Appendix A

APPENDICES FOR SECTION 5 – AIR QUALITY AND ODOUR

APPENDIX A-1

APPENDIX 5.1: AIR QUALITY BASELINE REPORT

REPORT N^{O} 70029220-02-C-BASE/AQ

ENVIRONMENTAL BASELINE: AIR QUALITY

DUQM REFINERY, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

FOR DRPIC ONLY: CONFIDENTIAL

AUGUST 2017

DUQM REFINERY PROJECT

DUQM REFINERY, OMAN

Duqm Refinery & Petrochemical Industries Company

Confidential

Project no: 70029220
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1 INTRODUCTION

1.1 BACKGROUND

This report represents the methodology and results of an environmental air quality and odour baseline survey carried out at, and around the area close to, the Duqm Refinery Project, Oman.

1.2 SCOPE OF REPORT

The purpose of the air quality and baseline survey was to provide a robust and full data set at a fixed location of air pollutants and odour sources for a minimum period of three months, while also providing a wider range of air quality data from additional measurements across the study area. The survey results are expected to represent typical baseline ambient air levels and baseline odour at both background locations and at location close to sensitive receptors.

This report sets out the methodology employed and a summary of the results, along with details of the measurement data and equipment.

1.3 PROJECT OVERVIEW

The Duqm Refinery Project comprises the Refinery itself and its Off-site Facilities. The components of the Project are described in Table 1.1 below.

Table 1.1: Duqm Refinery Project

PROJECT COMPONENT	DESCRIPTION
→ Duqm Refinery	A 230,000 barrels per day complex refinery on a plot of 9km^2 area to the north of the main industrial area within the Duqm Special Economic Zone (SEZ). This includes: • Site clearance and levelling (completed in late 2016); • Product pipelines and service lines to the Duqm Export Terminal; • Construction accommodation/Workers' Camps; and • Laydown areas.
→ Off-site Facilities	i. **Crude oil storage facility at the Ras Markaz (RM) Crude Oil Storage Terminal**: eight tanks located within, and part of the wider Terminal, approximately 80km from the Refinery. The large-scale Tank Terminal (to be run by Oman Oil Tank Terminal Company, OTTCO) in its entirety is not part of the Project. ii. **'DRPIC Crude Pipeline':** 28-inch diameter 80km crude oil import pipeline to transport crude oil from RM to Duqm Refinery. iii. **Product 'Export Terminal'**: on the lee breakwater of the Port of Duqm, close to to the south-east of the Refinery plot. Topside works only, i.e., storage for products and export handling facilities.

The transition of crude oil from its import, via a Single Point Mooring (SPM) at Raz Markaz, to the export of refined products through the Project facilities follows these key stages:

1. Offload of crude oil from offshore vessel delivery. Crude oil is stored within the crude import and storage facility at Ras Markaz Tank Farm of which only eight crude oil tanks are part of the Project.
2. The oil is transferred to the Duqm Refinery through the 80.7km Crude Import Pipeline. The Duqm Refinery will have a design capacity of 230,000 barrels per day and will produce the following products:
   a. Naphtha;
   b. Liquid Petroleum Gas (LPG);
   c. Jet A-1;
   d. Diesel;
   e. Heavy Sulphur Fuel Oil (intermittently);
   f. Petroleum Coke (Solid); and
   g. Sulphur (Solid).
3. Once the crude oil is refined to the final products, then these are marine exported via the Duqm Export Terminal. The liquid products are conveyed to the terminal via pipelines within a service corridor and the solid products via ground transport.

1.4 PREVIOUS BASELINE WORK

Previous baseline air quality and odour survey work has been documented as follows (see also References):

- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery* (HMR, 2015);
- Environmental and Social Impact Assessment (ESIA) Scoping Report for the Proposed Duqm Integrated Power and Water Plant (DIPWP), Duqm, Sultanate of Oman;
- Sections 5 (ambient air quality) and 6 (impact assessment), and Appendix 3 of the *Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report* (WorleyParsons Oman Engineering, 2016);
- Duqm Industrial and Free Zone Masterplan Sultanate of Oman, Final EIA Report;
- Appendices B and E of the *Environmental Impact Assessment Study Report for Duqm Refinery Construction Camp* (HMR, 2014)*;*
- Environmental Impact Assessment (EIA) Study Report, Duqm Refinery;
- Sections 2, 6 and 7 of the *Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project* (WorleyParsons Oman Engineering, 2015);
- EIA for Service Corridor, Duqm, Environmental Impact Assessment Report;
- ESIA for Ras Markaz Crude Oil Park;
- Environmental Impact Assessment (EIA) Report for Duqm Sea Water for Industrial Zone Project (SWIP); and
- Equator *Principles Supplementary Report on Associated Facilies – Gensis Technip, March 2016*

The previous baseline air quality studies and odour included measurements in and around Project components and relevant receptors. These are summarised in the following Section.

1.5 FINDINGS OF THE PREVIOUS AIR QUALITY AND ODOUR ASSESSMENTS IN THE DUQM REGION

Duqm Ras Markaz Oil Pipeline Concept Study & FEED, Environmental Impact Assessment Report - Oman Gas Company, May 2016

As part of the zone development, SEZAD undertook continuous ambient air quality studies at three locations within the Duqm SEZ area between 2012 and 2013, recording concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2) and particulate matter of diameter less than or equal to ten micrometers (microns) PM_{10}.

The monitoring detected exceedances of both the USEPA and Omani provisional standards for Ozone (8 hour average, 177$\mu g/m^3$, Sep 2013); SO_2 (1 hour average, 211 $\mu g/m^3$, Sep 2013) and PM_{10} (24 hour average, 244 $\mu g/m^3$ Mar 2013).

In addition, PM_{10} monitoring was undertaken at 70 locations along the pipeline for up to 15 minutes at each location. Concentrations ranged from 10 to 339 $\mu g/m^3$ as a 15 minute average. High dust levels were recorded during periods of high wind speeds.

Ras Markaz Crude Oil Park Project – HMR Consultants, October 2015

Ambient concentrations of CO, NO, NO_2, NO_x, O_3, hydrogen sulphide (H_2S), SO_2, methane (CH_4), Total Non-Methane Hydrocarbons (TNMHCs) and PM_{10} were monitored using a continuous analyser for a period of one month. Monitored concentrations were within the relevant standards with the exception of 24 hr PM_{10} concentrations which reached 244$\mu g/m^3$.

Duqm Industrial and Free Zone Masterplan – Jurong Consultants, June 2010

PM_{10} monitoring was undertaken at ten sites for a period of less than one day at each location. Period mean concentrations ranged between 13.4 and 73.0 $\mu g/m^3$ and it was stated that gusting wind may have played a role in the higher concentrations measured.

In addition, diffusion tubes for sulphur dioxide and nitrogen dioxide were deployed at four locations for a period of 36 days. Mean SO_2 concentrations ranged from 11.97 to 19.60 $\mu g/m^3$ and nitrogen dioxide concentrations ranged between 2.93 and 4.07 $\mu g/m^3$.

Duqm Refinery Air Quality Baseline Study Report (HMR, Dec. 2014)

Baseline air quality was assessed using a series of several short monitoring surveys (ranging between 11 to 18 days) at five locations within the Duqm Refinery study area. A Continuous Air Quality Monitoring Station (CCAQMS) was used to monitor concentrations of SO_2, NO_x, CO, O_3, H_2S, PM_{10} and total non-methane hydrocarbons (TNMHC). Monitoring locations included the Duqm Refinery site (October 2013 and June 2014), Wadi Dhanjart, the Village of Nafun, the heavily Industrialised area to the north of Duqm town, Duqm Town and the Airport. During the surveys several exceedances of air quality standards were observed, these occurred principally at the Refinery site, and included an exceedance of the O_3 8-hr standard in the June to July 2014 air quality monitoring period, which was not observed during the previous monitoring undertaken at the site in October 2013. Also an exceedance of the PM_{10}, air quality standard was observed at both the Refinery site and in Duqm Town. Ozone exceedances are more likely during summer periods than winter periods due to the higher UV intensities, and elevated PM_{10} concentrations were attributed to the characteristic Shamal winds which occur in the summer months.

Duqm Liquid Bulk Berths Project – Worley Parsons, September 2015

Diffusion tube monitoring was undertaken at eight sites, measuring SO_2, volatile organic compounds (VOC), O_3, oxides of nitrogen (NO_x) – made up of nitrogen monoxide (NO) and nitrogen dioxide (NO_2) concentrations over a period of 21 days. Concentrations of SO_2, VOC, NO_x and NO_2 were all well below the relevant standards (<5µg/m^3 in each case). Ozone concentrations ranged between 59 and 78 µg/m^3 over the period.

Environmental Impact Assessment Report for Duqm Sea Water for Industrial Zone Project – HMR Consultants, July 2015

Concentrations of SO_2, NO_x, CO, O_3, H_2S, PM_{10} and total non-methane hydrocarbons (TNMHC) were monitored using a continuous analyser for a period of approximately two weeks at each of three locations. 24 hr average concentrations of SO_2 exceeded the standard with a maximum value of 160.3µg/m^3 as did 8-hour average concentrations of O_3 with a maximum of 125.2 µg/m^3. All other measured concentrations fell within the relevant standards.

Environmental Impact Assessment Report for Duqm Refinery Construction Camp – HMR Consultants, December 2014

Ambient concentrations of CO, NO, NO_2, NO_x, O_3, H_2S, SO_2, CH_4, Total Non-Methane Hydrocarbons (TNMHCs) and PM_{10} were monitored using a continuous analyser at three separate sites over a total period of 39 days. 8 hr average concentrations of O_3, exceeded the standard with a maximum value of 193µg/m^3 as did 24 hour average concentrations of PM_{10} with a maximum of 227 µg/m^3 and NMHCs with a maximum value of 260 µg/m^3. All other measured concentrations fell within the relevant standards. Odour sampling was carried out using sorbent tubes. Sorbent tube sampling is NIOSH/OSHA approved method for collecting most hazardous gases and vapours from the air. All VOCs sampled for odour were below the detection limits.

Environmental and Social Impact Assessment Report for the proposed Duqm Integrated Power and Water Plant (DIPWP), Duqm – Marafiq; BEYA 2015

Ambient concentrations of O_3, PM_{10}, SO_2, H_2S, CO, NO_2, CH_4 and NMHC were monitored at five locations for a period of approximately 24 hours at each location. 24 hr PM_{10} concentrations exceeded the 24hr standard at one location, with a maximum concentration of 506µg/m^3. In addition, elevated concentrations of ozone were recorded (a maximum of 68.1µg/m^3 as 24 hr average), indicating a likely exceedance of the 8 hour standard for O_3. All other measured concentrations fell within the relevant standards.

Scoping Report and ESIA[1] for the Proposed DIPWP – ADP Consultants, December 2016

Ambient air quality monitoring was carried out in December 2016 on continuous basis over just 24hrs hours at four separate locations measuring SO_2, H_2S, NO_2, NO_x, CO, O_3, CH_4, NMHC and PM_{10}. Measured concentrations of O_3 over the 24hr period were elevated (between 53.5 to 68.1 µg/m^3) though well within the Omani 8 hr air quality standard of 120 µg/m^3, as the monitoring period was greater than the standard duration, an exceedance of the O_3 standard at these locations were possible. In addition PM_{10} concentrations at all five sample locations were within the 24hr national ambient air standard of 125 µg/m^3 though exceeded the WHO annual standard

[1] Due to the timing of the availability of an updated ESIA Report (end of July 2017) the results were not available in time for this Report.

of 20 µg/m^3, which was not applicable over these very short monitoring durations. All other parameters were well below the Omani nation air quality standards.

1.6 SUMMARY OF THE AIR QUALITY MONITORING STUDIES UNDERTAKEN IN THE DUQM REGION TO DATE

The previous air quality survey undertaken in the Duqm region detected exceedances of PM_{10}, O_3 and SO_2 concentrations against the Omani air quality standards. A continuous analyser was deployed for only six of the nine air quality surveys and only for a maximum period of one month at any one site. In the studies which deployed diffusion tubes exposed over several weeks, the likelihood that a non-compliance against a 24hr air quality standard would have been detected is low. These previous studies, even though short in duration, and in two cases limited to a diffusion tube study, detected several non-compliances of pollutants, two of which (PM_{10} and O_3) would be considered to be as result of natural processes, and not as an consequence of anthropogenic emissions.

2 METHODOLOGY

2.1 RELEVANT AIR QUALITY AND ODOUR STANDARDS

2.1.1 Provisional Omani Ambient Air Quality Standards

2.2 GUIDANCE

In preparation of the new baseline survey to be carried out to enhance the set of historic measurements, it was important to take account of any existing Omani and international Air Quality Standards.

There are no formal Omani standards for air quality, however Provisional Ambient Air Quality Standards have been developed (see Table 2-1 below) along with 'Ministerial Decision No. 118/04 on the Control of Air Pollution from Stationary Source'. In addition to these, international standards from the United States Environmental Protection Agency (USEPA), United Kingdom and European Union (EU) provide air quality limits values for pollutants not addressed in the Provisional Ambient Air Quality Standards (see Table 2-2).

Where applicable, the Omani Provisional Ambient Air Quality Standards will be required to be met, and where a limit value for a pollutant is not presented within either the Omani standards, the IFC (referring to World Health Organization, WHO) standards will be considered the project specific air quality standard.

Table 2-1: Provisional Omani: Ambient Air Quality Standards

Pollutant	Averaging Period	Omani Air Quality Standard (MD 41/2017)		Previous Provisional Omani AAQS	
PM_{10}	24 hour	150	µg/m^3	125	µg/m^3
	1 Year			-	-
NO_2	24 hour	130	µg/m^3	112	µg/m^3
	1 hour	250	µg/m^3	-	-
	1 year			-	-
SO_2	24 hour	150	µg/m^3	125	µg/m^3
	1 hour	350	µg/m^3	-	-
	3 hour			-	-
	10 minutes			-	-
CO	8 hour	10	mg/m^3	6	mg/m^3
	1 hour	30	mg/m^3	-	-
H_2S	24 hour			40	µg/m^3
	1 hour	30	µg/m^3		
O_3	8 hour	120	µg/m^3	120	µg/m^3
HCNM	3 hour	160	µg/m^3	160	µg/m^3
Lead	3 month	1.5	µg/m^3	-	-
	1 year			-	-
$PM_{2.5}$	24 hours	65	µg/m^3	-	-
	1 year			-	-
NH_3	24 hours	200	µg/m^3		

Pollutant	Averaging Period	Omani Air Quality Standard (MD 41/2017)		Previous Provisional Omani AAQS	
Benzene	1 year			-	-
Arsenic	1 year			-	-
Cadmium	1 year			-	-
Nickel	1 year			-	-
PAH	1 year			-	-

2.2.1 IFC EHS Guidelines

For pollutants where no Omani standards apply, air quality guidelines IFC general (WHO) international standards have been adopted. These criteria are shown in Table 2.2.

Table 2.2: Ambient Air Quality Standards

Pollutant	Averaging Period	IFC General (WHO)	
PM_{10}	24 hour	50	µg/m^3
	1 Year	20	µg/m^3
NO_2	24 hour	-	-
	1 hour	200	µg/m^3
	1 year	40	µg/m^3
SO_2	24 hour	20	µg/m^3
	1 hour	-	-
	3 hour	-	-
	10 minutes	500	µg/m^3
CO	8 hour	-	-
	1 hour	-	-
H_2S	24 hour	-	-
O_3	8 hour	100	µg/m^3
HCNM	3 hour	-	-
Lead	3 month	-	-
	1 year	-	-
$PM_{2.5}$	24 hours	25	µg/m^3
	1 year	10	µg/m^3
Benzene	1 year		
Arsenic	1 year	-	-
Cadmium	1 year	-	-
Nickel	1 year	-	-
PAH	1 year	-	-

2.2.2 USEPA and EU Air Quality Standards

For reference the United States Environmental Protection Agency (USEPA), United Kingdom and European Union (EU) air quality standards have been set out to provide a guideline value air for those pollutants which have no Omani or WHO standards equivalent (see Table 2-3 below).

Table 2-3: USEPA, UK and EU Air Quality Standard

POLLUTANT	AVERAGING PERIOD	US EPA		EU		UK	
PM_{10}	24 hour	150	µg/m^3	50	µg/m^3	50	µg/m^3
	1 Year	-	-	40	µg/m^3	40	µg/m^3
NO_2	24 hour	-	-	-	-	-	-
	1 hour	0.1	ppm	200	µg/m^3	200	µg/m^3
	1 year	0.053	ppm	40	µg/m^3	40	µg/m^3
SO_2	24 hour	-	-	125	µg/m^3	125	µg/m^3
	1 hour	0.075	ppm	350	µg/m^3	350	µg/m^3
	3 hour	0.5	ppm	-	-	-	-
	10 minutes	-	-	-	-	-	-
CO	8 hour	9	ppm	10000	µg/m^3	10000	µg/m^3
	1 hour	-	-	-	-	-	-
H_2S	24 hour	-	-	-	-	-	-
O_3	8 hour	0.07	ppm	120	µg/m^3	120	µg/m^3
HCNM	3 hour	-	-	-	-	-	-
Lead	3 month	0.15	µg/m^3	-	-	-	-
	1 year	-	-	0.5	µg/m^3	0.5	µg/m^3
$PM_{2.5}$	24 hours	35	µg/m^3	-	-	-	-
	1 year	12	µg/m^3	25	µg/m^3	25	µg/m^3
Benzene	1 year	-	-	5	µg/m^3	5	µg/m^3
Arsenic	1 year	-	-	6	ng/m3	-	-
Cadmium	1 year	-	-	5	ng/m3	-	-
Nickel	1 year	-	-	20	ng/m3	-	-
PAH	1 year	-	-	1	ng/m3	-	-

2.2.3 Odour Nuisance Standards

No nuisance thresholds exist for odour in Oman. Therefore complaints of odour nuisance was assumed to be equivalent to the odour detection thresholds at receptors from known odourous emission from the refinery activities.

Odour thresholds for VOC other anticipated emissions from refinery activities are[2] provided in Table 2-4 below. These odour detection values represent a conservative assessment, as they are from the lower end of the detection range of odour threshold values.

[2] Reference Guide to Odor Thresholds for Hazardous Air Pollutants published by the Unites States Environmental Protection Agency (US EPA), 1992

Table 2-4: Odour Thresholds for Refinery Emissions to Air[3&4]

COMPOUND	ODOUR SOURCE	ODOUR THRESHOLD	
		mg/m^3	ppm
Hydrogen Sulphide	Crude Oil, Sulphur tanks, desulphurisation & Waste Water Treatment	0.014	0.01
Ammonia	Reimpregnation and Waste Water Treatment	3.48	5
Dimethyl Disulphide	Crude Oil, Sulphur tanks, desulphurisation	0.002	0.001
Benzene	Crude Oil and Refined Naphtha	2.50	0.78
Toluene	Crude Oil and Refined Naphtha	7.6	28.6
Ethylbenzene	Crude Oil and Refined Naphtha	0.40	0.092
Xylenes	Crude Oil and Refined Naphtha	0.60	0.14
Hexane	Crude Oil and Refined Naphtha	459	130

2.3 INTERNATIONAL STANDARDS ORGANISATION

In order to comply with IFC requirements, baseline monitoring should adhere to ISO reference methods, where applicable. Compliance of ambient air monitoring methods used within this baseline study is detailed in Table 2-5 below.

2.4 EQUIPMENT

A continuous air quality monitoring station (CAQMS) was deployed at the selected sampling site on 3rd May 2017. The CAQMS was equipped to continuously monitor for the following air quality parameters:

- $PM_{10;}$
- $PM_{2.5;}$
- $NO_{2;}$
- SO_2;
- $O_{3;}$
- CO;
- H_2S;
- VOCs;
- BTEX; and

[3] Occupational Safety and Health Guideline for Methyl Mercaptan, US Dept. Health and Human Services, 1988
[4] Occupational Safety and Health Guideline for Hexane, US Dept. Health and Human Services, 1988

- CH_4

Measurements were carried out for three months at a single fixed background location. The data was then used to providing both short-term and annualised baseline ambient air concentrations.

In addition an anemometer was installed to measure wind speed and wind direction at the sample site. The equipment deployed in the Air Quality monitoring survey is shown in Table 2-5 below.

Table 2-5: List of Air Quality Monitoring Station Equipment

Item No.	Item	Purpose	Number of Items	ISO Standard Compliance
1	Steel Framed Enclosure	Enclosure for the safe containment of sensitive Air Quality monitoring instrumentation	1	-
2	Not Available Beta Attenuation using a Metone BAM	Monitoring particulate airborne matter (PM_{10})	1	Equivalent Method to ISO EN 12341
3	Metone BAM Beta Attenuation Monitor	Monitoring particulate airborne matter ($PM_{2.5}$)	1	Equivalent Method to ISO EN 14097
4	Serinus 50, UV Fluorescent detector	Monitoring Ambient air concentrations of Sulphur Dioxide	1	Compliant with Method ISO EN 14214A
5	Serinus 51 UV Fluorescent detector	Monitoring Ambient air concentrations of Hydrogen Sulphide	1	No ISO Method
6	Gas Chromatograph and Flame ionisation detector	Monitoring Ambient air concentrations of Benzene, Toluene, Ethyl Benzene and Xylene	1	Compliant with Method ISO EN 14662
7	Gas Chromatograph and Flame ionisation detector	Monitoring Ambient air concentrations of Total Volatile organic compounds	1	Compliant with Method ISO EN 16017
8	Serinus 30, Dispersive Infrared detector	Monitoring Ambient air concentrations of Carbon Monoxide	1	Compliant with Method ISO EN 14626
9	Serinus 40, Chemiluminesence detector	Monitoring Ambient air concentrations of Nitrogen Dioxide	1	Compliant with Method ISO EN 14211
10	Serinus 10 Non Dispersive UV detector	Monitoring Ambient air concentrations of Ozone	1	Compliant with Method ISO EN 14625
11	Gas Chromatograph and Flame ionisation detector	Monitoring Ambient air concentrations of Methane	1	No ISO Method
12	Anemometer/Vane using a Gill Met Station	Measuring Wind speed and wind direction	1	-
13	NO_2 Passive Sampling Tubes	Monitoring Ambient air concentrations of Nitrogen Dioxide	6	-
14	SO_2 Passive Sampling Tubes	Monitoring Ambient air concentrations of Sulphur Dioxide	6	-
15	O_3 Passive Sampling Tubes	Monitoring Ambient air concentrations of Ozone	6	-
16	BTEX Passive Sampling Tubes	Monitoring Ambient air concentrations of Benzene, Toluene, Ethyl Benzene, and Xylenes	6	-

Figure 2-1: Continuous Air Quality Monitoring Station at the Sample Location

In addition to the CAQMS, passive samples were deployed at six locations across the study area for NO_2, SO_2, H_2S and BTEX, for a total of three months. However due to contamination via dust intrusion of the final batch (July 2017), only two months of passive sample data was available for the period May and June only. Each sample was collected and a new sample deployed each month. These provided a spatial distribution of baseline ambient air concentrations for up to a total period of two months.

The passive samples deployed across the study area are shown in Table 2.6 and Figure 2-2 below.

Table 2.6 Passive Diffusion Samples Deployed Across the Study Area

ITEM NO.	ITEM	PURPOSE	NUMBER OF ITEMS
1	NO_2 Passive Sampling Tubes	Monitoring ambient air concentrations of Nitrogen Dioxide	6
2	SO_2 Passive Sampling Tubes	Monitoring ambient air concentrations of Sulphur Dioxide	6
3	H_2S Passive Sampling Tubes	Monitoring Ambient air concentrations of H_2S	6
4	BTEX Passive Sampling Tubes	Monitoring Ambient air concentrations of Benzene,	6

ITEM NO.	ITEM	PURPOSE	NUMBER OF ITEMS
		Toluene, Ethyl Benzene, and Xylenes	

Figure 2-2: Passive Diffusion Tube Sampling Sites, across the study area

2.5 SURVEY LOCATIONS

Air quality survey sites were selected on the basis that they provided a safe, secure location representative of either a background site or a sensitive receptor. The CAQMS was located at the Sebacic Acid plant, which is approximately 200m to the south east of the Refinery perimeter. The Sebacic Acid plant provided access to a continuous power source and a secure background location, representative of the current conditions at, or close to the Refinery site (see Figure 2-3).

The passive diffusion sample sites were selected on the basis that a range of criteria were met, including fulfilling the data gaps and providing a range of representative sample locations.

Surveillance of Nafoon Village was undertaken to determine a suitable discrete sample position for diffusion tube monitoring at that location. As a consequence of the surveillance exercise, it was concluded that Nafoon Village did not represent a secure sampling location where a set of diffusion tube samples could be left undisturbed or uncorrupted for a monthly period. This was due to a combination of its remote location, lack of public realm structures, lack of anonymity of sampling staff (visiting outsiders were closely observed by villagers) and the presence of grazing animals in the area. The Quarry road site was identified as a suitable alternative sampling location to Nafoon Village, which similarly to Nafoon Village, was location to the north of the proposed Refinery site, and outside the immediate influence of major industrial activities or major transport routes.

Figure 2-3: CAQMS Site Location

Table 2-7: Baseline Air Quality Monitoring Locations

Measurement Location	Site Category	Sample Deployment	Latitude	Longitude	Nearest Project Component
Quarry Road, North of site	Background Rural	Passive Samplers	19.794795 N	57.662465 E	Refinery
Refinery Site Gatehouse	Project Location	CAQMS/ Passive Samplers	19.739108 N	57.648629 E	Refinery
CAQMS, Sebacic Acid Plant	Background Industrial	Passive Samplers	19.718025 N	57.672829 E	Refinery
Duqm Town centre	Urban	Passive Samplers	19.628775 N	57.633750 E	Refinery Export Terminal
Rock Garden	Background Rural	Passive Samplers	19.625286 N	57.633750 E	Refinery Export Terminal
Export Terminal	Background Industrial	Passive Samplers	19. 601503 N	57.672579 E	Export Terminal

2.6 SAMPLING PROCEDURE

The CAQMS monitored air pollutants continuously from 3rd May 2017 until 6th August 2017.

For NO_2, SO_2, O_3, CO, H_2S and O_3, samples were collected and analysed every five minutes. For BTEX, VOCs and Methane, samples were collected and analysed every 15mins. For PM_{10} and $PM_{2.5}$ samples are collected and measured every 60 mins.

The analysers within the CAQMS were automatically calibrated every 24hr using calibration gas held within the CAQMS. The O_3 analysers are calibrated using a photometer which acts as its own O_3 calibration source.

An additional calibration was carried out by the specialist environmental engineers (Exova, Dubai, UAE) every four weeks, when they attended site to inspect the CAQMS and its equipment, as well as conduct filter changes and attend to any routine servicing which may arise.

Passive samples were deployed, exposed for one month and then collected and replaced. The exposed samples were stored in a fridge, before being dispatched to the laboratory by the Exova environmental engineers. Analysis for diffusion tubes, once received at the laboratory, took up to 15 working days.

Sampling for H_2S, BTEX and NMHC's was considered representative of odour sampling. As the vapour of these chemicals are pungent, and are likely to be present in of residual form and as a consequence of fugitive emissions of those compounds during operation of both the Crude Export Terminal and Refinery.

3 BASELINE AIR QUALITY

3.1 SURVEY RESULTS

Ambient air quality results at the Sebacic Acid plant have been reported for the monitoring period between 3rd May 2017 and 6th August 2017.

3.1.1 Ambient Air Quality and Odour Monitoring Results, Duqm

Results from the CAQMS are summarised in Table 3-1, as period average and compliances against 24 hourly, 8 hourly and 3 hourly standards where relevant. More detail on the data recorded at the CAQMS is presented in Appendices A and B, the latter with maximum concentrations.

Table 3-1: Ambient Air Quality Monitoring Station Results – Duqm, May to August 2017

Pollutant	Period Mean	Max Concentration (Averaged to Standard)	Omani AQ Standard (MD 41/2017)	Compliant
O_3 Conc µg/m³	74.73	172.69 (8 hrs)	120 (8hrs)	No (Exceeds 8hr standard)
CO Conc mg/m³	0.51	0.0088 (8 hrs)	10 (8 hrs)	Yes
		0.041 (1 hr)	30 (1 hr)	
NO µg/m³	1.84			
NO_2 µg/m³	3.32	10.29 (24 hr)	130 (24 hr)	Yes
		58.48 (1 hr)	250 (1 hr)	
SO_2 µg/m³	6.26	14.46 (24 hr)	150 (24 hr)	Yes
		15.90 (1 hr)	350 (1 hr)	
H_2S µg/m³	1.34	9.83(1hr)	30 (1 hr)	Yes
$PM_{2.5}$ Conc ug/m³	64.35	158.92 (24 hr)	65 (24 hr)	No
PM_{10} Conc ug/m³	151.53	488.92 (24 hr)	150 (24 hr)	No
CH_4 µg/m³	770.72			-
NMHC µg/m³	0.00	0.00	160 (3 hr)	Yes
TVOCs µg/m³	4,174			-
Benzene µg/m³	0.00	0.00		Yes
Toluene µg/m³	0.38			-
EthylBenzene µg/m³	0.00			-
M&P-Xylenes µg/m³	0.00			-
O-Xylene µg/m³	0.00			-

*Assuming NMHC = Butane

Air quality and odour monitored by the CAQMS was generally good during the sampling period 3rd May to 6th August 2017, though particulate matter and ozone were both elevated. A power interruption to the CAQMS occurred on 2nd June, which resulted in a four day data gap due to repairs being required to the CAQMS. This sampling period loss was made up be an additional four days sampling by the CAQMS at the end of the third month.

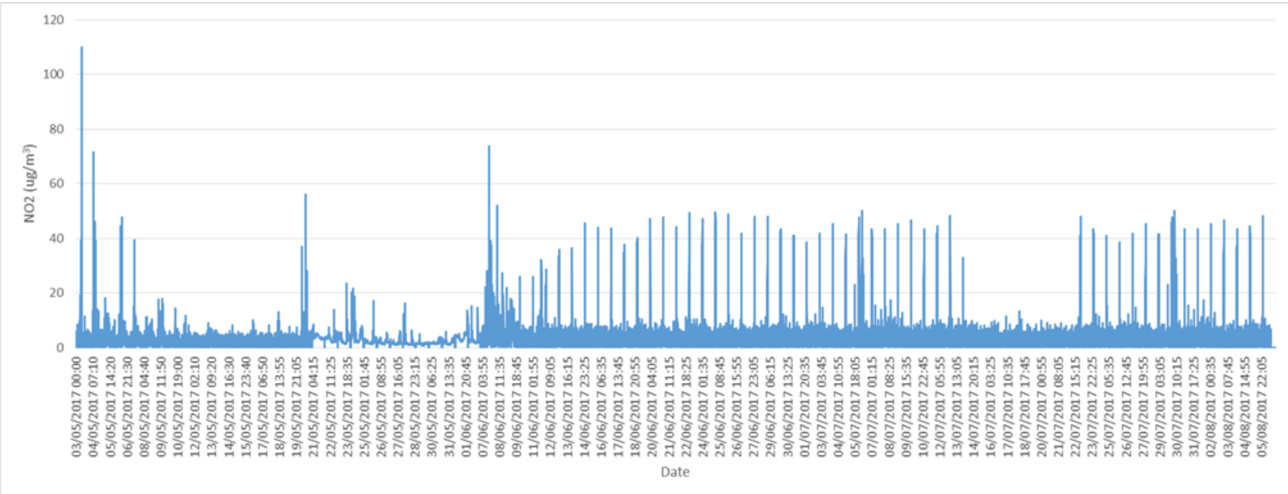
Monitoring results indicate that both NO_2 and SO_2 were both low in concentration during the sampling period, implying that there are no significant industrial emissions sources within the proximity of the CAQMS. However, O_3, PM_{10} and $PM_{2.5}$ all exceeded short-term concentrations limits. In the case of both PM_{10} and $PM_{2.5}$, the period mean exceeded the 24hr air quality standards for both pollutants. O_3 and PM are known to originate as a consequence of natural processes, such as strong sunlight and UV radiation in the case of O_3, and re-entrainment of dust and sand in the case of PM. Therefore, though the baseline survey has detected exceedances of ambient air pollutants, these pollutants are highly likely to originate from natural processes and not as a consequence of existing anthropogenic activity locally.

The periods of elevated particulate matter were extended and not attributable to localised sources. Therefore, though construction activity at the Sebacic Acid Plant would have contributed to the elevated particulate matter concentrations, it was not considered to be the primary source of particulates resulting in the exceedance of both the PM_{10} and $PM_{2.5}$ air quality standard,

Temporal plots of NO_2, SO_2 and O_3 concentrations over the sampling 3rd May to 6th August period indicate the pattern of detection by the CAQMS over time (Figures 3-1 to 3-3).

