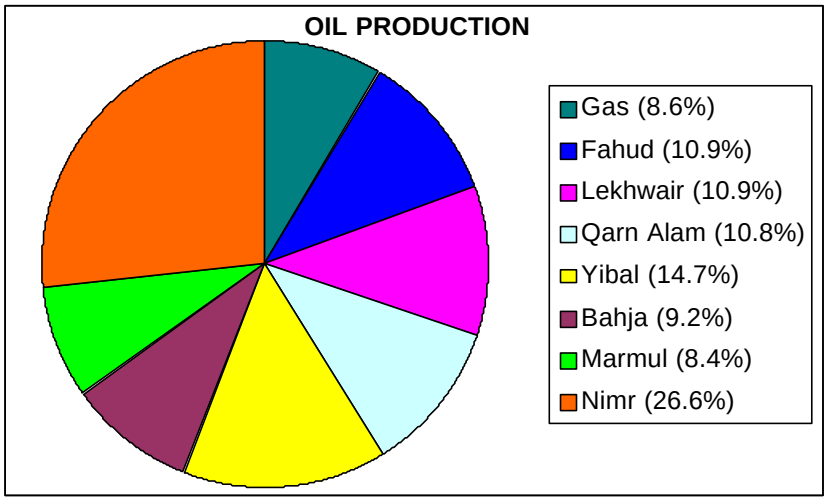
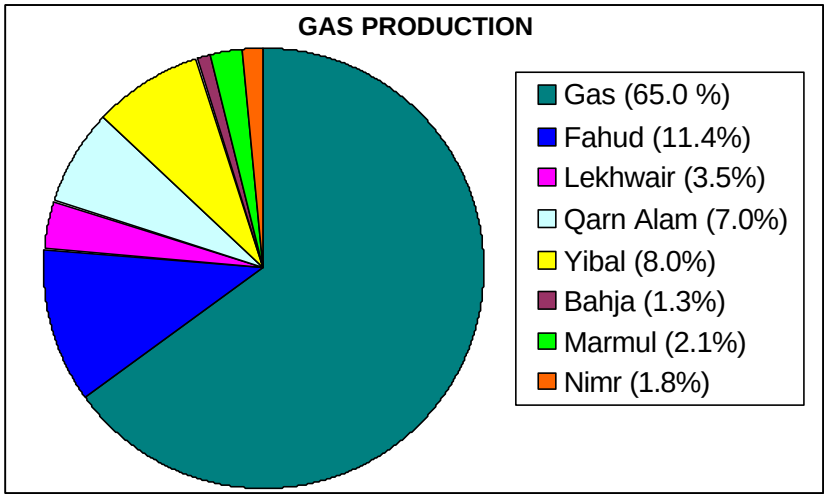


Figure 1.2: Asset Organisation Structure in PDO







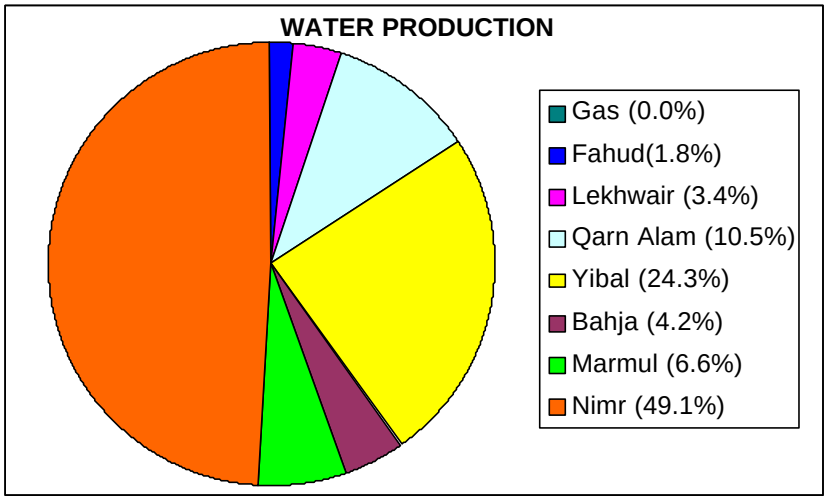


Figure 1.3: Asset-wise Break-up of Land Area, Oil, Gas and Produced Water

In addition to the seven production assets, there are eight service assets in PDO, which provide technical, analytical, engineering, supply and transportation support to the production assets. A brief description of the services assets is presented below in Table 1.2.

Table 1.2: Description of Service Assets in PDO

Service Asset	Main Activities and Areas of Operation
GeoSolutions Asset	- Provide geo-services to frontier exploration and production assets for the identification and development of hydrocarbon reserves within PDO's concession area - The areas of technical service include seismic data acquisition & processing; geological support & laboratory services; geomatics support; sub-surface information management & technology support, and reservoir characterisation.
Well Engineering Asset	- Design, construction, in-well maintenance and abandonment of production or exploration wells - Development and implementation of new drilling technologies - Maintaining well data from drilling and pumping operations
Engineering Asset	- Plan, manage and execute preventive and remedial maintenance work for all production facilities throughout PDO's concession area - Manage and execute all well maintenance services throughout PDO's concession area - Manage and execute civil engineering construction work throughout PDO's concession area - Provide technical specialist service in detailed engineering design, field execution, material selection, process control and automation for all new projects throughout PDO's concession area
Infrastructure Asset	TERMINAL OPERATIONS DEPARTMENT - Operate and maintain the Mina Al Fahal Tank Farm consisting of 10 crude oil storage tanks with a total storage capacity of 5 million barrels - Operate and maintain the offshore oil export facilities in Mina Al Fahal consisting of three single point moorings and two coastal buoy moorings - Operate and maintain the oil export metering systems and offshore oil pollution combating equipment in Mina Al Fahal POWER SYSTEMS DEPARTMENT - Operate and maintain ten power stations consisting of 22 gas turbines throughout PDO's concession area - Operate and maintain twenty-two 132 kV sub-stations throughout PDO's concession area - Operate and maintain 1276 km long 132 kV overhead electrical transmission lines throughout PDO's concession area PIPELINE DEPARTMENT - Operate and maintain 1510 km long main oil line for transportation of liquid hydrocarbons from all production assets to the export terminal in Mina Al Fahal - Operate and maintain 670 km long south Oman gas line for transportation of dry sweet gas hydrocarbons from Saih Nihayda (Qarn Alam Asset) to Marmul asset - Operate and maintain the main oil line booster stations in Hubara (Bahja Asset), Sahma (Bahja Asset) and Nahada (Fahud Asset)
Gas Asset	- Operate and maintain, on behalf of the government, gas treatment facilities (government gas plant, government butane plant and butane storage and loading facility) in Yibal - Operate and maintain, on behalf of the government, liquefied natural gas upstream facilities in Saih Rawl, Barik and Saih Nihayda

Logistics Asset	Provide dedicated logistics support to all other assets in PDO through sub-contracting for the following services: - Cargo handling and haulage including rig moves - Passenger commuting by land and air - Fleet management - Warehousing including central chemical storage
Estate Services Asset	- Provide and maintain accommodation facilities for PDO staff in Mina Al Fahal - Maintain air-conditioning and refrigeration system within PDO area in Mina Al Fahal - Provide catering and laundry services for PDO staff in Mina Al Fahal - Supply potable water and maintain electrical power distribution systems within PDO area in Mina Al Fahal - Manage sewage treatment plants, treated sewage re-use and solid waste disposal for waste generated within PDO area in Mina Al Fahal - Manage the incinerator located in Mina Al Fahal for thermal destruction of clinical wastes generated throughout PDO's concession area
Production Chemistry Asset	- Provide drilling chemistry support including analysis of drilling fluids and cements, technical specifications for drilling fluids and cements, evaluation of new drilling fluid and cement products and technologies for all assets in PDO - Provide process and treatment support including expert advice on all chemical and physical processes related to production, treatment and transportation of gas and oil for all assets in PDO - Provide laboratory support for physico-chemical analysis of well fluids, crude oil, gas, produced water, groundwater, treated water, sewage, raw materials and process chemicals for all assets in PDO

1.2 Environmental Impact Assessment

The environmental impact assessment (EIA) for all the production and service assets was first conducted during the period of 1998–2000, and based on this the environmental management plans and programmes were developed. The previous environmental assessment studies for logistics asset were completed in September 1999 (*Reference 1*). It is an internal requirement in PDO to review and update of the EIA once in every three years, in order to periodically reassess the environmental impacts and appropriately revise the environmental management plans and programmes. Accordingly, PDO has retained HMR Environmental Engineering Consultants (HMR Consultants) to carry out the first review and update of the EIA for all its assets.

This study was conducted over the period of June – December 2002 and presents the review and update of the environmental assessment for the Logistics asset

1.3 Objectives and Scope of Study

The objectives of the present environmental assessment are as follows:

- Updating the environmental inventories in the asset, taking into consideration all developments and activities that have taken place since the last environmental assessment conducted in September 1999.
- Reviewing the environmental requirements in the asset, taking into consideration any recent changes in the legislative and corporate regulations and specifications
- Auditing the environmental performance for the current year.
- Updating the environmental baseline data, wherever required.
- Reviewing the significant aspects and reassessing the environmental impacts, in view of the above.
- Revising the environmental mitigation and monitoring plan, wherever required.

The social and health impact assessment components are not included in the present study. The quantitative risk analysis is also not included in the present study.

1.4 Method of Study

This study was carried out in three stages. In the first stage, the previous EIA report (Reference 1) and other available environmental documents were reviewed. Based on this review, detailed and structured checklists were prepared for asset data verification and environmental performance audit. Subsequently, in the second stage, a site visit was undertaken to check the ground realities and to collect all necessary information. During the site visit, the key operating personnel were interviewed, and a detailed environmental audit of the various facilities in the asset was conducted. In the third stage, all the data collected were analysed and the significant environmental hazards (aspects) were identified. Then the environmental effects (impacts) were reassessed using PDO's "Hazards and Effects Management Procedure (HEMP)" as described in the PDO's document GU-195 "Environmental Assessment Guideline" (*Reference 2*). Following the reassessment, the environmental mitigation measures and the monitoring plans were revised as appropriate.

1.5 Structure of Report

This report is prepared based on the table of contents suggested for environmental assessment report in PDO's "Environmental Assessment Guideline" *(Reference 2)*. A non-technical executive summary is presented at the beginning of the report.

Section 1 overview of PDO activities and description of all the production and service assets. The scope and objective of the work is presented.

Section 2 presents the regulatory framework and outlines the environmental regulations governing the environmental aspects in the work.

Section 3 details the description of logistics asset along with the consumption of utilities and materials in the asset.

Section 4 describes the various waste products and energies released to the environment from activities performed in logistics asset. Characterisation and quantification of the various waste products released to the environment are presented in this section and their treatment and disposal practices are analysed.

Section 5 presents a detailed description of the environment status within the logistics asset.

Section 6 provides a description of the significant environmental hazards associated with the asset activities identifying the environmental effects. These effects are assed based on the methodology outlined in PDO's document GU-195. The identified potential environmental impacts were rated based on the PDO's environmental risk criteria attached in appendix.

Section 7 summarises the significant environmental effects and mitigation measures in the asset for adverse impacts. Additional mitigation measures aimed at minimizing the potential environmental risks and improvement of the overall performance were also suggested.

Section 8 lists the references used for this document.

Other useful information not included in the main text is presented in the appendices. The details of the personnel responsible in the preparation and review of the report are presented in *Appendix 1.*

2 REGULATORY FRAMEWORK

2.1 Omani Regulations

The Omani regulations on environmental protection, control and management are covered under two basic laws *viz*., the "Law for the Conservation of the Environment and Prevention of Pollution" first promulgated in 1982 as Royal Decree (RD) 10/82 and superseded in November 2001 as RD 114/2001 and the "Law on Protection of Sources of Potable Water from Pollution" promulgated in November 2001 as RD 115/2001. The responsibility for the implementation of this law rests with the Ministry of Regional Municipalities, Environment and Water Resources (MRME&WR), which issues regulations, standards and guidelines through "ministerial decisions (MDs)". Within MRME&WR, the authority responsible for environmental permitting, inspection and control in the Sultanate of Oman is the Directorate General of Environmental Affairs (DGEA).

The current Omani environmental laws and regulations are listed below in chronological order.

Table 2.1: Environmental Laws and Regulations in Oman

(Presented in Chronological Order)

Title	Reference Number
Protection of certain species of birds	MD 4/76
Law on the development of water resources and its amendments	RD 76/77, RD 82/88, RD 29/00
Omani drinking water standards	OS8/78
Law on national heritage protection	RD 2/80, RD 6/80
Law for the conservation of the environment and prevention of pollution and its amendments	RD 10/82 (superseded), RD 63/85, MD 5/86, RD 71/89, MD 2/90, RD 31/93, RD 114/2001
Regulations concerning the disposal of liquid effluents to marine environment	MD 7/84
Regulations for the discharge of industrial and commercial effluents	MD 8/84
Regulations for septic tanks and holding tanks	MD 5/86 (superseded), MD 421/98
Regulations for air pollution control from stationary sources	MD 5/86
Regulations for the registrations of existing wells and new well permits	MD 2/90
Regulations for the management of the solid non-hazardous wastes	MD 17/93
Regulation for the management of hazardous wastes	MD 18/93
Regulations for wastewater re-use and discharge	MD 145/93, RD 115/2001
Regulating issuance of environmental permits	MD 300/93
Regulation on the removal of vegetation	MD 128/93
Regulation on hunting, capture or firing at wild animals	MD 207/93
Regulations for noise pollution in public environment	MD 79/94
Regulations for noise pollution in the working environment	MD 80/94
Law on handling and use of chemicals	RD 46/95
Regulations for the handling of toxic substances	MD 248/97

Title	Reference Number
Regulations for control and management of radioactive materials substances	MD 249/97
Regulation on the use of desalination units on wells	MD 342/97
Law on protection of potable water sources from pollution	RD 115/2001

2.2 Shell Group Environmental Guidelines

The Royal Dutch Shell Group has a formulated an extensive HSE management system covering all Shell's activities including hydrocarbon exploration and production. The system includes a series of comprehensive set of guidelines, standards and procedures. These guidelines have been incorporated into PDO's series of specifications where applicable; yet remain as reference documents covering specific operations and activities.

The Shells Group environmental specifications (standards and guidelines) are listed below in Table 2.2.

Table 2.2: Shell Group Environmental Specifications

Reference Number	Title
EP 95-0110	Management of Contractor HSE
EP 95-0120	Competence Assurance for HSE-critical Activities
EP 95-0140	Exploration & Production HSE Strategy and Policy Implementation Guide
EP 95-0220	Concept Selection
EP 95-0300	Overview Hazards and Effects Management Process
EP 95-0330	Drinking Water Guidelines
EP 95-0352	Quantitative Risk Assessment
EP 95-0370	Environmental Assessment
EP 95-0371	Social Impact Assessment Guidelines
EP 95-0375	Environmental Quality Standards - Air
EP 95-0376	Monitoring Air Quality
EP 95-0377	Quantifying Atmospheric Emissions
EP 95-0380	Environmental Quality Standards - Water
EP 95-0381	Monitoring Water Quality
EP 95-0385	Environmental Quality Standards - Soil and Groundwater
EP 95-0386	Monitoring Soil and Groundwater
EP 95-0387	Contaminated Soil and Groundwater
EP 95-0390	Waste Management Guidelines
None	Guide for Risk Based Management of Potentially Contaminated Land

2.3 PDO Corporate Environmental Specifications

PDO has established a comprehensive health, safety and environment (HSE) management system, based on ISO 14001, the international standard for environmental management and EP: 95-0000, the Royal Dutch Shell group guidelines on HSE management. PDO has developed environmental specifications for application throughout its facilities within Oman, based on the Omani regulatory standards and Shell Group guidelines. PDO's specifications, which are described in the following

sections, fully comply with the Omani regulatory standards, and in most cases are more stringent. The list of PDO's environmental specifications SP-1005 to SP-1012 and SP-1170 version dated 7/2002 is presented below in Table 2.3.

Table 2.3: PDO's Environmental Specifications

Reference Number	Title
SP-1005	Specification for Emissions to Atmosphere
SP-1006	Specification for Aqueous Effluents
SP-1007	Specification for Accidental Releases to Land and Water
SP-1008	Specification for the Use of Energy, Materials and Resources
SP-1009	Specification for Waste Management
SP-1010	Specification for Environmental Noise and Vibration
SP-1011	Specification for Flora and Fauna Protection
SP-1012	Specification for Land Management
SP-1170	Specification for Management of Naturally Occurring Radioactive Materials

In the following sections, the various environmental standards given under the above specifications are summarized.

2.4 Environmental Standards

2.4.1 Emissions to Atmosphere

PDO specification SP-1005on emissions to atmosphere addresses both stationary and mobile sources and is largely based on MD 5/86 “Regulations for Air Pollution Control from Stationary Sources” and Shell Exploration and Production International best practices. These are presented below in Table 2.4.