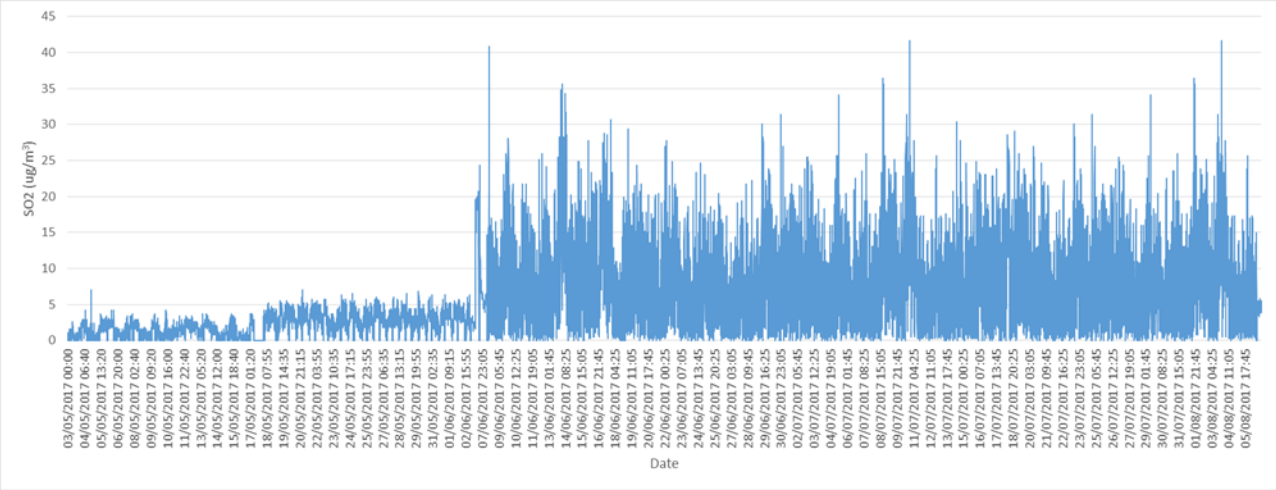
NO_2 concentrations detected at the CAQMS can be seen to remain low (< 5µg/m^3) over the majority of the monitoring period (Figure 3-1). A number of short-term incidents of elevated NO_2 concentrations can be seen to influence the NO_2 detected. These incidents are low in frequency and do not result in an exceedance of NO_2 standards. The short-term nature of these elevated peaks implies a rapid dispersion of the NO_2, which suggests that the source of the NO_2 was local to the CAQMS, possibly local vehicle activity.

Figure 3-1: NO_2 Concentration at the CAQMS between 3rd May to 6th August 2017



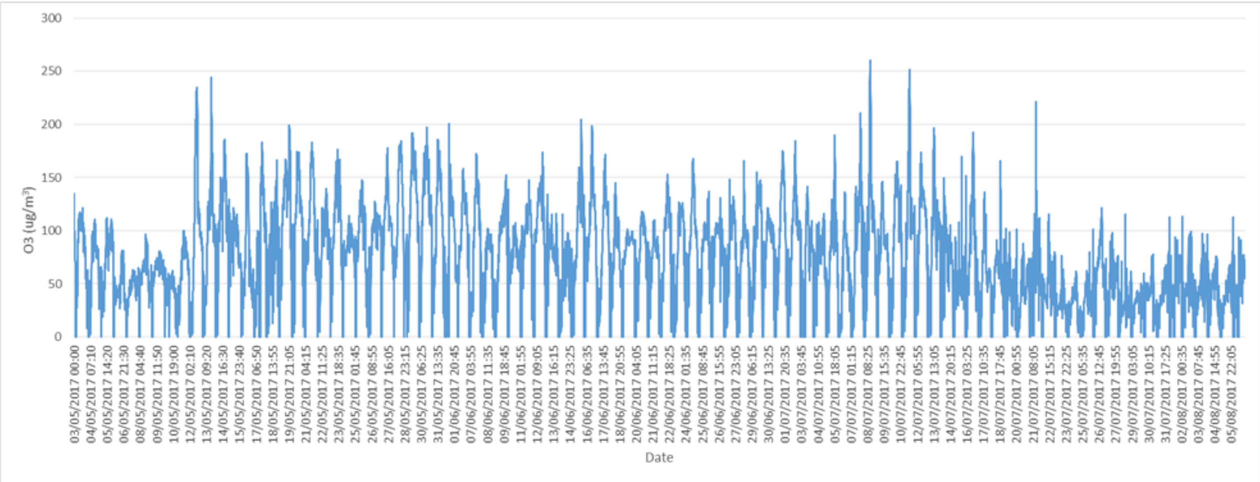
SO_2 concentrations detected at the CAQMS remained below <42µg/m^3 over the whole of the monitoring period (Figure 3-2). Due to the lack of peaks and the homogenous concentration profile of SO_2 over the monitoring period, it can be implied that there is no local source of SO_2 close the CAQMS. SO_2 concentrations over the sampling period did not exceed the SO_2 standards. The step changes in the SO_2 concentrations magnitude are aligned with dates of routine calibrations against a validated SO_2 reference as standard.

Figure 3-2: SO_2 Concentration at the CAQMS between 3rd May to 6th August 2017



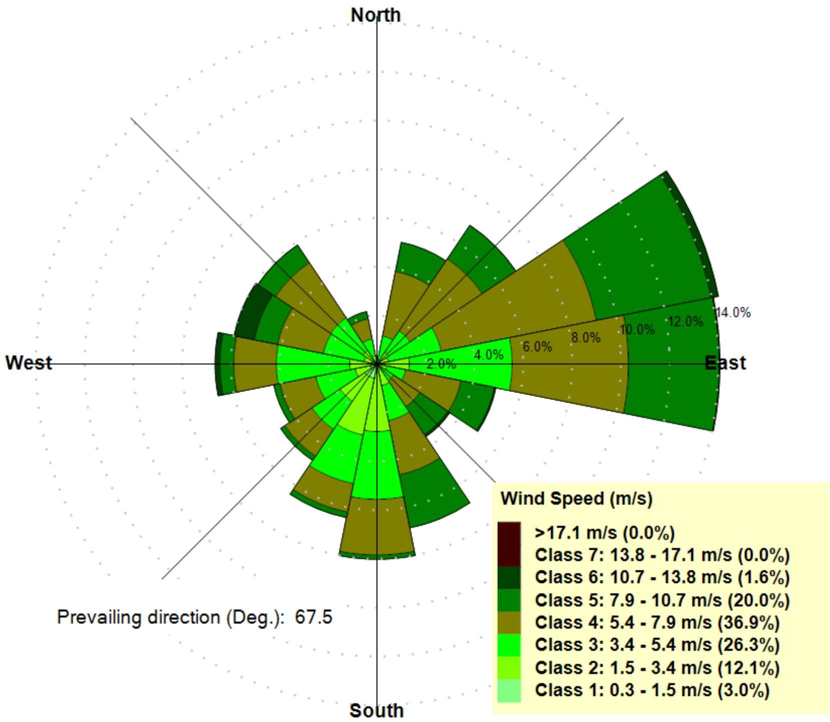
O_3 concentrations detected at the CAQMS can be seen to follow a diurnal cycle across the monitoring period (Figure 3-3). This is in response to the sunlight and UV light contributing to the production of O_3 during the day, and its subsequent absorption and decay overnight. Peaks in O_3 concentration can be observed during the late afternoon, and are only in very short duration. From the 12th May until the end of the sampling period, O_3 concentrations at the CAQMS exceeded the air Omani air quality standard of 60 µg/m^3 over an 8-hour period. Prior to this, not all elevated O_3 episodes exceed the standard average over the 8-hour period, though O_3 concentrations can be observed as elevated at some period of the day for the majority of days during the sampling programme.

Figure 3-3: O_3 concentration at the CAQMS between 3rd May to 6th August 2017



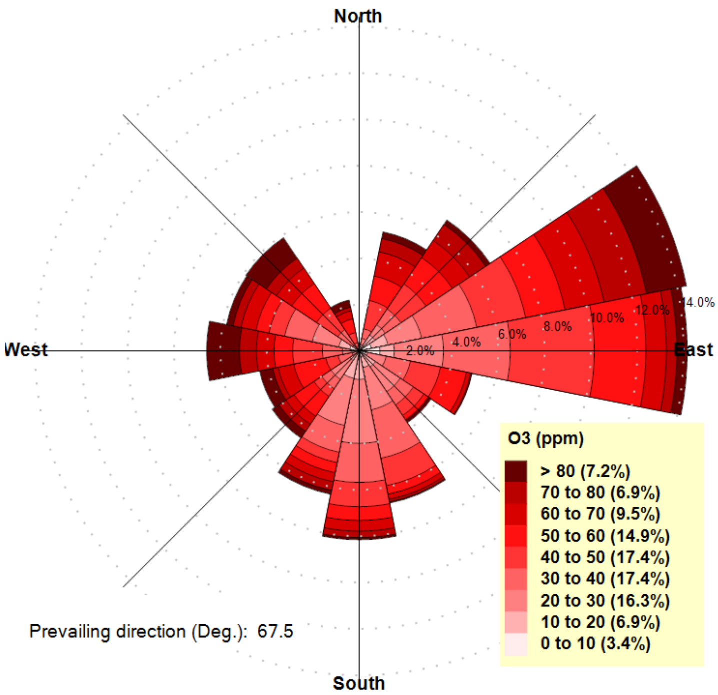
Wind direction and wind speed monitored at the CAQMS over the sampling period 3rd May to 6th August illustrates that the prevailing wind on-site is easterly (Figure 3-4). The resultant easterly windrose relates to wind coming off the nearby coast, and may correlate with adiabatic winds, strong on-shore winds during the late afternoon due to heating of the land mass.

Figure 3-4: Windrose from the CAQMS Site



Correlating wind direction with O_3 concentrations detected over the sampling period 3rd May to 6th August at the CAQMS provides an Ozone-rose, which illustrates the wind direction during various concentrations of O_3 (see Figure 3-5). Elevated O_3 concentrations coincide with an easterly wind direction, which implies that the coast may represent a significant source of O_3.

Figure 3-5: Ozone-Rose from the CAQMS Site



Results from the diffusion tube survey are summarised in Table 3-2 below. Concentrations of pollutants monitored by diffusion tube across the study area were all very low, and indicate that none of the pollutants monitored by diffusion tube were likely to be at risk of exceeding any annual average limits (e.g. such as for Benzene or NO_2).

The spatial variation of pollutant concentrations observed by the diffusion tube results can be seen to vary with respect to the proximity to populated areas. With higher concentrations of NO_2 being detected at the Duqm Town sample site and the Rock garden sample site (within 1km of Duqm Town); whereas the NO_2 concentrations elsewhere were all consistent, even at the CAQMS location (Sebacic Acid Plant). Therefore it can be implied that the current impact of vehicle emissions upon local air quality and NO_2 concentrations within the study low is currently low to negligible.

The concentrations of SO_2 monitored across the study area over the two month diffusion tube survey were low. As the Oman air quality limit value is assessed over a sample duration of 24 hours, no firm assessment of SO_2 limit value or standards compliance can be reached on the monthly diffusion tube samples. However, there is an implication that there is currently no dominating source of SO_2 within the study area, such as the Desalination plant power station, and that baseline concentrations at remote locations to the north of the proposed refinery site (e.g. Quarry Road locations and Nafoon Village) are likely to remain very low.

Table 3-2: Diffusion Tube Survey Results for Duqm Refinery Baseline Survey

Pollutant	NO_2	SO_2	H_2S	Benzene	Toluene	Ethyl Benzene	m,p-Xylene	o-xylene
Duqm Town	8.33	0.32	-	-	-	-	-	-
Rock Garden	9.74	0.38	1.00	0.37	<0.21	<0.25	<0.25	<0.25
Dry Dock Camp	5.32	1.71	-	-	-	-	-	-
Quarry Road	5.16	0.16	0.22	0.25	<0.21	<0.25	<0.25	<0.25
Refinery Gate house	5.66	0.50	0.12	0.215	<0.21	<0.25	0.315	<0.25
CAQMS	6.56	1.29	-	-	-	-	-	-

Further detail is presented in Appendix C.

4 SUMMARY AND CONCLUSIONS

4.1 SUMMARY

This air quality and odour baseline survey and around the area close to the Duqm Refinery Project, Oman found that pollutants concentrations were low to very low for a number of pollutants, including odorous air pollutants. However air quality exceedances were observed for O_3, PM_{10} and $PM_{2.5}$.

4.2 CONCLUSIONS

This baseline air quality and odour survey has resulted in a robust and full data set, totalling three months in duration.

Exceedances of the air quality standards for the three pollutants O_3, PM_{10} and $PM_{2.5}$ were determined as being attributable largely to emissions from natural sources, both regionally and locally, and not as a result of industrial activity or emissions from road vehicles. Therefore it can be concluded from the baseline study, that the study area airshed is considered to be degraded for these three specific pollutants, and non-degraded for the remaining air pollutants including NO_2, CO, SO_2, CH_4, NMHC, TVOCs, Benzene, Toluene, Ethyl Benzene and Xylenes.

5 REFERENCES

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Appendix A

AMBIENT AIR QUALITY MONITORING STATION RESULTS – DUQM MAY 2017

Table 1: Ambient Air Quality Monitoring Station Results – Duqm May to August 2017

	Wind Speed	Wind Dir.	Amb Temp	O3 Conc ppb	CO Conc ppm	NO ppb	NO_2 ppb	SO_2 Conc ppb	H_2S Conc ppb	$PM_{2.5}$ Conc ug/m^3	PM_{10} Conc ug/m^3
Mean	7.99	87.42	29.39	45.06	0.45	1.50	1.80	2.31	1.88	64.35	151.53
Minimum	0.17	9.40	21.60	0.00	0.00	0.00	0.00	0.00	-0.60	0.00	0.00
Date of minimum	05/05/2017 06:05	25/06/2017 17:10	05/07/2017 05:15	03/05/2017 03:00	03/05/2017 01:00	03/05/2017 01:00	03/05/2017 01:00	03/05/2017 00:55	26/05/2017 23:55	17/05/2017 12:45	04/05/2017 16:55
Maximum	16.12	355.70	45.60	130.10	41.23	126.60	58.48	15.90	28.40	985.00	985.00
Date of Maximum	30/06/2017 08:45	02/06/2017 23:55	31/05/2017 12:30	08/07/2017 13:20	07/06/2017 10:25	03/05/2017 11:00	03/05/2017 11:00	10/07/2017 22:00	18/07/2017 11:40	30/05/2017 07:40	04/05/2017 08:55
Data Capture	99.8%	99.8%	99.6%	94.0%	98.0%	95.4%	98.0%	97.8%	97.3%	84.1%	85.0%

Table 2 Ambient Air Quality Monitoring Station Results – Duqm May to August 2017

	CH_4 ppb	NMHC ppb	TVOCs ppb	Benzene ppb	Toluene ppb	EthylBenzene ppb	M&P-Xylenes ppb	O-Xylene ppb
Mean	1082.15	0.00	1185.72	0.00	0.01	0.00	0.00	0.00
Minimum	455.44	0.00	567.65	0.00	0.00	0.00	0.00	0.00
Date of minimum	09/07/2017 05:00	-	03/05/2017 07:50	-	03/05/2017 00:00	-	-	-
Maximum	13905.49	0.00	13905.49	0.00	11.34	0.00	0.00	0.00
Date of Maximum	03/05/2017 18:15	-	03/05/2017 18:15	-	14/05/2017 08:45	-	-	-
Data Capture	99.9%	99.9%	99.7%	99.7%	99.7%	99.7%	99.7%	99.7%

Appendix B

MAXIMUM POLLUTANT CONCENTRATIONS MONITORED AT BASELINE LOCATION

Appendix B

Table 1: Maximum concentrations of Air Quality Pollutants at Sebacic Acid Plant, Duqm Against Air Quality Standards (non-compliance in bold)

Pollutant	Standard	Averaging period	Max concentration	Date max
PM_{10}	125	24 hour	**488.92**	17/06/2017
NO_2	112	24 hour	10.29	08/06/2017
SO_2	125	24 hour	14.46	14/06/2017
CO	6000	8 hour	8.80	08/06/2017
H_2S	40	24 hour	3.28	18/07/2017
O_3	120	8 hour	**172.69**	12/05/2017
HCNM	160	3 hour	0	-
$PM_{2.5}$	25	24 hour	**158.92**	31/05/2017

Appendix C

DIFFUSION TUBE SURVEY RESULTS FOR DUQM REFINERY BASELINE SURVEY

Table 1: Diffusion Tube Survey Results for Duqm Refinery Baseline Survey

Site Name	Exposure Data		NO2	SO2	H_2S	Benzene	Toluene	Ethyl Benzene	M,P-Xylene	O-Xylene
	Date On	Date Off	µg/m³							
Duqm Town	02/05/2017	02/06/2017	6.64	0.07	-	-	-	-	-	-
Rock Garden	02/05/2017	02/06/2017	2.32	0.09	0.08	0.54	<0.20	<0.24	<0.24	<0.24
Dry Dock Camp	02/05/2017	02/06/2017	4.32	0.13	-	-	-	-	-	-
Quarry Road	02/05/2017	02/06/2017	3.04	0.07	0.16	0.3	<0.20	<0.24	<0.24	<0.24
Refinery Gate house	02/05/2017	02/06/2017	8.44	0.06	0.09	0.23	<0.20	<0.24	0.38	<0.24
CAQMS Sebacic Acid Plant	02/05/2017	02/06/2017	8.27	0.06	-	-	-	-	-	-
CAQMS Sebacic Acid Plant	02/05/2017	02/06/2017	4.04	-	-	-	-	-	-	-
CAQMS Sebacic Acid Plant	02/05/2017	02/06/2017	4.77	-	-	-	-	-	-	-
Duqm Town	02/06/2017	02/07/2017	10.01	0.57						
Rock Garden	02/06/2017	02/07/2017	17.15	0.68	1.92	0.2	<0.21	<0.25	<0.25	<0.25
Dry Dock Camp	02/06/2017	02/07/2017	6.32	3.30						
Quarry Road	02/06/2017	02/07/2017	7.29	0.26	0.28	0.2	<0.21	<0.25	<0.25	<0.25
Refinery Gate house	02/06/2017	02/07/2017	2.87	0.95	0.15	0.2	<0.21	<0.25	0.25	<0.25
CAQMS Sebacic Acid Plant	02/06/2017	02/07/2017	2.47	2.52	-	-	-	-	-	-
CAQMS Sebacic Acid Plant	02/06/2017	02/07/2017	11.90	-	-	-	-	-	-	-
CAQMS Sebacic Acid Plant	02/06/2017	02/07/2017	7.93	-	-	-	-	-	-	-

Appendix B

APPENDICES FOR SECTION 5 – NOISE

APPENDIX B-1

APPENDIX 5.1: BASELINE NOISE

REPORT N^{O} 70029220-102-BS01

ENVIRONMENTAL BASELINE: NOISE

DUQM REFINERY PROJECT, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

CONFIDENTIAL

JUNE 2017

ENVIRONMENTAL BASELINE: NOISE

DUQM REFINERY PROJECT, OMAN

Duqm Refinery & Petrochemical Industries Company

Issue 1
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1 INTRODUCTION

1.1 BACKGROUND

This report presents the methodology and results of an environmental baseline noise survey carried out around the geographic area of the Duqm Refinery Project, Oman.

1.2 PREVIOUS BASELINE WORK

Previous baseline noise survey work has been documented as follows:

- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery* (HMR, 2015)
- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery Construction Camp* (HMR, 2014)
- Section 6.15 of the *Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project* (WorleyParsons Oman Engineering, 2015)
- Section 5.10 and Appendix 3 of the *Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report* (WorleyParsons Oman Engineering, 2016)

The previous baseline noise studies included measurements in and around Project components and relevant receptors. These studies noted that data was collected during periods of high winds, and the results show high noise levels indicative of measurements taken in windy conditions. To ensure a robust characterisation of baseline noise levels, a further survey has been conducted as detailed below. Relevant extracts from the previous baseline survey work are included in Appendix A and discussed below.

1.3 SCOPE OF REPORT

The purpose of the survey was to provide supplemental and updated typical baseline ambient noise levels at locations considered representative of local noise-sensitive receptors.

This report sets out the methodology employed and a summary of the results, along with details of the measurement data and equipment.

1.4 PROJECT OVERVIEW

The Duqm Refinery Project comprises the Refinery itself and its Off-site Facilities. The components of the Project are described in Table 1.1 below.

Table 1.1: Duqm Refinery Project

PROJECT COMPONENT	DESCRIPTION
• Duqm Refinery	A 230,000 BDP complex refinery on a plot of 9km^2 area to the north of the main industrial area within the Duqm Special Economic Zone. Includes: • Site clearance and levelling (completed in late 2016) • Product pipelines and service lines to the Duqm Export Terminal • Construction accommodation/workers' camps • Laydown areas.
• Off-site Facilities	i. **Crude storage facility at the Ras Markaz (RM) Crude Oil Terminal**: eight tanks located within, and part of the wider Tank Farm, approx. 80km from the Refinery. The large-scale Tank Farm (Oman Oil Tank Terminal Company, OTTCO) in its entirety is not part of the Project. ii. **'DRPIC Crude Pipeline':** 28-inch diameter 80km crude oil import pipeline to transport crude oil from RM to Duqm Refinery. iii. **Product 'Export Terminal'**: on the lee breakwater of Port of Duqm, immediately to the south-east of the Refinery plot. Topside works only, i.e., to establish storage for products and export handling facilities.

The transition from crude oil import (via a Single Point Mooring, (SPM) at Raz Markaz to the export of refined products through the Project facilities follows these key stages:

1. Offload of crude oil from offshore vessel delivery. Crude oil is stored within the crude import and storage facility at Ras Markaz Tank Farm of which only eight crude oil tanks are part of the Project.
2. The oil is transferred to the Duqm Refinery through the 80.7km Crude Import Pipeline. The Duqm Refinery will have a design capacity of 230,000 barrels per day and will produce the following key products:
   a. Naptha
   b. Liquid Petroleum Gas (LPG)
   c. Jet A-1
   d. Diesel
   e. Heavy Sulphur Fuel Oil
   f. Petroleum Coke (Solid)
   g. Sulphur (Solid)
3. Once the crude oil is refined to the final products then these are marine exported via the Duqm Export Terminal. The liquid products are conveyed to the terminal via pipelines within a service corridor and the solid products via ground transport.

2 METHODOLOGY

2.1 GUIDANCE

2.1.1 International Finance Corporation

General guidance on noise management to international standards is provided in the IFC Environmental Health and Safety Guidelines: Environmental (IFC, 2007). Specific advice is given concerning noise monitoring microphone positioning and equipment precision as follows:

- Monitors should be located approximately 1.5 metres (m) above the ground and no closer than 3 m to any reflecting surface; and
- Noise monitoring should be carried out using a Type 1 or 2 sound level meter meeting all appropriate IEC standards.

2.1.2 International Standards Organisation

Guidance on sound measurement techniques and good practice can be found in ISO 1996 Part 1 (ISO, 1982) and Part 2 (ISO, 1987), relevant sections of which have been followed wherever appropriate and practicable[1].

2.1.3 International Electrotechnical Commission

Specifications for the accuracy and parameters of sound measurement equipment are contained in IEC 61672-1 (IEC, 2013). All sound measurement equipment used in the survey conforms to the 'Class 1' specifications, which is equivalent to the performance of the older 'Type 1' specification used in withdrawn versions of this standard (ie IEC 60804:2000) and referred to in the IFC Guidelines.

2.2 SURVEY LOCATIONS

Prior to undertaking the baseline noise survey, details of indicative noise monitoring locations and the noise survey methodology were included in a Field Survey Plan, which was provided to DRPIC. Locations were selected to represent the existing receptors in closest proximity to the project components.

Coordinates for each monitoring location are provided in Table 2.1. The project components which will be nearest to the residential locations are also indicated. The monitoring locations are shown graphically in Appendix B.

[1] Revisions of these standards are available, but have not been universally adopted by member countries.

Table 2.1: Baseline Noise Survey Noise Monitoring Locations

Measurement Location	Latitude	Longitude	Nearest Project Component
Wadi Saay Location 1	19°37'52.50"N	57°38'14.60"E	Refinery / Export Terminal
Wadi Saay Location 2	19°38'27.70"N	57°38'10.00"E	Refinery / Export Terminal
Wadi Saay Location 3	19°38'55.20"N	57°38'28.10"E	Refinery / Export Terminal
Nafun Location 1	19°48'25.90"N	57°43'27.90"E	Refinery
Nafun Location 2	19°48'9.90"N	57°44'6.00"E	Refinery
Antoot Fishing Area	19°42'24.70"N	57°40'36.20"E	Refinery / Export Terminal
Dhahr Location 1	19°16'46.80"N	57°36'14.20"E	Pipeline / Crude Oil Storage
Dhahr Location 2	19°15'56.20"N	57°37'14.70"E	Pipeline / Crude Oil Storage
Dhahr Location 3	19°14'9.10"N	57°37'9.40"E	Pipeline / Crude Oil Storage

2.3 EQUIPMENT

Sound level measurements were made at each measurement location using a Rion NL-52 sound level meter. The measurement microphone was a type UC-53A, which was fitted during measurements with a double-skin foam wind shield type WS-15 to ensure adequate protection against wind noise and pressure fluctuations at the microphone. The microphone was mounted at a height of 1.2 m above ground level. An example of the sound measurement setup is shown in Figure 2.1

Figure 2.1: Example setup of sound level measurement equipment

The meter was field-calibrated on site using a Rion NC-74 calibrator prior to and following each set of measurements. The calibration levels were within accepted tolerances (ie < ±0.5 dB) during all calibration procedures. Measurements were made of the local wind speed at each measurement location using a handheld Lutron LM-81 anemometer.

The calibrator, meter, preamp and microphone assembly were all within certified laboratory calibration at the time of the survey; the relevant calibration certificates are included in Appendix C.

2.4 PROCEDURE

Measurements were made over one, two or three separate 15-minute periods at each measurement position, depending on the steadiness of the noise climate assessed by the survey engineer. It was initially intended to make measurements during evening and night periods at all the Wadi Saay and Nafun locations. This was achieved at the Wadi Saay locations, but safety and security issues encountered during measurements at Nafun on Tuesday 25th April prohibited late night measurements at the Nafun locations. Nevertheless, a measurement was made at both Nafun locations during the late evening (and daytime) periods, and as the primary noise source was wind interaction with surfaces and vegetation, the night-time noise levels would be expected to be similar. Furthermore, the Wadi Saay locations are representative of the nearest residential receptors to the Refinery and Export Terminal sites, and will therefore be the worst-case in terms of noise impact from the development. Noise levels were also measured during the daytime at the Antoot and Dhahr areas.

3 BASELINE NOISE

3.1 SURVEY RESULTS

The noise levels measured at each of the noise monitoring locations are shown in Table 3.1. The noise levels are summarised in terms of the range of the measured L_{Aeq} (ambient) and L_{A90} (background) noise levels. The primary noise source and wind speed measured at each location are also indicated. Detailed monitoring records are shown in Appendix D.

Table 3.1: Summarised Baseline Noise Survey Measurement Results

LOCATION	DATE, dd/mm/yy	TIME PERIOD, hrs	PERIOD DESCRIPTION	L_{Aeq} RANGE, dB	L_{A90} RANGE, dB	WIND SPEED, m/s	PRIMARY NOISE SOURCE(S)
Wadi Saay Location 1	25/04/17	1509 – 1539	Day	50 – 51	45 – 46	2 – 3	Distant construction noise along Highway 32, wind
	26/04/17	0922 – 0952	Day	52	44	2 – 3	Occasional road traffic & construction activity on Highway 32, wind
	24/04/17	1807 – 1837	Evening	52 – 53	45	3 – 5	Very occasional road traffic on Highway 32, wind
	24/04/17	2317 – 2332	Night	45 – 46	41	2 – 4	Wind
Wadi Saay Location 2	25/04/17	1554 – 1624	Day	46 – 47	40 – 41	2 – 3	Wind
	26/04/17	1001 – 1031	Day	44 – 45	39	3 – 4	Wind
	24/04/17	1911 – 1956	Evening	49 – 51	41 – 43	4 – 5	Wind
	25/04/17	0004 – 0034	Night	42 – 44	38	4 – 5	Wind
Wadi Saay Location 3	26/04/17	1038 – 1108	Day	52	43 – 44	2 – 3	Occasional road traffic & construction activity on Highway 32, wind
	26/04/17	1804 – 1834	Evening	49 – 50	44	4 – 5	Very occasional road traffic on Highway 32, wind
	25/04/17	2328 - 2358	Night	51 – 52	40 – 41	4 – 5	Wind
Nafun Location 1	25/04/17	1212 – 1242	Day	41 – 42	39	2 – 3	Wind, very occasional local vehicles
	25/04/17	2217 - 2232	Evening	42	38	2 – 3	Wind, very occasional local vehicles
Nafun Location 2	25/04/17	1303 – 1348	Day	54	52 – 53	4 – 5	Wind, sea
	25/04/17	2241 – 2253	Evening	48	45	4 – 5	Wind, sea – note: measurement cut short for safety reasons
Antoot Fishing Area	25/04/17	1053 - 1123	Day	42 – 44	35 – 36	4 – 5	Wind / sea
Dhahr Location 1	26/04/17	1226 – 1256	Day	46 – 47	38	5 - 7	Occasional local vehicles, wind
Dhahr Location 2	26/04/17	1309 – 1339	Day	46 – 48	39 – 41	4 – 5	Occasional local vehicles, wind
Dhahr Location 3	26/04/17	1403 – 1433	Day	43 – 45	36	2 – 3	Occasional local vehicles, wind

The results in Table 3.1 indicate that noise levels were steady throughout measurement periods, with small variations of around 1-3 dB. The most prevalent noise source around the area was wind interaction with buildings, surfaces and vegetation. Measured average wind speeds were below 5 ms^{-1} during all measurements with the exception of the daytime measurements at Dhahr Location 1, when speeds measured up to 7 ms^{-1}. The noise levels measured at this location are considered to be valid due to the additional microphone protection afforded by the double-layer windshield, which ensures measurement accuracy up to higher wind speed ranges. The area around Duqm is generally characterised by relatively high winds, so the noise environment captured during the survey is considered sufficiently representative of normal ambient conditions. No precipitation was encountered during the survey.

The overall mid-points of the measured equivalent sound levels (L_{Aeq}) are shown for each location and period in Figure 3.1. This shows that levels around Wadi Saay vary in the approximate range 45-50 dB(A) across day, evening and night-time. Sound levels around Nafun are around 40-50 dB(A) – levels at Nafun Location 2 were slightly higher due to the closer proximity to the sea, and associated contributions from surf sound. Sound levels around Dhahr were typically around 45 dB(A).

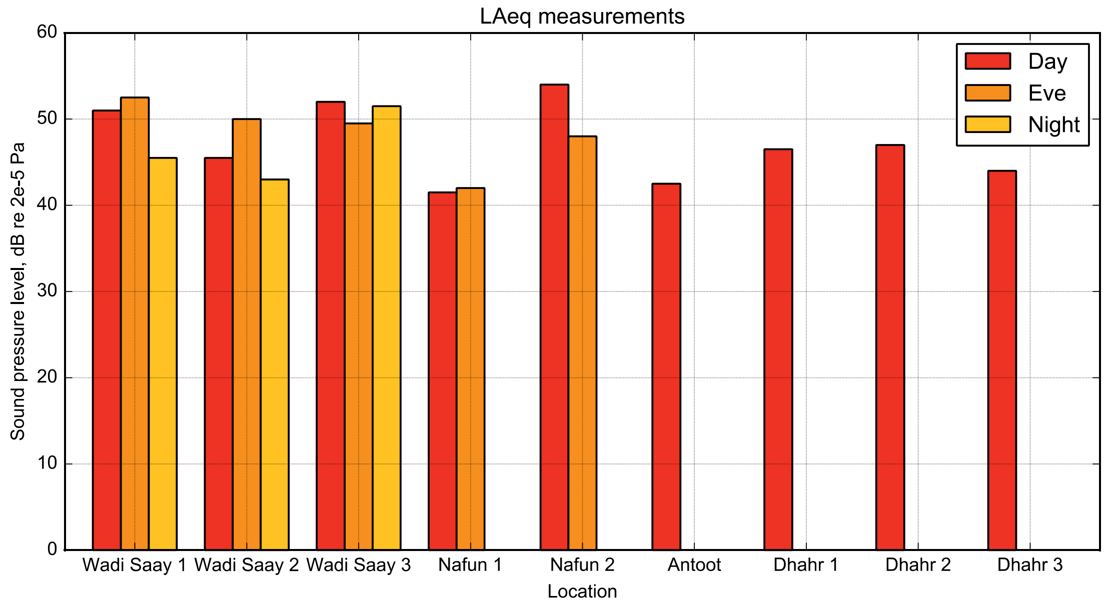

Figure 3.1: Mid-point equivalent continuous sound levels measured at all locations

In comparison with the previous baseline survey work, the measurements taken indicate that during periods of low winds (ie < 5ms^{-1}), noise levels at comparable locations around Nafun and Duqm are generally somewhat lower than reported during higher wind conditions.