Table 2.4: Air Emission Standards

Parameter	Maximum Permissible Concentration
Hydrogen chloride	200 mg/Nm^3
Hydrogen fluoride	100 mg/Nm^3
Oxides of nitrogen (as NO_2)	200 mg/Nm^3
Phosphorus as (P_2O_5)	50 mg/Nm^3
Hydrogen sulphide	5 ppmv (7 mg/Nm^3)
Total particulates	100 mg/Nm^3

Note: Nm^3 refers to volume at 0 ^oC and 1atm.

In addition to the above emission limits, PDO has specified the following requirements to minimise air pollution and fugitive emissions:

(a) There shall be no continuous venting of gas in new projects.

(b) Fugitive emissions occurring as a result of leaks from components (such as pipe connections, valves, rotating shafts and other packed components) shall be

minimised through enhanced maintenance programs. There shall be no significant visible emissions of fugitive dust.

(c) No smoke emitted shall be as dark or darker than shade 1 on the Ringlemann scale (equivalent to 20% opacity).

(d) No odorous substances shall be emitted to the environment that are recognisable at residences for more than 150 hours per year.

(e) CFCs, HCFCs or HFCs shall not be knowingly vented to the atmosphere. They shall be recovered and re-used during servicing and maintenance. No equipment or product containing CFCs shall be selected for purchase or lease. Further, no equipment or product containing HCFCs shall be selected for purchase or lease, unless no alternatives are available in the market.

(f) There shall be no halon releases to the atmosphere for maintenance, testing or any other purposes. Halon releases are permitted under emergency situations only. No new halon fire fighting systems in new projects shall be purchased, and no virgin halons shall be used for recharging any existing halon fire fighting systems in use.

2.4.2 Ambient Air Quality

Presently, there are no Omani standards for ambient air quality. In their absence, MRME&WR recommends the use of United States Environmental Protection Agency's (USEPA) national ambient air quality (NAAQ) standards. PDO uses World Health Organisation (WHO) - European Union (EU) and Netherlands standards, which are more stringent than USEPA's NAAQ standards. PDO's ambient air quality standards are given as both limit values and guide values. The "limit values" are the maximum permissible concentrations in the ambient air, which if exceeded will result in non-compliance. The "guide values" are the desirable upper limits. PDO's ambient air quality standards are given in Table 2.5 below.

Table 2.5: Ambient Air Quality Standards

Parameter	Averaging Period	Limit Value ($\mu g/m^3$)	Guide Value ($\mu g/m^3$)
Oxides of nitrogen as NO_2	1 hour 4 hour 24 hour 1 year	400 - 150 -	- 95 - 30
Sulphur dioxide	10 minutes 1 hour 24 hours 1 year	500 350 125 50	- - 125 30
Hydrogen sulphide	30 minutes 24 hours	- 150	7 -

Carbon monoxide	1 hour 8 hour	40000 6000	- -
Benzene	1 hour 1 year	- 10	7.5 5
Total suspended particulate matter	1 year	120	-
Particulate products of incomplete combustion	24 hours 1 year	125 50	- -

2.4.3 Aqueous Effluents

PDO specification SP-1006 on aqueous effluent discharge is derived from a number of Ministerial Decisions (in particular, MD 7/84, MD 5/84 and MD145/93). The effluents include production water and other various process waters, sewage and storm water run-off. The specification covers both land and marine discharges. The details are presented below.

- **Production Water:**

The approved PDO Production Water Management Plan, which has been agreed upon with the government consists of five principles. These principles govern the disposal of production water (or other hyper saline brines), and are listed below in the order of preference.

(a) Minimise the volumes of water produced during oil extraction.

(b) Maximise reuse of such produced waters.

(c) Phase out the use of shallow disposal wells and prevent disposal into useable or exploitable aquifers.

(d) Return production water to the producing reservoir.

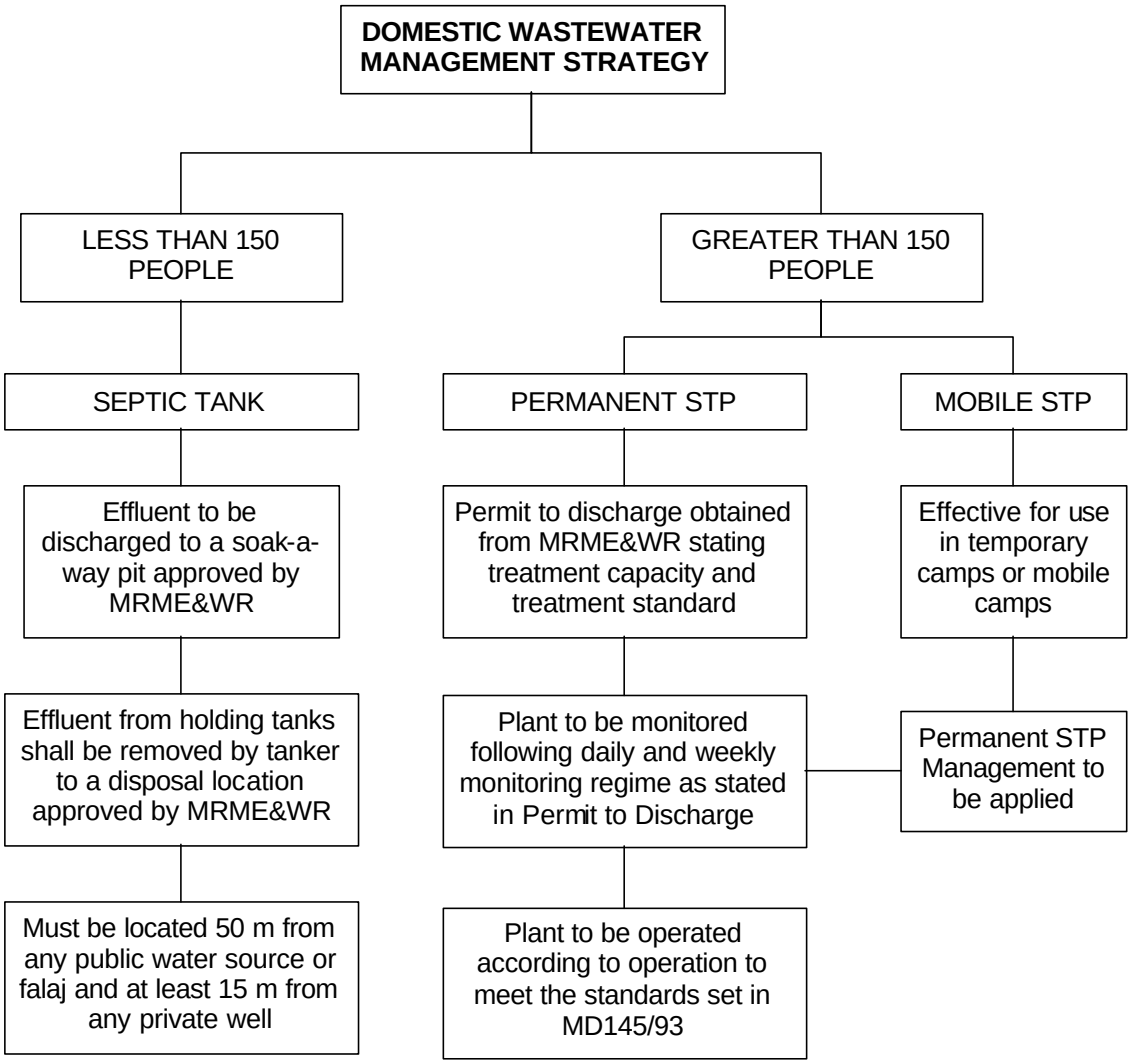
(e) Dispose surplus waters to formations, which have salinity greater than 35,000 mg/L, in conjunction with case-specific monitoring programs.

- **Other Process Effluents:**

The disposal of other process (such as reverse osmosis plants, hydrotest, maintenance etc.) effluents is dependent on the location and degree of the contamination. If the effluent is to be discharged to land then the quality of the water shall satisfy the water quality standards as identified in MD 145/93. Where the water is to be disposed of to the marine environment the effluent shall meet the water quality standards as per MD 7/84. In the event that the water quality standards are not met then the effluent discharge should be segregated and undergo treatment so as not to impact on the receiving environment.

- **Sewage Effluent:**

PDO have developed a strategy to select the wastewater treatment technology for various operations across the company. The strategy uses the population size of each camp as a basis for selecting a wastewater treatment option. This approach is summarised in the flowchart shown in below:



- **Storm Water Runoff:**

There are no legal requirements with respect to the discharge of storm water runoff uncontaminated by hydrocarbons. Potentially hydrocarbon contaminated storm water runoff shall be segregated and treated to the standards specified for on land discharge or marine disposal.

- **On Land Discharge:**

The following are PDO's standards for on land discharge and re-use of treated wastewater, which are the same as Omani standards (MD145/93 and RD 115/2001).

There are two types of standards (Standard A-1 and A-2), which differ from each other based on the intended re-use of treated sewage effluent. They are presented in Table 2.6.

Table 2.6: Classification of Standards A-1 and A-2 for Re-use of Treated Wastewater

Specification	Standard A-1	Standard A-2
Crops	- Vegetables likely to be eaten raw - Fruit likely to be eaten raw and within 2 weeks of any irrigation	- Vegetables to be cooked or processed - Fruit if no irrigation within 2 weeks of cropping - Fodder, cereal and seed crops
Grass and ornamental areas	- Public parks, hotel lawns recreational areas - Areas with public access. - Lakes with public contact (except place which may be used for praying and hand washing)	- Pastures - Areas with no public access

The treated wastewater if discharged on land shall meet the following specifications given In Table 2.7.

Table 2.7: Standards for Treated Wastewater Discharged on Land

Parameter	Units	Standard A-1	Standard A-2
Biochemical oxygen demand (5 days @ 20^0C)	mg/L	15	20
Chemical oxygen demand	mg/L	150	200
Suspended solids	mg/L	15	30
Total dissolved solids	mg/L	1500	2000
Electrical conductivity	µS/cm	2000	2700
Sodium absorption ratio	-	10	10
pH	-	6 - 9	6 -9
Aluminium (as Al)	mg/L	5	5
Arsenic (as As)	mg/L	0.100	0.100
Barium (as Ba)	mg/L	1	2
Beryllium (as Be)	mg/L	0.100	0.300
Boron (as B)	mg/L	0.500	1.000
Cadmium (as Cd)	mg/L	0.010	0.010
Chloride (as Cl)	mg/L	650	650
Chromium (total as Cr)	mg/L	0.050	0.050
Cobalt (as Co)	mg/L	0.050	0.050
Copper (as Cu)	mg/L	0.500	1.000
Cyanide (total as CN)	mg/L	0.050	0.100
Fluoride (as F)	mg/L	1	2
Iron (total as Fe)	mg/L	1	5
Lead (as Pb)	mg/L	0.100	0.200
Lithium (as Li)	mg/L	0.070	0.070
Magnesium (as Mg)	mg/L	150	150
Manganese (as Mn)	mg/L	0.100	0.500
Mercury (as Hg)	mg/L	0.001	0.001
Molybdenum (as Mo)	mg/L	0.010	0.050
Nickel (as Ni)	mg/L	0.100	0.100

Parameter	Units	Standard A-1	Standard A-2
Nitrogen: Ammoniacal (as N) : Nitrate (as NO_3) : Organic (Kjeldahl) (as N)	mg/L	5 50 5	10 50 10
Oil and grease (total extractable)	mg/L	0.500	0.500
Phenols (total)	mg/L	0.001	0.002
Phosphorus (total as P)	mg/L	30	30
Selenium (as Se)	mg/L	0.020	0.020
Silver (as Ag)	mg/L	0.010	0.010
Sodium (as Na)	mg/L	200	300
Sulphate (as SO_4)	mg/L	400	400
Sulphide (total as S)	mg/L	0.100	0.100
Vanadium (as V)	mg/L	0.100	0.100
Zinc (as Zn)	mg/L	5	5
Faecal coliform bacteria	Number per 100 mL	200	1000
Viable nematode ova	Number per L	<1	<1

The sludge generated from the treatment of domestic wastewaters may be applied on land for agricultural use, subject to the conditions set in Table 2.8. After spreading the sludge, there must be at least a three-week period before any grazing or harvesting of forage crops. Sludge application on land prohibited in the following cases:

- On soils while fruits or vegetable crops, other than fruit trees, are growing or being harvested
- For six months preceding the harvesting of fruit or vegetables that are normally eaten raw, and grown in contact with the soil
- On soils with pH less than 7

Table 2.8: Maximum Permissible Metal Concentrations in Sludge

Metal	Maximum Permissible Concentration (mg/kg dry solid)	Maximum Application Rate (kg/ha/yr)	Maximum Permissible Concentration in Soil (mg/kg dry solid)
Cadmium	20	0.150	3
Chromium	1000	10	400
Copper	1000	10	150
Lead	1000	15	30
Mercury	10	0.100	1
Molybdenum	20	0.100	3
Nickel	300	3	75
Selenium	50	0.150	5
Zinc	3000	15	300

Any sludge containing metal concentration above the following prescribed limits shall be disposed in sanitary landfills or to other facilities with approval from MRME&WR.

- **Marine Disposal:**

Any effluent discharged into the marine environment shall meet the specifications given below in Table 2.9, which are same as or more stringent than the discharge limits into the marine environment as per MD 7/84.

Table 2.9: Standards for Treated Wastewater Discharged into Marine Environment

Parameter	Discharge limit
Arsenic	0.05 mg/L
Cadmium	0.05 mg/L
Chromium	0.50mg/L
Copper	0.50 mg/L
Cyanide	0.10 mg/L
Iron	2.00 mg/L
Lead	0.10 mg/L
Mercury	0.001 mg/L
Nickel	0.10 mg/L
Selenium	0.02 mg/L
Silver	0.005 mg/L
Zinc	0.10 mg/L
Chlorine (salt)	2.50 mg/L (minimum)
Hydrogen ions	6-9 units
Sulfide salts	0.10 mg/L
Sticking solid particles	30.0 mg/L
Sludge	75.0 Jackson sight unit
BOD	30.0 mg/L
Oil & grease	5.0 mg/L
Carbolic acids (phenols)	0.10 mg/L
Ammonium nitrates	40.0 mg/L
Phosphates	0.10 mg/L
Faecal coliforms	100 MPN/100 mL (80% samples)
Faecal streptococci	100 MPN/100 mL
Salmonella	Zero MPN/L

2.4.4 Accidental Releases to Land and Water

PDO specification SP-1007 on accidental releases to land and water focuses on minimising the effect on groundwater, and soil. The requirements are outlined below:

- Equipment, processes, pipelines etc. containing material harmful to the environment shall be designed, maintained, operated and abandoned to prevent accidental releases to the environment
- In case of a loss of containment to the environment, the contamination shall be assessed and the soil and groundwater shall be cleaned to a level compatible with the environmental quality standard of the receiving environment (available EP 95-0385)

2.4.5 Use of Energy, Materials and Resources

PDO specification SP-1008 on the use of energy, materials and resources attempts on the efficient use of natural resources. The requirements under this specification are outlined in Table 2.10.

Table 2.10: Applicable Requirements for the Use of Energy, Materials and Resources

Indicators	Requirement
Energy	- Efficient use of energy at all times shall be demonstrated
Water Resources	- RD 82/88 controls the exploitation of groundwater in the interest of agricultural and development plans - MD 2/90 requires all wells used for the detection or extraction of groundwater be registered with MRME&WR - Efficient water use shall be demonstrated for hydrocarbon production
Land Use	- Under PDO's concession agreement, land no longer necessary for operations shall be handed back to the government
Use of Chemicals	- The manufacture, import, storage, handling and use of any chemical substance shall comply with RD 46/95 - Under RD/248/97, the manufacture, export, transport, storage, handling use, and disposal of any chemical substance will require a permit from MRME&WR - Chemicals shall only be bought with valid Safe Handling of chemicals (SHOC) card. The chemicals shall be stored with the SHOC card visible

2.4.6 Waste Management

PDO specification SP-1009 on waste management defines what are hazardous and non-hazardous wastes, and outlines the waste management strategy in PDO. This specification complies with Omani regulations MD 17/93 and MD 18/93 dealing with non-hazardous and hazardous waste management. The classification of non-hazardous and hazardous wastes is specified under SP 1009 as below in Table 2.11.

Table 2.11: Classifications of Hazardous and Non-Hazardous Wastes

Hazardous Wastes	Non-Hazardous Wastes
Hazardous empty drums	Kitchen refuse
Waste lubricants	Domestic waste
Pigging sludge	Tree/grass cuttings
Tyres	Water-based drilling mud and cuttings
Batteries	Office waste
Clinical waste	Non-hazardous waste chemicals
Naturally occurring radioactive material	Non-hazardous empty drums
Sewage sludge	Scrap metal
Oil-based drilling mud and cuttings	
Hazardous waste chemicals and lab waste chemicals	
Oily sand /soil	
Oily sludge	

PDO's waste management hierarchy is as below:

- Pollution prevention: elimination, change or reduction of operating practices, which result in wastes
- Source reduction: generation of less wastes through more efficient processes
- Re-use: the use of materials or products that are reusable in their original form
- Recycling/recovery: the conversion of waste into usable materials, or the extraction of energy or materials from the waste
- Treatment: the destruction, detoxification and/or neutralisation of residues
- Responsible disposal: depositing wastes using appropriate methods for a given situation

Based on the above hierarchy, the detailed waste handling and disposal procedures are given in the specification SP-1009. The procedures for the handling and disposal of NORM wastes are given under the specification SP-1170. These are discussed in Section 2.4.10 in this chapter.

2.4.7 Environmental Noise and Vibration

PDO specification SP-1010 on environmental noise and vibration is based on Omani standards MD 79/94 and MD 80/94. PDO standards on ambient noise, which are the same as Omani standards (MD 79/94) are summarized in Table 2.12 below.

Table 2.12: Ambient Noise Standards

Type of District	**Maximum Permissible Noise Level [as L_{eq} in dB (A)]**		
	Workdays – Day time (7am –6pm)	**Workdays – Evening (6pm –11pm)**	**Workdays Night time (11pm- 7am) and Holidays**
Rural, residential, recreational	45	40	35
Suburban residential	50	45	40
Urban residential	55	50	45
Urban residential with some workshops or business	60	55	50
Industrial and commercial	70	70	70

2.4.8 Flora and Fauna

PDO specification SP-1011 on protection of wildlife is developed in response to several Omani royal decrees and ministerial decisions on environmental protection. The

specification outlines specific ecological zones and based on their importance, defines specific requirements for carrying out projects. These are summarized in Table 2.13 below.

Table 2.13: Classification of Environmentally Sensitive Areas

Ecological Zone	Description	Requirements
Zone 1: Areas of Concern	National reserves or sanctuaries	Activities shall be restricted
	Areas that provide habitat to particularly sensitive wildlife	
	Areas containing high proportions of endemic flora or fauna	
	Woodlands	
	Areas of exceptional natural beauty	
Zone 2: Areas of Interest	Areas having significant natural features and beauty	Activities shall be restricted for those not compatible with the protection of the area
	Areas showing features of geological or climatic history	
	Artificially created areas to attract wildlife and migratory birds	
Arabian Oryx Sanctuary	Area defined by RD 9/94	Case-specific approval from MRME&WR

2.4.9 Land Management

There is currently no specific Omani legislation on land management (site preparation, abandonment and restoration). PDO's policy on abandonment requires that redundant assets shall be removed where appropriate and the environment restored to, or as near as reasonably practicable, to its original state. PDO specification SP-1012 on land management is summarized below in Table 2.14.

Table 2.14: Land Management Requirements

Project Stage	Requirements
Site Selection	- Selection of a site shall be carried out in accordance with PDO's procedure on HEMP and environmental assessment guideline
Site Preparation	- Earthmoving shall be conducted to minimize environmental effects - Trees shall not be felled or removed - Borrow pits shall not be excavated more than 2m in depth - Borrow pits shall not be excavated in wadis, in areas used by grazing livestock or in areas which would cause nuisance to local inhabitants - A 20m wide right-of-way shall be provided for all pipelines (10m each side) - Where pipelines or roads cross wadis, earthmoving shall be carried out to minimize flow or characteristics of shallow aquifers

Project Stage	Requirements
Site Abandonment and Restoration	- Restored land shall be visually similar to the surrounding landscape - All waste materials shall be removed - Hydrocarbon shall be removed from site if concentrations greater than 1% weight - Areas having less than 1% weight hydrocarbon contamination shall be covered with 0.6m of clean sand within 6 months of abandonment - All pipelines, process equipment and instrumentation shall be removed - All camp facilities shall be removed and site re-graded. Any soak pits shall be backfilled - Borrow pits shall be filled with 0.3m of clean sand and graded to match the surrounding contours

2.4.10 NORM Waste Disposal

Oil sludges, pigging wastes, tubulars and water/well accessories from reservoir locations are known to contain NORM materials. The monitoring, handling, transport, storage, treatment and disposal of NORM wastes are specified under SP-1170 "Specification for Management of Naturally Occurring Radioactive Materials". This specification conforms to MD 249/97, " Regulations for the Control and Management of Radioactive Materials". Any waste having radioactivity greater than 100 Bq/g (for solids) and 100 kBq/L (for liquids) is classified as radioactive waste. Such waste shall be sent to PDO's dedicated storage facility in Zauliyah as soon as possible. Normal transport vehicles can be used. However, the waste shall be packaged as per the detailed procedures given in the specification. Any recyclable items shall be released only after they are decontaminated by an authorised contractor at the designated site, such that the radioactivity level is reduced to <100 Bq/g. If decontamination is not possible, the wastes shall be retained at the storage site until the radioactivity level drops to <100 Bq/g.

3 ASSET DESCRIPTION

3.1 Introduction

Logistics asset is one of the eight service providers in PDO. The areas of operation of the asset cover the entire interior concession area in south and central Oman as well as Mina Al Fahal (MAF) on the coast The main responsibility of the logistics asset is to provide dedicated logistics support to all other assets in PDO for cargo haulage, passenger commuting, fleet management and warehousing.

The asset provides four different specialist services *viz.,* cargo haulage and handling, warehousing, passenger commuting and fleet management. Cargo haulage and handling services include rig moves and well test units; cargo consolidation and delivery; loading and unloading of cargo; water haulage; and clearing and forwarding of cargo. The warehousing services include the receipt and storage of materials; issue and despatch of materials; processing of surplus materials and preservation of materials. The passenger commuting services include the management of air transport; land transport; emergency evacuation and chauffeur services. The fleet management services include the management of light vehicles (pool car and permanent allocation); special vehicles and fuel supply. It may be noted that these services are not provided directly by the logistics asset. Instead, the asset provides these services through contractors. Thus the role of the logistics asset is to provide these services to all internal customers in PDO through a combination of contract management and consultancy.

The logistics asset works under the overall direction of the Technical Support Director. At the asset level, it is managed by the Logistics Manager, assisted by four departmental heads. The asset management structure including the health, safety and environment (HSE) management structure is shown in Figure 3.1.

3.2 Description of Facilities

3.2.1 General

The logistics asset does not possess any physical facilities. The facilities required for providing the logistic services are owned by the other assets, but their operational and management responsibility rests largely with the logistics asset. The facilities where the logistics asset has operational control include airstrips and associated facilities; road vehicles and automobile workshops; fuelling stations; and warehouses and storage yards.

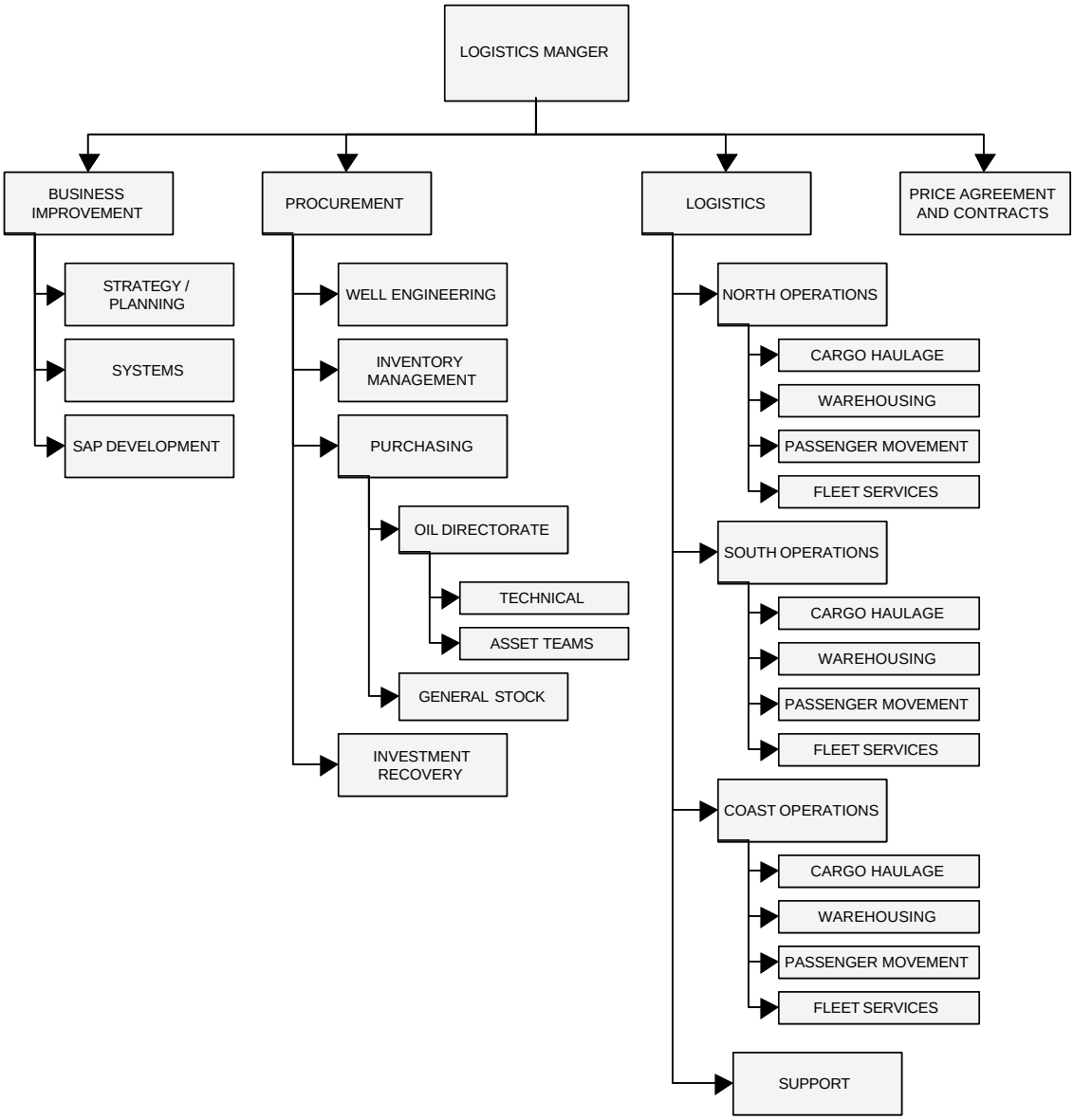


Figure 3.1: Asset Management Structure for Logistics Asset

The asset has no operational control over the aircrafts and fire / crash tenders. Details of the facilities where logistics asset has operational control are given in Table 3.1.

Table 3.1: Details of Physical Facilities Under the Operational Control of Logistics Asset

Facilities	Area of Location									
	Mina Al Fahal	Fahud	Lekh-wair	Yibal	Qarn Alam	Bahja	Rima	Nimr	Marmul	PDO Total
Airports (airstrips and associated buildings)	0#	1	1	0	1	1	0	1	1	6
Aviation fuel bulk storage and aircraft re-fuelling facilities	0#	1	0	0	0	0	0	1	1	3
Air mobile tractors, air conditioning units etc.	0#	1	0	0	0	0	0	0	1	2
Warehouses	1	1	0	0	0	0	0	0	1	3
Storage yards	1	1	0	0	0	0	0	1	1	4
Central chemical stores	1	1	0	0	0	0	0	1	1	4
Automobile fuelling stations	0	1	1	1	1	1	1	1	1	8
Automobile workshops - light vehicles	0	1	1	1	1	1	1	1	1	8
Automobile workshops - heavy vehicles	0	1	0	0	0	0	0	1	1	3
Road vehicles -light										660
Road vehicles - heavy and specialised										75

 # The PDO does not have a dedicated airport in MAF. The Seeb Airport is used for the landing, takeoff and parking of the aircraft used by PDO. The fire / crash tenders used in the interior airports are not under the operational control of the logistics asset.

A brief description of the major facilities under the operational control of logistics asset is presented in the following sections.

3.2.2 Airports

Presently, there are six airstrips in operation in PDO's concession area located in Fahud, Lekwair, Qarn Alam, Bahja, Nimr and Marmul. The airports operate every day of the week from 7 AM to 6 PM. However, they are manned only during the aircraft landing and take-off periods. The average scheduled flight frequency in the interior locations is less than one flight per day. The interior airports also handle unscheduled flights involving chartered flights and helicopters at the special request of a customer. The fleet currently used for air travel within PDO's concession area consists of three ATR 42-500 turboprop aircrafts each with a seating capacity of 46 passengers. The aircraft operation and maintenance services are contracted to Oman Aviation Services Company S.A.O.G.

Each airstrip has an unpaved runway. The associated facilities at each airstrip include the passenger building, fire / crash tender vehicles and car park. Aviation fuel storage and aircraft re-fuelling facilities are available in only three locations *viz.*, Fahud, Nimr and Marmul. The aviation fuel storage capacities in these locations are 94.3 kL, 54.0 kL and 81.0 kL respectively. There are no aircraft hangars in any of the interior locations. The fire / crash tenders are normally stationed in the PDO camp and brought to the airstrip only during the aircraft landing and takeoff periods.

Each passenger building has a check-in counter, a waiting area and toilets. There is no canteen or pantry, however there are vending machines for packaged snacks and soft drinks. Sewage from the toilets is collected in a septic tank and the overflow flows into a soak pit.

3.2.3 Storage Facilities

- **Overview**

The logistics asset deals with the storage and issue of all materials and equipment bought by PDO for use in any asset. The storage facilities provided for these materials include warehouses, storage yards and chemical stores.

The warehouses are located in MAF, Fahud and Marmul. A new warehouse is currently planned in Qarn Alam asset. Within the warehouses, separate areas are provided for the storage of materials that require special handling or storage environment. Heat sensitive materials such as rubber linings, thermometers, instruments etc. are stored in separate cold storage rooms. These areas are provided with temperature control and emergency power supply systems. Separate storage areas are also provided within the warehouses for new project supplies and emergency equipment.

Outdoor storage yards are located in MAF, Fahud, Nimr and Marmul. Here heavy equipment and bulk materials like pipes, drilling casings, drilling strings etc. are stored.

Chemicals are stored in the central chemical stores, located in MAF, Fahud, Nimr and Marmul adjacent to the storage yards. Toxic chemicals are stored in separate areas within the chemical stores with access control. Compressed gas cylinders are also stored in covered outdoor areas adjacent to the chemical stores. Details of the chemical stores and present storage practices are elaborated in a separate report titled on “Environmental Audit of Central Chemical Stores” prepared in 2003 in parallel with the review and update of environmental impact assessment.

The warehouses, storage yards and chemical stores operate from 7 AM to 6 PM on all days in the interior and from 7 AM to 4 PM on weekdays (Saturday to Wednesday) in the coast. These facilities are manned by PDO staff with labour supplied by contractors.

- **Central Chemical Stores in MAF**

The central chemical stores in MAF are located within PDO's supply area in MAF industrial area. This supply area consists of several warehouses and storage yards for a range of materials consumed in MAF. The chemical stores within the supply area consist of toxic material store, warehouse #3 and gas storage shed. In toxic material store, highly toxic chemicals and laboratory chemicals are stored. In warehouse #3, marine chemicals and fire fighting chemicals are stored. Both facilities are permanent buildings. The industrial gas cylinders are stored in an open shed adjacent to warehouse #2 of the supply area. The used cylinders are stored at separate location very near to the gas cylinder storage area.

The toxic material store is a permanent building with a partition to separate toxic chemicals and laboratory chemicals. This building is made up of masonry wall up to roof level with concrete flooring. Forced ventilation is provided with exhaust ducts and fans, and the vented air is passed through filters. Drains covered with gratings are provided inside the building, through which any accidental chemical spills are collected into a spillage collection pit located outside the building. The collection pit is a concrete pit with a removable steel cover.

Only half of warehouse #3 is used for the storage of marine chemicals and fire fighting chemicals. A separate enclosure with false roofing is constructed within warehouse #3 for the storage of these materials. The enclosure is provided with forced ventilation system. Covered drainage is provided inside the room to drain any accidental chemical spills into a waste pit located outside of the warehouse. The waste pit is covered with concrete slab. Pipe connection is provided to remove and dispose the chemical waste collected in the pit.

Gas cylinders are stored in a shed adjacent to warehouse #2. The shed is constructed with solid wall of about 2 m height and about 1.5 m steel lattice above the wall. The shed is divided into several compartments with masonry walls. Cylinders are stored in those compartments. Each compartment is provided with a name board and SHOC card for the gas stored in it. The shed has natural ventilation. No drains are provided, since no chemicals are expected.

Personal protective equipment such as coveralls, aprons, hand gloves, facemasks and boots and first aid kits are provided in the toxic material store. Further, an emergency

shower is also provided just outside the building. Portable fire extinguishers are provided outside the toxic material store and warehouse #3. A fire hydrant is also provided near to toxic material store.

- **Central Chemical Stores in Fahud**

The central chemical stores in Fahud are located near the main warehouse, adjacent to the ROP camp. The storage area is sub-divided into mud chemical storage, hazardous chemical storage and bulk chemical storage.

Mud chemicals are stored in open area without any concrete flooring, roofing or spillage collection system.

Hazardous chemicals are stored in three sheds. One is a built-up air-conditioned (cold storage) room, where currently greases and paints are stored. The other two are open shed with roofing, concrete flooring and drainage facility. Since the capacity of the hazardous stores is not adequate, many hazardous chemicals are stored in open space without any hard standing and spillage collection facility.