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Appendix A

PREVIOUS BASELINE NOISE STUDIES

5 NOISE

Noise level measurements were conducted using Integrating and Logging Sound Level Meter (ISLM), Quest SoundPro. The instrument is capable of measuring equivalent continuous noise levels (Leq) with standard measurement settings conforming to regulatory requirements. Various locations within the site and outside the site boundary were chosen based on the rationale that maximum noise is expected to be generated from within the site and there will be a carry both crosswind and downwind.

Data was captured for at least 15 minutes at each location - during daytime, evenings and nights (and holidays) – for the time periods as shown below. These time periods are defined in Article (6) of MD 79/1994.

Workdays (daytime) - A : after 7am and up to 6pm

Workdays (evenings) - B: after 6pm and up to 11pm

Holidays and nights - C : after 11pm and up to 7am

Parameters such as frequency weighting, the time weighting and the measurement time were set prior to site visit. All sound level measurements followed the procedure prescribed in ANSI standards (ANSI Standard S1.4). During the monitoring period, L_{eq} along with L_{max} and L_{min} were recorded. Weather conditions were normal however; there was excess wind during the measurements. Though the wind speed was approximately 7 m/s when the measurements were taken, Duqm is inherently a windy area as observed from wind rose plots earlier. The ambient noise levels are presented in **Table 12** and measurement locations and the noise contours presented in **Figure 10**, **Figure 11** and **Figure 12** respectively for daytime, evening and night. The noise contours are generated using Surfer Modelling software which uses Kriging regression.

Noise measurements were undertaken during the first week of September. The rationale for choosing noise locations is based on the location of sensitive receptors in the buffer zone area (near & far) given the predominant wind direction. Further, nine locations within the proposed site have been chosen at 1 km^2 grid to cover noise baseline within the entire site.

Table 12: Noise Levels

Location		**A**	**B**	**C**	**Location**		**A**	**B**	**C**
Limits (L_{eq})		**65 dB(A)**	**60 dB(A)**	**55 dB(A)**	**Limits (L_{eq})**		**65 dB(A)**	**60 dB(A)**	**55 dB(A)**
N1D1	L_{eq}	73.2	57.7	51.0	N7D7	L_{eq}	66.0	54.7	53.1
	L_{max}	86.2	68.5	60.9		L_{max}	85.7	63.8	63.9
	L_{min}	50.4	44.9	44.9		L_{min}	48.1	46.3	47.5
N2D2 (Wadi Dhanjart)	L_{eq}	70.9	63.8	57.4	N8D8	L_{eq}	64.8	48.8	53.5
	L_{max}	88.7	76.0	73.9		L_{max}	79.2	57.3	64.8
	L_{min}	53.7	46.2	44.2		L_{min}	50.4	46.4	46.8

Location		A	B	C	Location		A	B	C
Limits (L_{eq})		**65 dB(A)**	**60 dB(A)**	**55 dB(A)**	**Limits (L_{eq})**		**65 dB(A)**	**60 dB(A)**	**55 dB(A)**
N3D3 (Nafun)	L_{eq}	57.0	57.4	47.8	N9D9	L_{eq}	69.9	62.0	58.0
	L_{max}	71.1	68.7	59.3		L_{max}	86.6	80.0	67.9
	L_{min}	48.5	48.3	44.5		L_{min}	53.8	45.3	45.3
N4D4	L_{eq}	57.0	62.0	62.2	N10D10	L_{eq}	73.2	53.9	62.6
	L_{max}	77.8	74.8	72.6		L_{max}	82.6	68.9	79.3
	L_{min}	45.8	45.5	47.7		L_{min}	46.3	44.7	44.4
N5D5	L_{eq}	68.0	57.8	56.5	N11D11	L_{eq}	65.7	59.7	59.4
	L_{max}	85.5	69.6	68.0		L_{max}	82.7	74.1	70.7
	L_{min}	54.1	49.5	46.3		L_{min}	50.3	47.1	48.5
N6D6	L_{eq}	71.1	56.0	60.2	N12D12 (Wadi Al Kahban)	L_{eq}	60.7	63.9	51.5
	L_{max}	89.1	72.4	80.1		L_{max}	79.2	84.8	69.1
	L_{min}	52.2	48.5	45.7		L_{min}	45.9	44.3	44.2

The site is within a dedicated special economic zone and will have various types of commercial developments in the future. As this is not a dedicated industrial estate, noise levels have been compared with those stipulated for suburban residential area in MD 79/94. The measurements indicate that noise levels at certain locations exceed the limits specified for different time intervals i.e. day, evening and night. High noise levels at N2D2 can be attributed to traffic from the quarrying activities. Locations N9D9, N10D10 and N11D11 are near dirt tracks linking Road 32 to the beach and the nearby power and desalination unit which have intermittent traffic that contribute to higher noise. Locations N12D12, N4D4 and N7D7 are located close to Road 32, where vehicular traffic contributes to higher noise levels. Higher noise levels at N1D1, N5D5 and N6D6 can be attributed to environmental disturbances[9].

Further, inherently higher noise levels can be attributed to that from the strong winds, which is a common feature in the Duqm region and also from the surfing noise of the waves considering close proximity to the coast. In a recent EIA Report for Duqm Industrial and Freezone Masterplan **Invalid source specified.** ambient noise monitoring survey was conducted at 10 locations within the RDB between July and August 2010. The locations and recorded noise measurements are shown in **Figure 13**. The results indicate that the noise levels at several locations are higher. The noise levels measured during current study are hence consistent with the previous study and the threshold values at certain locations exceed limits specified in MD 79/94.

[9] Avifaunal squawk and dog barking were noted during the survey.

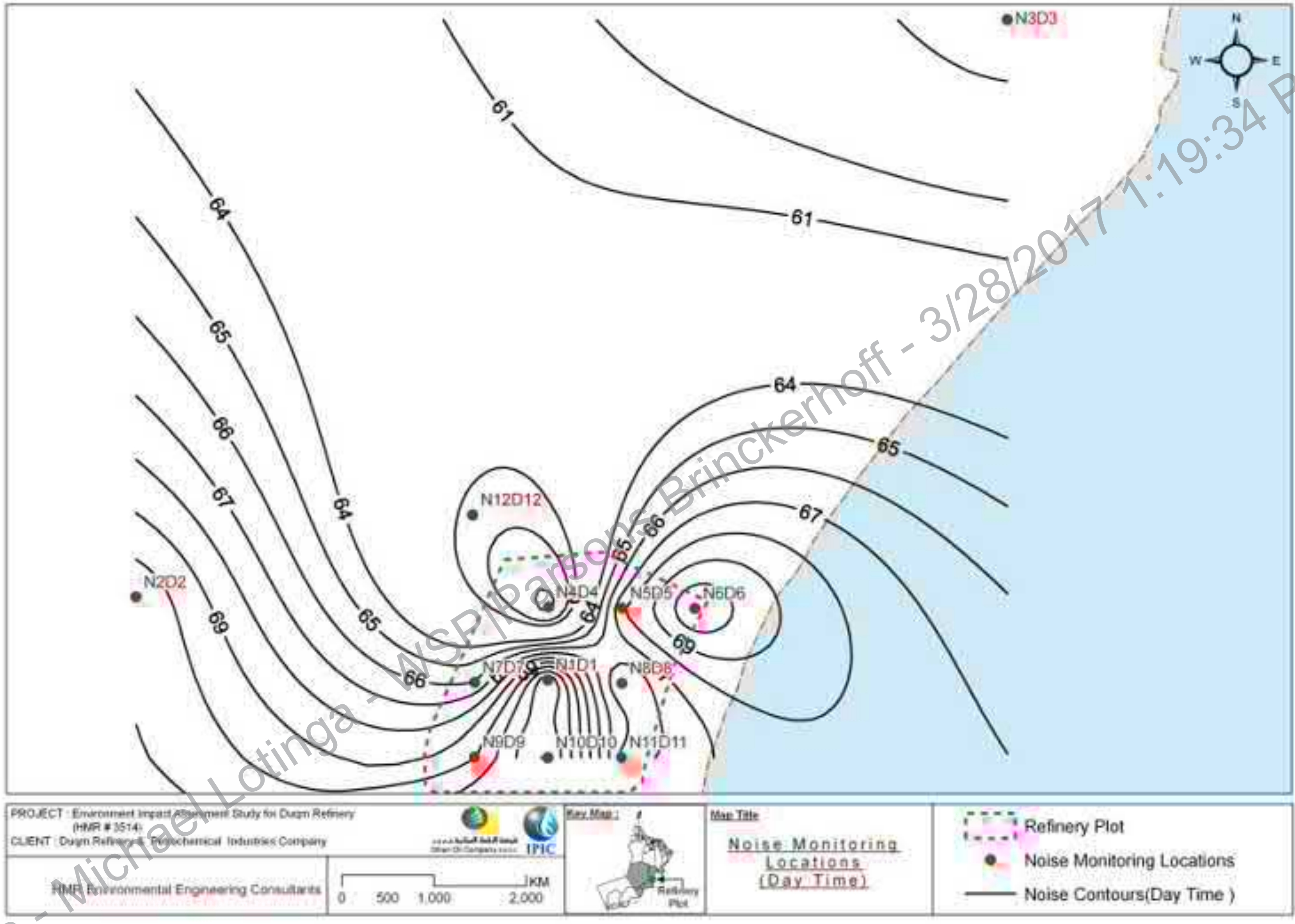

Figure 10: Noise Contours (Daytime)

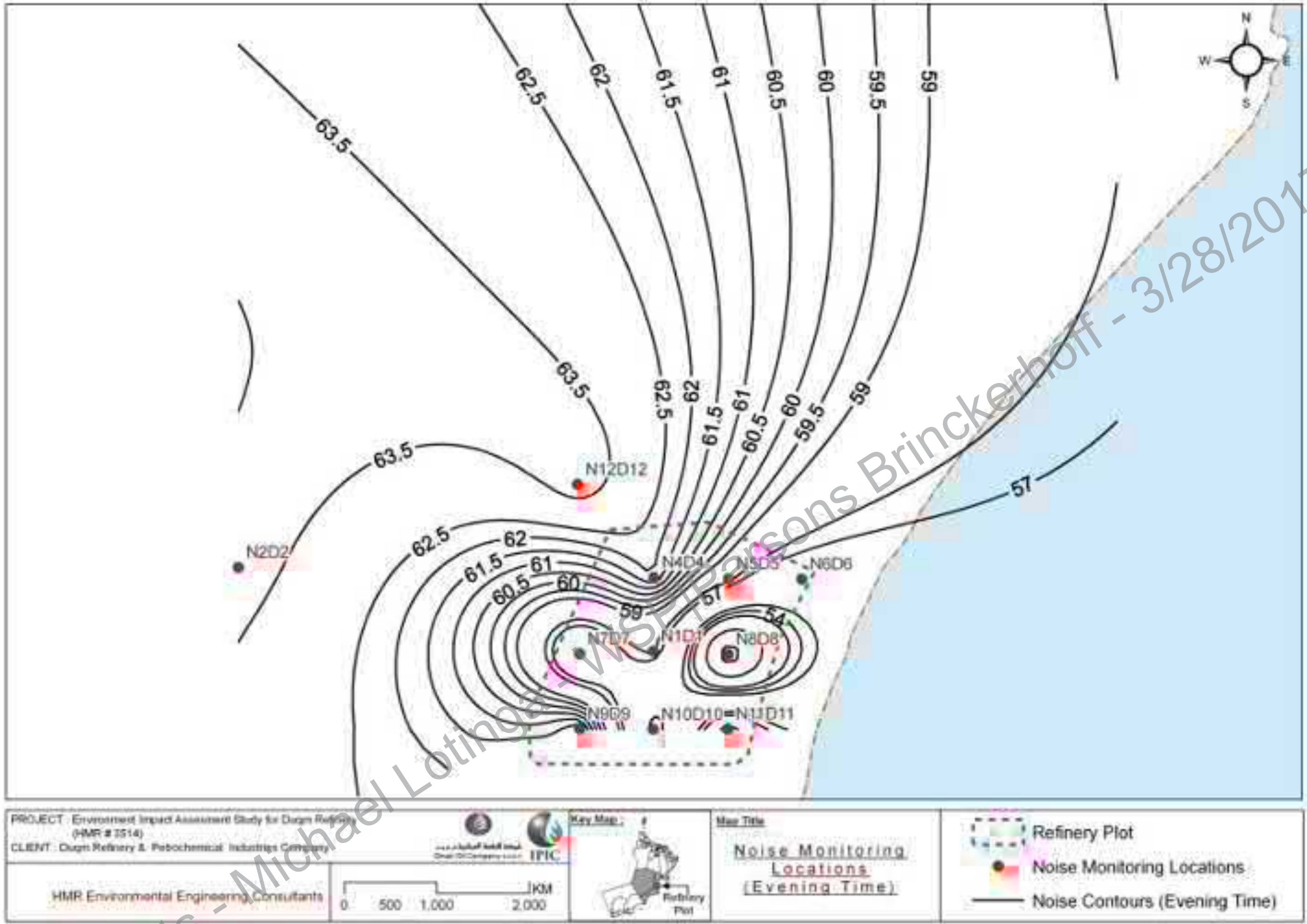

Figure 11: Noise Contours (Evening)

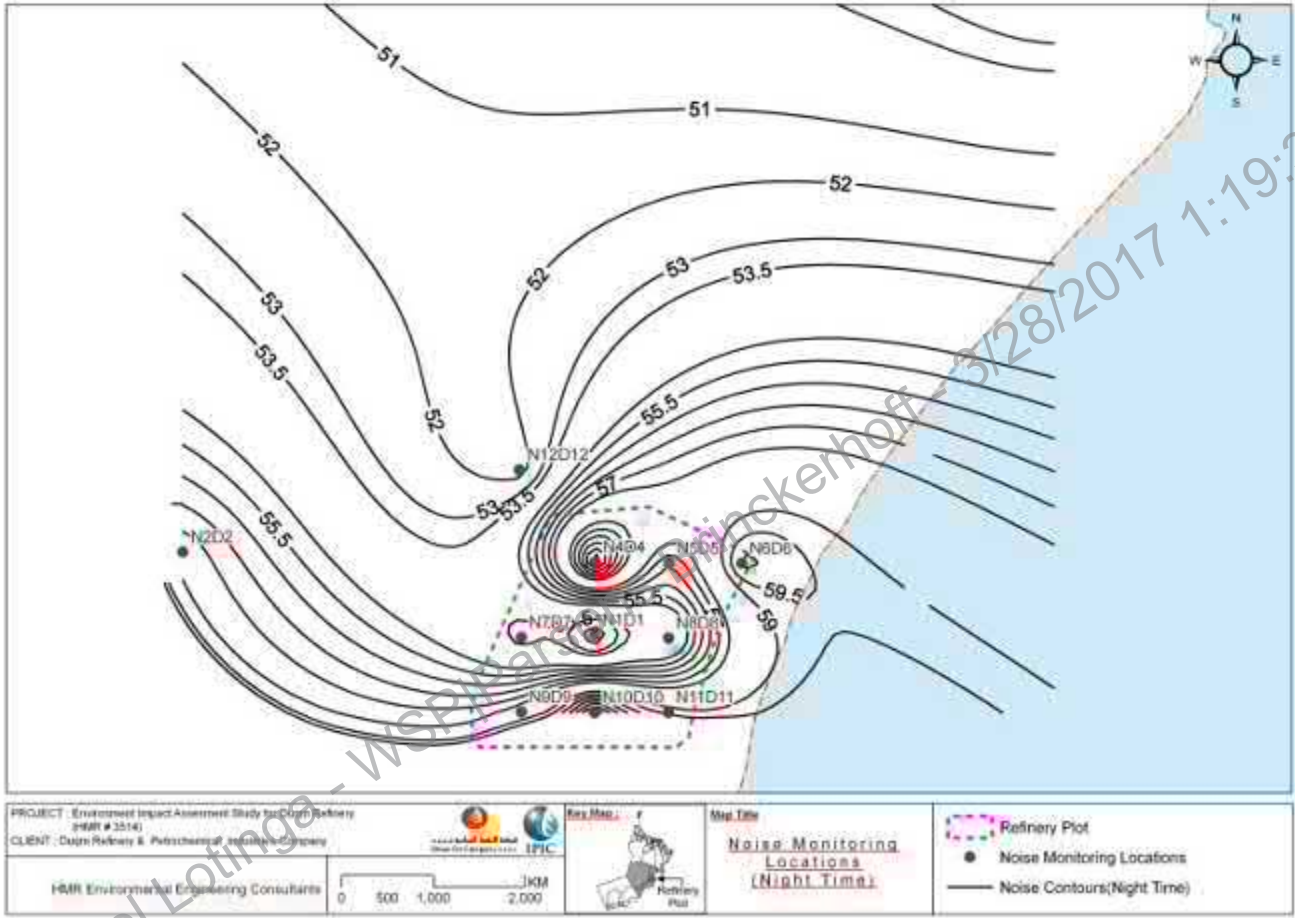

Figure 12: Noise Contours (Night)

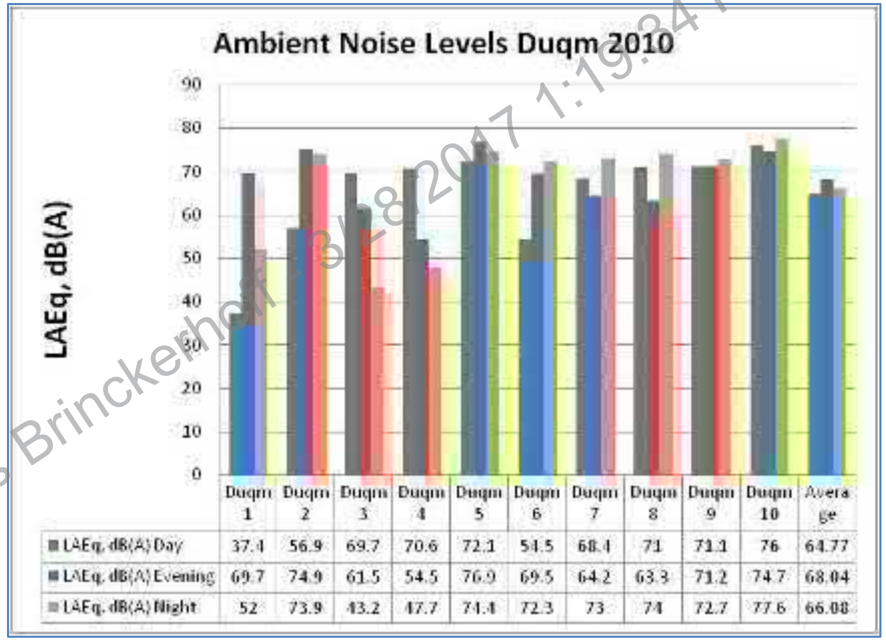

Figure 13: Noise Measurement Locations and Noise Levels by 5 Oceans[10]

[10] Source: (5 Oceans, 2011)

Table 6-11: Ambient Dust Levels

Location	5/6-Jan-2015			26/27-Jan-2015			20-Aug-2015		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
DF1	7	12	12	2	8	12	14	34	36
DF2	6	9	9	2	12	14	20	48	49
DF3	8	13	13	2	6	6	18	62	73
DF4	4	7	7	2	9	9	18	80	92
DF5	4	8	9	2	11	12	16	35	37
DF6	3	4	4	2	5	9	16	42	45
DF7	4	6	7	4	8	14	19	54	57
DF8	3	8	8	3	6	7	17	78	82
DF9	-	-	-	2	6	6	19	46	49
Say Village	16	52	52	-	-	-	20	54	92

***NOTE**: All readings measured in µg/m³*

From the above table, it can be seen that the dust levels during August 2015 is higher than that during January 2015. The primary reason for this is the presence of trucks transporting construction material (soil) around the monitoring locations (during January measurements, there were no trucks on the road connecting LBW to the Highway 32; and lesser number of construction vehicles at other locations). Further, the wind speed during August measurements were in the range of 6 to 9 m/s; while the wind speed during January measurements were between 3 and 4 m/s.

The USEPA NAAQS does not specify standard for TSP and regulates TSP through the quantities of $PM_{2.5}$ and PM_{10}. The NAAQS specifies the following limits for $PM_{2.5}$ and PM_{10}:

- $PM_{2.5}$ annual standard (primary) 12 µg/m³ and (secondary) 15 µg/m³
- $PM_{2.5}$ – 24-hr standard: 35 µg/m³
- PM_{10} – 24-hr standard: 150 µg/m³

Although, Table 6-11 represents the spot readings for a period of 15 minutes; comparison with USEPA NAAQS shows that the potential for exceedances in the present setting is low.

6.15 Noise

6.15.1 Past Noise Studies

A number of baseline studies have been undertaken in Duqm; and noise levels were assessed in two studies, available with WorleyParsons. The Duqm Industrial and Free Zone Master Plan – Final EIA Report, for Jurong, June 2011 and the Q3 Report Environmental Baseline Study for Duqm

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Development and Surroundings, for SEZAD, March 2013, undertook noise monitoring at 3 locations. Figure 6-37 below presents the locations where daytime monitoring was undertaken. It should be noted that the entire DLBB Project area has been demarcated for industrial activity and hence comparison was made against the industrial standard

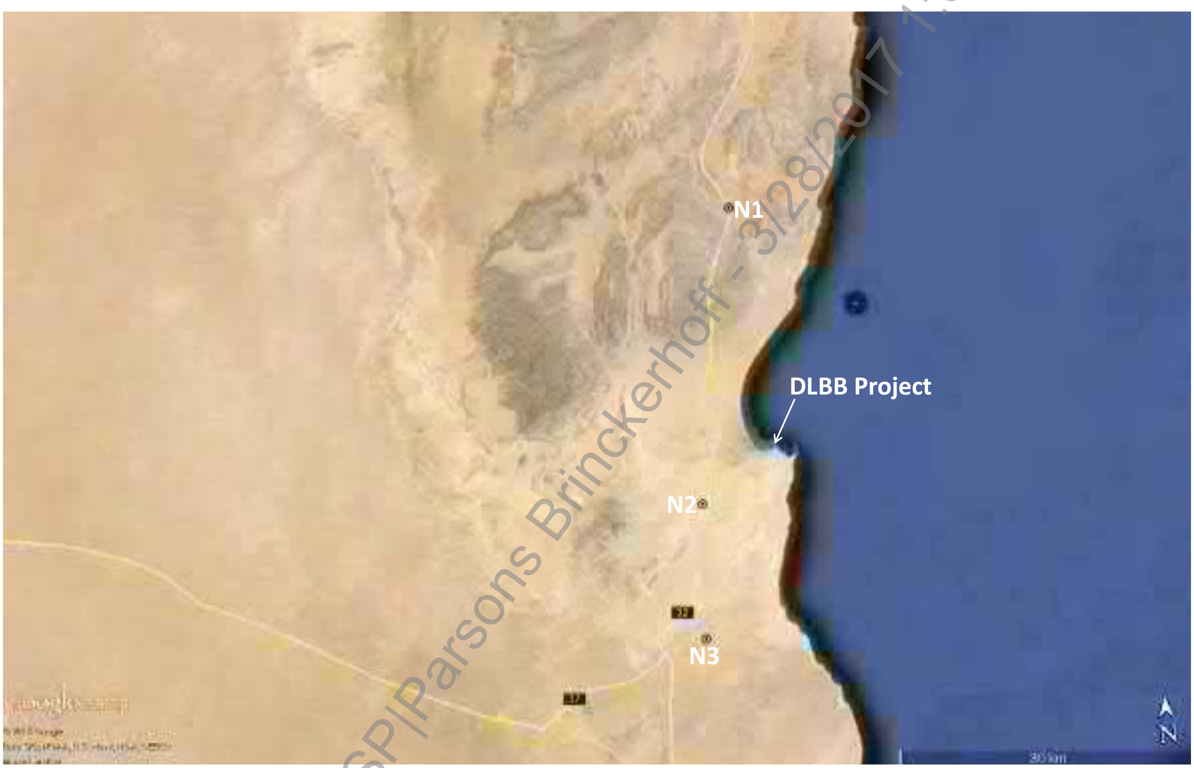

Figure 6-37: Historic Noise Monitoring Locations

It can be seen from the above figure, that monitoring was undertaken along roads (marked yellow in figure) and represents a measure of noise from road traffic in an industrial area. Table 6-12presents a summary of the comparison.

Table 6-12: Historic Noise Monitoring Locations

Location	October 2012	November 2012	Day Time Noise Level in Industrial Area from Road Traffic
	$L_{A\text{-}eq}$	$L_{A\text{-}eq}$	
DF1	41.3	45.5	70
DF2	55.1	52.4	
DF3	62.7	44.6	
Note: all readings measured in dBA			

A review of the above table shows that the noise levels are within the proposed standards.

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6.15.2 Current Noise Studies

The noise survey were undertaken at the nine ambient air quality monitoring locations and at Say village (near the main road) to measure the equivalent continuous ($L_{A\text{-}eq}$), and maximum and minimum sound levels ($L_{A\text{-}max}$ and $L_{A\text{-}min}$) in the DLBB Project area. The survey was undertaken using the hand held Bruel & Kjaer Model 2250 sound level meter. Ambient noise survey was carried out on three occasions – first when the diffusion tubes were installed on 5/6-Jan 2015, second when the tubes were retrieved on 26/27-Jan-2015, and third on 19 and 20-Aug-2015.

It should be noted that the DLBB Project area has been designated for industrial development and hence deemed as an industrial area. As per MD 79/94 the permissible $L_{A\text{-}eq}$ are as presented in Table 6-13.

Table 6-13: Permissible $L_{A\text{-}eq}$ Limits as per MD 79/94

Type of Area	Source of Noise	Daytime Limit (7 am to 6 pm)	Evening Time Limit (6 pm to 11 pm)	Night Time Limit (11 pm to 7 am)
Industrial and commercial	Industrial plants and public works	70	70	70
	Road traffic	70	65	60
NOTE: All units in dB(A).				

Table 6-14 presents the ambient noise levels recorded at the measuring locations. In the last column of the table the applicable limit prescribed in MD 79/94 is mentioned for comparison. The noise levels were measured during day time. It must be noted that the current source of noise is road traffic. However, the future the main source of noise will be industrial plants. It is further understood that the Say village will be relocated to another location; thus, the monitoring location at Say village is also considered as industrial and commercial area. Accordingly, limit of 70 dB(A) applies to all locations.

Table 6-14: Ambient Noise Levels Measured at Site

Location	5/6-Jan-2015			26/27-Jan-2015			19-Aug-2015			20-Aug-2015		
	$L_{A\text{-}max}$	$L_{A\text{-}min}$	$L_{A\text{-}eq}$	$L_{A\text{-}max}$	$L_{A\text{-}min}$	$L_{A\text{-}eq}$	$L_{A\text{-}max}$	$L_{A\text{-}min}$	$L_{A\text{-}eq}$	$L_{A\text{-}max}$	$L_{A\text{-}min}$	$L_{A\text{-}eq}$
DF1	73.27	33.17	**51.60**	61.62	39.00	**42.49**	53.7	49.2	**51.3**	61.6	58.0	**59.9**
DF2	52.51	33.30	**38.37**	67.09	39.52	**43.61**	59.1	54.5	**57.3**	64.0	59.3	**62.0**
DF3	-	-	**-**	70.99	30.81	**46.27**	47.5	39.9	**43.1**	47.3	44.2	**45.5**
DF4	69.74	35.95	**42.81**	74.10	37.33	**43.85**	54.4	47.7	**50.2**	56.2	50.8	**53.2**
DF5	76.92	47.91	**58.14**	70.64	29.16	**42.72**	61.4	50.3	**55.0**	49.1	42.2	**46.2**
DF6	64.75	33.12	**44.47**	74.39	31.19	**42.14**	60.5	52.3	**55.6**	44.6	42.2	**43.5**
DF7	75.51	28.67	**48.40**	66.18	43.73	**46.82**	56.7	47.8	**50.5**	53.2	49.6	**51.5**
DF8	58.22	27.94	**40.72**	59.12	38.77	**43.57**	54.7	44.0	**50.7**	51.8	48.0	**50.0**
DF9	65.28	29.01	**44.74**	63.85	38.41	**42.96**	64.4	56.5	**60.3**	52.9	48.3	**50.2**

Location	5/6-Jan-2015			26/27-Jan-2015			19-Aug-2015			20-Aug-2015		
	L_{A-max}	L_{A-min}	L_{A-eq}	L_{A-max}	L_{A-min}	L_{A-eq}	L_{A-max}	L_{A-min}	L_{A-eq}	L_{A-max}	L_{A-min}	L_{A-eq}
Say*	75.00	44.38	**56.75**	-	-	**-**	64.2	60.7	**62.4**	63.3	60.0	**61.6**
***NOTE**: All units in dB(A); *Say means the Say Village*												

From the above table it can be seen that the ambient L_{A-eq} levels measured around the LBW and near the main road in Say village during January as well as August are below applicable standard limits. However, the L_{A-eq} levels measured in August are mostly higher than the L_{A-eq} levels measured in January. This is because there are more construction vehicles plying the road connecting LBW to the Highway 32 in August than in January (when there were no trucks moving on this road). Further, the wind speed during measurements in August were higher the wind speed during measurements in January.

6.16 Terrestrial Ecology

The study of ecology and biodiversity is an important part of any baseline survey as it sustains the basic needs of the society. The most ecologically important areas in Oman, on account of the highest species diversity and concentration of endemic species, are in the mountains of Dhofar and the Al Hajar Mountains of Northern Oman.

The Duqm region is important from the perspective of biological diversity which needs to be conserved for its productivity, regulation of climate and ecosystem services. The main objective of the ecological baseline study is to collect adequate ecological information of the proposed development and its vicinity to establish a baseline ecological status of the area.

This section provides a characterization of the ecological conditions in the study area, based on primary survey data and secondary supporting literature of the area. Secondary data has been collated from for the study area previous environmental impact assessment studies carried out and academic research relevant to this areas. This sections deal with the habitat types in the study area, prevalent flora and fauna found during the site survey and their present status as per the Red List from International Union for Conservation of Nature (IUCN). The major factors that influence the distribution of flora and fauna in this biome are topography, elevation, distance from the sea and the extent of salt water intrusion.

As highlighted in the EIA Scoping report for the DLBB Project (Doc. No. SEZAD-DPTC-00-WP-EV-REP-0001) the study area for the terrestrial ecological study was restricted to 1 km radius around the LBW. Figure 6-38 below presents the extent of the study area.

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On account of high wind speeds exceedances in dust levels were recorded between:

- KM-370 to KM-380
- KM-380 to KM-400
- KM-400 to KM-410

It may be said that the ambient condition in these area represents days with high dust levels. As dust is expected to be a significant emission from project operation emphasis must be placed on the management of dust during the construction phase.

5.10 Ambient Noise Levels

The noise survey was undertaken at about 70 locations to measure the L_{Aeq} and the maximum (L_{Amax}) and minimum (L_{Amin}) sound levels. The survey was undertaken using the hand held Bruel & Kjaer Model 2250 sound level meter. Table 5-18 presents the range of L_{Aeq} monitored at the sections. Appendix 3 presents the noise readings.

Table 5-18: Ambient Noise Levels (Summary)

Section	Ambient Noise Levels (dB(A)) L_{Aeq} range	
	Min	Max
KM-0 to KM-10	**50.9**	**59.5**
KM-10 to KM-20	43.1	**61.2**
KM-20 to KM-130	36.5	**49.4**
KM-130 to KM-300	37.8	**46.8**
KM-310 to KM-330	35.3	45
KM-330 to KM-340 (a)	**50.1**	**61.8**
KM-340 to KM-370 (a)	44.2	**56.4**
KM-370 to KM-380 (a)	**57.6**	**71.2**
KM-380 to KM-400 (a)	**57**	**64.5**
KM-400 to KM-410 (a)	(c)	(c)
KM-410 to KM-421.5 (a)	**45.8**	**54.9**

Notes:

(a) High wind speeds were recorded at these stations over 8 m/s.