Bulk chemical storage consists of five cylindrical steel tanks each of 27 m^3 capacity for liquid chemicals. Out of these, two tanks are empty and presently not in use. The tanks are provided with concrete bunding with drainage facility. Vents are provided for the tanks for breathing.

Emergency showers are provided at the hazardous chemicals storage sheds. An eye wash facility is provided at the mud chemicals storage area. However no personal protection equipment are presently available in the chemical stores. Portable fire fighting equipments are provided inside the chemical store.

- **Central Chemical Stores in Nimr**

The central chemical stores in Nimr are located outside the PDO's main camp, behind the fuel filling station. This is a fairly new area facility with about 4 ha land area. The storage area is sub-divided into distinct areas for the storage of hazardous chemicals, mud chemicals and other miscellaneous chemicals.

Hazardous chemicals are stored in two sheds with concrete flooring and permanent roofing. The sheds are closed on three sides with the front side open. Mud chemicals are stored in uncovered open yards on concrete flooring. Other miscellaneous chemicals in bags and containers are stacked in an open area with no concrete flooring and permanent roofing. However, all the chemical bags and containers are covered with tarpaulins sheets to protect from direct sunlight.

The storage areas for hazardous chemicals and mud chemicals are provided with drainage systems covered with gratings. Two spillage collection pits are provided at the either end of the floor to collect any accidental chemical spills. The collection pits are made of concrete with removable covers.

Personal protective equipment such as coveralls, aprons, hand gloves, facemasks and boots and first aid kits are provided in the storage areas. Emergency showers are provided at the hazardous chemicals storage sheds. An eye wash facility is provided at the mud chemicals storage area. Currently, no fire fighting equipment are available in the storage areas. It is understood that the construction of this storage facility is not yet completed and the necessary fire protection equipments will be installed shortly.

- **Central Chemical Stores in Marmul**

The central chemical stores in Marmul are located near the Main Production Station and adjacent to the supply yard. The total chemical storage area is about 5 ha. This area is sub-divided into three distinct areas, *viz*., hazardous chemicals storage, liquid chemicals storage and mud chemicals storage areas.

The hazardous chemicals storage area is an open area, which is fenced off from the other chemical storage areas. The hazardous chemicals are stored in individual containers placed on un-floored surface in the open yard with no cover. No bunding or drainage system is provided for any spill containment. In the liquid chemicals storage area, liquid chemicals in drums are stored on a platform made up of steel pipes. This provides a collection space below the platform for the collection of any liquid spills. However, no drainage facility provided for the collection of the spills. This storage area is also an open yard with no roof or cover. The mud chemical storage area is also similar in design to the hazardous chemicals storage area.

Personal protective equipment such as coveralls, aprons, hand gloves, face masks and boots and first aid kits are provided in the facility. An emergency shower and an eye wash station are also provided near the hazardous chemicals storage area. The mud chemicals storage area is also provided with an eye wash facility. Portable fire extinguishers are provided inside the hazardous chemicals and mud chemicals storage areas.

It is understood that this storage facility is under closure. It is proposed to decommission this facility by the end of this year. Upon closure, the entire inventory will be transferred to the central chemical store located in Nimr. Consequently, the Nimr facility will serve the entire South Oman assets.

3.2.4 Automobile Fuelling Station

Automobile fuelling stations are located in all the production assets (Fahud, Lekhwair, Yibal, Qarn Alam, Bahja, Nimr and Marmul) and in MAF. They are located near PDO's main camp in each area. They are operated and maintained by Al Maha on behalf of logistics asset. Petrol and diesel are dispensed in these stations for PDO staff, contractor staff and public. No car wash or vehicle maintenance facilities are available in these stations. Sanitary facilities are provided in these stations and the sewage is connected to the nearest sewage treatment plant.

For the bulk storage of diesel and petrol, over-ground and underground tanks are provided. All are fixed roof steel tanks, each of 50 kL capacity. Over-ground tanks are provided with bund walls to contain any leaks and spills. Oil spillage collection pit is provided inside the bund wall to collect the spillage and from there it is vacuumed for disposal in case of any leakages. For underground storage tanks, monitoring pits are provided below the storage tanks to check for any leakages from the storage tanks. Vents are provided to the storage tanks for atmospheric release of vapours during filling and breathing. Fire hydrants and portable fire extinguishers are provided in all fuelling stations. There is no spillage collection system or drainage facility provided for the oily contaminated water or spillages from the fuelling area.

3.2.5 Automobile Workshops

All the production assets (Fahud, Lekhwair, Yibal, Qarn Alam, Bahja, Nimr and Marmul) and MAF area are provided with automobile workshops for the maintenance and repair of light vehicles provided by the logistics asset. On behalf of logistics asset, the workshops in Fahud, Lekhwair, Yibal and Qarn Alam are operated by ACM Limited, while the workshops in Bahja, Nimr and Marmul are operated by Saud Bahwan Group. Heavy and specialised vehicle workshops are provided in three locations, *viz*., Fahud, Nimr and Marmul. These workshops are operated on behalf of logistics asset by Al Nadha Al Omaniya Company.

The services provided in the automobile workshops include water washing, oil change, battery servicing, air-conditioning services, limited engine works, tyre change and air filling. Facilities are provided for waste and wastewater collection and disposal.

3.2.6 Road Vehicles

Logistics asset has a fleet of about 660 light vehicles and about 75 heavy and specialised vehicles. The light vehicles include both two-wheel drive and four-wheel

drive. These vehicles meet the Shell standards and PDO specifications, and are fitted with necessary safety equipment. Each vehicle carries a fuel card for cash-free refuelling in any of the PDO fuelling stations.

3.3 Activity Description

3.3.1 Overview

The operational activities of logistics asset cover the entire interior concession area in south and central Oman as well as MAF on the coast Logistics asset provides dedicated logistics support to all other assets in PDO for cargo haulage, passenger commuting, fleet management and warehousing. The operation of the logistic asset has the following operational dimensions:

- About 430,000 number of passengers transported by air and land annually
- About 35 million tonne-km of cargo transported annually
- About 300 rig movements annually
- About 300,000 m^3 water haulage annually
- Hundred of materials and chemicals stored in three main warehouses, four storage yards and four central chemical stores

As explained earlier, these services are provided by the logistics asset through contractors. However, the warehousing services are directly administered by logistics asset. The principal contractors engaged by logistics asset to provide the logistics support services are listed below in Table 3.2.

Table 3.2: Principal Service Contractors of Logistics Asset

Service Provided	Name of the Contractor
Air transport services including air craft operation and maintenance	Oman Aviation Company
Aviation fuel supply and handling	Shell Oman Marketing Company
Passenger transport services in MAF	Al Sumri Trad & Cont. Est
Passenger transport services in Fahud, Lekhwair, Yibal and Qarn Alam	Al Khatmah Trad & Cont. Est
Passenger transport services in Bahja, Nimr and Marmul	Oman National Transport Corporation
Cargo handling and haulage in MAF	Majan International Agencies
Cargo handling and haulage in Fahud, Lekhwair, Yibal and Qarn Alam	Ofsat
Cargo handling and haulage in Bahja, Nimr and Marmul	Truckoman
Water haulage in Fahud, Lekhwair, Yibal and Qarn Alam	Fahud Desert Trading
Water haulage in Bahja, Nimr and Marmul	Nimr Contracting Company
Automobile fuelling stations throughout PDO	Al Maha

Automobile workshops for light vehicles in Fahud, Lekhwair, Yibal and Qarn Alam	ACM Limited
Automobile workshops for light vehicles in Bahja, Nimr and Marmul	Saud Bahwan Group
Automobile workshops for heavy / specialised vehicles throughout PDO	Al Nadha Al Omaniya Company

3.3.2 Passenger Transport

Land transport services include operating mass transport within the interiors (mostly for airport pick-up and drop-off for air commuters), providing pool cars for permanent PDO staff and temporary visitors to interior assets, medical emergency evacuation for patients and permanent transport to senior managements. The list of contractors who will provide the land transport services is shown in Table 3.2. For mass transport within the interior locations, 20-seater and 6-seater buses are used. The car pool has about 660 light vehicles, most of which are four-wheel drive. All the vehicles used in PDO are routinely checked for compliance with road assurance standards (RAS) and no vehicle older than 8 years is used. Only those persons holding PDO driving permit are allowed to drive. All passengers are required to wear seatbelts and speed limits are strictly enforced.

Air transport is provided to PDO staff, contractor staff and approved visitors from and to five interior locations (Fahud, Lekwair, Qarn Alam, Bahja, Nimr and Marmul) and MAF on the coast. Three ATR 42-500 turboprop aircrafts, each with a seating capacity of 46 passengers are used exclusively for this purpose. These aircrafts are operated and maintained by Oman Aviation Services Company S.A.O.G. under a contract to operate scheduled flights. International flight safety procedures are strictly enforced. The aircrafts are checked for airworthiness once in 12-18 months by Shell Aircraft, London. Except for delayed flights or emergencies, the flights are scheduled only during the daytime.

In addition to the scheduled flights, unscheduled flights are also provided at the special request of a customer (PDO asset or government) and for emergency evacuation. The emergencies may include medical emergency of a PDO / contractor staff or visitor and accident emergency such as unsafe rig. In addition, if needed, international charters of helicopters and other aircraft are also handled in PDO airports.

3.3.3 Cargo Handling and Haulage

The cargo includes the materials, chemicals and equipment imported for use in any PDO asset. On behalf of logistics asset, three contractors provide the cargo handling and haulage services in the coast and the interior. Depending on the nature of the

cargo, appropriate loading, unloading and transport methods are used. Where hazardous and sensitive substances are handled, the necessary safety precautions are taken. The cargo trucks are thoroughly inspected before they are used in PDO and RAS compliance is regularly checked. All the truck drivers are required to have PDO driving permit and undergo mandatory HSE training in PDO approved training institutions.

For standard cargo haulage, the delivery time is normally 72 hours. Hotshot (urgent) cargoes can be delivered within 48 hours. An efficient waybill system that includes any special loading, unloading and transport instructions ensures that the cargo is continuously tracked and the performance is monitored. The cargo loading and unloading equipment include cranes, forklifts, spreader bars for containers and vacuum trucks for liquid spill recovery.

3.3.4 Rig Movements

Rig movement involves the transportation by road of the drilling equipment and associated facilities from one location to another. Typically, about 20 trucks are used for every rig movement. The number of trucks will increase if rig camp movement is also required. The rig movement procedure involves the following steps:

- Pre-rig move HSE evaluation and rig movement notification
- Site clearance
- Moving rigs in accordance with different distance bands
- Arranging the escort of rig movement with ROP
- Close supervision of security and safety

3.3.5 Water Haulage

Logistics asset provide water haulage services for transportation of drinking water to the PDO's accommodation camps (where piped connections are not available from the RO plants), rig sites and to some local communities and His Majesty's patrol camps. Further, the haulage of raw water to the drilling sites is also provided by logistics asset. Water is transported in a dedicated water tanker of 20 m^3 capacity The list of contractors engaged by logistics asset for water haulage is given in Table 3.2. above.

3.3.6 Material and Chemical Storage

Unlike all the other activities of the logistics asset, the material and chemical storage activities are directly performed by the logistics asset staff with the necessary labour

provided by the contractors. The receipt, storage, issue and despatch of materials and chemicals are carried out in compliance with the logistics asset procedure PR-1279 " Material Receipt, Storage, Issue and Despatch" and procedure PR-1278 "Chemical Receipt, Storage, Despatch and Disposal". In addition, PDO specification SP-1194 "Chemical Management" is also applied which outlines the requirements to be followed by PDO staff and contractors in the selection, purchase, packaging, transport (including the cleaning of mobile tanks), storage, use and disposal of chemicals. This specification works in conjunction with the SHOC card system.

3.3.7 Automobile Fuelling and Maintenance

Automobile fuelling stations dispensing petrol and diesel are located near PDO camps in MAF, Fahud, Lekhwair, Yibal, Qarn Alam, Bahja, Nimr and Marmul. They are operated and manned only during the daytimes by Al Maha staff on behalf of logistics asset. Their operation is similar to that of any standard Al Maha filling station. No other services such as car wash, oil change etc. are provided in these stations.

Automobile maintenance services including water washing, oil change, battery servicing, air-conditioning services, limited engine works, tyre change and air filling are provided in automobile workshops located separately from the fuelling stations. Such facilities are located in MAF, Fahud, Lekhwair, Yibal, Qarn Alam, Bahja, Nimr and Marmul. The wash water and any floor washings are collected in concrete pits. The collected wastewater is periodically transferred to the nearest land farm for watering the windrows. Waste oils are collected in separate containers and periodically transferred to the oil saver pit in the nearest waste management centre. Waste tyres are collected and stacked and periodically transferred to the waste management centre. Used batteries are stored in plastic containers after draining the acid from the battery. The drained acid is neutralised with caustic and then drained to sewage treatment plant. Automatic withdrawal and filling units are available in some workshops to empty and refill the refrigerants from the air conditioning units. Where not available, the refrigerants emptied are released into the atmosphere through fume hoods.

3.4 Materials and Utilities

The Logistics asset is not a major consumer of materials and utilities, except for the fuel consumed by the vehicles. Some minor materials and chemicals are consumed for the inspection and maintenance activities performed by the asset team. The fuel current annual consumption in logistics asset is given in Table 3.3 below.

Table 3.3: Fuel Consumption in Logistics Asset

Item	Description (Nature and Purpose)	Annual Consumption
Fuel for vehicles	Diesel and petrol for vehicles	27500 t[#]
Aviation fuel	Fuel for aircrafts	3450 t

 # The total quantity of automobile fuel dispensed in all the fuelling stations through out PDO is 55000 tpa. In the absence of actual data, it is assumed that 50% of this quantity is consumed by the vehicles operating under the control of logistics asset.

4 RELEASES TO ENVIRONMENT

4.1 Introduction

In this section, the various waste products and energies released into the environment from the various activities performed by the logistics asset are discussed. The contribution from any activities that are directly handled by the production assets for logistics asset are not included in this report, since they are included in their corresponding EIA reports. However, the contributions from all those activities that are performed by contractors under direct contract with the logistics asset are included in this report.

In order to identify the sources of waste generation, the activities performed by the logistics asset may be classified under the following headings:

- Activities related to air transport of passengers and cargo
- Activities related to land transport of passengers, cargo and water
- Activities related to movement of rigs and associated facilities
- Activities related to bulk storage of equipment, materials, chemicals
- Activities related to storage and dispensation of aviation and automobile fuels
- Activities related to operation of automobile workshops

The wastes released into the environment from all the activities discussed above may be classified into the following groups, based on their physical state as well as nature:

- Air emissions
- Liquid effluents
- Solid wastes
- Noise
- Accidental leaks and spills

In order to quantify and characterize these releases, the currently available database is used. In cases where data are not available or insufficient, an attempt is made to estimate the quantities and characteristics using theoretical or empirical equations. Where estimates based on theoretical or empirical equations are considered not reasonably accurate, recommendations are made for direct measurement.

4.2 Air Emissions

4.2.1 Overview

The sources of air emissions in the activities performed on behalf of logistics asset include both stationary and mobile sources. The stationary sources are the bulk fuel storage tanks. In addition, fuel filling pumps and chemical stores may also release some fugitive air emissions. The mobile sources include the aircrafts used for air transport and the road vehicles used for passenger and cargo transport and rig movement. The emissions from the bulk fuel storage tanks are basically the vapours released through vents while the emissions from filling stations are fugitive vapour emissions. The emissions released from the mobile sources are the gases of combustion of petroleum oils.

The quantification and characterisation of these emissions are discussed in the following sections.

4.2.2 Emissions from Stationary Sources

The air emission sources include fuel storage tanks, fuel filling points and area sources like chemical stores. Among these, fuel storage tanks are the most significant source of air emissions from stationary sources.

Aviation fuel is stored at three locations *viz.*, Fahud, Nimr and Marmul airstrips. The fuel storage capacities are 94.3 kL, 54.0 kL and 81.0 kL respectively at Fahud, Nimr and Marmul. The fuel storage tanks are fixed roof underground tanks provided with atmospheric vents to release hydrocarbon vapours generated during tank filling and due to normal evaporation.

The automotive fuel storage tanks are located in the fuelling stations located in all the production assets (Fahud, Lekhwair, Yibal, Qarn Alam, Bahja, Nimr and Marmul) and in MAF. The storage tanks are either underground or over-ground fixed roof tanks of 50 kL capacity each. Each tank is provided with an atmospheric vent for the release of the hydrocarbon vapours generated during tank filling and due to normal evaporation.

The sources of fugitive emissions include fuel filling pumps and chemical stores. Fuel filling pumps are provided at the three aviation fuel storage tanks and the eight automotive fuelling stations. The emissions from these sources are hydrocarbon vapours released during refuelling of aircrafts or automobiles. With respect to

chemical stores, some low boiling liquid chemicals stored in drums in the outdoors may release vapours due to evaporation through brim sealing, particularly during the summers. In terms of quantity, the fugitive emissions from chemical stores are not considered significant.

The vent and fugitive hydrocarbon vapour emissions are estimated in PDO using Tier 3 emission factors given in the Shell group specification EP 95-0377 on "Quantifying Atmospheric Emissions" (*Reference 3*), which are based on USEPA's AP-42 methods. For fixed roof tanks, the emission factor for total hydrocarbon emissions is given as 132 g per tonne of throughput. The emission factor for fugitive emissions from loading operations (for crude oil into tank trucks) is given as 388 g per tonne of throughput, which is assumed to apply for fugitive emissions from refuelling points. Thus the combined vent and fugitive emissions from fuel storage and refuelling operations is taken as 520 g per tonne of throughput. Based on the above, the vent and fugitive hydrocarbon emissions from these sources of logistics asset are estimated as given in Table 4.3 below.

Table 4.1: Hydrocarbon Vapour Emissions from Fuel Storage and Filling Facilities of Logistics Asset

Sources and Location	Throughput (Tonnes per Year)	Emission Quantity (Tonnes per Year)
Aviation fuel storage and refuelling facilities	3450	1.8
Automotive fuel storage and refuelling facilities	27500	14.3
Asset total	-	16.3

It may be noted that these emissions are released from eleven locations spread over the entire PDO's concession area.

4.2.3 Emissions from Mobile Source

Air emissions from mobile sources are the engine exhaust gases released from road vehicles and aircrafts used by logistics asset. The types of road vehicles used for passenger transport, cargo and water haulage and rig movement may be classified as light duty petrol vehicles (cars and 4-wheel drives), medium duty diesel vehicles (buses and vans) and heavy duty diesel vehicles (trucks). The aircrafts used in PDO are three ATR 42-500 model turboprop aeroplanes. The engine exhausts from both road vehicles and aircrafts are the products of combustion of petroleum fuel oil. The significant pollutants present in these emissions are NO_x, CO and PM_{10}, which includes the unburnt HC. The emission factors (mass of pollutants emitted per fuel consumed) depend on the type of engine, type of the fuel, running speed, load conditions and environmental conditions.

In PDO, the air emissions from mobile sources are estimated in PDO using Tier 3 emission factors given in the Shell group specification EP 95-0377 on "Quantifying Atmospheric Emissions" (*Reference 3*), which are based on USEPA's AP-42 methods. However, for the sake of simplicity, EP 95-0377 specification uses common emission factors for all categories of land transport vehicles, and common emission factors for all categories of aircrafts as shown below:

Parameter	**Road Vehicles** (kg per tonne of fuel)	**Aircrafts** (kg per tonne of fuel)
CO_2	3200	3200
CO	27	5.2
NO_x as NO_2	38	12.5
SO_2	8	8
HC	5.6	0.9

In the above estimates, it is assumed that all vehicles are diesel driven, moderately aged and the sulphur content in the fuel is 0.4% by mass. The estimated total emissions from mobile sources in the asset are as given in Table 4.2 below.

Table 4.2: Air Emissions from Mobile Sources of Logistics Asset

Parameter	**Quantity (Tonnes per Year)**	
	Road Transport	**Air Transport**
Total quantity of fuel consumed – petrol / diesel / aviation fuel	27500	3450
Total emission of CO_2	88000	11040
Total emission of CO	743	18
Total emission of NO_x	1045	43
Total emission of SO_2	220	28
Total emission of HC	154	3

It may be noted that the emissions from aircrafts are released into air space roughly 5000-8000 m above the ground level. The emissions from road vehicles are distributed over 4000 km distance.

In addition to the engine exhausts, road dust is also generated from road vehicles due to the continuous heavy traffic on the graded roads. About 50% of the road dust is expected to contain respirable particulates (PM_{10}). It is not possible to estimate the dust emissions. Their impact will be very localised along the roads.

4.3 Liquid Effluents

4.3.1 Overview

No continuous liquid effluents are generated due to the activities performed for logistics asset. Hence any liquid effluents generated may be classified as either intermittent or accidental. The effluent streams generated include the following:

- Vehicle wash water and floor washings from the automotive workshops (intermittent)
- Sewage from the passenger buildings in the interior airports (intermittent)
- Fire fighting effluents (only during emergencies)
- Leaks and spills of oils and chemicals (accidental)

The oil and chemical leaks and spills occur only accidentally due to storage tank failure and accidents during transportation. The leaks and spills usually result in the contamination of soil or marine waters. These are discussed separately under Section 4.6. The leaks and spills involving water or treated sewage are not considered as waste streams, and hence not discussed in this section.

4.3.2 Quantification and Characterisation of Liquid Effluent

The quantities of the various liquid effluent streams generated from the activities of logistics asset are presented in Table 4.3 below, along with a brief description of their nature.

Table 4.3: Liquid Effluents Generated from Logistics Asset Activities

Liquid Effluent	Source of Generation	Quantity Generated	Typical Nature and Characteristics of Raw Effluent
Vehicle wash water and floor washings	Automobile workshops	About 200 L per wash	Contain traces of oil, detergents and suspended inorganic solids.
Sewage	Toilets in interior airport passenger buildings	Less than 10 L per person per day	Suspended and dissolved organic matter.

4.3.3 Effluent Treatment and Disposal

Vehicle wash water and any floor washings are collected in concrete pits in the automobile workshops. Periodically vacuum trucks transfer this effluent to the nearest land farm facility for spraying on the windrows of oily sands under bio-treatment.

Sometimes, this effluent may be transferred to a PDO sewage treatment plant (STP) for treatment.

For every passenger building in the interior airport, the sewage from the toilets is collected in underground septic tanks, where the overflow flow into soak pits. The sewage effluent from the passenger building is connected to the septic tank. In case of any overflow noticed from the soak pits, the excess volume is removed using vacuum trucks and then discharged to the nearest STP for treatment.

4.4 Solid Wastes

In PDO, the solid wastes are classified into broad categories as non-hazardous and hazardous. The sub-groups in each category are as below:

The non-hazardous wastes include the following groups:

- Domestic and office waste
- Water based drilling mud and cuttings
- Non-hazardous industrial waste

The hazardous wastes include the following groups:

- Oil based mud and cuttings
- Sewage sludge
- Waste lubricants
- Oily sludges
- Oily sand
- Pigging sludge
- Non-recyclable batteries
- Recyclable hazardous batteries
- Transformers and transformer cooling fluids
- Clinical wastes
- NORM wastes
- Chemical wastes (including miscellaneous hazardous wastes)

From the activities of logistics asset, only a few types of wastes are generated mainly from the automobile workshops and storage yards. The quantities of these wastes are already accounted in the product flow asset team, as they own these facilities. Their sources of generation and methods of disposal are shown in Table 4.6.

Table 4.4: Solid Wastes Generated by Logistics Asset Activities

Waste Type	Source of Generation	Method of Disposal
Batteries, Tyres, grease and cotton rags	Maintenance workshop	Sent to the nearest PDO Waste Management Centre.
Contaminated sand	Leaks and spills in the chemical storage yards and accidental spills during transportation	Sent to the nearest PDO land farm for bio-remediation.
Chemical waste	Redundant / expired chemicals and spilled chemicals from the chemical storage yard	Sent to the chemical waste landfill facility at Marmul
Metal scrap, plastic caps, wooden pallets	Damaged casings and strings at the storage yards	Sent to the nearest PDO Waste Management Centre

Among the solid wastes, chemical wastes from the chemical storage yard have the greatest environmental significance, due to their increasing inventories and landfilling.

4.5 Noise

The major noise generating sources for the logistic asset are aircrafts and automobiles used for the cargo and passenger transport. Noise generated from aircraft engines is significantly high. However, the average flight frequency is less than one per day and the airports are located far away from the accommodation and production facilities. The ground support staff in the airports is provided with earmuffs to protect them from the high noise levels.

The noise generated from automobile engines can be significant in the case of heavy vehicles. However, the traffic frequency of heavy vehicles at any location is not significant. It is likely that the noise levels in some locations such as storage yards and automotive workshops may be high. Currently no noise monitoring data are available to check compliance with workplace or ambient noise standards.

4.6 Accidental Leaks and Spills

In PDO, all accidental leaks and spills shall be promptly reported. There are three categories of accidental leaks and spills, as below:

- Oil leaks and spills
- Chemical leaks and spills
- Water leaks and spills

While water leaks and spills do not lead to any environmental consequences, they are reported as a matter of water conservation issue.

Leaks pertaining to the logistic asset are mainly from the chemical spills at the storage yards and during transport, oil spillage at the fuel storage tanks at the filling station and fuel spill during filling the vehicles. Chemical spills are reported but there is no record maintained to assess the quantity of the leaks. It was informed that the number of chemical spills occurred were very rare and on average once in two years.

Generally, it is observed throughout PDO that incident reporting is not accurate. Therefore, it is likely that the leaks and spills volumes, impacted areas and contaminated soil quantities are under-reported.

5 ENVIRONMENTAL SETTING

5.1 Introduction

Logistics asset is one of the eight service providers in PDO. Its main functional responsibility is to provide logistics support to all other assets in PDO for cargo haulage, passenger commuting, fleet management and warehousing. The areas of operation of the asset cover the entire interior concession area in south and central Oman as well as Mina Al Fahal (MAF) on the coast. As seen from these maps, the areas of operation of the Logistics asset stretch from Marmul in southern Oman to Fahud in central Oman to MAF on the northern coast covering a vast land area of 113,550 km^2. From an environmental viewpoint, the terrestrial environment is of interest in the interior areas and marine environment is of interest in MAF.

The generic description of environment throughout the PDO's concession area is given in the individual environmental impact assessment reports prepared for all the production assets. In this chapter, a brief description of the environment in the interior and coastal areas of operation of logistics asset is presented.

5.2 Topography

The topographical features from the southernmost part of the concession area (Marmul) to the northern coast (MAF) show three distinct zones as below:

- Desert plains with very low population within most of the concession area
- Low to medium altitude hills over the southernmost and northernmost parts
- A small coastal plain surrounded with urban population

Most of the concession area falls under central and south-central Oman and is characterised by flat gravel desert plains with occasional rocky outcrops interspersed with a few wadi channels. The altitude in the plains is mostly in the range of 100-150m above the mean sea level. The desert plains are very thinly populated.

Sand dunes occur over the western parts of central Oman forming a part of Rub Al Khali (the empty quarter). A large area constituting the southern part of Yibal asset and northwest part of Qarn Alam asset fall under Umm as Samim, the largest sabka (natural salt pan) of the Arabian Peninsula.

The natural vegetation is composed of desert plants and grasses, and is restricted to the wadi plains only. Among all the assets, Nimr and Marmul assets have relatively denser vegetation. Wadi Raunib in Rima is one of the most significant naturally

vegetated areas. Rahab Farms in Marmul asset are the most significant cultivated vegetated areas within the concession area.

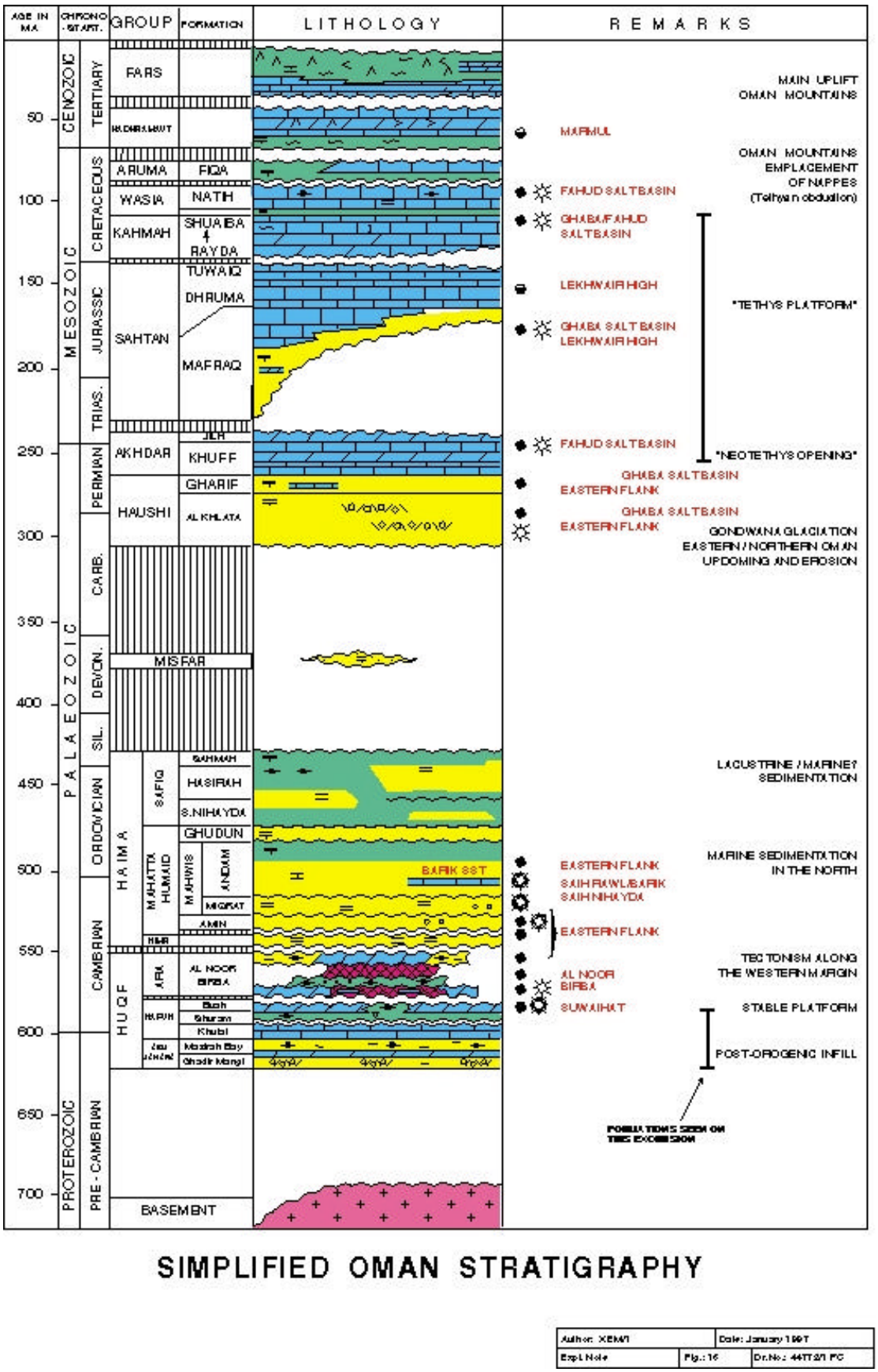
Hills of low to medium altitude are encountered over the southernmost and northernmost parts of the concession area. In the south, from Thuleilat (Marmul asset) onward, the altitude rises steeply up to 600m above the men sea level into Dhofar mountains. Similarly, in the north from Fahud onward, several hills up from 300-600m altitude are encountered. At the high point of MOL near Izki, the altitude is about 670 m above the mean sea level.

The MAF terminal area is located within the MAF industrial area on the shore of MAF bay and surrounded by hills, rising to 214 m altitude above the sea level on the eastern boundary. There are large urban settlements adjacent to MAF area to northwest.

5.3 Geology and Soil

The geology of most of the PDO's concession area comprises of mainly limestone with shale, dolomite and sandstone. The central plains mostly consist of flat limestones of oligocene and miocene ages to mid-tertiary. The limestone plains are covered sparsely with alluvial gravel or aeolian sand. The hills from Fahud to MAF along the pipeline routes are formed from sedimentary carbonate strata comprising limestones, sandstones and dolomites dating from the Permian to the late Cretaceous. Towards the north, the low hills are comprised of tertiary sedimentary sandstones, limestones and conglomerates overlying igneous and metamorphic rocks formed under ocean sediments in the Mezozoic period. The rock types include gabbros, Hartsburgites, basalts and locally pillow larva. The simplified stratigraphy map of Oman is shown in Figure 5.1.

No site-specific data are available on the soil quality. Generally, the soils in the asset are classified as unsuitable for agricultural purposes, as per the Ministry of Agriculture and Fisheries General Soil Map of Oman. The soil map of PDO's concession area is given in Figure 5.2.