(b) Measurements were taken between 15 to 19 November and 7 to 11 December 2015

(c) No readings were taken

The noise levels presented in Table 5-18 were compared with MD 79/94 for noise pollution control in public environment. The MD defines the allowable daytime noise level as a result of industrial plants and public works in rural recreational area as 45 dB(A). This standard was exceeded at a number of

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locations, however there was no specific sources and represents the natural ambient condition. It should be noted that between KM-330 to KM-421.5 the high wind speed was the primary cause for exceedance.

5.11 Existing Pipeline ROW

The project shares its ROW with an existing pipeline in the section KM-0 to KM-70 i.e. a total of 70 km. The Ras Markaz Nahadha Oil Pipeline travels along the 36” Qarn Alam-Al Nahadha Oil Pipeline. Figure 5-22 highlights areas shared by the Ras Markaz Oil Pipeline project with existing pipeline in two areas.

Figure 5-22: ROW shared with existing pipelines

5.12 Existing Infrastructure

The initial site visit/ route reconnaissance exercises, identified several existing graded/blacktop roads and Over Head Line/buried power/utility cables. Listed below are the significant crossings observed during the site visit:

- 23 crossings with Route 31 (Muscat - Salalah) and 32 (Muscat – Al Mahout – Duqm – Ras Markaz)
- 52 graded roads at various concession areas
- 16 overhead electric lines

	RH /Temp	TSP	PM10	PM2.5	Leq	Lmax	Lmin
KM-0 to KM-10	35/31 °C	-	-	-	54.8	55.1	54.2
	37/30 °C	0.049	0.037	0.007	51.8	55.1	50.2
	33/31°C	0.006	0.03	0.034	59.5	60.5	58.5
	28/34°C	0.006	0.021	0.028	50.9	57.1	45.3
KM-10 to KM -20	-	0.034	0.027	0.005	-	-	-
	26/32°C	0.021	0.016	0.005	43.3	44.3	42.3
	26/32°C	0.017	0.021	0.005	43.1	44.2	41.2
	25/32°C	0.016	0.014	0.005	44.4	52.1	41.2
	25/32°C	0.03	0.029	0.016	61.2	70.3	51.2
	17/34°C	0.042	0.016	0.008	49.2	49.7	48.8
	22/31°C	0.014	0.013	0.003	48.6	52.5	47
KM-20 to KM-130	51/27°C	0.016	0.015	0.005	47.8	51.7	44.9
	49/29°C	0.027	0.025	0.006	39.8	44.3	37.8
	47/28°C	0.02	0.018	0.006	44.4	53.7	40.8
	45/28°C	0.029	0.026	0.009	36.5	42.2	34.1
	35/33°C	0.064	0.017	0.005	44.1	48.3	41.1
	36/33°C	0.196	0.141	0.01	48.8	50.2	48
	36/32°C	0.033	0.02	0.005	43.2	53.4	36
	36/30°C	0.022	0.015	0.006	42.8	43.9	41.9
	31/32°C	0.027	0.022	0.005	39.6	41.5	38
	24/32°C	0.03	0.013	0.003	51.8	58.6	46.9
	23/32°C	0.02	0.015	0.003	46.1	49.6	44.4
	19/35°C	0.025	0.01	0.004	42.5	48.6	38.7
	20/31°C	0.042	0.024	0.002	44.4	49.1	40.6
	19/31°C	0.042	0.024	0.002	43.3	48.2	41.6
	59/24°C	0.039	0.036	0.009	44.7	50.9	43.1
	60/24°C	0.039	0.036	0.009	49.4	57.2	42.8
	36/28°C	0.057	0.048	0.009	42.9	44.5	41.9
KM-130 to KM-310	-	-	-	-	36.6	45	35.3
	19/2°C	0.072	0.037	0.01	46.8	48.4	44.9
	24/30°C	0.02	0.018	0.005	38.1	43.9	35
	18/32°C	0.051	0.04	0.006	43.8	45.3	42.4
	18/32°C	0.051	0.4	0.006	42.4	45.5	41.4
	19/31°C	0.038	0.033	0.009	42	43	41.1
	51/27	0.048	0.044	0.022	37.8	47.8	33.3
	37/29	0.034	0.026	0.006	43.2	47.4	41.7
	35/30	0.017	0.013	0.006	44.2	48	42.1
	31/30	0.046	0.029	0.005	44.4	46	43.3
	40/29	0.013	0.01	0.006	45.2	47	43.3
	43/28	0.02	0.016	0.007	43.6	45.7	42.7
	41/29	0.018	0.017	0.006	43	44.4	41.8
	47/28	0.02	0.015	0.007	45.2	46.4	44.6

	RH /Temp	TSP	PM10	PM2.5	Leq	Lmax	Lmin
KM-310 to KM-330	36/24	0.1	0.071	0.013	43.3	45.5	40.5
	37/26	0.084	0.063	0.009	45	48.7	41.3
	42/26	0.037	0.021	0.008	35.3	43.5	33.3
	43/26	-	-	0.007	-	-	-
KM-330 to KM-340	26/28	0.094	0.076	0.025	61.8	64.5	58.4
	31/23	0.089	0.084	0.035	50.1	51.9	48
	49/18	0.042	0.039	0.01	52.7	56.4	50
KM-340 to KM-370	56/16	0.022	0.022	0.01	54.1	61.9	44
	51/16	0.044	0.036	0.011	52.9	55.8	49.9
	51/18	0.091	0.061	0.015	44.2	49.4	40.3
	44/21	0.091	0.061	0.015	47.6	54.4	42.2
	43/21	0.075	0.04	0.011	54.2	60	45.9
	43/21	0.27	0.024	0.006	52.5	58.9	44.9
	41/22	0.038	0.032	0.011	56.4	58.2	54.9
	36/24	0.091	0.076	0.02	54.7	59.6	52.8
	33/24	0.123	0.103	0.028	52	58.9	49
	28/25	0.134	0.127	0.056	-	-	-
KM-370 to KM-380	25/26	0.376	0.302	0.091	57.6	59.6	56.9
	25/26	0.358	0.307	0.074	71.2	72.4	69.4
KM-380 to KM-400	31/25	0.484	0.344	0.085	57	58.6	54.5
	28/27	0.312	0.268	0.076	64.5	66.9	61.2
KM-400 to KM-410	36/23	-	-	-	-	-	-
	35/23	0.385	0.339	0.068	-	-	-
	35/23	0.377	0.295	0.073	59.9	62.4	56.6
KM-410 to KM-421.5	53/21	0.178	0.125	0.018	50.6	54.4	45.7
	49/21	0.145	0.116	0.017	54.9	57.5	51.3
	47/21	0.095	0.074	0.013	45.8	49	42.9
	38/22	0.32	0.24	0.026	62.7	66.5	57.9

#	GPS Coordinates (m)		Dust Concentration	MECA AAQS –
D8	583451	2116730	0.088	
D9	580958	2116724	0.088	
D10	578332	2116689	0.084	
D11	578321	2118619	0.080	
D12	578305	2119775	0.083	125
D13	580803	2117833	0.084	
D14	579793	2121828	0.078	

On comparison of thee measured dust levels with the OAAQS, it is seen that the dust levels measured at all locations are within the standards limits. Graphical representation of dust concentration has been provided in ***Figure 4-18***.

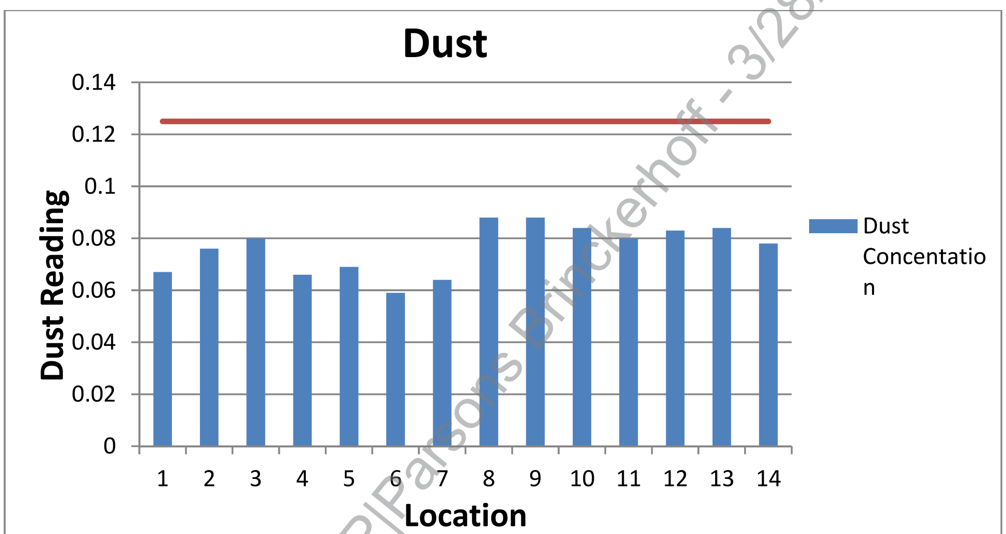


Figure 4-18: Graphical Representation of Dust Concentration

4.8 Noise Monitoring

The proposed site currently has no noise significant sources located within several kilometres. Given the isolated location of the proposed site, vehicular traffic noise is similarly restricted. Current anthropogenic sources of noise in the area include operation of fishing boats, movement of fishermen's vehicles and the fish unloading area.

Noise monitoring was carried out at 13 locations. Noise monitoring locations are presented in ***Figure 4-20***. Noise level measurements were conducted using Integrating and Logging Sound Level Meter (ISLM), Quest SoundPro which is capable of measuring equivalent continuous noise levels (Leq). Noise levels were measured for 15mins at each location- during day and evening times as defined in Article (6) of MD 79/1994.

- Workdays (daytime) - A : after 7am and up to 6pm
- Workdays (evenings) - B : after 6pm and up to 11pm

ESIA Consultants - Michael Lotinga - WSP|Parsons Brinckerhoff - 3/28/2017 1:35:37 PM - 62.6.164.67

- Holidays and nights - C : after 11pm and up to 7am

Weather conditions were normal and there was no excess wind during the measurements. Wind speeds were measured using a hand-held anemometer simultaneously with noise measurements to ensure that the wind speeds were less, as high wind speeds would lead to errors in the measured noise levels. The ambient noise levels during daytime, evening and night are presented in ***Table 4-16.***

Table 4-16: Ambient Noise Level

#	UTM co-ordinates		Noise			Omani Standard[5]
	Easting	Northing	L_{eq}	L_{min}	L_{max}	
Daytime (7:00am to 6:00pm)						
N1	578278	2120759	37.8	29.5	54.3	70
N2	578998	2120752	38.7	29.4	65.1	
N3	580006	2120767	48.7	43.7	63.3	
N4	580876	2119370	50.2	33.8	67.7	
N5	583005	2119492	58.0	28.2	71.8	
N6	583422	2118806	56.6	25.9	67.7	
N7	583477	2117825	51.7	26.0	66.3	
N8	583451	2116730	32.9	25.9	55.0	
N9	580958	2116724	44.6	28.1	62.3	
N10	578332	2116689	33.6	26.3	57.3	
N11	578321	2118619	38.0	30.2	58.0	
N12	578305	2119775	41.0	31.3	56.0	
N13	580803	2117833	32.3	24.8	54.4	
N14	579793	2121828	40.4	33.8	67.8	
Evening Time (6:00pm to 11:00pm)						
N1	578278	2120759	70.6	46.0	83.7	70
N2	578998	2120752	63.8	43.5	81.1	
N3	580006	2120767	89.0	56.9	104.6	
N4	580876	2119370	71.5	50.6	87.3	
N5	583005	2119492	77.2	47.7	92.7	
N6	583422	2118806	86.1	52.8	99.1	

[5] Ambient noise standards issued under MD 79/94 from industrial sources applicable to the proposed park (Industrial and Commercial)

ESIA Consultants - Michael Lotinga - WSP|Parsons Brinckerhoff - 3/28/2017 1:35:37 PM - 62.6.164.67

#	UTM co-ordinates		Noise			Omani Standard[5]
	Easting	Northing	L_{eq}	L_{min}	L_{max}	
N7	583477	2117825	84.4	63.5	96.9	
N8	583451	2116730	89.0	54.2	101	
N9	580958	2116724	90.4	55.1	102.3	
N10	578332	2116689	80.3	68.1	91.9	
N11	578321	2118619	93.6	73.9	103.7	
N12	578305	2119775	75.4	56.7	88.5	
N13	580803	2117833	86.0	53.4	98.1	
N14	579793	2121828	66.5	43.8	86.7	

From the table it is observed that the noise measured during Daytime and Evening time) are well below the applicable Omani standard except the evening time at all locations except N2 and N14. As this is dedicated industrial estate, noise levels have been compared with those stipulated for industrial area in MD 79/94. The measurements indicate that noise levels at certain locations exceed the limits specified for evening time intervals. The area is currently devoid of any industrial activities. The inherently higher noise levels can be attributed to that from the strong winds, which is a common feature in the region considering the open nature of the entire site and also from the surfing noise of the waves for locations in close proximity to the coast. The results are consistent with the readings obtained for earlier baseline studies undertaken for SEZAD and for the ESIA of the industrial development zone of Duqm. These studies have also recorded values which exceed the rural threshold for some locations and the industrial source threshold values at different time intervals specified in MD 79/94. Noise level interpretations are graphically presented in ***Figure 4-19.***

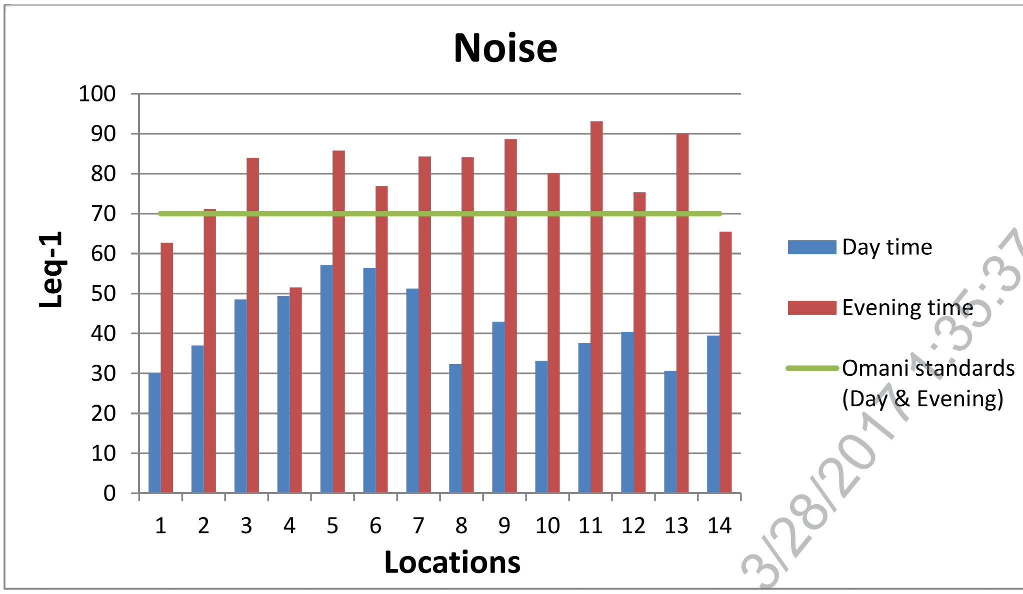
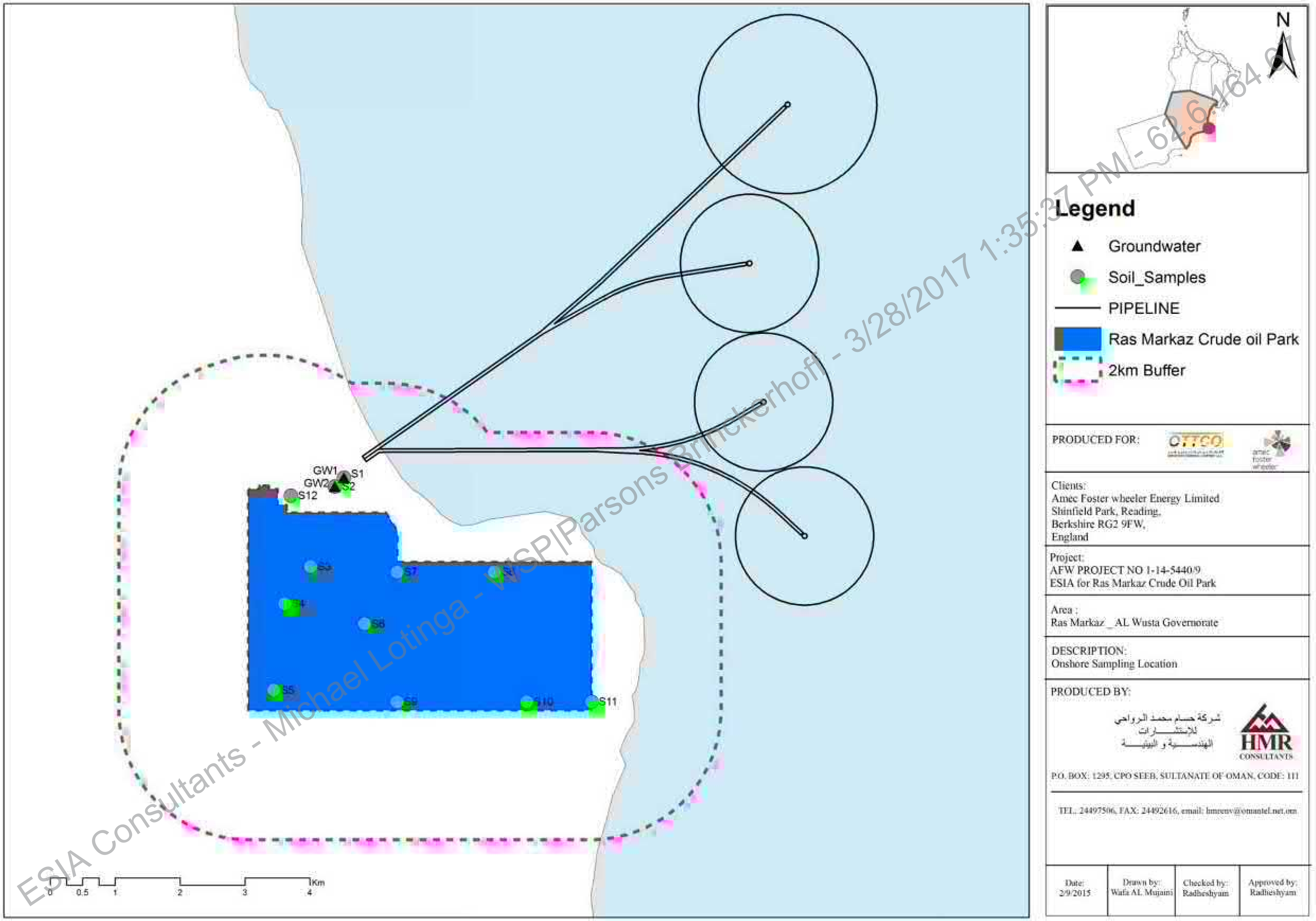


Figure 4-19: Graphical Representation of Noise Results

ESIA Consultants - Michael Lotinga - WSP|Parsons Brinckerhoff - 3/28/2017 1:35:37 PM - 62.6.164.67


GW1
GW2
S1
S2
S12
S3
S7
S4
S6
S5
S9
S10
S11
0 0.5 1 2 3 4 Km
N
Legend
Groundwater
Soil_Samples
PIPELINE
Ras Markaz Crude oil Park
2km Buffer
PRODUCED FOR:
OTTCO
amec foster wheeler
Clients:
Amec Foster wheeler Energy Limited
Shinfield Park, Reading,
Berkshire RG2 9FW,
England
Project:
AFW PROJECT NO 1-14-5440/9
ESIA for Ras Markaz Crude Oil Park
Area :
Ras Markaz _ AL Wusta Governorate
DESCRIPTION:
Onshore Sampling Location
PRODUCED BY:
شركة حسام محمد الرواحي للإستشارات الهندسية و البيئية
HMR CONSULTANTS
P.O. BOX: 1295, CPO SEEB, SULTANATE OF OMAN, CODE: 111
Date: 2/9/2015
Drawn by: Wafa AL Mujaini
Checked by: Radheshyam
Approved by: Radheshyam

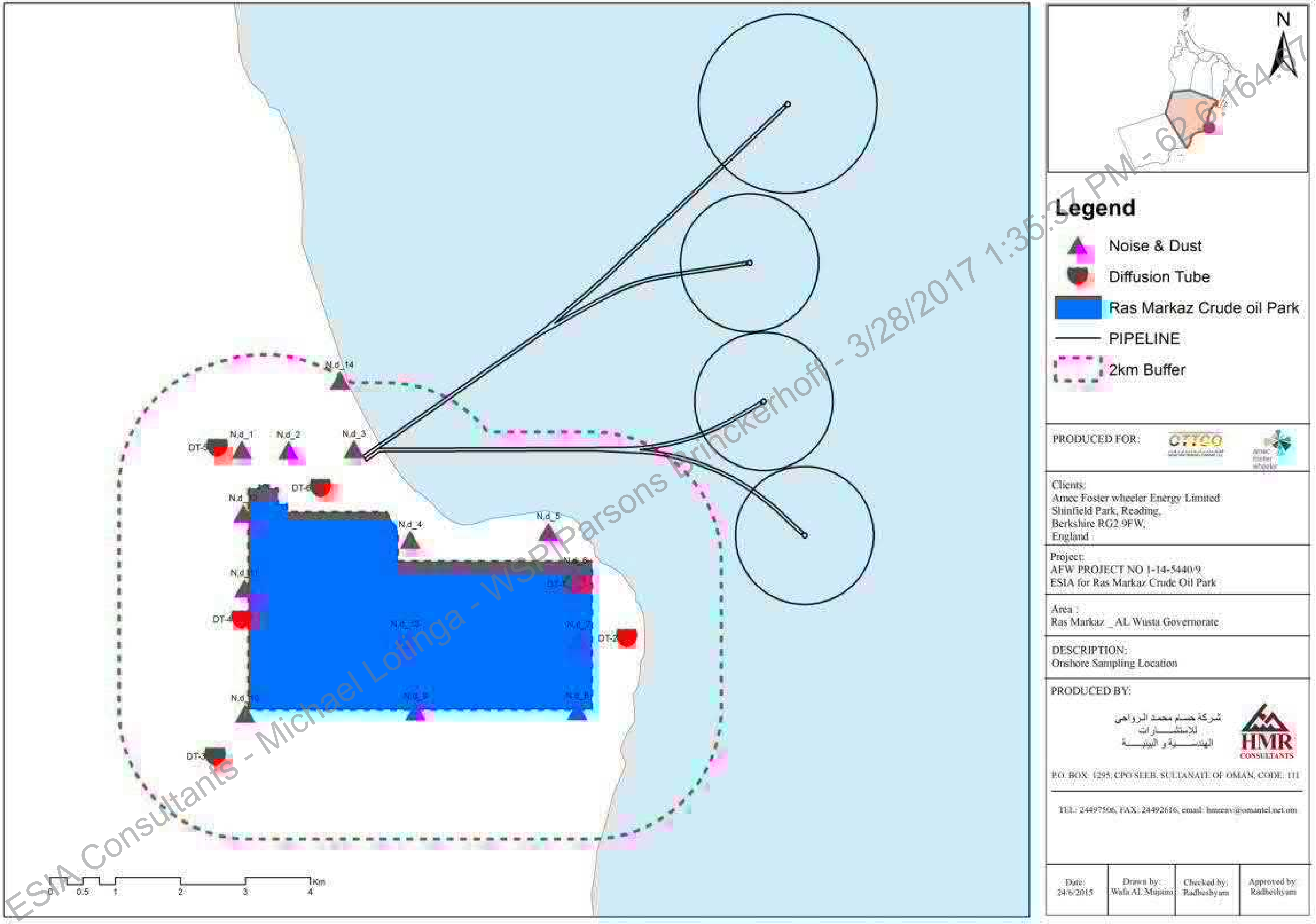
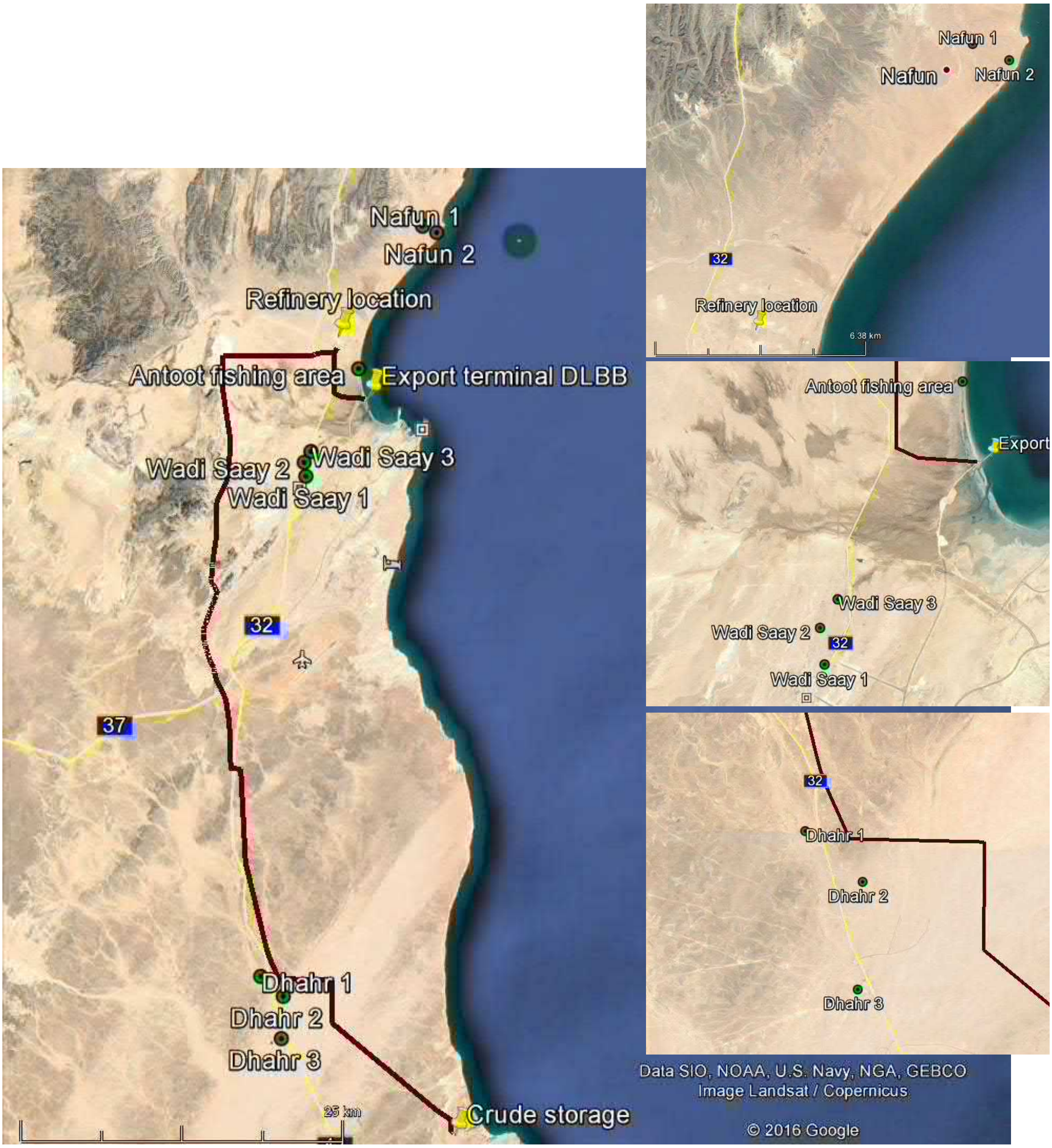


Figure 4-20: Onshore Sampling Location

Appendix B

SURVEY LOCATIONS

2017 Baseline Noise Survey Locations



Appendix C

CALIBRATION CERTIFICATES

Sound measurement equipment calibration certificates

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

UKAS CALIBRATION 7623

Date of Issue: 10 January 2017

Certificate Number: UCRT17/1010

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Page 1 of 2 Pages

Approved Signatory

M. Breslin [ ] K. Mistry [✓] J. Harriman [ ]

Customer	WSP Environmental Ltd 3rd floor Kings Orchard 1 Queen Street Bristol BS2 0HQ
Order No.	20038807
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification

Manufacturer	*Instrument*	*Type*	*Serial No. / Version*
Rion	Sound Level Meter	NL-52	01021291
Rion	Firmware		1.8
Rion	Pre Amplifier	NH-25	21333
Rion	Microphone	UC-59	04347
Rion	Calibrator	NC-74	35125825
	Calibrator adaptor type if applicable		NC-74-002

Performance Class 1

Test Procedure TP 2.SLM 61672-3 TPS-49

Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

Type Approved to IEC 61672-1:2002 YES Approval Number 21.21 / 13.02

If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003

Date Received 09 January 2017 ANV Job No. UKAS17/01002

Date Calibrated 10 January 2017

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	15 January 2015	17762	Campbell Associates

CERTIFICATE OF CALIBRATION

UKAS Accredited Calibration Laboratory No. 7623

Certificate Number
UCRT17/1010

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter NL-42 / NL-52
SLM instruction manual ref / issue	11-03
SLM instruction manual source	Manufacturer
Internet download date if applicable	N/A
Case corrections available	Yes
Uncertainties of case corrections	Yes
Source of case data	Manufacturer
Wind screen corrections available	Yes
Uncertainties of wind screen corrections	Yes
Source of wind screen data	Manufacturer
Mic pressure to free field corrections	Yes
Uncertainties of Mic to F.F. corrections	Yes
Source of Mic to F.F. corrections	Manufacturer
Total expanded uncertainties within the requirements of IEC 61672-1:2002	Yes
Specified or equivalent Calibrator	Specified
Customer or Lab Calibrator	Customers Calibrator
Calibrator adaptor type if applicable	NC-74-002
Calibrator cal. date	10 January 2017
Calibrator cert. number	UCRT17/1008
Calibrator cal cert issued by	7623
Calibrator SPL @ STP	93.99 dB Calibration reference sound pressure level
Calibrator frequency	1001.92 Hz Calibration check frequency
Reference level range	25 - 130 dB

Accessories used or corrected for during calibration - Wind Shield WS-10
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests		Start	End		
	Temperature	22.92	22.92	±	0.20 °C
	Humidity	36.4	35.1	±	3.00 %RH
	Ambient Pressure	100.02	100.07	±	0.03 kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	94.1	dB	Adjusted indicated level	94.0	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±				0.10	dB

Self Generated Noise	This test is currently not performed by this Lab.		
Microphone installed (if requested by customer) = Less Than	N/A	dB	A Weighting
Uncertainty of the microphone installed self generated noise ±	N/A	dB	

Microphone replaced with electrical input device - UR = Under Range indicated

Weighting	A			C			Z		
	10.4	dB	UR	15.3	dB	UR	21.0	dB	UR
Uncertainty of the electrical self generated noise ±							0.12	dB	

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

END

Calibrated by: A Patel

R 1

Additional Comments

None

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

UKAS CALIBRATION 7623

Date of Issue: 20 June 2016

Certificate Number: UCRT16/1202

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

M. Breslin [ ] K. Mistry [ ] J. Harriman [✓]

Customer	WSP Environmental Ltd 3rd Floor Kings Orchard 1 Queen Street Bristol BS2 0HQ			
Order No.	20026175			
Test Procedure	Procedure TP 1 Calibration of Sound Calibrators			
Description	Acoustic Calibrator			
Identification	*Manufacturer* Rion	*Instrument* Calibrator	*Model* NC-74	*Serial No.* 35173440

The calibrator has been tested as specified in Annex B of IEC 60942:2003. As public evidence was available from a testing organisation (PTB) responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of IEC 60942:2003.

ANV Job No.	UKAS16/06122	
Date Received	17 June 2016	
Date Calibrated	20 June 2016	
Previous Certificate	*Dated*	17 June 2015
	Certificate No.	1506353
	Laboratory	AV Calibration

Measurements

The sound pressure level generated by the calibrator in its WS2 configuration was measured five times by the Insert Voltage Method using a microphone as detailed below. The mean of the results obtained is shown below. It is corrected to the standard atmospheric pressure of 101.3 kPa (1013 mBar) using original manufacturers information.

Test Microphone	*Manufacturer*	*Type*
	Brüel & Kjær	4134

Results

The level of the calibrator output under the conditions outlined above was

94.01 ± 0.10 dB rel 20 µPa

Functional Tests and Observations

The frequency of the sound produced was	1002.78 Hz	±	0.13 Hz
The total distortion was	1.28 %	±	6.7 % of Reading

During the measurements environmental conditions were

Temperature	23	to	24	°C
Relative Humidity	43	to	51	%
Barometric Pressure	99.9	to	100.1	kPa

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

The uncertainties refer to the measured values only with no account being taken of the ability of the instrument to maintain its calibration.