SIMPLIFIED OMAN STRATIGRAPHY

Author: XEMT		Date: January 1997
Expl. Note	Fig.: 16	Dr.No.: 4477321 PC

Figure 5.1: Simplified Stratigraphy Map of Oman

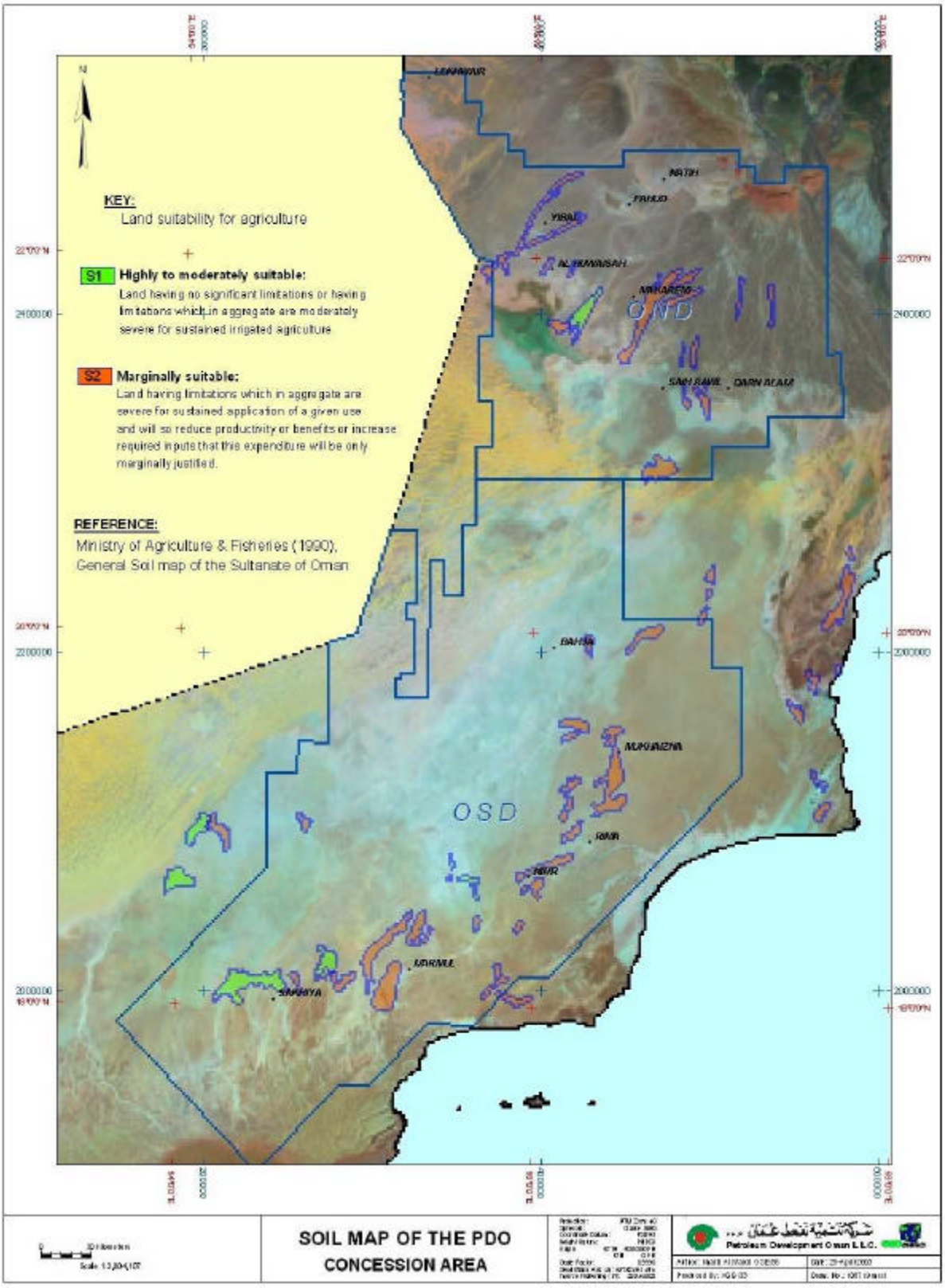


Figure 5.2: Soil Map of PDO's Concession Area

5.4 Hydrogeology and Groundwater Quality

The tertiary aquifers are the potentially exploitable groundwater resources in PDO's concession area. Tertiary aquifer systems in Oman are recharged from the flow from the Oman mountains to the north and Dhofar mountains to the south. Surface hydrology in this area is of no significance due to very scanty rainfall. The shallow aquifer systems consists of the Fars formations (0-150 m depth), Dammam formations (150-200 m depth), Rus formations (200-300 m depth) and Um er Raduma (UeR) formations (300-600 m depth).

Fars formations are basically formed by sedimentary carbonates. Groundwater availability in these formations is not significant in most of the assets. Dammam formations are primarily limestone beds and have very limited groundwater potential due to their reduced thickness. Rus formations are formed by gypsum anhydrite beds. They have significant groundwater potential in some assets. This aquifer appears to be confined at some places and connected with the UeR aquifer at other places.

UeR aquifer is the main prolific aquifer in the area. UeR formations are sub-divided into lower, middle and upper layers. The upper and middle layers are composed of limestone and dolomite, while the lower layers are composed of thin impermeable shale and marl. UeR aquifer is recharged in Dhofar mountains in south during monsoon from July to September. The groundwater is estimated to travel at a velocity of 10 m per year.

The mineral content in UeR water increases as it travels from south to north. Within the entire PDO concession area, only Marmul asset has groundwater that is potable without any pre-treatment. In all other assets the UeR water is very saline. The total dissolved solids content ranges from 1000 mg/L to 150,000 mg/L. The groundwater salinity map of the region is shown in Figure 5.3.

The historical well yield and water quality data collected from various water supply wells in the concession area have not shown any significant change over most parts of the concession area.

5.5 Climate

PDO's concession area as a whole has an arid climate, with very low rainfall. The climate is typically hot with significant fluctuations between maximum and minimum temperatures. The hottest temperatures occur throughout summer months (May – August) and cooler temperatures occur during the winter months (November-February).

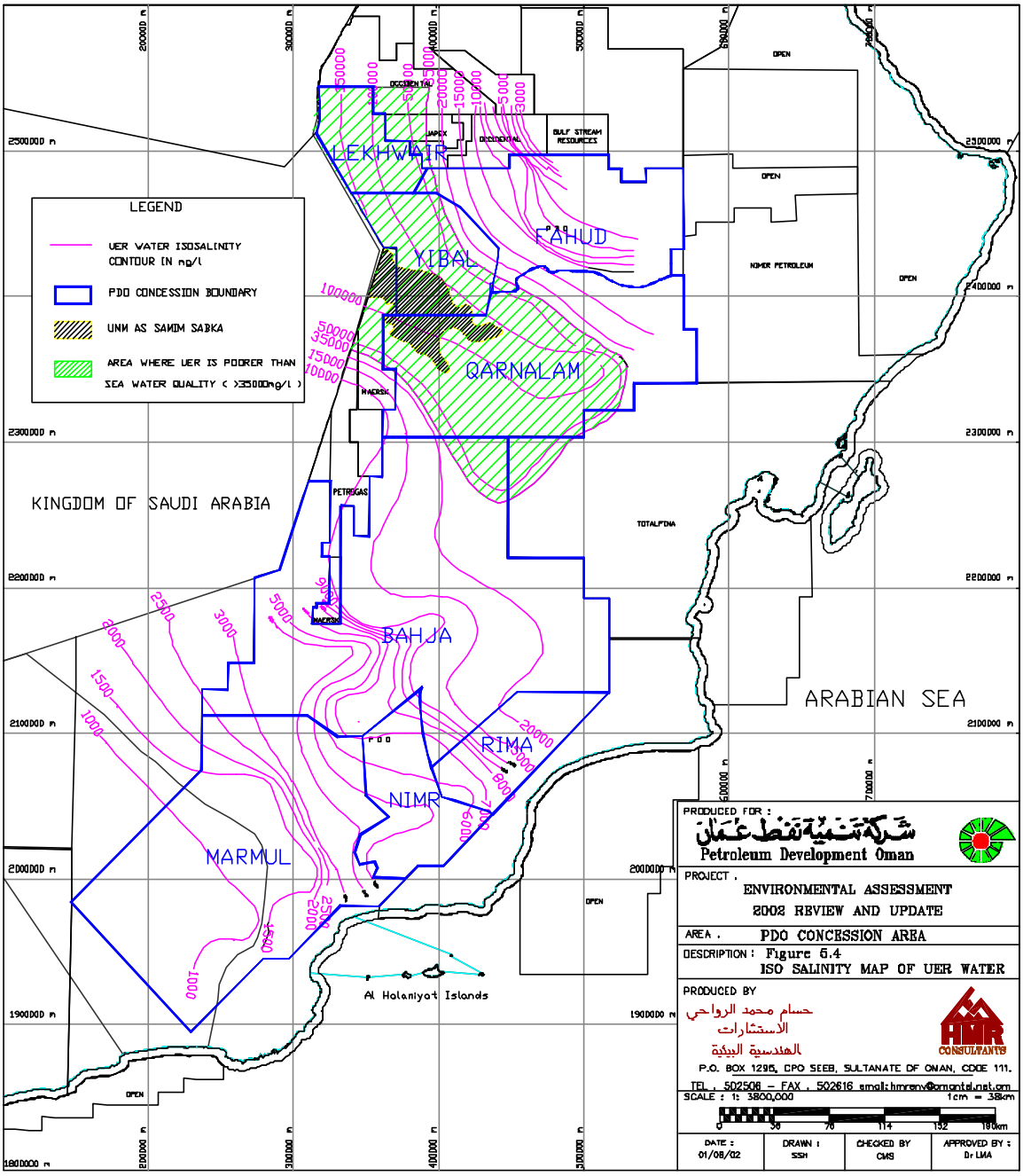


Figure 5.3: Iso-salinity Map of UeR Aquifer in Oman

The mean monthly temperatures range from around 19°C in January (with mean minimum of about 11°C and mean maximum of about 34°C) to about 37°C in July (with mean minimum of about 24°C and mean maximum of about 50°C). The maximum absolute temperature will be as high as 51°C and the minimum absolute temperature will be as low as 4°C.

Rainfall in this region is scanty and is highly variable in time and space. Historical data give an average of 34 mm per annum. Although the annual average rainfall is very low, flash floods are known to have occurred in the area. Most of the rainfall occurs during the winter season (December - February) with secondary peaks expected in late summer. Little rainfall is expected throughout the rest of the year.

Wind speeds vary considerably from calm to strong gusts. The dominant wind direction is from the south with an average wind speed of 8 knots.

5.6 Ambient Air Quality

Very limited air quality studies have been conducted anywhere in PDO concession area since PDO's exploration and production activities started. These data are available on the ambient air quality from the previous EIA report (*Reference 1*). It is generally believed that ambient air quality within PDO's concession area is of no significance due to two reasons. Firstly, there are no human settlements close to any operational facilities in the entire PDO concession area. Secondly, there aren't many air emission sources in PDO and the emission loads are not considered very significant.

However, in the absence of any measurements, the significance of ambient air quality cannot be established. Based on the uneven distribution of the emission sources, relatively shorter stack heights and atmospheric inversion conditions expected during winter nights, the concentration of some pollutants in ground level air may be elevated in certain locations and in PDO camps at sometimes. Therefore, it is necessary that air quality surveys be undertaken at periodic intervals at selected locations to determine whether the air quality in the asset is within the permissible limits.

5.7 Ambient Noise

No data are available on the ambient noise levels within the asset. It is believed that the ambient noise levels in this region are of no significance due to the fact that there are no human settlements close to any operational facilities. The high noise generating sources in the facilities such as production station, power stations, gathering stations,

and RO plant are unlikely to have any impact on the human settlements. However, they may have an impact on the noise levels in the PDO and contractor camps.

Therefore, it is necessary that noise surveys be undertaken at periodic intervals at selected locations to determine whether the noise levels in the accommodation areas are within the permissible limits.

5.8 Terrestrial Ecology

5.8.1 Flora

The natural flora in most of the concession area is composed of desert plants and grasses, and trees are rarely seen. The distribution pattern of vegetation is dependent on the water drainage pattern and the presence of adequate sand or fissures in the bedrock for plant establishment. With rainfall being very scanty and erratic, the fog moisture largely influences the vegetation in this region. The species diversity and density somewhat improves in the highlands in the southern and northern parts of the concession area. Coastal communities are encountered only in MAF.

The flora found in the central and southern plains in the concession area are typical to central Oman. Larger species such as *Prosopis cineraria* are present in low-lying sumps with deeper sand and *Acacia ehrenbergiana* is abundant. This region supports no trees or bushes, but characteristic forbs such as *Fagonia ovalifolia*, and species of *Cornulacea* and *Salsola* cover very large areas. The vegetation cover is relatively denser in the wadis with frequent grass tussocks of *Stipagrostic* sp., *Cymbogon schoenathus* and *Panicum turgidum* and includes scattered *Acacia ehrenbergiana* bushes. The wadis provide more forage for both wild and domesticated grazing animals due to plant height and coverage and the presence of grasses. Low-lying perennial shrubs cover the undeveloped areas within the concession area and serve as pastor grounds for local livestock, mostly camels and goats.

In the highlands, halophytes such as *Zygophyllum* decrease in abundance and the shrub communities become more diverse with additional species such as *Zyziphus spina-christi*, *Euphorbia larica, Fagonia sp., Dyerophytum indicum, Peroploca aphylla, Calotropis procera, Tephrosia* sp. and *Solanum*. Grass species increase in cover. With high spate flows, there is often little vegetation in the main wadi channels.

5.8.2 Fauna

Due to the sparse vegetal cover, fauna are not very abundant and diverse in this region. However several fauna groups including mammals, birds and reptiles are seen. Large mammalian species known to inhabit the area include the Arabian Gazelle (*Gazelle gazelle*), the Rhim Gazelle (*Gazella subgutturosa marica*), the Nubian Ibex (*Capra nubiana*). These animals are currently listed on the IUCN World Red List and the Regional Red List threat categories. The Arabian Oryx is seen in Mukhaizna field in Bahja asset. Mukhaizna field is located just outside the buffer zone of the Arabian Oryx Nature Reserve. Ruepell's Sand Fox and the Cape Hare are also thought to inhabit the some areas and burrow in earthen mounds associated with well development activities. A few smaller mammals, mostly gerbils, jirds and jerboas are also known be present in the vegetated areas.

Bird surveys revealed about 150 different species with a half of them breeding in this region. There are no regional Red Data Lists for birds and their threatened status in Oman is yet to be established. Distribution records for reptiles in the area indicate that 30 species inhabit the area. Both the monitor lizard (*Varanus griseus*) and the spiny tailed lizard (*Uromastyx thomasi*) are common throughout the region. All of the animal species recorded in the concession area are typical of the central plains.

5.8.3 Wildlife Sanctuaries

Two of the important wildlife sanctuaries in Oman namely the Arabian Oryx Nature Reserve and the Jebel Samhan Nature Reserve are in the proximity of in PDO concession areas. A small portion of the buffer zone of the Arabian Oryx Nature Reserve falls under into Bahja and Nimr assets. The Jebel Samhan Nature Reserve in the Dhofar governorate is to the south of Marmul asset.

- **Arabian Oryx Nature Reserve**

An area of 24785.4 km^2 in Al Wusta Region was proclaimed in 1994 as the Arabian Oryx Nature Reserve and subsequently declared a World Heritage Site by the United Nations Scientific and Cultural Organisation. At the heart of the Reserve is the Jiddah (central plateau), a foggy desert supporting diverse plant and animal communities. The Reserve is sanctuary for many wildlife species including the Arabian Oryx, which was reintroduced to the wild in 1982. The other mammals seen in the Reserve include Arabian Gazelle (*Gazelle gazelle*), Rhim Gazelle (*Gazella Subgutturosa marica*), Nubian Ibex (*Capra nubiana*), Arabian Wolf (*Canis lupus arabica*), Caracal (*Caracal caracal schmitzi*), Honey Badger (*Mellivora capensis*), Red Fox (*Vulpes*

vulpes arabica), Ruepell's Sand Fox (*Vulpes ruepelli*), Cape Hare (*Lepus capensis*) and Ethiopian Hedgehog (*Parachimus aetheopica*).

Among birds, 180 species have been recorded in the Reserve, with majority being migratory and only 26 breeding resident species. The resident species include Golden Eagle (*Aquila chrysaetos*) and Houbara Bustard (*Chlamoyodotis undulata*). Among reptiles, 24 species have been recorded including Monitor Lizard, *Malpolon moilensis, Cerastes cerastes* and *Uromastyx thomasi.* Over 140 species of plants have been recorded in the Reserve, with 12 endemic species. While some are short-living (rain supported), others are long-living (fog supported). Simr (*Acacia tortilis*) is scattered all over the Reserve, while Ghaf (*Prosopis cineraria*) and Salem (*Acacia ehrenbergiana*) grow mostly in shallow sand depressions called haylat.

The Reserve is presently divided into five administrative zones to facilitate management. The special protection zone is the core zone of the reserve that provides a safe haven for the Arabian Oryx and thus ensures their longterm survival in the wild of Oman. The objective is to manage this zone to keep human disturbance and competition from domestic stock to a minimum. The controlled use zone includes areas regularly used by the Oryx and tracts of land containing other important biological resources, wilderness, scenery of exceptional beauty and sites of archaeological interest. The management objective is to allow controlled access but keep development to a minimum. The buffer zone encompasses further sites of interest, but with control of activities in order to help protect the inner zones. The utility zone is demarcated for locating the essential Logistics facilities of the reserve. The special use zone constitutes the areas of land where a land use agreement has been reached with the government (military authorities) and private parties. The map of the Arabian Oryx Nature Reserve is shown in Figure 5.5.

- **Jebel Samhan Nature Reserve**

The Jebel Samhan reserve covering an area of 4500 km^2 contains a wilderness of limestone highlands rising steeply from coastal plain and sloping gently toward north. The deep cayopns with water pools and many plant species provide an ideal habitat for Arabian Leopard, Nubian Ibex, Arabian Gazelle, Striped Hyaenas, Wild Cats, Foxes and Wolves. The reserve has typical monsoon vegetation and is the only Arabian location of African tree Papea capensis. The reserve has a protected core zone where minimal human activity is permitted, surrounded by multiple use zone. PDO currently does not operate in any part of the reserve.

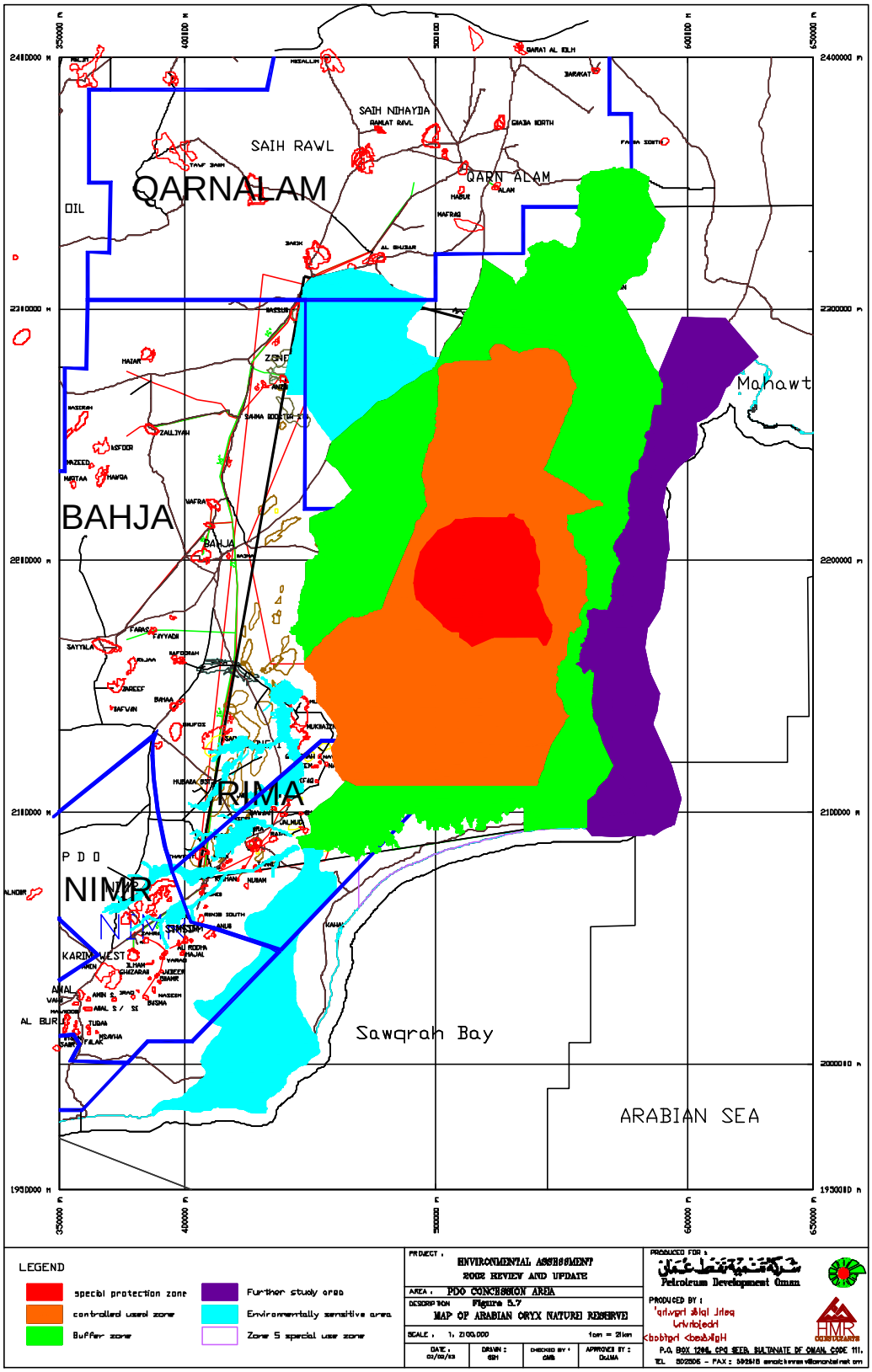


Figure 5.4: Map of Arabian Oryx Nature Reserve

5.9 Marine Ecology

5.9.1 General

The beaches along the coastline are composed primarily of fine sand derived from the neighbouring land with shallow areas extending up to 2 km offshore. The shoreline along the east coast of Oman is known to be mobile with a generally north west drift of sediment along the coastline. Several inlets along the coastline provide important habitats for coastal flora, birds and juvenile fish populations. The Dimaniyat Island Nature Reserve is an archipelago of nine islands approximately 16 km off the coastline. These islands provide a protected habitat for a diverse population of birds, marine, and terrestrial fauna.

5.9.2 Seawater Quality

The seawater temperature at MAF ranges from 25°C in winter (February and March) up to 39°C in summer (June and July). The salinity ranges from 35 to 40 parts per thousand. Recent studies did not indicate at gross contamination of the seawater in MAF bay. Earlier studies indicate high levels of phytoplankton chlorophyll in winter/spring dominated by diatom blooms (e.g. *Coscinodiscus, Skeletonema*). One characteristic of this region is the occurrence of red tides dominated by dinoflagellates (e.g. *Ceratium, Noctiluca*). During late summer and early autumn, nutrient enrichment produces blooms, which means that there is continuously high primary productivity and rich herbivorous zooplankton communities available (e.g. copepods). These in turn support large stocks of sardines, anchovies and larger pelagics.

5.9.3 Sediment Flora and Fauna

The coast has unstable sand substrates, which produce high turbidity leading to poor underwater light penetration. Such turbid conditions limit sea flora populations, such as sea grasses. The direct grazers on sea grasses include the green turtle *Chelonia mydas*, parrot fish and sea urchins. In Oman, there are four species of sea grass, the smaller *Halodule uninervis* and *Halophila ovalis* and the larger *Thalassodendron ciliatum* and *Syringodium isoetifolium* which form limited beds. In shallow water sediments along the coast, the typical infauna found include polychaetes, snails, olive shells, cowries, sand dollars and heart urchins. Very little is known about the deeper subtidal infauna of coastal areas of the Gulf of Oman. A variety of benthic macrofauna including polychaetes, molluscs, echinoderms can be expected to inhabit the deeper coastal zone.

Recent studies in MAF bay showed generally low levels of hydrocarbons and heavy metals in intertidal beach samples, with the exception of vanadium. The subtidal sediment samples in general indicated no contamination. The sediment samples taken from single buoy mooring locations were found to contain high levels of copper and tributyl tin, possibly due to the use of antifouling paints.

5.9.4 Fish Communities

The predominant pelagic species include the most important commercial fish in Oman, viz., the kingfish (*Scomberomorus commerson*), tunas and mackerel (*Scombridae*), the scad (*Decapterus russelli*, *Sardinella longiceps* and *Selar crumenophthalamus*) and others in the 20 to 100 m depth range. Other commercially important demersal species here include croakers (*Sciaenidae*), snappers (*Lutjanidae*), jacks (*Carangidae*), barracudas (*Sphyraenidae*), and emperors (*Lethrinidae*).

5.9.5 Turtles

There are five kinds of marine turtles found off the coasts of Oman; the Green Turtle *Chelonia mydas*, the Hawksbill *Eretmochelys imbricata*, the Olive Ridley *Lepidochelys olivacea*, the Loggerhead *Caretta caretta* and the Leatherback Turtle *Dermochelys coriaca*. The Green Turtle and the Hawksbill are regarded as "endangered". Both endangered species use the Dimaniyat Islands as a nesting ground.

5.9.6 Cetaceans

The toothed cetaceans and the baleen cetaceans are both found in the waters of Oman. The toothed cetaceans (suborder Odontoceti) are a more varied group of cetaceans and include the sperm whale *Physeter* spp. and dolphins and porpoises. The species include sperm whale (*Physeter macrocephalus)*, dwarf sperm whale (*Kogia simus)*, cuviers beaked whale (*Ziphius caviostris),* false killer whale (*Pseudorca crassidens)*, killer whale (*Orcinus orca)*, indo-pacific humpback dolphin (*Sousa chinensis)*, risso's dolphin (G*rampus griseus)*, bottlenose dolphin (*Tursiops truncatus)*, pantropical dolphin (S*tenella attenuata)*, spotted dolphin, spinner dolphin (*Stenella longirostris) and* common dolphin (*Delphinus delphis).*

The baleen whales (suborder *Mysticeti*) filter feed on zooplankton using comb-like plates of baleen or "whalebone" with which they sieve their prey from large volumes of water. Oman's baleen cetaceans are all large whales and belong to one family, the Balaenopteridae. They include humpback whale (*Megaptera novaeangliae)*, Bryde's

whale (*Balaenoptera edeni),* sei whale (*Balaenoptera borealis),* minke whale (*Balaenoptera acutorostrata),* blue whale (*balaenoptera musculus)* and fin whale (*Balaenoptera physalus).*

5.9.7 Coral Reefs

Most of the coast has unstable, sandy substrates with often high turbidity, making it largely unsuitable for coral growth. The rocky promontory of Ra's Sawadi and the Dimaniyat Islands located offshore are the only areas in the region with good coral development. The Dimaniyat Islands are situated 16 km offshore in clear, oligotrophic water and substantial patch and fringing reefs are found along leeward and protected shores of the nine islands in the chain. Abundant coral growth is found to 20 m depth. There are massive *Porites* colonies, *Acropora* colonies and large stands of *Pocillopora* on rubble substrates. The reefs here provide habitat and feeding ground for many fish. With the importance of these islands to nesting turtles (the hawksbill *Eretmochelys imbricata* and green turtle *Chelonia mydas*) and seabirds, the area was declared as the "Dimaniyat Islands Nature Reserve" in 1996 (RD 23/96).

With specific reference to MAF bay, the recent studies has indicated hard corals around the Fahal Island with about 45% cover. Soft corals are seen in the West Headland and East Headland sites with about 20% cover and with low cover (<5%) in Fahal Island. The common genera seen at all sites were *Sinularia* and *Sarcophyton* with occasional records of species of *Cladiella* and *Dedronephthya*. The overall conclusion from the coral reef survey is that coral communities in MAF have not significantly changed over the past five years.

5.10 Human Settlements

The human population density within PDO's concession area (interior areas) is extremely low and is to the order of 26 persons per 100 km^2. Within the total concession area of 113,550 km^2, the total current population is of the order of 30,000. The majority are the PDO and contractor staff living in the various accommodation camps located in the assets, and they number about 20,000 currently.

As for the civilian populations, the main populated areas are in the Wilayats of Haima (in Bahja asset) and Adam (in Fahud asset). Wilayat of Haima is in the Jiddat Al Harasiis plateau and has an estimated total civilian population of about 2500 persons. Wilayat of Adam has a total population of 8350 persons. In addition to the above, relatively small settlements can be found near to major wadis. These settlements are receiving various benefits from the PDO including water and power.

The Bedouin settlements are found to be mostly in the central and western parts of the PDO's concession area mostly around wadis. Particularly, Fahud, Nimr and Bahja assets are known to have more of Bedouin populations. The central plateau region, known as Jiddat al-Harassis is historically characterised by migratory populations due to the harsh climate and lack of freshwater sources. The principal inhabitants in Jiddat al-Harassis are the Harsoosis tribe. Historically, Harsoosis sustained on migratory pastoralism and adopted a nomadic lifestyle to cope with the harsh water-starved and desolate environmental conditions. Presently however, with year-round water supply provided by PDO and the government, Harsoosis have taken up permanent settlement and are no longer nomadic. A recent socio-economic survey indicates that there are an estimated 3,000 to 3,500 members of the Harsoosis residing within the central plateau.

In contrast, the human population within MAF terminal area and the surrounding areas are typically urban population. These areas form a major part of the Muscat Municipal areas. The main populated area near MAF terminal is the PDO's residential camp in Ras Al Hamra, housing about 4000 persons. The other major populated areas are Qurum Heights (about 1 km away) and Darsait (about 4 km away).

5.11 Archeological, Cultural and Recreation Resources

There are no forts, ruins or other archeological declared sites in PDO's concession area. However, abundant marine fossils are present in Jabal Fahud and Natih areas (Fahud asset). The significant cultural site within PDO's concession area include the old city of Adam in the Wilayat of Adam (Fahud asset), which dates back to pre-Islamic times. Adam is also the birthplace of Imam Ahmad bin Said, the founder of the Al Busaid dynasty. Within the Bahja asset, there are several traditional weavers. There is an ancient cemetery within the Nimr asset on the southeastern end of the Prosopis woodland in Wadi Ghubbarah.

Sand dunes in the western and northern part of the Lekhwair asset qualify as areas of exceptional natural beauty. The landscape is peaceful and this area is used as recreational area during the winter months. Umm as Samim, the largest sabkha of the Arabian Peninsula, and one of the largest in the world is also an area of visual interest in Qarn Alam asset. The Prosopis woodland in Al Ghubbarah and the eroded limestone hills with small caves and rock overhangs in Wadi Rawnab in the Nimr asset are also considered areas of visual interest. The dramatically sculptured shapes of the limestone hills south of Shalim in the Marmul asset are also considered as a major visual amenity. On the coast, the MAF bay and the beaches are of significant recreational value particularly for the PDO staff.

6 ENVIRONMENTAL IMPACTS

6.1 Methodology

In this chapter, the significant environmental hazards and effects present in the asset are identified and assessed based on the methodology outlined in PDO's document GU-195 "Environmental Assessment Guideline" (*Reference 2*). In PDO's terminology, the term "environmental hazard" is used for the sources (causes) of potential environmental effects, and term “effect” is used for the impact.

The environmental effects may include all those that are beneficial or adverse, short or long term (acute or chronic), temporary or permanent, direct or indirect, and local or strategic. The adverse effects may include all those leading to, harm to living resources, damage to human health, hindrance to other activities, impairment of quality for use, reduction of amenities, damage to cultural and heritage resources, and damage to physical structures.

For each identified potential environmental effect, the associated environmental risk is assessed based on its likelihood and significance. The likelihood (frequency) of occurrence of an effect, the significance of its consequence and the potential risk level are evaluated qualitatively as described below:

- Rating of likelihood (frequency) of occurrence of an effect:

  A (very low), B (low), C (medium), D (high), E (very high)

- Rating of significance of its consequence:

  slight, minor, localized, major and massive

- Rating of potential environmental risk level:

  l*ow, medium, high and extreme*

The criteria used for rating the environmental risk are discussed in detail in *Appendix 2.*

6.2 Potential Environmental Hazards and Effects

The potential environmental hazards and effects associated with the various activities performed in the asset are presented in *Appendix 3*. These are presented in the form of matrices. In the following sections, the impacts identified are qualitatively assessed according to the methodology presented in Section 6.1.

6.3 Beneficial Impacts

Several beneficial socio-economic and socio-cultural impacts accrue from PDO's service activities. Logistics asset, as a key service provider to the production assets shall be credited with a proportional share of these beneficial impacts. These beneficial impacts outweigh the adverse impacts, which are discussed in the subsequent sections. The major beneficial impacts from the asset are on the economy, employment, local amenities and ecology. These impacts are discussed below. They are however not rated or ranked as per the methodology discussed in Section 6.1 since PDO's rating criteria apply for adverse impacts only. Therefore, only descriptive treatment is given for the magnitude and significance of the beneficial impacts.

- Economy

In Oman, the national economy is significantly dependent on crude oil production, with petroleum sector contributing about 40% to the gross domestic product. More significantly however, nearly 75% of the government revenue is from oil exports. Thus, there is ever-increasing need for more production of crude oil to sustain the current economic (gross domestic product) growth rate of 10.8%. The total crude oil production in Oman is presently about 330 million barrels annually, out of which about 90% exported. PDO accounts for over 90% of the total crude oil produced in Oman. Thus the economic benefits from PDO activities are quite significant.

- Employment

PDO currently employs over 4000 permanent staff and 16000 contractor staff. In addition, a large number of persons, including local population in the interiors are also provided indirect employment to provide a number of supporting services. In the interior areas, providing service to PDO is the only alternative employment for the local communities, whose main occupation is farming and animal husbandry. Therefore, the beneficial impact on employment is also significant.

- Amenities

PDO provides and shares several amenities developed by PDO all over its concession area with the local population. They include the access roads, power supply, potable water supply, clinical facilities and telecommunication facilities. In addition, the assets provide financial and other material assistance to local schools, local bodies and cultural events.

- Ecology

While some adverse impacts on ecology may be expected from the asset activities, a few direct beneficial impacts on the ecology also exist. The most significant is the greening of the desert by re-using treated sewage effluents. The land within the PDO main camps and the contractor camps is significantly vegetated with trees, shrubs and lawns. In addition, PDO has developed a large farm in Rahab under "Desert Agriculture Project" over an area of over 100 ha. The significant vegetal cover developed in the asset has provided a habitat for the native fauna, most importantly birds and terrestrial invertebrates.