A small correction factor may need to be applied to the sound pressure level quoted above if the device is used to calibrate a sound level meter which is fitted with a free-field response microphone. See manufacturers handbook for details.

.... END ....

Note:

Calibrator adjusted prior to calibration?	NO	
Initial Level	N/A	dB
Initial Frequency	N/A	Hz

Additional Comments

None

Calibrated by: A Patel

R 1

Appendix D

SOUND MEASUREMENT RECORDS

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Wadi Saay Location 1

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
24/04/2017	18:07	15:00	3-5	SW	30+	53.2	78.5	59.2	56.8	45.0	Very occasional road traffic on Highway 32, wind
24/04/2017	18:22	15:00	3-5	SW	30+	52.0	68.2	58.2	55.8	44.6	Very occasional road traffic on Highway 32, wind
24/04/2017	23:17	15:00	2-4	SW	25+	46.1	60.6	50.7	48.9	40.5	Wind
24/04/2017	23:32	15:00	2-4	SW	25+	44.6	63.8	48.9	47.3	40.9	Wind
25/04/2017	15:09	15:00	2-3	SW	35+	49.5	64.2	54.1	51.8	45.0	Distant construction noise along road, wind
25/04/2017	15:24	15:00	2-3	SW	35+	50.6	63.4	55.5	53.8	45.7	Distant construction noise along road, wind
26/04/2017	09:22	15:00	2-3	SW	30+	52.0	71.3	57.9	53.9	43.7	Occasional road traffic & construction activity on Highway 32, wind
26/04/2017	09:37	15:00	2-3	SW	30+	51.6	66.0	58.0	54.3	43.9	Occasional road traffic & construction activity on Highway 32, wind



Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Wadi Saay Location 2

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	Time	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temperature (°C)	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
24/04/2017	19:11	15:00	4-5	SW	30+	48.7	69.5	53.9	51.3	41.4	Wind
24/04/2017	19:26	15:00	4-5	SW	30+	51.1	70.8	56.5	53.7	41.7	Wind
24/04/2017	19:41	15:00	4-5	SW	25+	51.0	75.9	55.4	53.1	42.5	Wind
25/04/2017	00:04	15:00	4-5	SW	25+	42.1	59.7	46.1	44.9	37.8	Wind
25/04/2017	00:19	15:00	4-5	SW	25+	44.1	61.2	47.2	45.4	38.1	Wind
25/04/2017	15:54	15:00	2-3	SW	35+	45.8	54.8	49.8	49.1	40.0	Wind
25/04/2017	16:09	15:00	2-3	SW	35+	47.3	65.0	51.4	49.3	40.7	Wind
26/04/2017	10:01	15:00	3-4	SW	30+	44.1	58.7	48.3	46.3	39.3	Wind
26/04/2017	10:16	15:00	3-4	SW	30+	44.9	70.0	48.5	46.7	39.1	Wind

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Wadi Saay Location 3

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
25/04/2017	23:28	15:00	4-5	SW	25+	51.2	69.5	57.2	55.3	40.3	Wind
25/04/2017	23:43	15:00	4-5	SW	25+	51.5	70.3	57.4	55.5	41.0	Wind
26/04/2017	18:04	15:00	4-5	SW	30+	49.4	62.4	53.6	52.4	43.9	Very occasional road traffic on Highway 32, wind
26/04/2017	18:19	15:00	4-5	SW	30+	50.3	69.4	54.7	53.5	43.9	Very occasional road traffic on Highway 32, wind
26/04/2017	10:38	15:00	2-3	SW	30+	52.2	64.5	56.9	55.8	43.8	Occasional road traffic & construction activity on Highway 32, wind
26/04/2017	10:53	15:00	2-3	SW	30+	51.5	82.6	54.8	53.2	43.1	Occasional road traffic & construction activity on Highway 32, wind

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Nafun Location 1

Measurement Period			**Weather**			**Statistical Noise Levels / dB**					**Description of Audible Noise**
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
25/04/2017	12:12	15:00	2-3	SW	35+	42.1	62.6	45.2	43.6	38.9	Wind, very occasional local vehicles
25/04/2017	12:27	15:00	2-3	SW	35+	41.4	48.9	44.3	43.4	39.0	Wind, very occasional local vehicles
25/04/2017	22:17	15:00	2-3	SW	25+	41.6	57.4	45.2	43.9	38.3	Wind, very occasional local vehicles

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Nafun Location 2

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
25/04/2017	13:03	15:00	4-5	SW	35+	53.6	59.3	55.2	54.9	51.9	Wind / sea
25/04/2017	13:18	15:00	4-5	SW	35+	54.0	57.0	55.5	55.2	52.6	Wind / sea
25/04/2017	13:33	15:00	4-5	SW	35+	53.8	57.0	55.4	55.0	52.3	Wind / sea
25/04/2017	22:41	15:00	4-5	SW	25+	48.2	69.8	50.2	48.2	45.3	Wind / sea - measurement cut short due to safety concerns

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Antoot Fishing Area

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
25/04/2017	10:53	15:00	4-5	SW	30+	42.1	62.3	46.1	44.6	35.0	Wind / sea
25/04/2017	11:08	15:00	4-5	SW	30+	43.9	55.0	49.1	47.6	35.6	Wind / sea

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Dhahr Location 1

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	Time	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temperature (°C)	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
26/04/2017	12:26	15:00	5-7	SW	35+	45.8	67.5	50.9	48.8	37.8	Wind
26/04/2017	12:41	15:00	5-7	SW	35+	47.4	69.8	52.1	50.0	38.1	Wind



Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Dhahr Location 2

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	**Time**	**Elapsed Minutes**	**Wind Speed (m/s)**	**Wind Direction (from)**	**Temperature (°C)**	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
26/04/2017	13:09	15:00	4-5	SW	35+	47.7	67.1	52.8	51.2	40.6	Wind
26/04/2017	13:24	15:00	4-5	SW	35+	46.3	58.9	51.4	49.6	39.4	Wind

Noise Monitoring Form

Project:	**Duqm Refinery**	**Job Number:**	**70029220**
Equipment:	Rion NL-52 Kit E	**Engineer:**	Paul Doyle
Pre-Calibration Level:	94.0	**General Weather Description:**	Day: Hot, Sunny. Evening/Night: Hot
Post-Calibration Level:	94.0	**Location:**	Dhahr Location 3

Measurement Period			Weather			Statistical Noise Levels / dB					Description of Audible Noise
Date	Time	Elapsed Minutes	Wind Speed (m/s)	Wind Direction (from)	Temperature (°C)	L_{Aeq}	L_{Amax}	L_{A01}	L_{A10}	L_{A90}	
26/04/2017	14:03	15:00	2-3	SW	35+	42.7	64.7	47.0	42.9	35.5	Wind, very occasional local vehicles
26/04/2017	14:18	15:00	2-3	SW	35+	45.4	77.8	47.1	44.7	36.4	Wind, very occasional local vehicles



APPENDIX B-2

APPENDIX 5.2: ACGIH VIBRATION TLVS

HAND–ARM (SEGMENTAL) VIBRATION

The TLVs® in Table 1 refer to component acceleration levels and durations of exposure that represent conditions under which it is believed that nearly all workers may be exposed repeatedly without progressing beyond Stage 1 of the Stockholm Workshop Classification System for Vibration-induced White Finger (VWF), also known as Raynaud's Phenomenon of Occupational Origin (Table 2). Since there is a paucity of dose–response relationships for VWF, these recommendations have been derived from epidemiological data from forestry, mining, and metal working. These values should be used as guides in the control of hand–arm vibration exposure; because of individual susceptibility, they should not be regarded as defining a boundary between safe and dangerous levels.

It should be recognized that control of hand–arm vibration syndrome (HAVS) from the workplace cannot occur simply by specifying and adhering to a given TLV®. The use of 1) antivibration tools, 2) antivibration gloves, 3) proper work practices that keep the worker's hands and remaining body warm and also minimize the vibration coupling between the worker and the vibration tool are necessary to minimize vibration exposure, and 4) a conscientiously applied medical surveillance program are ALL necessary to rid HAVS from the workplace.

TABLE 1. TLVs® for Exposure of the Hand to Vibration in Either X_h, Y_h, or Z_h Directions

Total Daily Exposure Duration☆	Values of the Dominant,★ Frequency-Weighted, rms, Component Acceleration Which Shall not be Exceeded a_K,($a_{K_{eq}}$)	
	m/s^2	g^{Δ}
4 hours and less than 8	4	0.40
2 hours and less than 4	6	0.61
1 hour and less than 2	8	0.81
less than 1 hour	12	1.22

☆The total time vibration enters the hand per day, whether continuously or intermittently.

★Usually one axis of vibration is dominant over the remaining two axes. If one or more vibration axes exceeds the Total Daily Exposure, then the TLV® has been exceeded.

$g^{\Delta} = 9.81\ m/s^2$.

Notes for Table 1:

1. The weighting network provided in Figure 1 is considered the best available to frequency weight acceleration components. However, studies suggest that the frequency weighting at higher frequencies (above 16 Hz) may not incorporate a sufficient safety factor, and CAUTION must be applied when tools with high-frequency components are used.
2. Acute exposures to frequency-weighted, root-mean-square (rms), component accelerations in excess of the TLVs® for infrequent periods of time (e.g., 1 day per week or several days over a 2-week period) are not necessarily more harmful.
3. Acute exposures to frequency-weighted, rms, component accelerations of three times the magnitude of the TLVs® are expected to result in the same health effects after 5 to 6 years of exposure.

4. To moderate the adverse effects of vibration exposure, workers should be advised to avoid continuous vibration exposure by cessation of vibration exposure for approximately 10 minutes per continuous vibration hour.
5. Good work practices should be used and should include instructing workers to employ a minimum hand grip force consistent with safe operation of the power tool or process, to keep their body and hands warm and dry, to avoid smoking, and to use antivibration tools and gloves when possible. As a general rule, gloves are more effective for damping vibration at high frequencies.
6. A vibration measurement transducer, together with its device for attachment to the vibration source, should weigh less than 15 grams and should possess a cross-axis sensitivity of less than 10%.
7. The measurement by many (mechanically underdamped) piezoelectric accelerometers of repetitive, large displacement, impulsive vibrations, such as those produced by percussive pneumatic tools, is subject to error. The insertion of a suitable, low-pass, mechanical filter between the accelerometer and the source of vibration with a cut-off frequency of 1500 Hz or greater (and cross-axis sensitivity of less than 10%) can help eliminate incorrect readings.
8. The manufacturer and type number of all apparatus used to measure vibration should be reported, as well as the value of the dominant direction and frequency-weighted, rms, component acceleration.

TABLE 2. Stockholm Workshop HAVS Classification System for Cold-induced Peripheral Vascular and Sensorineural Symptoms

Vascular Assessment

Stage	Grade	Description
0	——	No attacks
1	Mild	Occasional attacks affecting only the tips of one or more fingers
2	Moderate	Occasional attacks affecting distal and middle (rarely also proximal) phalanges of one or more fingers
3	Severe	Frequent attacks affecting ALL phalanges of most fingers
4	Very Severe	As in Stage 3, with trophic skin changes in the finger tips

Note: Separate staging is made for each hand, e.g., 2L(2)/1R(1) = stage 2 on left hand in two fingers: stage 1 on right hand in one finger.

Sensorineural Assessment

Stage	Symptoms
0SN	Exposed to vibration but no symptoms
1SN	Intermittent numbness, with or without tingling
2SN	Intermittent or persistent numbness, reducing sensory perception
3SN	Intermittent or persistent numbness, reducing tactile discrimination and/or manipulative dexterity

Note: Separate staging is made for each hand.

Continuous, Intermittent, Impulsive, or Impact Hand–Arm Vibration

The measurement of vibration should be performed in accordance with the procedures and instrumentation specified by ISO 5349 (1986)[1] or ANSI S3.34-1986[2] and summarized below.

The acceleration of a vibration handle or work piece should be determined in three mutually orthogonal directions at a point close to where vibration enters the hand. The directions should preferably be those forming the biodynamic coordinate system but may be a closely related basicentric system with its origin at the interface between the hand and the vibrating surface (Figure 2) to accommodate different handle or work piece configurations. A small and lightweight transducer should be mounted so as to record accurately one or more orthogonal components of the source vibration in the frequency range from 5 to 1500 Hz. Each component should be frequency-weighted by a filter network with gain characteristics specified for human-response vibration measuring instrumentation, to account for the change in vibration hazard with frequency (Figure 1).

Assessment of vibration exposure should be made for EACH applicable direction (X_h, Y_h, Z_h) since vibration is a vector quantity (magnitude and direction). In each direction, the magnitude of the vibration during normal operation of the power tool, machine, or work piece should be expressed by the root-mean-square (rms) value of the frequency-weighted component accelerations, in units of meters per second squared (m/s^2), or gravitational units (g), the largest of which, a_K, forms the basis for exposure assessment.

For each direction being measured, linear integration should be employed for vibrations that are of extremely short duration or vary substantially in time. If the total daily vibration exposure in a given direction is

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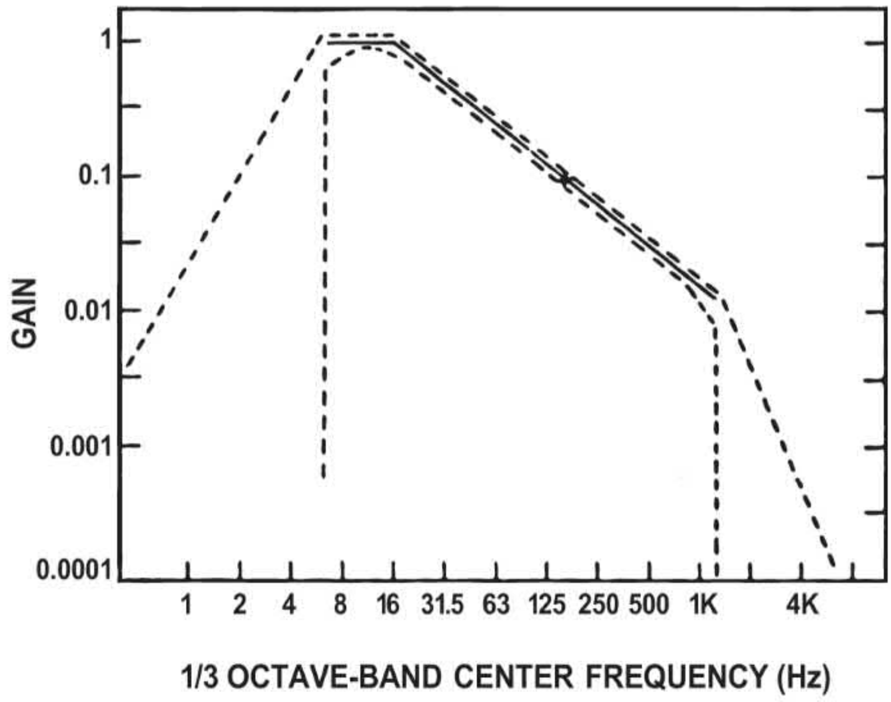

FIGURE 1. Gain characteristics on the filter network used to frequency-weight acceleration components (continuous line). The filter tolerances (dashed lines) are those contained in ISO 5349 and ANSI S3.34-1986.

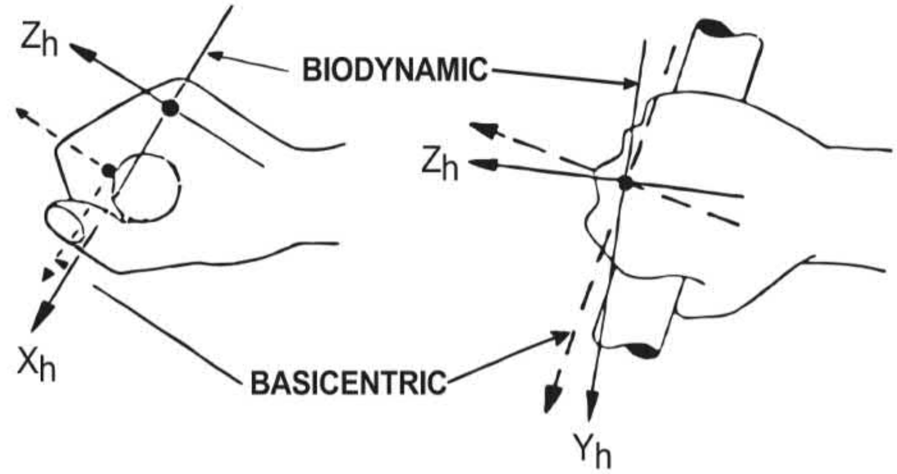

FIGURE 2. Biodynamic and basicentric coordinate systems for the hand, showing the directions of the acceleration components (ISO 5349[1] and ANSI S3.34–1986[2]).

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composed of several exposures at different rms accelerations, then the equivalent, frequency-weighted component acceleration in that direction should be determined in accordance with the following equation:

$$\left(a_{K_{eq}}\right) = \left[\frac{1}{T}\sum_{i=1}^{n}\left(a_{K_i}\right)^2 T_i\right]^{1/2}$$

$$= \sqrt{\left(a_{K_1}\right)^2 \frac{T_1}{T} + \left(a_{K_2}\right)^2 \frac{T_2}{T} + \ldots \left(a_{K_n}\right)^2 \frac{T_n}{T}}$$

where: $T = \sum_{i=1}^{n} T_i$

$T =$ total daily exposure duration

$a_{K_i} =$ *ith* frequency-weighted, rms acceleration component with duration T_i

These computations may be performed by commercially available human-response vibration measuring instruments.

References

1. International Standards Organization: ISO 5349 (1986): Guide for the Measurement and the Assessment of Human Exposure to Hand Transmitted Vibration. ISO, Geneva (1986).
2. American National Standards Institute: ANSI S3.34-1986: Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand. ANSI, New York (1986).

WHOLE–BODY VIBRATION

The TLVs® in Figures 1 and 2 (tabulated in Tables 1 and 2) refer to mechanically induced whole-body vibration (WBV) acceleration component root-mean-square (rms) magnitudes and durations under which it is believed that nearly all workers may be exposed repeatedly with minimum risk of back pain, adverse health effects to the back, and inability to operate a land-based vehicle properly. The biodynamic coordinate system to which they apply is displayed in Figure 3. These values should be used as guides in the control of WBV exposure, but because of individual susceptibility, they should not be regarded as defining a boundary between safe and dangerous levels.

Notes:

1. Vibration acceleration is a vector with magnitude expressed in units of m/s^2. The gravitational acceleration, g, equals 9.81 m/s^2.
2. Figures 1 and 2 each show a family of daily exposure time–dependent curves. They indicate that human vibration resonance occurs in the 4 to 8 Hz frequency range for the z axis and in the 1 to 2 Hz frequency range for the x and y axes, where the axes are defined in Figure 3.
3. WBV measurements and equivalent exposure time calculations for interrupted exposures, where the rms acceleration levels vary appreciably over time, should be made according to ISO 2631 or ANSI S3.18-1979.[1,2]
4. The TLV® is valid for vibration crest factors of 6 or less. Crest factor is defined as the ratio of peak to rms acceleration, measured in the same direction, over a period of 1 minute for any of the orthogonal x, y, and z axes. The TLV® will underestimate the effects of WBV and must be used with caution when the crest factor exceeds 6.
5. The TLV® is not intended for use in fixed buildings (*see* ANSI S3.29-1983),[3] in off-shore structures, or in ships.
6. A summary of WBV measurement and data analysis procedures follows:[4]
   a. At each measurement point, three orthogonal, continuous, rms acceleration measurements are simultaneously made and recorded for at least 1 minute along the biodynamic coordinates shown in Figure 3.
   b. Three very light-weight accelerometers, each with a cross-axis sensitivity of less than 10%, are perpendicularly mounted to a light-weight metal cube and placed in the center of a hard rubber disc (per SAE, J1013).[5] The total weight of the disc, cube, accelerometers, and cables should not exceed 10% of the total weight of the object to be measured. Measurements are made by placing the instrumented rubber disc on the top of the driver's seat, under the driver's buttocks, as the vehicle is operated.
   c. For each axis, a $^1/_3$ octave band (1 to 80 Hz), separate Fourier spectrum analysis is required for comparison to Figure 1 or Figure 2, as appropriate.

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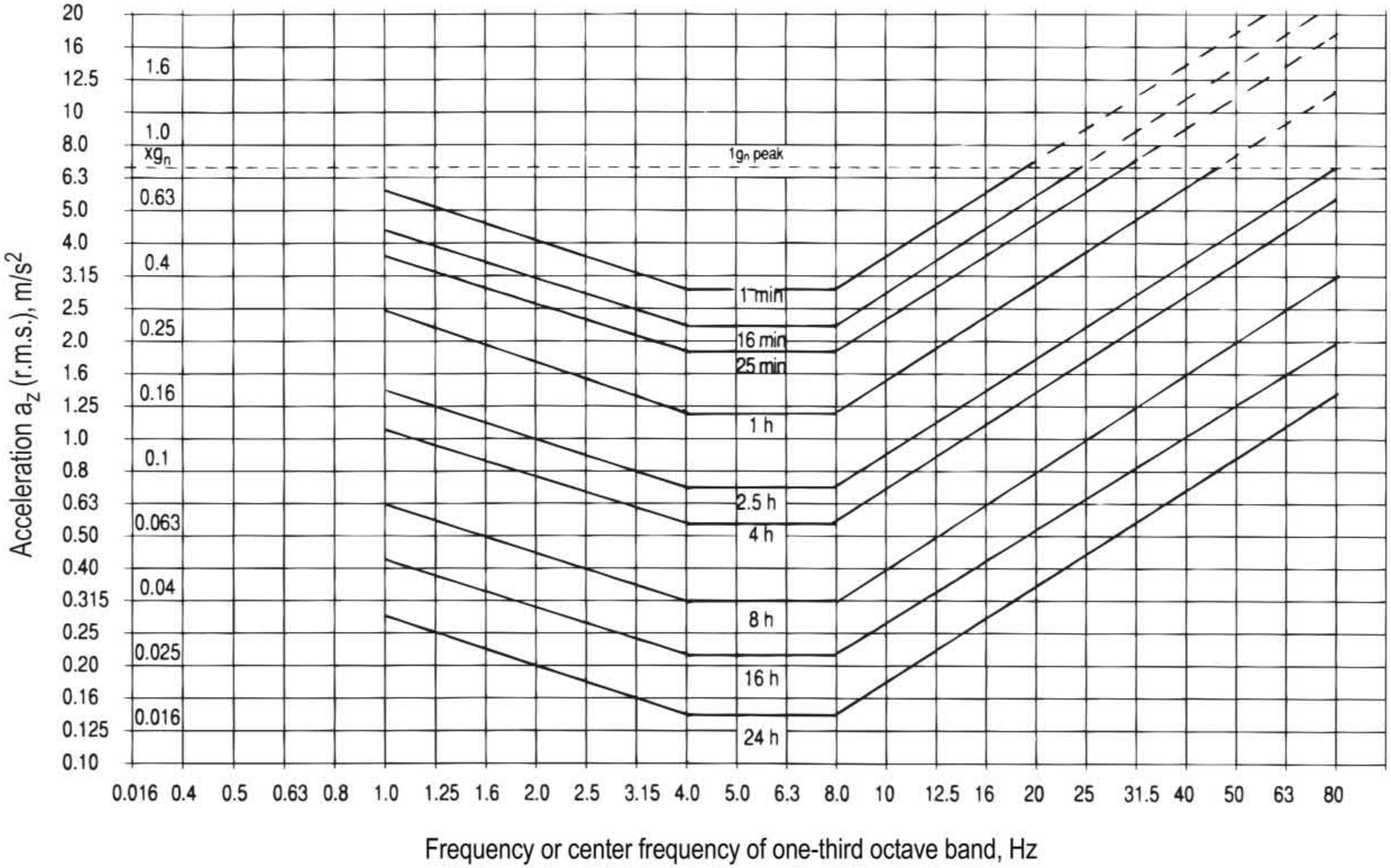

FIGURE 1. Longitudinal (a_z) acceleration TLVs® as a function of frequency and exposure time. Adapted from ISO 2631.[1]

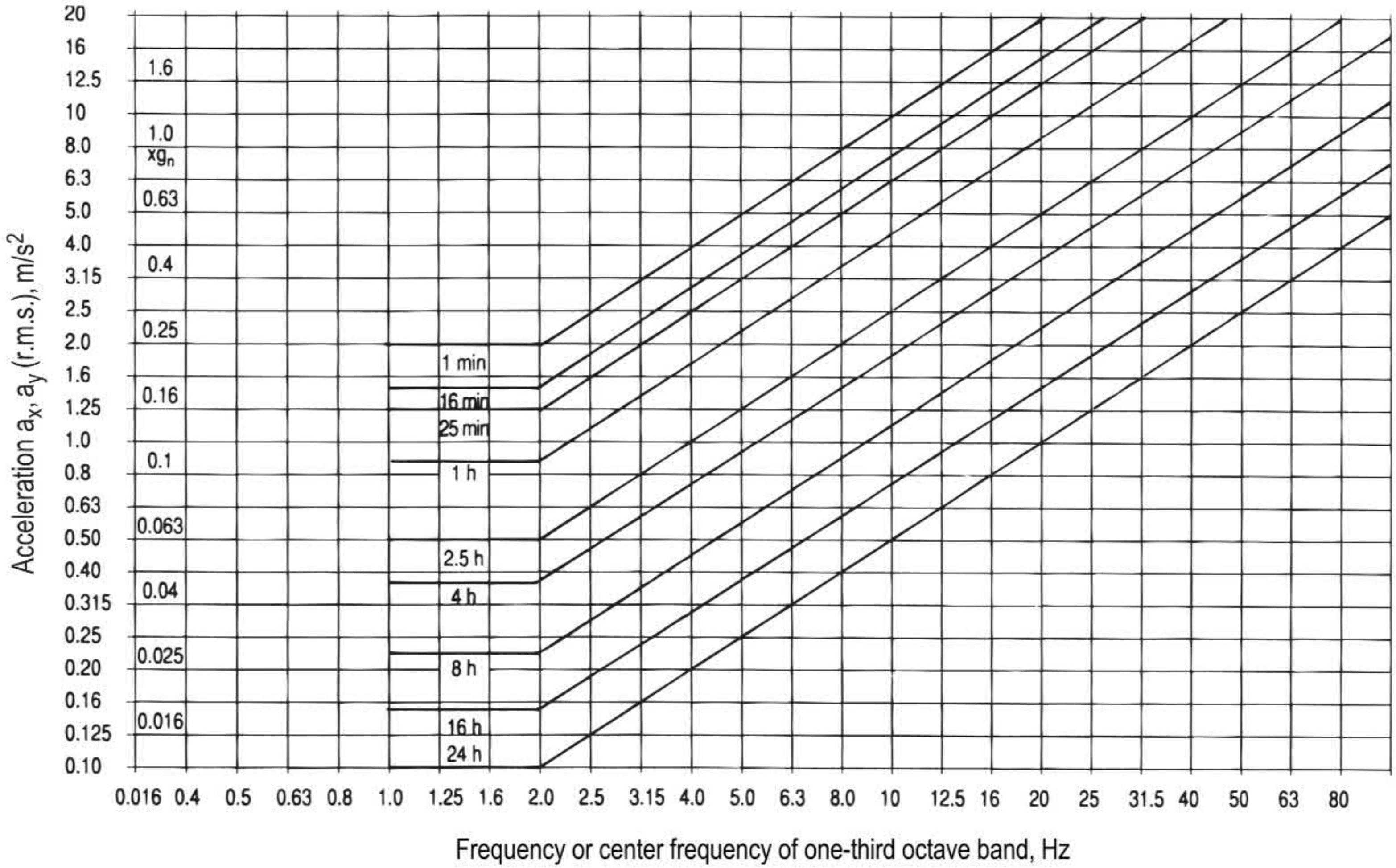

FIGURE 2. Transverse (a_x, a_y) acceleration TLVs® as a function of frequency and exposure time. Adapted from ISO 2631.[1]

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TABLE 1. Numerical values for vibration acceleration in the longitudinal, a_z, direction [foot-to-head direction] [*see* Figure 1]. Values define the TLV® in terms of rms value of pure (sinusoidal) single-frequency vibration or of rms value in one-third-octave band for distributed vibration. (Adapted from ISO 2631)

	Acceleration, m/s²								
Frequency	**Exposure times**								
Hz	**24 h**	**16 h**	**8 h**	**4 h**	**2.5 h**	**1 h**	**25 min**	**16 min**	**1 min**
1.0	0.280	0.383	0.63	1.06	1.40	2.36	3.55	4.25	5.60
1.25	0.250	0.338	0.56	0.95	1.26	2.12	3.15	3.75	5.00
1.6	0.224	0.302	0.50	0.85	1.12	1.90	2.80	3.35	4.50
2.0	0.200	0.270	0.45	0.75	1.00	1.70	2.50	3.00	4.00
2.5	0.180	0.239	0.40	0.67	0.90	1.50	2.24	2.65	3.55
3.15	0.160	0.212	0.355	0.60	0.80	1.32	2.00	2.35	3.15
4.0	0.140	0.192	0.315	0.53	0.71	1.18	1.80	2.12	2.80
5.0	0.140	0.192	0.315	0.53	0.71	1.18	1.80	2.12	2.80
6.3	0.140	0.192	0.315	0.53	0.71	1.18	1.80	2.12	2.80
8.0	0.140	0.192	0.315	0.53	0.71	1.18	1.80	2.12	2.80
10.0	0.180	0.239	0.40	0.67	0.90	1.50	2.24	2.65	3.55
12.5	0.224	0.302	0.50	0.85	1.12	1.90	2.80	3.35	4.50
16.0	0.280	0.383	0.63	1.06	1.40	2.36	3.55	4.25	5.60
20.0	0.355	0.477	0.80	1.32	1.80	3.00	4.50	5.30	7.10
25.0	0.450	0.605	1.0	1.70	2.24	3.75	5.60	6.70	9.00
31.5	0.560	0.765	1.25	2.12	2.80	4.75	7.10	8.50	11.2
40.0	0.710	0.955	1.60	2.65	3.55	6.00	9.00	10.6	14.0
50.0	0.900	1.19	2.0	3.35	4.50	7.50	11.2	13.2	18.0
63.0	1.120	1.53	2.5	4.25	5.60	9.50	14.0	17.0	22.4
80.0	1.400	1.91	3.15	5.30	7.10	11.8	18.0	21.2	28.0

TABLE 2. Numerical values for vibration acceleration in the transverse, a_x or a_y, direction [back-to-chest or side-to-side] [*see* Figure 2]. Values define the TLV® in terms of rms value of pure (sinusoidal) single-frequency vibration or of rms value in one-third-octave band for distributed vibration. (Adapted from ISO 2631)

	Acceleration, m/s^2								
	Exposure times								
Frequency Hz	24 h	16 h	8 h	4 h	2.5 h	1 h	25 min	16 min	1 min
1.0	0.100	0.135	0.224	0.355	0.50	0.85	1.25	1.50	2.0
1.25	0.100	0.135	0.224	0.355	0.50	0.85	1.25	1.50	2.0
1.6	0.100	0.135	0.224	0.355	0.50	0.85	1.25	1.50	2.0
2.0	0.100	0.135	0.224	0.355	0.50	0.85	1.25	1.50	2.0
2.5	0.125	0.171	0.280	0.450	0.63	1.06	1.6	1.9	2.5
3.15	0.160	0.212	0.355	0.560	0.8	1.32	2.0	2.36	3.15
4.0	0.200	0.270	0.450	0.710	1.0	1.70	2.5	3.0	4.0
5.0	0.250	0.338	0.560	0.900	1.25	2.12	3.15	3.75	5.0
6.3	0.315	0.428	0.710	1.12	1.6	2.65	4.0	4.75	6.3
8.0	0.40	0.54	0.900	1.40	2.0	3.35	5.0	6.0	8.0
10.0	0.50	0.675	1.12	1.80	2.5	4.25	6.3	7.5	10.0
12.5	0.63	0.855	1.40	2.24	3.15	5.30	8.0	9.5	12.5
16.0	0.80	1.06	1.80	2.80	4.0	6.70	10.0	11.8	16.0
20.0	1.00	1.35	2.24	3.55	5.0	8.5	12.5	15.0	20.0
25.0	1.25	1.71	2.80	4.50	6.3	10.6	15.0	19.0	25.0
31.5	1.60	2.12	3.55	5.60	8.0	13.2	20.0	23.6	31.5
40.0	2.00	2.70	4.50	7.10	10.0	17.0	25.0	30.0	40.0
50.0	2.50	3.38	5.60	9.00	12.5	21.2	31.5	37.5	50.0
63.0	3.15	4.28	7.10	11.2	16.0	26.5	40.0	45.7	63.0
80.0	4.00	5.4	9.00	14.0	20.0	33.5	50.0	60.0	80.0

d. If the rms acceleration of any of the spectral peaks equals or exceeds the values shown in Figure 1 or Figure 2 for the relevant time periods, then the TLV® is exceeded for that exposure time. The axis with the highest spectral peak intersecting the curve with the shortest exposure time dominates and determines the permissible exposure.