6.4 Impacts on Air Environment

The potential environmental effects on the air environment and the associated environmental hazards are listed below:

Environmental Hazards
- Release of gaseous emissions from stationary sources
- Release of gaseous emissions from mobile sources
- Generation of noise from mobile sources

Potential Environmental Effects
- Global warming
- Air pollution
- Noise pollution

- **Global Warming**

CO_2 and methane emissions contribute to global warming. For logistics asset, most of the CO_2 emissions are from the fuel combustion in the automobiles and the aircrafts. The total CO_2 emissions from all automobiles operating under logistics asset throughout the interior locations and in MAF are in the order of 88,000 tpa or 240 tpd. The total CO_2 emissions from the three aircrafts operating under logistics asset between Seeb Airport and the interior locations 11,400 tpa or 31 tpd. Thus it may be seen that the quantities of global warming gases released as a result of the asset activities is not significant, particularly when compared to the land area covered by the asset. Based on the above discussion, the overall impact on global warming is rated as below:

Impact Rating	**Global Warming**
Nature of impact (beneficial / adverse)	Adverse
Duration of impact (short term / long term)	Short term
Likelihood of occurrence (very low / low / medium / high / very high)	Very low
Significance of impact (slight / minor / localized / major / massive)	Slight
Potential risk level (low, medium, high and extreme)	Low

- **Air Pollution**

Air pollutants such as NO_x, SO_2, CO and unburnt hydrocarbons are released into the atmosphere through the automobile and aircraft engine exhaust gases. The total emission loads from all automobile operating under the control of logistics asset are 2.9 tpd for NO_x, 2.0 tpd for CO, 0.6 tpd for SO_2 and 0.4 tpd for hydrocarbons. The emission loads from the aircrafts are less than 0.1 tpd for each pollutant. These quantities are not significant considering that they are released over a large area.

The emission of road dust on graded roads particularly during summer months may be significant. The fugitive emissions of hydrocarbon vapours from fuel filling stations and of chemical vapours from outdoor chemical storage yards (in Fahud and Marmul) may occasionally lead to high concentration in the air. However, such occurrence will be highly localised and general public are not expected to be affected. Based on the above discussion, the overall impact on ambient air quality is rated as below:

Impact Rating	**Air Pollution**
Nature of impact (beneficial / adverse)	Adverse
Duration of impact (short term / long term)	Long term / Short term
Likelihood of occurrence (very low / low / medium / high / very high)	Low
Significance of impact (slight / minor / localized / major / massive)	Slight
Potential risk level (low, medium, high and extreme)	Low

- **Noise Pollution**

Any impacts on ambient noise are limited to only mobile noise generating sources, which include automobiles and aircrafts. The flight frequency is less than once a day per location and the road traffic frequency at any location is not significant. While sufficient data on source noise levels are not available, it is reasonable to expect that any adverse impacts on ambient noise will be highly localized and intermittent. Further, there are no human settlements in the asset areas except for PDO and contractors camps. Based on the above discussion, the impact on ambient noise is assessed as below:

Impact Rating	**Increase in Ambient Noise Levels**
Nature of impact (beneficial / adverse)	Adverse
Duration of impact (short term / long term)	Long term / Short term
Likelihood of occurrence (very low / low / medium / high / very high)	Low
Significance of impact (slight / minor / localized / major / massive)	Slight
Potential risk level (low, medium, high and extreme)	Low

6.5 Impacts on Land Environment

The potential environmental effects on the land environment and the associated environmental hazards are listed below:

Environmental Hazards
- Discharge of raw sewage on land
- Accidental spills and leaks of liquid fuels
- Accidental spills and leaks of chemicals

Potential Environmental Effects
- Land contamination

Sewage generated in the facilities under the operational control of logistics asset is intermittent and small. Sewage generated from the automobile fuelling stations, automobile workshops and chemical stores is diverted to the nearest PDO STP for treatment. Only in the passenger buildings in the interior airports, the sewage collected in septic tanks and the overflow is discharged into soak pits. Considering that sewage in the passenger buildings is generated only intermittent and in small quantities, the potential for any raw sewage to be released on land due to overflow from soak pits is very small

Accidental leaks and spills may occur for the liquid fuels in the filling stations from storage tanks or during road transport and during refuelling. The automobile fuels and the aviation fuel are highly volatile and therefore any spills will readily evaporate. No spills have been reported.

For chemicals, accidental leaks and spills may occur in the central chemical stores during storage and handling or during road transport. The frequency of accidental spills / leaks in the central, chemical stores are reported to be low. However, no records are maintained and the quantities of spills are not reported. It may be noted that any land contamination due to chemicals spills shall be treated as extremely hazardous since most chemicals are toxic, non-biodegradable and persistent, even though it may be highly localised. Based on the above discussion, the overall impact on land contamination is rated as below:

Impact Rating	**Land Contamination**
Nature of impact (beneficial / adverse)	Adverse
Duration of impact (short term / long term)	Long term
Likelihood of occurrence (very low / low / medium / high / very high)	Low
Significance of impact (slight / minor / localized / major / massive)	Minor
Potential risk level (low, medium, high and extreme)	Medium

6.6 Impacts on Water Environment

Any potential adverse effect on the water environment may be expected only as a consequence of land contamination. Further, land contamination can lead to groundwater pollution only if the quantities of release are significant and shallow

groundwater conditions exist. Except on the coast in MAF, the groundwater table is at least 150 m deep. The potential risk level for land contamination is rated as medium. Therefore, the potential risk on groundwater or marine water pollution is considered to be low.

6.7 Impact on Terrestrial Ecology and Wildlife

Any adverse impacts on terrestrial ecology and wildlife may be expected from the operation of the airstrips in the interior locations and rig movements. All the airstrips are located on barren desert plains with no significant vegetal cover and far away from any ecological sensitive areas. Rig movements can potentially result in damage to vegetation if the transportation routes are not properly selected. One of the rig movement procedural requirements is to carry out a pre-rig movement HSE evaluation. Therefore, the potential risk level on terrestrial ecology and wildlife is considered low.

6.8 Impact on Social Environment

Under social environment, employment, agriculture, animal husbandry, native lifestyle, cultural heritage, public health and safety, landscape and aesthetics are considered. Most of the impacts on social environment are beneficial, which are discussed in Section 6.2. The only adverse impact on social environment that may result directly from the activities of logistics asset is the impact on public safety and health for the land and air transportation and bulk storage of hazardous substances.

The hazards associated with potential impact on public safety and health are listed below:

Environmental Hazards
- Road transport of personnel and cargo
- Air transport of personnel and cargo
- Bulk storage of fuels
- Bulk storage of chemicals

Potential Environmental Effects
- Public safety and health

Logistics asset operates about 660 light vehicles and 75 heavy / specialised vehicles for land commuting throughout PDO's concession area. For air transport, three aircrafts are operated at a flight frequency of less than once a day per aircraft. Since most of PDO's concession area is uninhabited, the potential risk to public safety due to accidents involving the road vehicles or aircrafts is considered very low.

The total cargo transported by logistics asset is about 35 million tonne-km annually. Some of this cargo includes hazardous chemicals. Any major accidents involving the

cargo vehicles can result in significant spillage of hazardous substances affecting public safety and health risk. As a policy all vehicles are regularly checked for RAS compliance and only PDO driving permit holders are allowed to drive the vehicles. SHOC cards are provided with all consignments. All these measures minimise the accident potential risk. No major accidents involving hazardous cargo have been reported in recent times.

The storage of aviation fuel at three interior airports and automotive fuel at eight filling stations has inherent potential for fire risk, due to their high flammability. These facilities are provided far away from residential places. All these facilities are provided with the necessary fire protection and fire fighting equipment.

The bulk chemical storage facilities are located away from any residential places and within the industrial areas. All these facilities are provided with the necessary personal protection and fire fighting equipment.

PDO's concession area is very thinly populated and there are no human settlements except for PDO and contractor camps. Based on the above discussion, the impacts on public health and safety are assessed as below:

Impact Rating	**Public Health and Safety**
Nature of impact (beneficial / adverse)	Adverse
Duration of impact (short term / long term)	Short term
Likelihood of occurrence (very low / low / medium / high / very high)	Low
Significance of impact (slight / minor / localized / major / massive)	Localised - Major
Potential risk level (low, medium, high and extreme)	High

7 SUMMARY OF SIGNIFICANT ENVIRONMENTAL EFFECTS AND MITIGATION MEASURES

The identification and assessment of environmental hazards and effects in the asset are discussed in Chapter 6. All adverse environmental effects with medium to extreme risk are considered as significant environmental effects. In this chapter, the additional mitigation measures required for minimizing the environmental consequences from these effects are developed. It may be noted that PDO has a comprehensive environmental management plan as a part of the HSE management system (refer Chapter 2), which is implemented in the asset. No change in the existing environmental management system is required. However, certain additional mitigation measures will reduce the potential environmental risk and improve the overall environmental performance.

The significant environmental effects are listed below along with explanatory notes.

Environmental Effect	Impact Rating	Potential Risk Level	Comments
Public safety and health	• Adverse • Short term • Low occurrence • Localised to major significance	• High risk	• Large quantities of highly flammable materials (aviation fuel, petrol and diesel) are transported by road and stored in bulk at several sites. • Several hazardous chemicals are transported by road and stored in bulk at several sites. • Three aircrafts are routinely flown to the interior locations for air commuting.
Land contamination	• Adverse • Long term • Low occurrence • Minor significance	• Medium risk	• Chemicals spills and leaks are probable in chemical storage yards. • Many chemicals are toxic, non-biodegradable and persistent.

The recommended additional mitigation measures for reducing the environmental risk levels and improving the environmental performance are listed below against each of the environmental specifications of PDO, *viz.*, SP-1005 to SP-1012 and SP-1170.

Specification	Areas of Non-compliance or Concern	Recommended Additional Mitigation Measures
SP-1005: Specification for Emissions to Atmosphere	• With aging, the emission performance of automobile engine may deteriorate.	• Emission checks shall be routinely done for all vehicles.
SP-1006: Specification for Aqueous Effluents	• In airport passenger buildings, the overflow of raw sewage from soak pits on to land may be hazardous since it may carry pathogenic organism.	• Septic tanks and soak pits shall be checked on annual basis and cleaned if necessary.

Specification	Areas of Non-compliance or Concern	Recommended Additional Mitigation Measures
SP-1007: Specification for Accidental Releases to Land and Water	• Not all chemicals leaks and spills are reported. • Incident reporting on accidental releases is not comprehensive.	• All chemical leaks and spills, irrespective of the quantity shall be reported and quantified. • Contaminated soils shall be promptly recovered and transferred to the waste management centre.
SP-1008: Specification for Use of Energy, Materials and Resources	• Efficient use of fuel in automobiles under the operational control of logistics asset is not demonstrated.	• Fuel conservation measures shall be promoted.
SP-1009: Specification for Waste Management	• It is likely that not all contaminated soils are recovered.	• Contaminated soils shall be promptly recovered and transferred to the waste management centre.
SP-1010: Specification for Environmental Noise and Vibration	• None	• None
SP-1011: Specification for Flora and Fauna	• None	• None
SP-1012: Specification for Land Management	• None	• None
SP-1170: Specification for Management of Naturally Occurring Radioactive	• None	• None

8 REFERENCES

1. PDO, *Supply Asset – Environmental Assessment Report*, September 1999

2. *HEALTH, SAFETY AND ENVIRONMENT GUIDELINE - Environmental Assessment* GU 195, PDO, July 2002

3. HSE Manual, *Quantifying Emissions EP-95-0377*, Exploration and Production PDO, Sept'95

APPENDIX 1: DETAILS OF PERSONNEL RESPONSIBLE FOR PREPARATION AND REVIEW OF THE REPORT

HMR Environmental Engineering Consultants, Oman are responsible for the preparation of this report on environmental assessment of Logistics asset area. HMR is the leading environmental engineering consultancy in Oman. HMR specialized in the fields of environmental management, water resources management, environmental assessment, environmental auditing, environmental monitoring, pollution control and environmental training.

HMR has a large pool of environmental engineers and scientists, who have work experience throughout the world and the Arabian Gulf. HMR also has technical collaborations and associations with a number of international engineering consulting companies. HMR is registered with the World Bank as well as with the Ministry of Regional Municipalities and Environment, Sultanate of Oman.

The following HMR Staff are responsible for the technical component of this report.

Name of EIA Team Member	Position in HMR	Position in EIA Team	Role in Project Execution
Dr. Laks M. Akella	Senior Consultant	Team Leader and Project Manager	Project management, data analysis and editorial review
C. S. Shaji	Consultant	EIA Expert	Data collection, site audit and report preparation
Robert Spence	Senior Consultant	EIA Expert	Data collection and site audit
C. M. Sushanth	Consultant	EIA Expert	Data collection and site audit
Babu Krishanan	Consultant	EIA Expert	Data collection and site audit
Krishnasamy	Consultant	EIA Expert	Data collection and site audit
Vinod Gopinath	Environmental Technician	EIA Expert	Data collection and site audit
Shubha Srinivas	IT Consultant	Cartographer	Cartography
Nabeela Ismaily	IT Consultant	Cartographer	Cartography
Randa Mounir	Consultant	Team Member	Editing

On behalf of the client, Petroleum Development Oman, the following individuals are responsible for the review of the EIA report at all stages of the study.

Name of Reviewer	Position in PDO	Role in Project Development
Dr. Muralee R. Thumarukudy	CSM/22	Senior Corporate Environmental Advisor
Ahmed Al Sabahi	CSM/25	Environmental Advisor
Suhail Sheibany	TLM11	HSE Advisor

APPENDIX 2: PDO'S ENVIRONMENTAL RISK EVALUATION CRITERIA

Rating of Consequence of Effect on Environment	**Rating of Frequency of Occurrence**				
	A. Very low: Not heard of but could occur	**B. Low :** Has occurred in other industry	**C. Medium** Has occurred in oil and gas industry	**D. High:** Occurs several times a year in oil and gas industry	**E. Very high:** Occurs several times a year in PDO
Slight Effect : Local environmental damage. Within the fence and within systems. Negligible financial consequences	**LOW RISK**				
Minor Effect: Contamination. Damage sufficiently large to attack the environment. Single exceedence of statutory or prescribed criterion. Single complaint. No permanent effect on the environment.		**MEDIUM RISK**			
Localized Effect: Limited loss of discharges of known toxicity. Repeated exceedence of statutory or prescribed limit. Affecting neighborhood.					
Major Effect: Severe environmental damage. The company is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedence of statutory limits		**HIGH RISK**			
Massive Effect: Persistent severe environmental damage or severe nuisance or nature conservancy extending over a large area. In terms of commercial or recreational use, a major economic loss for the company. Constant, high exceedence of statutory or prescribed limits	**EXTREME RISK**				

APPENDIX 3: ENVIRONMENTAL HAZARDS AND EFFECTS IDENTIFICATION MATRIX: LOGISTICS ASSET

Environmental Hazards	**Environmental Sensitivities**																					
	Natural Resources			**Air Environment**			**Water Environment**			**Land Environment**			**Ecology and Wildlife**			**Social Environment**					
	Mineral Resources	Groundwater Resources	Claim on Local Assets	Climate (Global Warming)	Ambient Air Quality	Ambient Noise	Surface Hydrology & Water Quality	Hydrogeology & Ground Water Quality	Marine Water Quality	Land Use	Loss of Vegetation	Soil Quality	Flora	Fauna	Wildlife Habitats	Employment	Agriculture & Animal Husbandry	Native Lifestyle	Cultural Heritage	Public Health & Safety	Landscape & Aesthetics
Land take																					
For construction of storage facilities			**X**							**X**	**X**		**X**	**X**	**X**						
Utilization of Human Resources																					
Employment of migrant construction workers																				**X**	
Employment of permanent workers																				**X**	
Release of Air Pollutants																					
Dust from road traffic					**X**																
Gaseous emissions from stationary sources				**X**	**X**																
Gaseous emissions from mobile sources				**X**	**X**																
Accidental release of toxic gases and vapours					**X**															**X**	
Release of Energy into Atmosphere																					
High level noise from stationary sources						**X**															

Environmental Hazards	Environmental Sensitivities																				
	Natural Resources			Air Environment			Water Environment			Land Environment			Ecology and Wildlife			Social Environment					
	Mineral Resources	Groundwater Resources	Claim on Local Assets	Climate (Global Warming)	Ambient Air Quality	Ambient Noise	Surface Hydrology & Water Quality	Hydrogeology & Ground Water Quality	Marine Water Quality	Land Use	Loss of Vegetation	Soil Quality	Flora	Fauna	Wildlife Habitats	Employment	Agriculture & Animal Husbandry	Native Lifestyle	Cultural Heritage	Public Health & Safety	Landscape & Aesthetics
High level noise from mobile sources						X															
Discharges of Liquid Effluents																					
Land disposal of treated sewage								X				X									
Accidental spillage of hazardous liquids								X				X									
Disposal of Solid Wastes																					
Handling and transport of hazardous wastes																				X	
Functional Activities																					
Road transport of hazardous substances														X						X	
Bulk storage of hazardous substances																				X	
Road travel														X						X	
Air travel														X						X	

Note: Filled-in cells indicate potential interaction and blank cells indicate no or negligible interaction.