7. The total-weighted rms acceleration for each axis can be calculated using Equation 1 with the appropriate axis weighting factors taken from Table 3. For the x axis (analogous equations and definitions apply to the y and z axes), the equation is:

$$A_{wx} = \sqrt{\Sigma\,(W_{fx}\,A_{fx})^2} \qquad (1)$$

where: A_{wx} = total weighted rms acceleration for the x axis
W_{fx} = weighting factor for the x axis at each 1/3 octave band frequency from 1 to 80 Hz (Table 3)
A_{fx} = rms acceleration value for the x axis spectrum at each 1/3 octave band frequency from 1 to 80 Hz

8. If the vibration axes have similar acceleration magnitudes as determined by Equation 1, the combined motion of all three axes could be greater than any one component and could possibly affect vehicle operator performance.[1,2] Each of the component results determined by Equation 1 may be

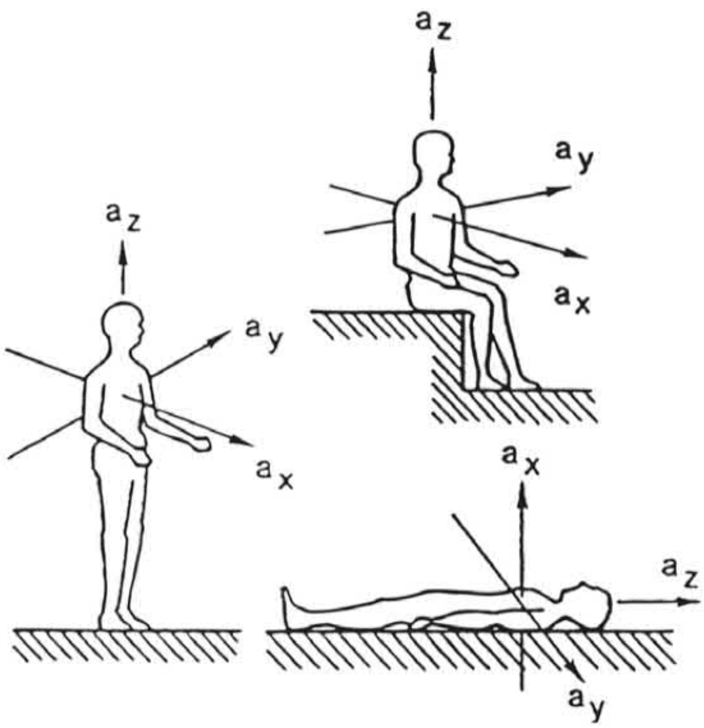

FIGURE 3. Biodynamic coordinate system acceleration measurements (adapted from ISO 2631). a_x, a_y, a_z = acceleration in the direction of the x, y, and z axes; x axis = back-to-chest; y axis = right-to-left; z axis = foot-to-head.

used in Equation 2 to find the resultant, which is the overall weighted total rms acceleration, A_{wt}:

$$A_{wt} = \sqrt{(1.4\ A_{wx})^2 + (1.4\ A_{wy})^2 + (A_{wz})^2} \qquad (2)$$

The factor of 1.4 multiplying the x and y total, weighted rms acceleration values is the ratio of the values of the longitudinal and transverse curves of equal response in the most sensitive human response ranges.

The Commission of the European Communities now recommends 0.5 m/s^2 as an action level for an 8 hour per day overall weighted total rms acceleration. This may be compared with the results of Equation 2.

9. Short-duration, high-amplitude, multiple-vibration shocks may occur with crest factors greater than 6 during the workday, in which cases the TLV® may not be protective (Note 4). Other methods of calculation that include the "4th power concept" may be desirable in these instances.[6]

TABLE 3. Weighting Factors Relative to the Frequency Range of Maximum Acceleration Sensitivity[A] for the Response Curves of Figures 1 and 2 (Adapted from ISO 2631)

	Weighting factor for	
Frequency Hz	Longitudinal z Vibrations [Figure 1]	Transverse x, y Vibrations [Figure 2]
1.0	0.50	1.00
1.25	0.56	1.00
1.6	0.63	1.00
2.0	0.71	1.00
2.5	0.80	0.80
3.15	0.90	0.63
4.0	1.00	0.5
5.0	1.00	0.4
6.3	1.00	0.315
8.0	1.00	0.25
10.0	0.80	0.2
12.5	0.63	0.16
16.0	0.50	0.125
20.0	0.40	0.1
25.0	0.315	0.08
31.5	0.25	0.063
40.0	0.20	0.05
50.0	0.16	0.04
63.0	0.125	0.0315
80.0	0.10	0.025

[A] 4 to 8 Hz in the case of $\pm a_z$ resonance vibration.
1 to 2 Hz in the case of $\pm a_y$ or a_x resonance vibration.

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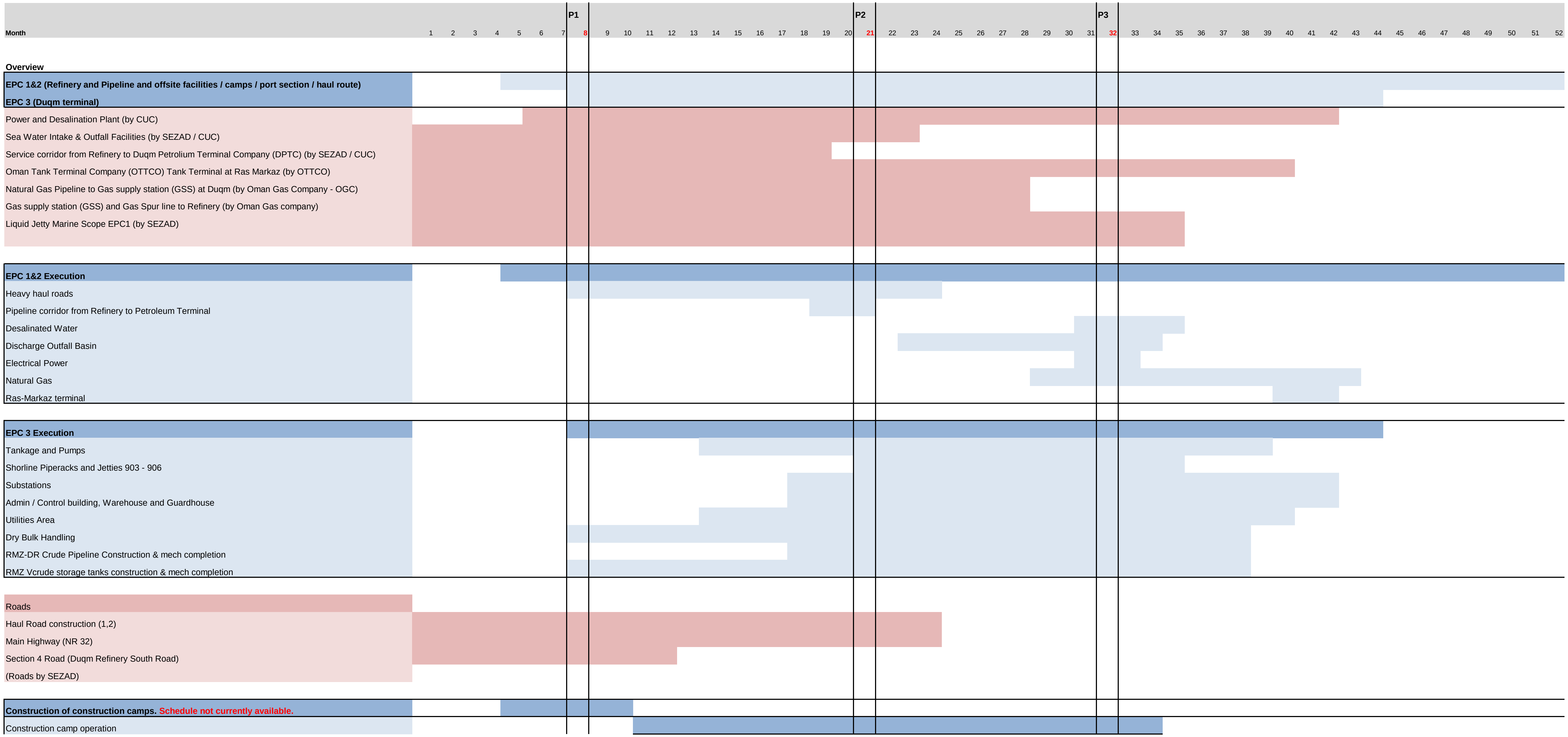
10. WBV controls may include the use of "air-ride" suspended seats, suspended cabs, maintenance of vehicle suspension systems, proper tire inflation, and remote control of vibrating processes. Seats with arm rests, lumbar support, an adjustable seat back, and an adjustable seat pan are also useful.
11. The following good work practices may also be useful for workers operating vehicles:[7,8]
    a. Avoid lifting or bending immediately following exposure.
    b. Use simple motions, with minimum rotation or twisting, when exiting a vehicle.

References

1. International Standards Organization: ISO 2631/1: Evaluation of Human Exposure to Whole-Body Vibration. ISO, Geneva (1985).
2. American National Standards Institute: ANSI S3.18: Guide for the Evaluation of Human Exposure to Whole-Body Vibration. ANSI, New York (1979).
3. American National Standards Institute: ANSI S3.29: Guide for the Evaluation of Human Exposure to Whole-Body Vibration in Buildings. ANSI, New York (1983).
4. Wasserman, D: Human Aspects of Occupational Vibration. Elsevier Publishers, Amsterdam (1987).
5. Society of Automotive Engineers. SAE J1013: Measurement of Whole Body Vibration of the Seated Operator of Off Highway Work Machines. SAE, Warrendale, PA (August 1992).
6. Griffin, M: Handbook of Human Vibration. Academic Press, London (1990).
7. Wilder, D: The Biomechanics of Vibration and Low Back Pain. Am. J. Ind. Med. 23:577–588 (1993).
8. Wilder, D; Pope, M; Frymoyer, J: The Biomechanics of Lumbar Disc Herniation and the Effect of Overload and Instability. J. Spinal Disorders 1:16–32 (1988).

APPENDIX B-3

APPENDIX 5.3: CONSTRUCTION PHASING



P1
P2
P3
Month
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
Overview
EPC 1&2 (Refinery and Pipeline and offsite facilities / camps / port section / haul route)
EPC 3 (Duqm terminal)
Power and Desalination Plant (by CUC)
Sea Water Intake & Outfall Facilities (by SEZAD / CUC)
Service corridor from Refinery to Duqm Petrolium Terminal Company (DPTC) (by SEZAD / CUC)
Oman Tank Terminal Company (OTTCO) Tank Terminal at Ras Markaz (by OTTCO)
Natural Gas Pipeline to Gas supply station (GSS) at Duqm (by Oman Gas Company - OGC)
Gas supply station (GSS) and Gas Spur line to Refinery (by Oman Gas company)
Liquid Jetty Marine Scope EPC1 (by SEZAD)
EPC 1&2 Execution
Heavy haul roads
Pipeline corridor from Refinery to Petroleum Terminal
Desalinated Water
Discharge Outfall Basin
Electrical Power
Natural Gas
Ras-Markaz terminal
EPC 3 Execution
Tankage and Pumps
Shorline Piperacks and Jetties 903 - 906
Substations
Admin / Control building, Warehouse and Guardhouse
Utilities Area
Dry Bulk Handling
RMZ-DR Crude Pipeline Construction & mech completion
RMZ Vcrude storage tanks construction & mech completion
Roads
Haul Road construction (1,2)
Main Highway (NR 32)
Section 4 Road (Duqm Refinery South Road)
(Roads by SEZAD)
Construction of construction camps. Schedule not currently available.
Construction camp operation

APPENDIX B-4

APPENDIX 5.4: REFINERY NOISE MODELLING REPORT

مصفاة الدقم
DUQM REFINERY

amec foster wheeler

AMEC FOSTER WHEELER REPORT

NOISE ASSESSMENT REPORT

DRP001-FED-RPT-M-000-001
5660-8440-RP-000-004

REV D2

Contract No:	1-14-5651/99	**DRPIC Contract No**	DRPIC-0106932-0000001DB-6609836
Client's Name:	Duqm Refinery & Petrochemical Industries Company LLC		
Project Title:	Duqm Refinery Project		
Project Location:	Duqm, Oman	**REV Status:**	IFF
Document Category	Class 1		

REVISION	**O1**	**Signature**	**D1**	**Signature**	**D2**	**Signature**
DATE	06 FEB 15		21 MAY 15		24 JULY 15	
ORIG. BY	R HACK	RH	R HACK	RH	R HACK	
APP BY	M WATKINS	MAW	M WATKINS	MAW	M WATKINS	

CONTENTS

1. SCOPE

This noise report has been prepared for the DUQM Refinery Project in Duqm, Sultanate of Oman. The objective of the noise calculation is to assess the noise impact at the site boundary and within the plant units.

This includes a calculation of work area and boundary noise levels to check whether the limits are exceeded. Community noise impact has also been considered.

2. DEFINITIONS AND ABBREVIATIONS

The following are used in this report.

Company	Duqm Refinery & Petrochemical Industries Company
FEED Engineer	The Entity Contracted by the Company to carry out Front End Design for the Refinery.
EPC Contractor	The Entity Contracted by the Company to carry out detail engineering, procurement, construction and commissioning of the Refinery.
Vendor	Supplier of equipment and support services for a particular piece of equipment/package.
MBD	Mechanical Basis of Design
EDB	Environmental Design Basis

3. REFERENCED CODES AND STANDARDS

3.1 International Standards and Regulations

Document Title	Document No.
Regulations for noise pollution control in working environment	MD 80/94
Noise pollution control in public environment	MD 79/94
Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation	ISO 9613-2:1996
Acoustics – Determination of sound power levels of noise sources using sound pressure	ISO 3744:1994

3.2 Project Documents

The following project documents have been referenced while preparing this report.

Document Title	Document No.
Mechanical Basis of Design (MBD)	DRP001-FED-SPE-M-000-001
Environmental Design Basis (EDB)	DRP001-FED-SPE-Z-000-001
Equipment Noise	DRP001-FED-SPE-M-000-007

4. NOISE LIMITS

Two distinct categories of noise limits are considered in this report:

- Work area noise limits.
- Community noise limits.

4.1 Work Area Noise Limits

4.1.1 Absolute Limit

As per reference document MD 80/94 the absolute maximum of 130dB shall apply to any location which personnel may visit.

4.1.2 Work Area Limit

The work area noise limit is 85dB(A) for all walkways, passages and accessible work and maintenance locations. Company review and approval is required for any deviations above the sound level limit.

4.2 Community Noise Limits

As per MD 79/94, the noise levels from the facility shall not cause an increase in the community noise levels to above the limits in the table below:

Type of District	Leq, T, dB(A)		
	Over time Period		
	A	B	C
Rural residential recreational	60	40	35
Suburban residential	65	45	40
Urban residential	65	50	45
Urban residential with some workshops or business; city hubs	65	55	50
Industrial/Commercial	70	70	70

Table 1: Community Noise

- Workdays Daytime (A) : 07:00 to 18:00
- Workdays Evening (B) : 18:00 to 23:00
- Holidays and Nights (C) : 23:00 to 07:00

5. CALCULATION METHOD AND INPUT DATA

All significant noise radiating plant equipment is allocated an octave band sound power level. These sound power levels were obtained from:-

- Calculations based on FEED Engineer algorithms derived from library noise data. The data source code in the Noise Allocation Table is ‘E’.
- Vendor’s supplied noise data estimated from similar equipment. The data source code in the Noise Allocation Table is ‘EM’.
- Vendor noise level submitted with quote. The data source code in the Noise Allocation Table is ‘Q’.

Currently no Vendor noise data is available in terms of sound pressure level at 1m from equipment.

As Vendor noise data is not available, the sound pressure level at 1m for equipment train has been calculated as per ISO 3744 using the relationship between sound power level, sound pressure level and estimated equipment dimensions derived from unit plot plans.

Proprietary software ‘SoundPlan’ version 7.2 was used to generate a noise contour map. The SoundPlan applies ISO 9613-2 industry standard to carry out noise calculations. Input data to the software comprised octave band sound power levels for each noise radiating item of equipment item and scaled plot plans.

5.1 Assumptions

- This report is for noise generated during normal plant operation only.
- Equipment items with <10kW rating are not considered as the noise level is assumed insignificant. Typical examples are pumps with <10kW rating.
- Control valve noise has not been included in the present revision of the report. The piping noise is not included as there is no significant source of piping noise in the new equipment.
- Only one pump in a pair is active at any time.
- All Driven equipment listed in attachments 8 to 24, are combined. The calculated SWL value is for the driven equipment and driver together.
- The applied spectral frequency band adjustments were derived from an in-house database for specific equipment types.
- The Air Fin Heat Exchanger noise is conservatively modelled using dimension from the unit plot plans due to lack equipment data.
- Equipment has been assumed to satisfy the 85dB(A) @ 1m limit.

6. CALCULATION SUMMARY

A Noise Allocation Table in given below and shows the sound power that has been calculated for each area as defined in the overall plot plan.

Unit Number	Octave band centre frequency (Hz)								dB	dB(A)	Source
	63	125	250	500	1000	2000	4000	8000			
Unit 640	124	125	126	127	124	119	112	106	133	128	E
Unit 730	106	106	106	106	106	104	102	100	114	111	E
Unit 700	101	101	101	101	101	99	97	95	109	106	E
Unit 570	110	110	110	110	110	108	106	104	118	115	E
Unit 710	108	108	108	108	108	106	104	102	116	113	E
Utilities Unit 400	110	111	111	112	110	106	103	100	118	115	E
Unit 340 T1/T2/T3	134	132	129	125	120	116	113	108	138	127	E
SWS_CSW Unit 330	123	121	118	114	112	108	104	101	126	117	E
ARU Unit 320	125	123	120	116	113	109	105	102	128	119	E
LTU Unit 170	110	110	110	110	110	108	106	104	118	115	E
DHT Unit 160	128	126	123	119	117	113	110	106	131	122	E
KTU Unit 150	104	104	104	104	104	104	102	98	112	110	E
Unit 136	121	119	116	113	110	107	103	101	124	116	E
CAR Unit 135	123	121	118	115	113	109	105	102	127	118	E
DCU Unit 130	130	128	125	123	120	116	111	107	133	125	E
HCU Unit 120	131	129	126	123	120	116	113	109	135	125	E
CDU Unit 100/105/110	126	124	122	118	116	112	109	106	130	121	E
TOTAL	**138**	**137**	**134**	**132**	**129**	**125**	**120**	**116**	**142**	**134**	

Table 2: Total Sound Power Level Octave band Calculation for all considered equipment

6.1 Receptor Locations

As an aid to the reporting of results, the following in-plant and boundary receptor locations (illustrated in Attachment 1), have been created;

- R1 to R8 (boundary line receptors)
- Main Administration Building
- Mosque
- Maintenance Centre
- Main Stores

- Chemical Store
- Main control Building

The Soundplan model will be specifically interrogated to identify the noise levels at these specific locations.

7. ANALYSIS

This noise study is required to assess “in-plant” and “community” noise within the refinery, so it is necessary to model each noise generating item of equipment individually, or clusters where relevant. This approach has the potential of yielding greater accuracy of plant noise distribution.

At this point in the project cycle the exact equipment locations and elevations are still subject to change. Therefore the equipment selected to be included in the model have been positioned manually on the overall site plot plan with locations corresponding approximately to the individual unit plot plans.

7.1 In-Plant Noise Distribution

Attachments 2 to 7 show the predicted noise contour plot within the plant area and site boundary.

Within the site, it can also be deduced that of the unit plot plans the work area limit of 85dB(A) has been broadly satisfied.

However a more in depth review of the noise contour plot, will highlight some noise hotspots, within units 340 (T1, T2 & T3), 120 and 160. These hotspots may in part be caused by the conservative equipment noise estimation methodology or a real effect caused by the close proximity of certain noise generating equipment.

Typical approaches to mitigating against the noise hotspots are;

- Imposing lower equipment noise limits on equipment in the locality of the hotspots.
- The use of actual vendor data can in certain circumstances eliminate noise hotspots.
- Additional acoustic treatment of some equipment may reduce or eliminate the noise hotspots.
- The imposition of noise exclusion zone, within which the wearing of hearing protection is mandatory. This approach will not eliminate the hotspot and requires client agreement.

7.2 In-plant Receptor Location Noise

Based on the equipment noise data in allocation tables listed attachments 8 to 24, the following noise values have been derived from the Soundplan model for the specially created in-plant receptor locations. Buildings within the plant boundary are classed as Industrial/Commercial, and the noise limit defined in Table 3 are applicable.

Receiver	Calculated Noise	Noise Limit
	dB(A)	
Main control building	67.2	70
Main store	61.3	70
Maintenance Store	60.2	70
Mosque	58.9	70
Administration building	53.9	70
Chemical Store	64.9	70

Table 3: Sound Pressure Level at selected in-plant receptor locations (Att 1)

7.3 Site Boundary Receptor Location Noise

Based on the equipment noise data in allocation tables listed attachments 8 to 24, the following noise values have been derived from the Soundplan model for the specially created site boundary receptor locations.

Receiver	Calculated Noise
	dB(A)
FENCE_R1	50.2
FENCE_R2	46.6
FENCE_R3	43.0
FENCE_R4	46.6
FENCE_R5	49.4
FENCE_R6	61.1
FENCE_R7	52.0
FENCE_R8	59.0

Table 4: Sound Pressure Level at selected at site boundary receptor locations (Att 1)

It can be deduced that the sound pressure level predicted at the site boundary does not exceed the 70dB(A) limit as summarised in Table 1.

8. CONCLUSIONS

Following conclusions can be drawn from this noise report:-

- The site boundary noise limit of 70dB(A) as defined in MD 79/94 is predicted not to be exceeded.
- The work area noise limit of 85dB(A) is broadly satisfied.
- A number of noise hotspots exceeding the 85dB(A) limit have been identified. Equipment vendor noise data can be incorporated into subsequent revisions of this assessment in the FEED stage once the process and plot plans have been finalised. Should the noise hotspots remain; additional measures as described in section 7.1 can be implemented to mitigate against the noise hotspots.
- The noise at buildings within the site boundary are below the noise limit, defined in table 1.
- The in-plant points of interest including the site mosque, main administration building, main control building and stores range from 53 up to 68dB(A).
- The above described analysis should be revisited once the unit and overall plot plans have been finalised and equipment vendor noise data becomes available by the EPC Contractor.

9. RECOMMENDATIONS

This assessment is based on equipment items achieving 85dB(A) in the work area or at 1m from equipment surfaces. Further noise control work will be required during the EPC phase that will include but not limited to the following.

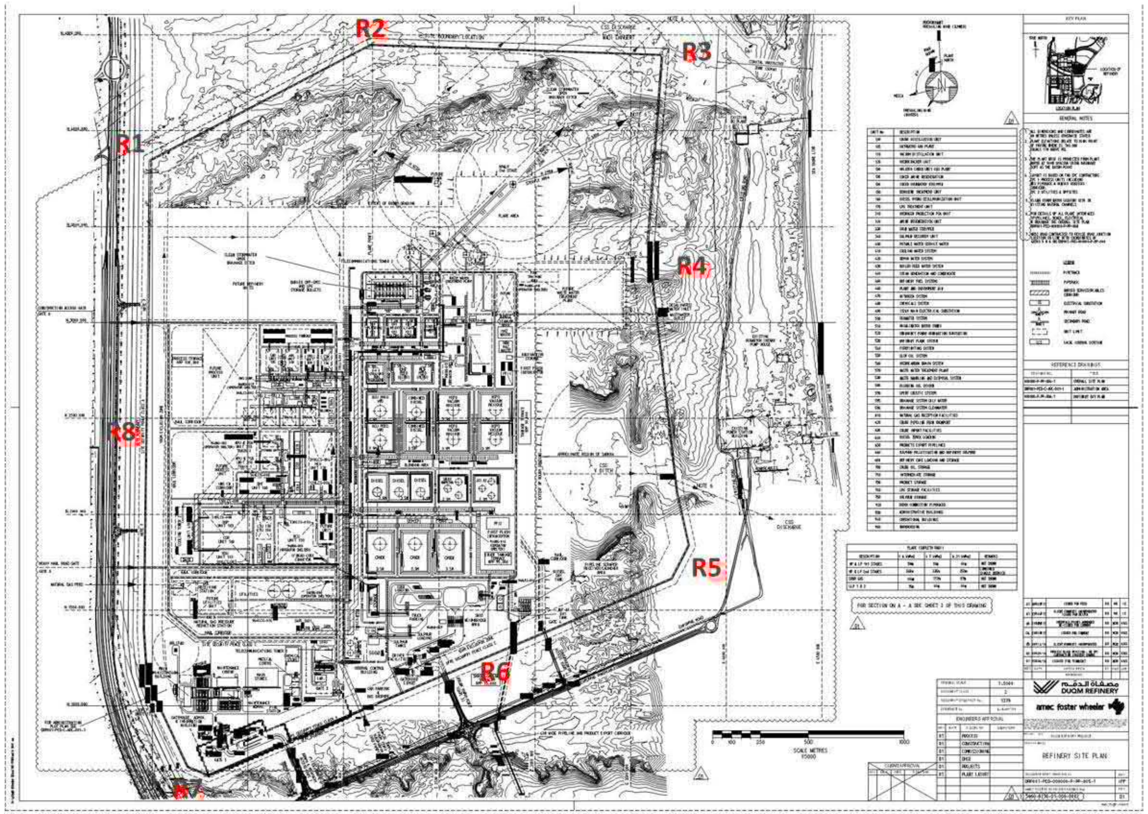
- Carry out initial noise survey of plant areas where new noise radiating equipment will be located to obtain background noise levels (This will be considered a fixed condition).
- Agree noise standards to be applied to the project with the Company or representative.
- Obtain equipment noise levels (octave band) from equipment suppliers.
- Provide a Noise Allocation Table for noise radiating equipment and update throughout the project with manufacturer's noise data.
- Construct noise contour maps and update during EPC phase.
- Provide plot limits for restricted areas if this approach is agreed by Company.
- Specify noise control mitigation measures.
- Identify equipment items that require a full load noise test during Factory Acceptance Tests and arrange tests.

- Repeat the noise survey following plant start-up.
- Take corrective action where the survey identifies locations where agreed noise limits have been exceeded.

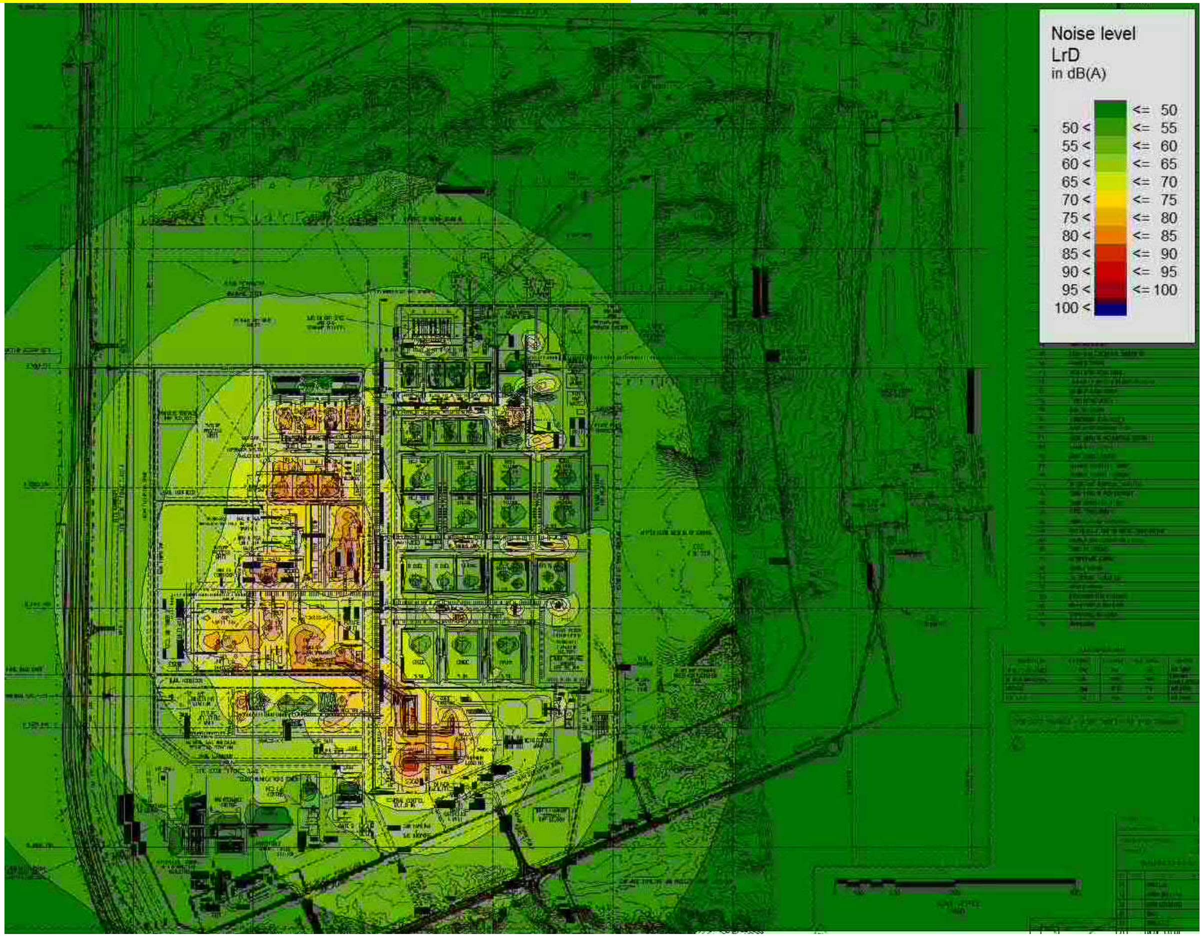
10. REFERENCE

Unit plot plan CDU 100 VDU 110 SGP 105	DRP001-FED-100000-P-PP-001-1, rev IFF
Plot plan Unit 120 - HCU	DRP001-CLG-120000-P-PP-001-1, rev IFF
Unit plot plan CAR 135	DRP001-FED-135000-P-PP-001-1,rev IFF
Plot plant Unit 150 unit 170	DRP001-UOP-150000-P-PP-002-1, rev IFF
Unit plot plan ARU 320	DRP001-FED-320000-P-PP-001-1, rev IFF
Plot plan Unit 160- DHT	DRP001-FED-160000-P-PP-001-1, rev IFF
Refinery Site Plan	DRP001-FED-000000-P-PP-005-1, rev IFF
Plot plan Unit SWS 330 Sheet 2	DRP001-FED-330000-P-PP-001-2, rev IFF
Plot plan Unit SWS 330 Sheet 1	DRP001-FED-330000-P-PP-001-1, rev IFF
Plot plan Unit CSW 136	DRP001-FED-136000-P-PP-001-1, rev IFF
Plot plan Unit 710 Intermediate Tankage	DRP001-FED-710000-P-PP-001-1, rev IFF
Plot plan Unit 740 LPG Storage, LPG Refrigeration & BOG Compression	DRP001-FED-740000-P-PP-001-1, rev IFF
Waste Water Treatment Plant plot plan Unit 570 sheet 2	DRP001-FED-570000-P-PP-001-1, rev IFF
Waste Water Treatment Plant plot plan Unit 570 sheet 2	DRP001-FED-570000-P-PP-001-2, rev IFF
Plot plan Unit 730 Product Tankage	DRP001-FED-730000-P-PP-001-1, rev IFF
Plot plan unit 700 Crude Oil Storage	DRP001-FED-700000-P-PP-001-1, rev IFF
Sulphur Recovery Unit 340 plot plan	DRP001-FED-340000-PP-P-001-2, rev IFF
Plot plan Unit 130 Delayed Coker	DRP001-FWH-130000-P-PP-001-1, rev IFF
Solids Export plot plan	DRP001-FED-000000-P-PP-007-1, rev IFF
Overall Utility Plot Plan	DRP001-FED-000000-P-PP-004-1, rev IFF

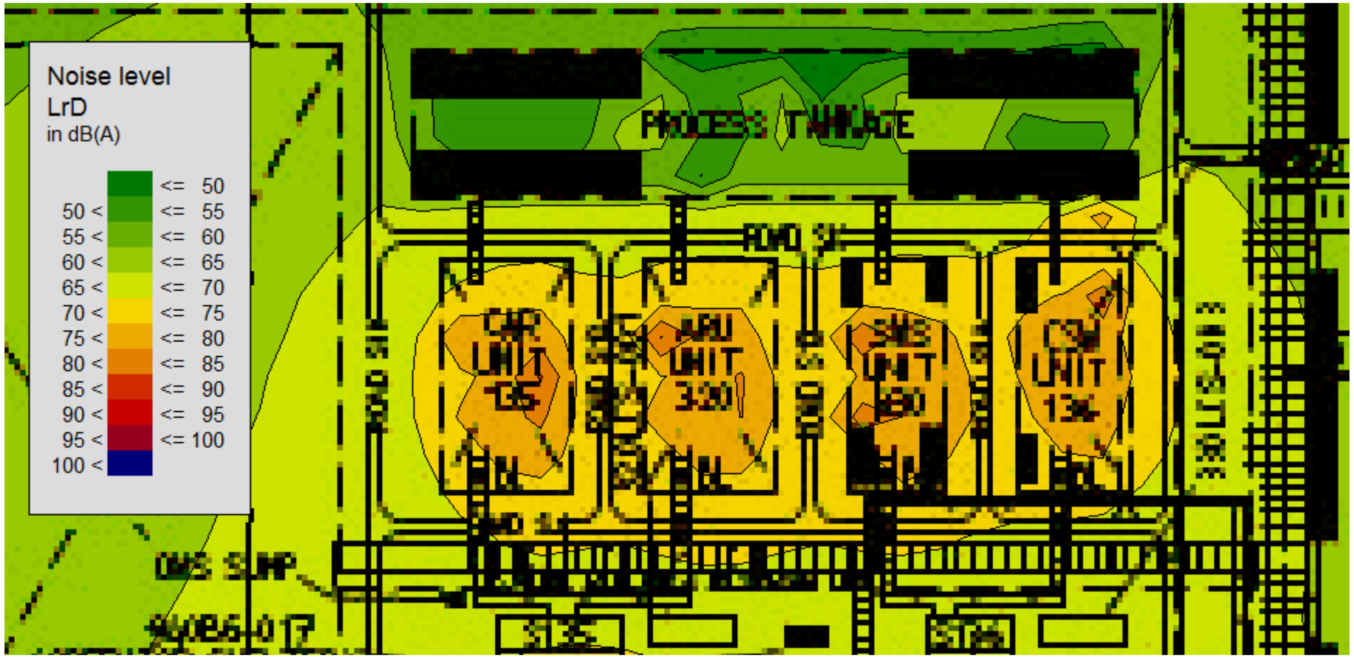
ATTACHMENT 1 RECEPTOR LOCATIONS



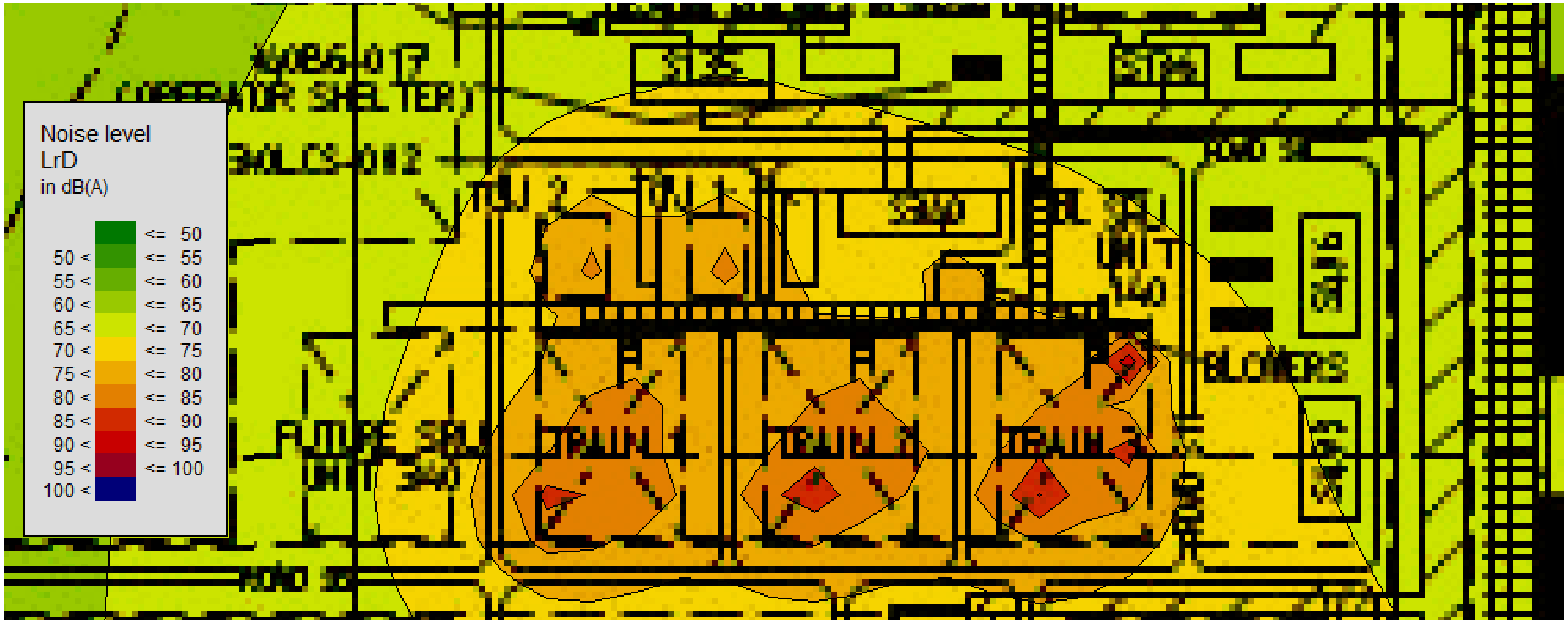
ATTACHMENT 2 DUQM REFINERY SITE NOISE DISTRIBUTION



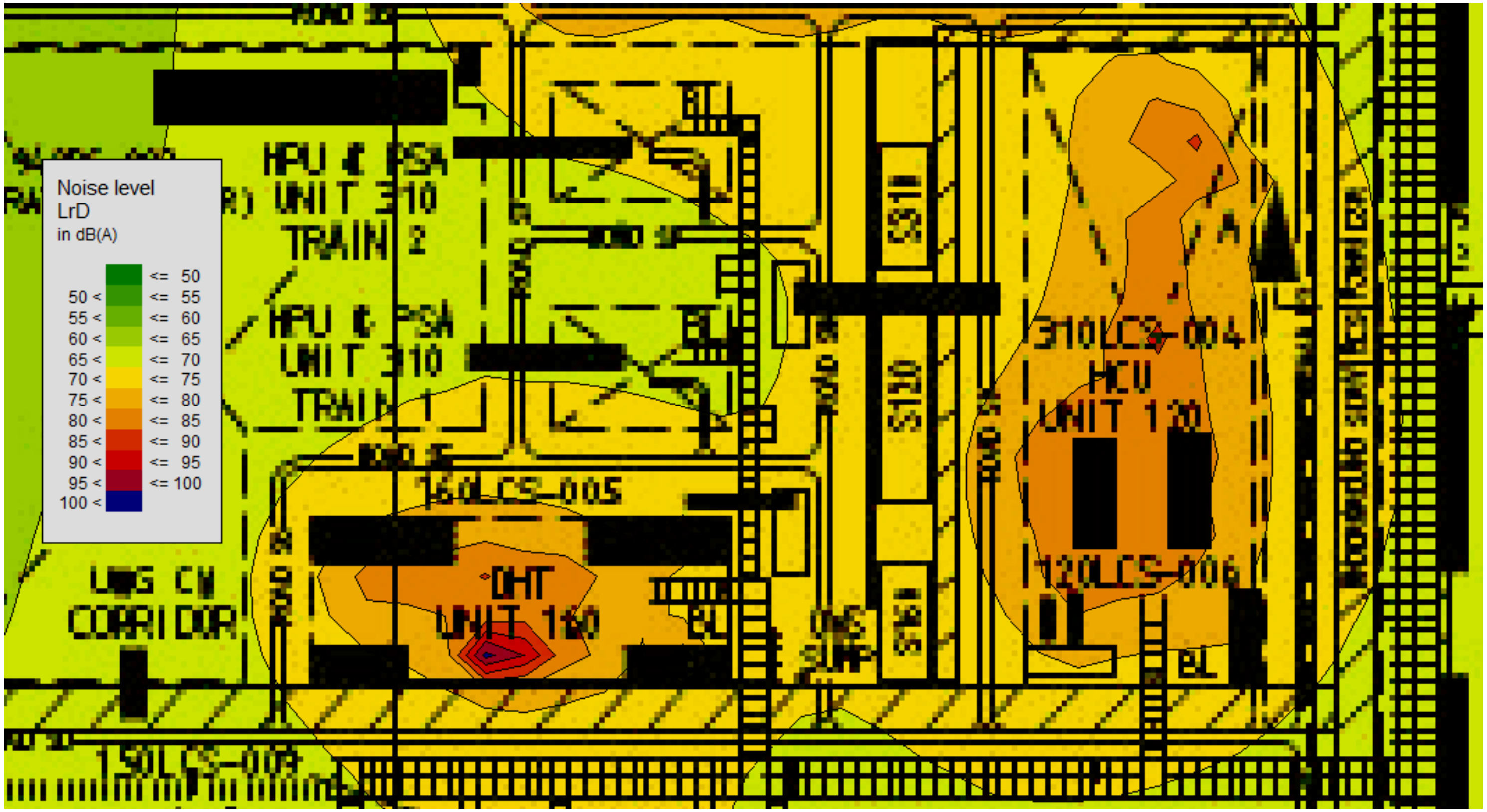
ATTACHMENT 3 NOISE DISTRIBUTION – UNIT 135/320/330/136



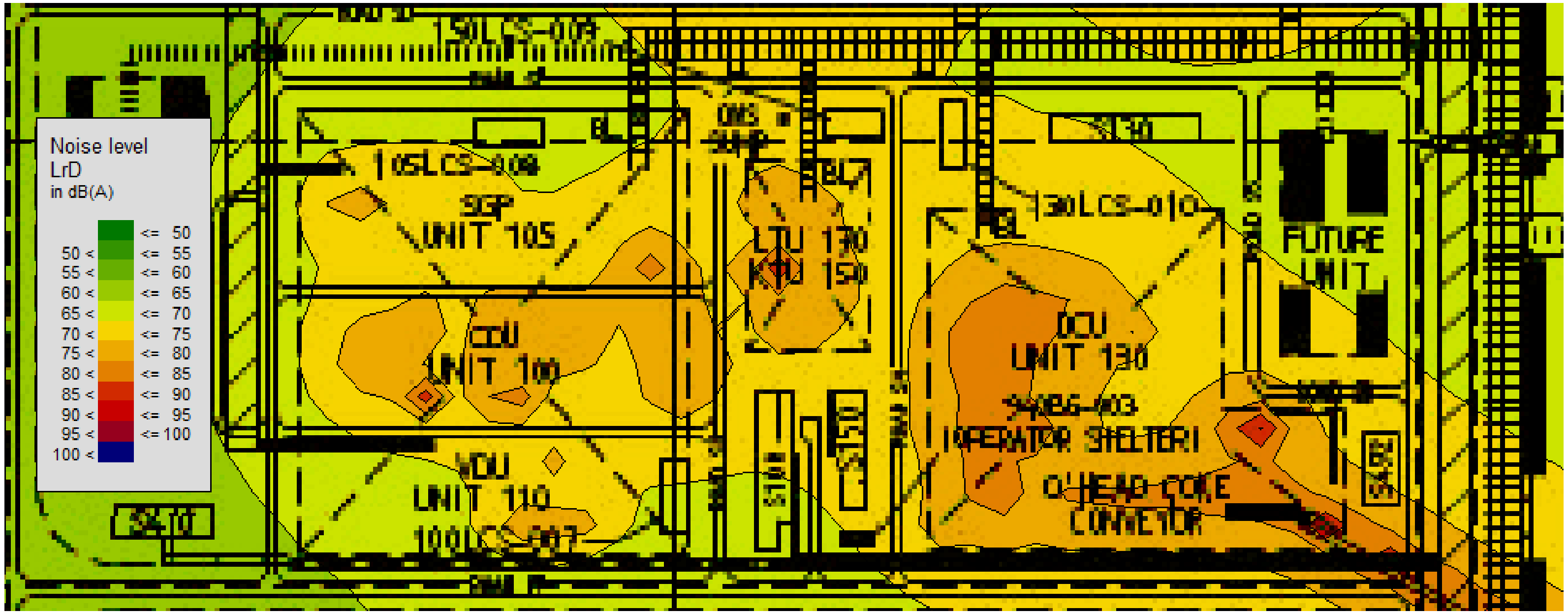
ATTACHMENT 4 NOISE DISTRIBUTION – UNIT 340 TRAIN 1/2/3



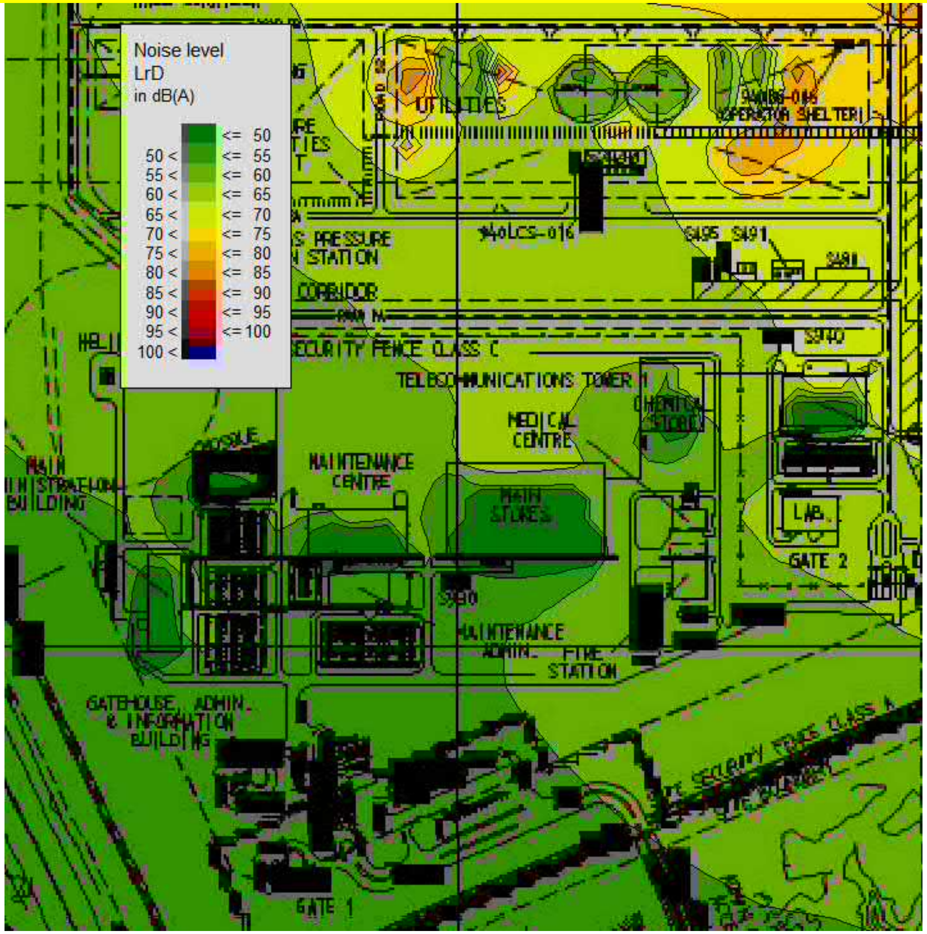
ATTACHMENT 5 NOISE DISTRIBUTION – UNIT 160/120/340 TRAIN 1 / 2



ATTACHMENT 6 NOISE DISTRIBUTION – UNIT 105/100/110/170/150/130



ATTACHMENT 7 NOISE DISTRIBUTION – UTILITIES/LOADING/OFFICE/MAINTENANCE AREAS



ATTACHMENT 8 EQUIPMENT NOISE BREAKDOWN FOR UNIT 100/105/110 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
100P-001A/B	Desalter Water Make-Up Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-002A/B	Desalter Water Circulation Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-003A/B/C	Flashed Crude Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
100P-004A/B/C	Top Pump Around Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
100P-005A/B/C	Kerosene Pump Around Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
100P-006A/B	LAGO Pump Around Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-007A/B	HAGO Pump Around Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-008A/B/C	Kerosene Product Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
100P-009A/B	LAGO Product Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-010A/B	HAGO Product Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-011A/B/C	Atmospheric Residue Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
100P-012A/B	CDU Sour Water Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-013A/B	CDU Overhead Liquids Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100P-050	CDU/VDU Closed Blowdown Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
110P-001A/B	LVGO Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
110P-002A/B	MVGO Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E

110P-003A/B	HVGO Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
110P-004A/B	Recycle Oil Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
110P-005A/B/C	Vacuum Residue Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
110P-007A/B	VDU Sour Water Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
100K-001	CDU Offgas Compressor Package	3 Stage Centrifugal Compressor	n/a	103	102	101	101	102	104	104	97	112	110	E
100AE-001	Crude Column Overhead Condenser	Air Fan Cooler	n/a	121	119	116	112	109	104	98	92	124	114	E
100AE-002	SR Diesel Product Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E
100AE-003	Offspec HAGO Cooler	Air Fan Cooler	n/a	115	113	110	106	103	98	92	86	118	108	E
100AE-004	Top Pumparound Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
105AE-001	Naphtha Air Cooler	Air Fan Cooler	n/a	115	113	110	106	103	98	92	86	118	108	E
105AE-002	Naphtha Stabiliser Air Condenser	Air Fan Cooler	n/a	117	115	112	108	105	100	94	88	120	110	E
105AE-051	Flash Steam Air Condenser	Air Fan Cooler	n/a	113	111	108	104	101	96	90	84	117	107	E
110AE-001	VGO Product Cooler	Air Fan Cooler	n/a	119	117	114	110	107	102	96	90	122	112	E

ATTACHMENT 9 EQUIPMENT NOISE BREAKDOWN FOR UNIT 120 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								**dB**	**dB(A)**	**Source**
Equipment No.	Equipment Description	Equipment Type	Comments	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**			
120P-001A/B	1st Stage Reactor Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-002A/B	2nd Stage Reactor Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-003A/B	Injection Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-004A/B	HP Lean Amine Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-005A/B	LP Lean Amine Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-006A/B	Product Stripper Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-008A/B/C	Product Stripper Bottoms Pump	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
120P-009A/B	Fractionator Overhead Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-010A/B	Fractionator Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-011A/B	Whole Naphtha Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-012A/B	Kerosene Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-013A/B/C	Light Diesel Pumparound Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
120P-014A/B	Light Diesel Stripper Bottoms Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-015A/B/C	Heavy Diesel Pumparound Pump	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
120P-016A/B	Heavy Diesel Stripper Bottoms Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-017A/B/C	Fractionator Bottoms Pump	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
120P-018A/B	Deethanizer Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E

120P-019A/B	Sponge Oil Absorber Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-020A/B	Sponge Oil Absorber Bottoms Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-021A/B	Diesel Sponge Oil Absorber Bottoms Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-022A/B	Naphtha Stabilizer Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-023A/B	Naphtha Stabilizer Bottoms Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-024A/B	Heavy Diesel Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-025A/B	Slop Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-026A/B	Hot Well Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-027A/B	Backwash Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-028	LP Injection Water Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
120P-029A/B	Rich Amine Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-030	Water Washer Feed Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
120P-031A/B	LPG Settler Water Circulation Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-032A/B	Deaerated Water Booster Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-051A/B	HC Liquid LP Flare Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-052A/B	HC Liquid HP Flare Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-054A/B	HC Liquid HP Flare Pump	Assumed Centrifugal	1live/1spare	101	101	101	101	101	99	97	95	109	106	E
120P-055A/B	1st Stage Furnace HP BFW Circulation Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-056A/B	2nd Stage Furnace HP BFW Circulation Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
120P-057A/B	Fractionator Feed Furnace HP BFW Circulation Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E

120K-001	Recycle Gas Compressor	Assumed Multistage Centrifugal	n/a	101	100	99	99	100	102	102	95	110	108	E
120K-002A/B/C/D	Make-up Hydrogen Compressor (individual)	Assumed Multistage Centrifugal	3live/1spare	104	103	102	102	103	105	105	98	112	111	E
120AE-001A-H	1st Stage Reactor Effluent Air Cooler	Air Fan Cooler	n/a	122	120	117	113	110	105	99	93	126	116	E
120AE-002A-D	2nd Stage HHPS Vapor Air Cooler	Air Fan Cooler	n/a	120	118	115	111	108	103	97	91	123	113	E
120AE-003	HLPS Vapor Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
120AE-004	Product Stripper Overhead Condenser	Air Fan Cooler	n/a	118	116	113	109	106	101	95	89	121	111	E
120AE-005	Fractionator Overhead Condenser	Air Fan Cooler	n/a	124	122	119	115	112	107	101	95	127	117	E
120AE-006	Kerosene Product Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
120AE-007 A/B	Naphtha Stabilizer Condenser	Air Fan Cooler	n/a	118	116	113	109	106	101	95	89	121	111	E
120AE-008 A-M	Fractionator Bottoms Start-up Air Cooler	Air Fan Cooler	n/a	124	122	119	115	112	107	101	95	127	117	E
120AE-009	Naphtha Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
120AE-010	UCO Product Bleed Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
120AE-011	Heavy Diesel Vacuum Drier Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
120AE-012 A-C	Diesel Air Cooler	Air Fan Cooler	n/a	119	117	114	110	107	102	96	90	123	113	E
120AE-013 A-D	Backwash Oil Air Cooler	Air Fan Cooler	n/a	120	118	115	111	108	103	97	91	123	113	E

ATTACHMENT 10 EQUIPMENT NOISE BREAKDOWN FOR UNIT 130 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
130P-001A/B/C	Heater Charge Pumps	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
130P-002A/B	Unstabilized Naphtha Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-003A/B	Fractionator Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-004A/B	LCGO Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-005A/B	HCGO Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-006A/B	HCGO Pumparound Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-007A/B	Fractionator Sour Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-008	Cutting Pump and Decoking Equipment	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
130P-009A/B/C/D	Clear Water Pumps	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
130P-010A/B	Quench Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-011A/B/C	Blowdown Circulating Oil Pumps	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
130P-012A/B	Blowdown Sour Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-013A/B	Sponge Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-014A/B	Blowdown Slop Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-015	Fines Removal Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
130P-022A/B	Condensate Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E

130P-023A/B	Condensate Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-051A/B	Compressor Interstage Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-054A/B	Debutanizer Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-055A/B	Debutanizer Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-056A/B	Debutanizer Overhead Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-057A/B	Total Naphtha Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-060A/B	Compressor Liquid Suction Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130P-062A/B	Amine Booster Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
130K-051	Coker Gas Compressor	Assumed Multistage Centrifugal Compressors	n/a	102	101	100	100	101	103	103	96	110	109	E
130PK-004	Solid Sludge Handling Package		n/a	112	113	114	115	112	107	99	92	121	116	E
130U-071	Coke Handling System Package (ISBL)		n/a	108	109	110	111	108	103	95	88	117	113	E
130PK-051	Ammonium Polysulfide System Package		n/a	105	106	107	108	105	100	92	85	113	109	E
130PK-003	HCGO Product Filter Package		n/a	108	109	110	111	108	103	95	88	116	112	E
130AE-001	Fractionator Overhead Condenser		n/a	123	121	118	114	111	106	100	94	126	116	E
130AE-002	Blowdown Condenser		n/a	121	119	116	112	109	104	98	92	125	115	E
130AE-003	Blowdown Circulation Oil Cooler		n/a	116	114	111	107	104	99	93	87	119	109	E
130AE-004	HCGO Product Cooler		n/a	119	117	114	110	107	102	96	90	122	112	E
130AE-005	LCGO Product Cooler		n/a	117	115	112	108	105	100	94	88	120	110	E
130AE-006	Condensate Cooler		n/a	116	114	111	107	104	99	93	87	119	109	E

130AE-007	Atmospheric Steam Condenser		n/a	116	114	111	107	104	99	93	87	119	109	E
130AE-008	Spalling Cooler		n/a	116	114	111	107	104	99	93	87	119	109	E
130AE-051	Compressor Interstage Cooler		n/a	119	117	114	110	107	102	96	90	122	112	E
130AE-052	Absorber Stripper Feed Condenser		n/a	119	117	114	110	107	102	96	90	122	112	E
130AE-053	Total Naphtha Cooler		n/a	116	114	111	107	104	99	93	87	119	109	E
130AE-054	Lean Sponge Oil Cooler		n/a	116	114	111	107	104	99	93	87	119	109	E

ATTACHMENT 11 EQUIPMENT NOISE BREAKDOWN FOR UNIT 135 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
135P-001A/B	Rich Amine Pump	Centrifugal Pump	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
135P-002A/B	Amine Filter Pump	Centrifugal Pump	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
135P-004	Wash Water Injection Pump	Centrifugal Pump	n/a	96	96	96	96	96	94	92	90	104	101	E
135P-101A/B	Lean Amine Pump	Centrifugal Pump	1live/1spare	102	102	102	102	102	100	98	96	110	107	E
135P-201A/B	Lean Amine Pump	Centrifugal Pump	1live/1spare	102	102	102	102	102	100	98	96	110	107	E
135P-202A/B	Regenerator Reflux Pump	Centrifugal Pump	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
135AE-001	Lean Amine Cooler	Air Fan Cooler	n/a	121	119	116	112	109	104	98	92	124	114	E
135AE-101	Regenerator OVHD Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
135AE-201	Regenerator OVHD Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E

ATTACHMENT 12 EQUIPMENT NOISE BREAKDOWN FOR UNIT 136 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
136P-001A/B	Sour Water Transfer Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
136P-002A/B	Sour Water Tank Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
136P-101A/B	Stripper Pump Around Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
136P-102A/B	Stripped Water Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
136P-201A/B	Stripper Pump Around Pump	Assumed Centrifugal	1live/1spare	98	98	98	98	98	96	94	92	106	103	E
136P-202A/B	Stripped Water Pump	Assumed Centrifugal	1live/1spare	99	99	99	99	99	97	95	93	107	104	E
136AE-001	Stripped Water Bottoms Cooler	Air Fan Cooler	n/a	117	115	112	108	105	100	94	88	121	111	E
136AE-101	Stripper Overhead Condenser	Air Fan Cooler	n/a	115	113	110	106	103	98	92	86	119	109	E
136AE-201	Stripper Overhead Condenser	Air Fan Cooler	n/a	115	113	110	106	103	98	92	86	119	109	E

ATTACHMENT 13 EQUIPMENT NOISE BREAKDOWN FOR UNIT 150 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
150P-003A/B	Circulation Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
150P-005	Water Addition Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
150P-007A/B	Caustic Addition Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
150P-008A/B	High Pressure Flare Knockout Drum Slops Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
150P-009A/B	Low Pressure Flare Knockout Drum Slops Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
150DS-001	Desuperheater		n/a	69	75	81	87	93	97	93	87	100	101	E
150K-001A/B	Air Compressor System	Assumed Multistage Centrifugal Compressors	1live/1spare	96	95	94	94	95	97	97	90	104	102	E

ATTACHMENT 14 EQUIPMENT NOISE BREAKDOWN FOR UNIT 160 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
160P-001 A/B	Unfiltered DHT Reactor Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-002 A/B	DHT Reactor Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-003 A/B	Coker Naphtha Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-004 A/B	Diesel Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-005 A/B	Fractionator Reboiler Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-006 A/B	Fractionator Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-007 A/B	Unstabilized Naphtha Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-008 A/B	Naphtha Stabilized Reflux Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-009 A/B	Stabilized Naphtha Product Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-010 A/B	Interstage Naphtha Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-011 A/B	Compressor Interstage KO Drum Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-012 A/B	Offgas Compressor Suction Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-013 A/B	Backwash Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-014 A/B	LP Lean Amine Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-015 A/B	HP Lean Amine Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-016 A/B	Injection Water Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-051 A/B	HC Liquid LP Flare Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E

160P-052 A/B	HC Liquid HP Flare Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160P-053 A/B	ATM Condensate Return Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
160K-001	Recycle Gas Compressor	Assumed Multistage Centrifugal	n/a	101	100	99	99	100	102	102	95	110	108	E
160K-002 A/B	Offgas Compressor	Assumed Multistage Centrifugal	n/a	101	100	99	99	100	102	102	95	110	108	E
160AE-001	Reactor Effluent Air Cooler	Air Fan Cooler	n/a	121	119	116	112	109	104	98	92	125	115	E
160AE-002	HLPS Vapor Air Cooler	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	119	109	E
160AE-003	Fractionator Overhead Air Cooler	Air Fan Cooler	n/a	123	121	118	114	111	106	100	94	126	116	E
160AE-004	Diesel Product Air Cooler	Air Fan Cooler	n/a	118	116	113	109	106	101	95	89	121	111	E
160AE-005	Stabilized Naphtha Product Air Cooler	Air Fan Cooler	n/a	119	117	114	110	107	102	96	90	123	113	E
160AE-006	Backwash Oil Air Cooler	Air Fan Cooler	n/a	118	116	113	109	106	101	95	89	121	111	E

ATTACHMENT 15 EQUIPMENT NOISE BREAKDOWN FOR UNIT 170 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
170P-101A/B	Caustic Prewash Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-102A/B	Spent Solvent Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-103A/B	Caustic Injection Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-104	Water-Caustic Addition Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-105A/B	COS Solvent Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-106A/B	Product Recycle Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-107	MEA Makeup Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-108	COS Solvent Makeup Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-109A/B	Merox WS Injection Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-110A/B	Caustic Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-111A/B	Wash Oil Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-112A/B	Disulfide Oil Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-113A/B	Vent Tank Drain Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-201A/B	Caustic Prewash Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-202A/B	Spent Solvent Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-203A/B	Caustic Injection Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-204	Water-Caustic Addition Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E

170P-205A/B	COS Solvent Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-206A/B	Product Recycle Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-207	MEA Makeup Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-208	COS Solvent Makeup Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-209A/B	Merox WS Injection Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-210A/B	Caustic Circulation Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-211A/B	Wash Oil Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-212A/B	Disulfide Oil Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
170P-213A/B	Vent Tank Drain Pump	Assumed centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E

ATTACHMENT 16 EQUIPMENT NOISE BREAKDOWN FOR UNIT 320 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
320P-001A/B	Rich Amine Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
320P-002A/B	Amine Filter Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
320P-008A/B	Condensate Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
320P-101A/B	Lean Amine Pump	Assumed Centrifugal	n/a	100	100	100	100	100	98	96	94	108	105	E
320P-201A/B	Lean Amine Pump	Assumed Centrifugal	n/a	100	100	100	100	100	98	96	94	108	105	E
320P-202A/B	Regenerator Reflux Pump	Assumed Centrifugal	n/a	100	100	100	100	100	98	96	94	108	105	E
320AE-001	Lean Amine Cooler	Air Fan Cooler	n/a	122	120	117	113	110	105	99	93	125	115	E
320AE-002	Condensate Drum Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E
320AE-101	Regenerator OVHD Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E
320AE-201	Regenerator OVHD Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E

ATTACHMENT 17 EQUIPMENT NOISE BREAKDOWN FOR UNIT 330 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
330P-001A/B	Sour Water Transfer Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
330P-005	Cold Condensate Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
330P-101A/B	Stripper Reflux Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
330P-102A/B	Stripped Water Pump	Assumed Centrifugal	n/a	99	99	99	99	99	97	95	93	107	104	E
330P-201A/B	Stripper Reflux Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
330P-202A/B	Stripped Water Pump	Assumed Centrifugal	n/a	100	100	100	100	100	98	96	94	108	105	E
330AE-001	Stripped Water Bottoms Cooler	Air Fan Cooler	n/a	118	116	113	109	106	101	95	89	121	111	E
330AE-002	Condensate Drum Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E
330AE-101	Stripper Overhead Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E
330AE-201	Stripper Overhead Condenser	Air Fan Cooler	n/a	116	114	111	107	104	99	93	87	120	110	E

ATTACHMENT 18 EQUIPMENT NOISE BREAKDOWN FOR UNIT 340 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
340P-105/205/305A/B	Contact Condenser Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-106/206/306A/B	Desuperheater Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-107/207/307A/B	Rich Amine Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-108/208A/B	Lean Amine Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-111/211/311A/B	Condensate Return Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-113/213/313A/B	LP Blowdown Drum Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340P-114/214/314A/B	Sulphur Transfer Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
340K-001A/B/C/D	Combustion Air Blowers		n/a	96	95	94	94	95	97	97	90	104	103	E
340K-102A/B/C	Incinerator Combustion Air Blowers		n/a	98	97	96	96	97	99	99	92	107	105	E
340K-202A/B/C	Incinerator Combustion Air Blowers		n/a	98	97	96	96	97	99	99	92	107	105	E
340K-302A/B/C	Incinerator Combustion Air Blowers		n/a	98	97	96	96	97	99	99	92	107	105	E
340AE-	Waste Steam Condenser		n/a	116	114	111	107	104	99	93	87	120	110	E

101/201/301														
340AE-102/202/302	Contact Condenser Cooler		n/a	116	114	111	107	104	99	93	87	120	110	E
340AE-103/203AB	Lean Amine Cooler		n/a	116	114	111	107	104	99	93	87	120	110	E
340AE-104/204	Regenerator Overhead Condenser		n/a	116	114	111	107	104	99	93	87	120	110	E
340AE-105/205/305	Flash Steam Condenser		n/a	116	114	111	107	104	99	93	87	120	110	E
340AE-106/206/306	Blowdown Flash Steam Condenser		n/a	116	114	111	107	104	99	93	87	120	110	E
340AE-107/207/307	Blowdown Cooler		n/a	116	114	111	107	104	99	93	87	120	110	E
340BR-101/201/301	Main Burner		n/a	90	96	100	99	95	90	85	80	105	101	E
340BR-102/202/302	Incinerator Burner		n/a	90	96	100	99	95	90	85	80	105	101	E
340F-101/201/301	Reaction Furnace		n/a	125	119	114	109	105	102	99	92	126	112	E
340F-102/202/302	Incinerator		n/a	95	102	101	99	95	90	85	80	107	101	E
340J-101/201/301	Pit Vent Ejector		n/a	68	74	80	86	92	96	92	86	100	100	E
340J-102/202/302	Tail Gas Start-Up Ejector		n/a	68	74	80	86	92	96	92	86	100	100	E
340SK-101/201/301	Stack		n/a	125	125	121	118	106	98	93	92	130	118	E

ATTACHMENT 19 EQUIPMENT NOISE BREAKDOWN FOR UNIT 400 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
400P-001A/B	Potable Water Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
400P-002A/B	Service Water Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
420P-001A/B/C	Demineralised Water Pumps	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
510P-001A/B/C	Desalinated Water Pumps	Assumed Centrifugal	2live/1spare	97	97	97	97	97	95	93	91	105	102	E
480P-001A/B	Caustic Solution Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
480P-002A/B	Caustic Tanker Offloading Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
480P-003	Caustic Drain Pump	Assumed Centrifugal	n/a	96	96	96	96	96	94	92	90	104	101	E
460K-001A/B	HP Instrument Air Compressors	Assumed Multistage Centrifugal	1live/1spare	96	95	94	94	95	97	97	90	104	102	E
510PK-001	RO Desalination Package		n/a	106	107	108	109	106	101	93	86	114	110	E
510PK-002	UV Disinfection Package		n/a	104	105	106	107	104	99	91	84	112	108	E

ATTACHMENT 20 EQUIPMENT NOISE BREAKDOWN FOR UNIT 710 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
710P-001A/B	Kerosene Transfer Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-002A/B	Combined Diesel Transfer Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-003A/B	LCGO Transfer Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-005A/B/C	VGO Transfer Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
710P-006A/B	VGO Circulation Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-007A/B	HCGO Storage Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-008A/B	HCGO Circulation Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
710P-009A/B/C	VR Storage Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
710P-010A/B/C	HSFO Storage Pump	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
710P-011A/B/C/D	VR/HSFO Circulation Pump	Assumed Centrifugal	n/a	99	99	99	99	99	97	95	93	107	104	E

ATTACHMENT 21 EQUIPMENT NOISE BREAKDOWN FOR UNIT 570 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
570P-001A/B/C	API De-Oiled Water Pump	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E
570P-004A/B/C/D	Balance Tank Mixing Pump	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
570P-005A/B	Off-Spec Sour Water Discharge Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-006A/B	Desalter Slops Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-007A/B/C/D	Equalisation Mixing Pump	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
570P-008A/B	Equalisation Discharge Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-009A/B	Off-Spec Equalisation Mixing Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-010A/B	Off-Spec Equalisation Discharge Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-012A/B	Slop Oil Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-013A/B	Oil Sludge Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-014A/B	Oily Area Drainage Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-019A/B	Sand Filter Feed Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-020A/B	Acid Transfer Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-021A/B	Reuse Water Distribution Pump	Assumed Centrifugal	1live/1spare	97	97	97	97	97	95	93	91	105	102	E
570P-022A/B/C	Thickener Supernatant Pump	Assumed Centrifugal	2live/1spare	98	98	98	98	98	96	94	92	106	103	E

590P-001AB/C/D	Spent Sulphidic Caustic Discharge Pump	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E

ATTACHMENT 22 EQUIPMENT NOISE BREAKDOWN FOR UNIT 700 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
700P-001A/B/C/D/E/F	Crude Charge Pumps	Assumed Centrifugal	5live/1spare	101	101	101	101	101	99	97	95	109	106	E

ATTACHMENT 23 EQUIPMENT NOISE BREAKDOWN FOR UNIT 730 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
730P-001A/B/C/D	Naphtha Product Export Pumps	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
730P-002A/B/C/D	Jet A-1 Product Export Pumps	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
730P-003A/B/C/D	Diesel Product Export Pumps	Assumed Centrifugal	3live/1spare	99	99	99	99	99	97	95	93	107	104	E
730P-004	Tankage Area Blowdown Pump	Assumed Centrifugal		99	99	99	99	99	97	95	93	107	104	E
730P-015A/B	Diesel Truck Loading Transfer Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E
730P-016A/B	Jet A-1 Truck Loading Transfer Pumps	Assumed Centrifugal	1live/1spare	96	96	96	96	96	94	92	90	104	101	E

ATTACHMENT 24 EQUIPMENT NOISE BREAKDOWN FOR UNIT 640 PLOT PLAN

				Sound Power Level										
				Octave band centre frequency (Hz)								dB	dB(A)	Source
Equipment No.	Equipment Description	Equipment Type	Comments	63	125	250	500	1000	2000	4000	8000			
640P-003	Truck Loading Closed Drain Drum Pump	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
640P-001A/B	Diesel Loading Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
640P-002A/B	Jet A-1 Loading Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-001A/B	SR Light Slops Storage Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-002A/B	Cracked Light Slops Storage Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-003A/B	SR Heavy Slops Storage Transfer Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-004A/B	Cracked Heavy Slops Storage Transfer Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-005A/B	SR Heavy Slops Pump Around Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
550P-006A/B	Cracked Heavy Slops Circulation Pumps	Assumed Centrifugal	n/a	97	97	97	97	97	95	93	91	105	102	E
585P-001A/B/C	Flushing Oil Pumps	Assumed Centrifugal	n/a	98	98	98	98	98	96	94	92	106	103	E
660PK-001ABC	Sulphur Granulation	Package	n/a	117	118	119	120	117	112	104	97	126	122	E

660PK-002	Sulphur Conveyer	Conveyer	285m long approx	117	118	119	120	117	112	104	97	125	121	E
680PK-001	Coke Transfer Conveyer	Conveyer	600m long approx	120	121	122	123	120	115	107	100	128	124	E
680PK-003	Coke Loading Conveyer	Conveyer	285m long approx	117	118	119	120	117	112	104	97	125	121	E

Appendix C

APPENDICES FOR SECTION 6 – LANDSCAPE & VISUAL

APPENDIX C-1

APPENDIX 6.1: BASELINE LANDSCAPE AND VISUAL REPORT

REPORT N^{O} 70029220-02-C-BASE/VL

LANDSCAPE & VISUAL CONTEXT

DUQM REFINERY, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

FOR DRPIC ONLY: CONFIDENTIAL

JULY 2017

wsp

LANDSCAPE & VISUAL CONTEXT

DUQM REFINERY, OMAN

Duqm Refinery & Petrochemical Industries Company

Confidential

Project no: 70029220
Date: July 2017

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1 INTRODUCTION

1.1 INTRODUCTION

This report provides a description and evaluation of the existing landscape resource and the visual receptors within the vicinity of the Duqm Refinery Project (the "Project"). It includes a review of relevant documents, desk-based and field survey observations to assess baseline landscape character and views.

> '*Landscape is an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors*.' (Council of Europe, 2000).

In terms of the above definition, this may include areas of special value as well as everyday landscapes. The landscape in the area of the Project has been described as 'inherently Omani' (Jurong Consultants EIA, 2011), comprising arid gravel plains, contained to the west by the Huqf escarpment and to the east by the Arabian Sea and the associated coastal landscape of dunes and cliffs.

Visual amenity is a separate but related consideration, reflecting the pleasantness of the view or outlook that people have of their surroundings and the overall composition and character of these views. Visual receptors may be residents, visitors or people in their workplace, such as fishermen.

1.1.1 Summary of Previous Baseline Work

Amongst the secondary sources of information used as part of the landscape work, the following reports were reviewed in preparation of this Report.

Table 1.1: Reviewed documents

NAME OF REPORT	AUTHOR/YEAR	RELEVANT INFORMATION
ESIA for the Proposed Duqm Integrated Power and Water Plant (DIPWIP)	ADP Consultant/BEYA Environmental Consultancy, 2016	Some geographical, climate and social context.
EIA for Service Corridor, Duqm – Environmental Baseline Report	HMR Consultants, 2015	Some detailed topographical information.
Duqm Refinery EIA Study Report, Appendix A – Environmental Baseline	HMR Consultants, 2015	Site observations about land use.
EIA for Duqm SWIP	HMR Consultants 2015	Description of local Wadi systems. Comparative study of changes in vegetation since commencement of development.

Name of Report	Author/Year	Relevant Information
Duqm Industrial and Free Zone Masterplan EIA	Jurong Consultants, 2011	Full landscape and visual assessment including classification of Landscape character areas and detailed assessment of landscape and visual baseline and value. Useful in describing typical coastal areas and landscape character including outside of the Special Economic Zone (SEZ) boundary.
Ras Markaz Crude Oil Park Project ESIA	Amec Foster Wheeler, 2015	Includes descriptions of geology, hydrology and ecology of study area, contributing to landscape characterisation.

In summary, information from the geology, ecology and land use sections of these reports contributes to an understanding of the landscape baseline. The communities' chapters set out a range of potential visual receptors, although there was a lack of consistency, perhaps due to the changeable nature of the local population. The investigations undertaken on socio-economic and health as part of the Consolidated Environmental and Social Impact Assessment (ESIA) work also contributed valuable insights into the character of the area, the potential receptors and observations that contributed to this landscape baseline. The Free Zone Masterplan EIA (Jurong, 2011) includes a full classification of local landscape types which we have adopted to apply to the study area of this Report.

1.2 SCOPE OF REPORT

This Report is part of the Consolidated ESIA scope of work that WSP is undertaking for DRPIC.

The intention of this Report is to set out the baseline conditions for landscape and visual receptors in order to be able to assess changes in the local environment caused by the development of the Project and how this would affect these receptors.

The study area for visual effects extends to the area from which the project could be visible, cut off at a distance of five kilometres (km) from the Project site areas (see below). The Zone of Theoretical Visibility (ZTV) has been established to show the area of land from which there could be a view of any part of the proposed project. The ZTV is shown on Figure 1 in Appendix A.

The study area for landscape effects covers the proposed project site and the wider landscape context within which the project may influence landscape character.

The Study Area for both landscape and visual impacts has been cut off at a radius of 5km from each of the project components, in order to focus on potentially significant effects. This reflects the largely flat, undeveloped landscape, lacking substantial vegetation which would interrupt views towards the Project, which would be of a large scale and therefore readily visible. Atmospheric conditions are generally dry, although occasional sea mists may reduce visibility. It is considered that even though the development may be visible from greater distances, it would not constitute a dominant element in the view, and would therefore be unlikely to cause significant landscape and visual effects.

1.3 PROJECT OVERVIEW

The Project comprises the Refinery itself and its Off-site Facilities. The components of the Project are described in Table 1.2 below.

Table 1.2 Duqm Refinery Project

PROJECT COMPONENT	DESCRIPTION
Duqm Refinery	A 230,000 BDP complex refinery on a plot of 9km^2 area to the north of the main industrial area within the Duqm Special Economic Zone. Includes: • Site clearance and levelling (completed in late 2016) • Product pipelines and service lines to the Duqm Export Terminal • Construction accommodation/workers' camps • Laydown areas.
Off-site Facilities	i. **Crude storage facility at the Ras Markaz (RM) Crude Oil Terminal**: eight tanks located within, and part of the wider Tank Farm, approx. 80km from the Refinery. The large-scale Tank Farm (Oman Oil Tank Terminal Company, OTTCO) in its entirety is not part of the Project. ii. **'DRPIC Crude Pipeline':** 28-inch diameter 80km crude oil import pipeline to transport crude oil from RM to Duqm Refinery. iii. **Product 'Export Terminal'**: on the lee breakwater of Port of Duqm, immediately to the south-east of the Refinery plot. Topside works only, i.e., to establish storage for products and export handling facilities. For marine works, see Associated Facilities below.
Associated Facilities	i. Natural gas spur line/metering station used to supply gas feedstock to DR from the national gas network (Oman Gas Company, OGC); ii. Export pipeline corridor – Construction of the corridor and infrastructure, i.e., pipe supports, bridges, fencing drainage, etc., including pipeline and services themselves under the Refinery. (Under SEZAD/Marafiq responsibility). Note: SEZAD has overall responsibility for the Pipeline Corridor, excluding the DR pipelines and cables, extending from the Refinery Boundary Marker fenceline to the Port fenceline; iii. The marine scope including dredging and reclamation and jetty and quay wall construction of the Duqm Export Terminal. (SEZAD); iv. Haul road or dedicated lane (on Existing Road) for solid product from DR to the Duqm Export Terminal. (SEZAD); v. Duqm Integrated Power and Water Plant (DIPWP) supplying electricity and desalinated water to DR (and in the future other consumers in the DSEZ. (Marafiq, also known as Central Utilities Company, CUC). Note that this now includes items vi and vii below; vi. Seawater supply network (to DIPWP). (Marafiq); vii. Common wastewater outfall for industrial zone users. (SEZAD); and viii. Offshore oil import facilities (including offshore single point mooring (SPM) and crude oil pipeline to shore at RM. (OTTCO).

The transition from crude oil import (via a Single Point Mooring, (SPM) at Raz Markaz to the export of refined products through the Project facilities follows these key stages:

1. Offload of crude oil from offshore vessel delivery. Crude oil is stored within the crude import and storage facility at Ras Markaz Tank Farm of which only eight crude oil tanks are part of the Project.

2. The oil is transferred to the Duqm Refinery through the 80.7km Crude Import Pipeline. The Duqm Refinery will have a design capacity of 230,000 barrels per day and will produce the following products:

- Naphtha;
- Liquid Petroleum Gas (LPG);
- Jet A-1;
- Diesel;
- Heavy Sulphur Fuel Oil (intermittently);
- Petroleum Coke (Solid); and
- Sulphur (Solid).

3. Once the crude oil is refined to the final products then these are marine exported via the Duqm Export Terminal. The liquid products are sent to the terminal via pipelines within a service corridor and the solid products via ground transport.

1.4 SOURCES OF INFORMATION

In compilation of the landscape work, we have utilised the following sources of information and data.

- Satellite imagery (Google Earth);
- World Mapping Project Oman Map (Reise Know-How Verlag, Bielefield, 2017);
- Site survey photographs by WSP team visiting March 2017; and
- Previous EIA reports for this and related projects (See References).

2 APPROACH AND METHODOLOGY

This methodology for the landscape and visual baseline appraisal is generally in accordance with guidance described in the ‘the Guidelines for Landscape and Visual Assessment’ (GLVIA) published by the Landscape Institute (LI) and the Institute of Environmental Management and Assessment (IEMA), 3rd edition (2013).

This report is the result of desk based study of the site conditions supplemented with information on the site and Project area provided by visitors to Duqm, an extensive library of photographs taken during site visits and interviews with specialists (e.g. for baseline survey of air quality, noise and socio-economics) upon their return. The evaluation and assessment of landscape and visual receptors is based on professional judgement of established criteria set out in the methodology below.

The assessment followed the following process.

2.1 LANDSCAPE

Describing the different elements that make up the landscape in the study area, such as:

- Geology;
- Topography;
- Waterbodies;
- Vegetation; and
- Human influence and land use.

This information is used to define landscape character types within the study area: geographical areas made up of a distinct combination of elements and aesthetic or perceptual aspects.

LANDSCAPE SENSITIVITY

The assessment of overall landscape sensitivity combines the judgements on the susceptibility of receptors to the proposed development. The capacity of the landscape to accept development is determined by the degree to which it is able to accommodate change (due to a specific development or land use change) without adverse effects on its character. Sensitivity will vary according to its physical aspects, landscape character/aesthetic aspects, landscape value (e.g. consensus via designations), landscape quality/conditions and cultural/natural heritage factors, including the value of the existing landscape and the extent and nature of the development proposed.

2.2 VISUAL AMENITY

Evaluating visual amenity (as defined in the Introduction) involves determining the extent of visibility of the proposals, followed by identification of visual receptors and their sensitivity to changes in their surroundings.

The Zone of Theoretical Visibility (ZTV) helps to establish the geographical extents of the study area. It was determined by digital modelling using specialist GIS software to analyse a Digital Terrain Model (DTM). The height of viewer is assumed to be 1.8m and the maximum height of the proposed development, based on the information available, is included in the model to assess its potential visibility. The ZTV is approximate only as vegetation and buildings may provide local screening. The output of this process is illustrated using a map of the area (Figure 1).

Visual receptors, such as users of buildings, recreational spaces, footpaths and transport routes, have differing sensitivities to their visual environment. Generally, this is dependent upon their interest in the visual environment, their viewing opportunity and duration, and the context of the views. These factors may be expressed in terms of:

- The value of the view/viewpoint;
- The importance of the viewpoint; and
- The nature of the viewer.

The nature of visual receptors likely to be impacted is categorised on a three point scale ranging between high, medium and low, with residents and those engaged in recreational activities which involve appreciation of the landscape defined as high sensitivity and road users and people in their workplace as low sensitivity. The sensitivity of the receptor is also dependent on the existing perceived quality of the landscape due to the presence of existing intrusive features.

Visual receptors have been identified based on existing mapping and previous reports on social impacts. Settlements in and around Duqm have been static for some time and the nature of the SEZ does not allow for new temporary settlements.

3 LANDSCAPE AND VISUAL BASELINE CONDITIONS

3.1 LANDSCAPE CHARACTER

3.1.1 Local Landscape Character

The landscape character is typical of mature marine fringe environments in the Al Wusta region, which is generally characterised by an open coastline backed by sand and alluvium plains and hills. The climate is arid to hyper arid with temperatures from 21-36℃. There is typically very low precipitation and high temperatures.

The following local landscape character area descriptions LCA1-4 were set out in the Duqm Industrial and Free Zone EIA Report.

Landscape Character Areas were determined that have the following distinct characteristics:

LCA1: BEACH AND DUNES

The Duqm coastal frontage is described as a low-relief crenulated bay, which has a classic fish-hook shape with the shank pointing to the north-east. The frontage has a well-developed beach enriched with offshore derived carbonate sediments, giving it a light colour. The coastal zone can be subdivided into three sub-categories: beach and back beach, khawrs and intertidal mudflats. Litter, some of which undoubtedly originates offshore, is ubiquitous along the whole length of the coast.

LCA1 is defined by land on one side and by open sea on the other side and the result is a distinct sense of space and openness. The dune ridge creates a limited sense of enclosure or containment. The landscape is characterized predominantly by the horizontality and muted hues of the coastal waters, which – according to the Industrial and Free Zone Masterplan EIA – may also include marine activities such as anchorage, and commercial shipping lanes. The development of the Duqm Port and Dry Dock has interrupted the naturalness of the landscape area. The result is a largely open, tranquil and natural landscape which is punctuated by the colours and noises of human features and activities. It has been assessed as of high quality, due to its integrity, high importance as it contributes to the unique identity of Oman, but of low rarity and therefore of only local importance.

Figure 3-1i: View of beach east of Duqm Refinery plot, Spring 2017

LCA2: LOW LYING ALLUVIUM PLAINS

The majority of the site comprises low lying alluvium plains that are naturally fragmented by low rocky outcrops, gravel hills, areas of sabkha and wadi courses. The wadi channels provide diversity to the landscape and topography and also provide pockets of more dense vegetation across the plain, which is generally sparsely vegetated. This LCA has already been subjected to some modification through the creation of the main highway that runs north to south through the site (R32), graded tracks, ad-hoc off-road driving, sand-mining and the development of materials sorting areas as well as other infrastructure/projects (e.g. Sebacic acid manufacturing plant) being developed by SEZAD and other proponents (e.g. Rural Area Electricity Company, RAECO).

The LCA is defined by the coast to the east and limestone and sandstone hills that enclose the area. The LCA is expansive and provides a real sense of space, openness and wildness. This sense of openness and exposure is interrupted by Duqm Town, or Wadi Saay, (LCA3) and also construction works that occur in the area to support the development of the Port and Dry Dock, SEZAD infrastructure projects and other developments underway in the SEZ. It is considered of high quality and high importance (contributing to the unique identity of Oman), but low rarity and thus of only local importance overall.

Figure 3-2: View of Alluvium Plains, Spring 2017

LCA 3: URBAN LANDSCAPE

This LCA is located within the low-lying alluvium plain to the south-east of the IDZ. This landscape is almost exclusively defined by low lying commercial and residential development which is connected by a main highway (R32) and minor arterial access roads. Streets are mainly residual spaces, with little or no vegetation other than wadi areas that flank the town to the west. Development is widely spaced, which provides an incoherent open development type with very little connectivity between areas of development. It is assessed of low quality, importance and rarity.

LCA 4: LIMESTONE AND SANDSTONE HILLS

The alluvium plains of the IDZ are enclosed by hills. These are large-scale upland and hillside landscapes lying between around 50 m and 190 m above mean sea level, backed by the Huqf escarpment, which abut (wholly or in part) the coast to the north and south of the IDZ. Consisting of ridges and ravines, and incised by wadis the hills generally consist of exposed rock with pockets of scrub and seasonal grassland. Due to their complex and often steep topography, infrequent but large fluvial flows and distance from the coast in some areas, this landscape does not contain human features (other than footpaths or small access roads). LCA4 possesses a distinct remote and exposed character and may offer striking views along the surrounding coast and sea. It is assessed as of high importance, high value (when part of the Arabian Oryx Sanctuary) and of regional importance.

In addition it has been necessary to include a further Character Area:

LCA 5: LIMESTONE/DOLOMITE COASTAL CLIFFS

The whole of the rocky coast between Shuwayr and Madrakah is bordered by black and white cliffs of 80m average height rising to 200m in places. They are of a depositional formation with layers of Oligo-Miocene limestone inter-bedded with dolomite and containing fragments of coral and other marine debris. They are edged by sandy beaches interspersed with a rocky shore line. There are typically heaps of eroded material forming dunes at the cliff base, particularly where wadis have cut through the softer rock. These cliffs make the foreshore inaccessible for much of their length. However, fishermen use those bays which have road connections. The cliffs and surf on the rocky shore present a sometimes harsh but dramatic character, with views enclosed by the attractive geological diversity of the cliff face on one side and open to the ocean on the other.

The cliffs are assessed to be of high quality, high importance and moderate rarity, and should be considered to be of regional importance.

Figure 3-2: View of Coast north of Ras Markaz, Spring 2017

3.2 RAS MARKAZ CRUDE IMPORT AND STORAGE (PROJECT FACILITY)

3.2.1 SITE CONTEXT

Eight tanks in this new facility will be part of the Project. The Crude Import and Storage Facility Site is located approximately 50km south of Duqm Town, on the coastal cliffs of Ras Markaz, at an elevation between 100-160m above sea level, set back approximately 1.7km from the shoreline. The beach area below will also be used for the landing siting of the proposed offshore single point mooring, subsea pipeline and related infrastructure being developed outside of the Project, as Associated Facilities. The area is currently largely undeveloped, with a natural coastal character and very limited settlement. Human activity is largely limited to fishing from the beach at Ras Markaz, approximately 2.5km north of the shore facilities (part of the AF). Detractors from the perceived natural character include highway 32 and litter from fishing activities.

3.2.2 LANDSCAPE CHARACTER

The Ras Markaz Site lies within both LCA2: Low lying Alluvium Plains and LCA5: Limestone/Dolomite Coastal Cliffs.

SENSITIVITY

The sensitivity (to the proposed crude import and storage facility) of the landscape is considered to be high due to its currently largely undeveloped state and regional importance, and the scale and industrial nature of the proposed facility.

3.2.3 VISUAL AMENITY

The study area is generally considered to be of a high scenic quality, with the conjunction of the sea and the arid, generally natural, landscape forming a distinctive attractive coastal character. There is potential for recreational activity on the shore and in the water although no support services for this exist..The ZTV indicates that the facility would be largely visible within a 1-2 km radius and this reduces to intermittent visibility with distance, particularly in areas further inland and to the south. It is assumed that there would be some visibility from the sea.

IDENTIFIED RECEPTORS

Desk based study and local knowledge indicates the following visual receptors:

- People that seasonally inhabit the few local individual temporary residences; and
- Fishermen on the beach and at sea.

There are no settlements apparent in the Study Area however there are some indications of individual buildings and there is a fishing landing site (Ras Markaz) 2.5 km to the north.

3.3 CRUDE IMPORT PIPELINE (PROJECT FACILITY)

3.3.1 SITE CONTEXT

The Pipeline ROW Site runs between the Ras Markaz Crude Oil Storage Terminal and the Refinery near Duqm. The corridor will include maintenance roads and the trench/windrow of the pipeline itself, covering a distance of 80.7km. The area is currently largely undeveloped, with a natural coastal character and scattered settlements. Detractors from the perceived natural character include the R 32 and N 37 and new built development including the Duqm Jaaluni International Airport and other infrastructure and development by SEZAD.

3.3.2 LANDSCAPE CHARACTER

The local landscape character area descriptions covering this area have been set out in section 3.1.above, and illustrated in Figure 2 Landscape Character.

The Crude Import Pipeline is a linear feature passing through LCA2: Low lying Alluvium Plains.

It will cross numerous wadis which intersect the plains. The study area is devoid of any wadis with perennial flow of fresh water. Water flows only for few hours after a heavy rain. These features support a more diverse flora and fauna than elsewhere in the region however, as sea fog supplements the water requirements of the vegetation. The main wadis in the study area are Wadi Jurf, Wadi Say, Wadi Dhanjart and Wadi Dhahr.

SENSITIVITY

LCA2 is considered to be of low sensitivity to this type of development. The pipeline will be buried in its operational period and access roads will be similar to existing features.

3.3.3 VISUAL AMENITY

The study area is generally considered to be of a high scenic quality, with the conjunction of the sea and the arid, generally natural, landscape forming a distinctive attractive coastal character. Industrial and residential development detracts from this visual amenity.

IDENTIFIED RECEPTORS

Desk based study and local knowledge indicates the following visual receptors:

- People that inhabit local settlements and individual residences;
- People in transit on the highway; and
- Settlements in the Pipeline study area such as As Sadanat (west of the airport in Duqm) and Qasadat (on the main Duqm to Madrakah, before the turning to Ras Markaz). Note, the Socio-economic and health baseline report (DRPIC Report No. 05-C-Base/Soc) contains more information on settlements in the area.

3.4 DUQM REFINERY (PROJECT FACILITY)

SITE CONTEXT

The Refinery Site plot has been cleared and levelled and the immediate surrounding area is currently largely undeveloped, with a natural coastal character, minimally influenced by agricultural land use including small-scale grazing and raising of crops. Detractors from the perceived natural character include the Duqm Port development to the south-east, the small existing power station (and plot for a new Integrated Power and Water plant), Sebacic Acid plant and highway routes 8, 16 and 32. Additionally, a common utilities corridor is routed to the north of the Refinery Site to the now-engineered Dangert Channel, which discharges to the sea approximately 2.5km to the east. The near flat topography provides extensive views inland to the mountains and out to sea.

The Site lies at low elevation within the drainage basin of the surrounding landscape where it meets the Arabian Sea, which ranges from 180m elevation to sea level. The site topography is undulating, varying between -0.3m and 17.8m above mean sea level.

It is understood that vegetation clearing in the developmental zone for the construction of road networks has been underway including considerable earth moving and ground work, in addition to quarrying and other ongoing port and construction-related excavation and dumping.

3.4.1 LANDSCAPE CHARACTER

The local landscape character area descriptions covering this area have been set out in section 3.1 above, and illustrated in Figure 2 Landscape Character.

The Refinery Facility Site lies within LCA: 2 Low lying Alluvium Plains and immediately adjacent to LCA1: Beach and Dunes.

SENSITIVITY

These areas are considered to be of medium sensitivity to this type of development due to their local importance and the existing intrusive development in this area.

3.4.2 VISUAL AMENITY

The study area is generally considered to be of a high scenic quality, with the conjunction of the sea and the arid, generally natural, landscape forming a distinctive attractive coastal character. This is a relatively well represented Omani landscape type. Recent industrial development detracts from this visual amenity.

The ZTV indicates that the Refinery would be widely visible within the study area and beyond the 5km study area boundary. This reflects the maximum stack height of 73m used in generating the ZTV, whereas the majority of the built form would be considerably lower in height and likely to be less extensively visible. It is assumed that this facility would be extensively visible from the sea.

IDENTIFIED RECEPTORS

Desk based study and local knowledge indicates the following visual receptors:

- People that inhabit local settlements and individual residences;
- People in transit on the highway;
- Duqm Port and Dry Dock staff and visitors; and
- Fishermen utilising beaches along the coast to the south and at sea.

Settlements in the Refinery Study Area include Duqm Town/Wadi Say. There is an existing fishing beach to the south east of the Site, Antout. The temporary facilities here are proposed to be relocated by SEZAD to a new fisheries harbour under construction.

3.5 DUQM EXPORT TERMINAL (PROJECT FACILITY)

3.5.1 SITE CONTEXT

The immediate Site area is currently largely undeveloped, with the exception of an existing breakwater, although it is adjacent to the large-scale development at Duqm Port, 3km to the south east. It has a changeable coastal character, including the area of sabkha where the Wadi Saay meets the sea. Detractors from the perceived natural character include the Duqm Port development and the existing power plant 4km to the northwest. There is very little interruption to views out to sea, which includes views of small-scale fishing activity as well as vessel movements into and out of the port and dry dock. Birdlife is prevalent in this location and the colonies of seabirds on the beach and in the air feature in many views.

The Site lies at low elevation within the drainage basin of the surrounding landscape where it meets the Arabian Sea, which ranges from 180m elevation down to sea level.

3.5.2 LANDSCAPE CHARACTER

The local landscape character area descriptions covering this area have been set out in section 3.1 above, and illustrated in Figure 2 Landscape Character.

The Export Terminal Project Facility Site lies within LCA1: Beach and Dunes and extends out to sea by approximately 4.5km, approaching the existing Commercial Quay. Pipelines and access roads to the Terminalwould fall within LCA2: Low lying Alluvium Plains.

SENSITIVITY

These areas are considered to be of medium sensitivity to this type of development due to their local importance, low lying open character and biodiversity value, tempered by the existing infrastructure in this area.

3.5.3 VISUAL AMENITY

The study area is generally considered to be of a high scenic quality, dominated by the seascape and distinctive, natural coastal character. However, industrial development and activity is already intruding on the extensive existing views, reducing the expected sensitivity of potential receptors.

The ZTV indicates that the Terminal will be widely visible within the study area, particularly on the low ground of the sabkha, and also beyond the 5km boundary. As the facility extends into coastal waters it is assumed that it will be widely visible from the sea as well. The majority of the terminal structures would be of low height, for example the tanks would be 24m (Worley Parsons, 2016), but any mast lighting would be visible in this area.

IDENTIFIED RECEPTORS

Desk based study and local knowledge indicates the following visual receptors:

- People that inhabit local settlements and individual temporary living areas (e.g. in containers);
- People in transit on the highway;
- Duqm Port and Dry Dock staff and visitors; and
- Fishermen at sea.

Settlements in the Terminal study area include Wadi Say/Duqm Town. The Renaissance Workcamp are located approximately 8km to the south west. There is also the previously mentioned fishing beach approximately 2.5km to the north.

3.6 SUMMARY

The landscape is typical and well represented throughout the Al Wusta region, with an open, wild, arid character. The coastal area is particularly scenic due to the intersection of land and sea which provides increased geological and ecological diversity and extensive views. There are no formal landscape designations applicable to this area, although the coast is protected by any development being set inland from its immediate edge. The area currently supports a limited population in scattered small settlements. The area has been marked and zoned for development by the Government, which will increase the population and introduce an increasingly industrial and urban character to the landscape, of which the Project will form a part.

3.7 REFERENCES

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Worley Parsons (2016, June), Equipment list for Duqm Liquid Bulk berths Project. DRPIC Report No. SEZAD-DPTC-21-WP-PR-LST-3001-B3_AFU for Duqm Terminal.

APPENDIX A-1

FIGURES

Figure ii: Zone of Theoretical Visibility

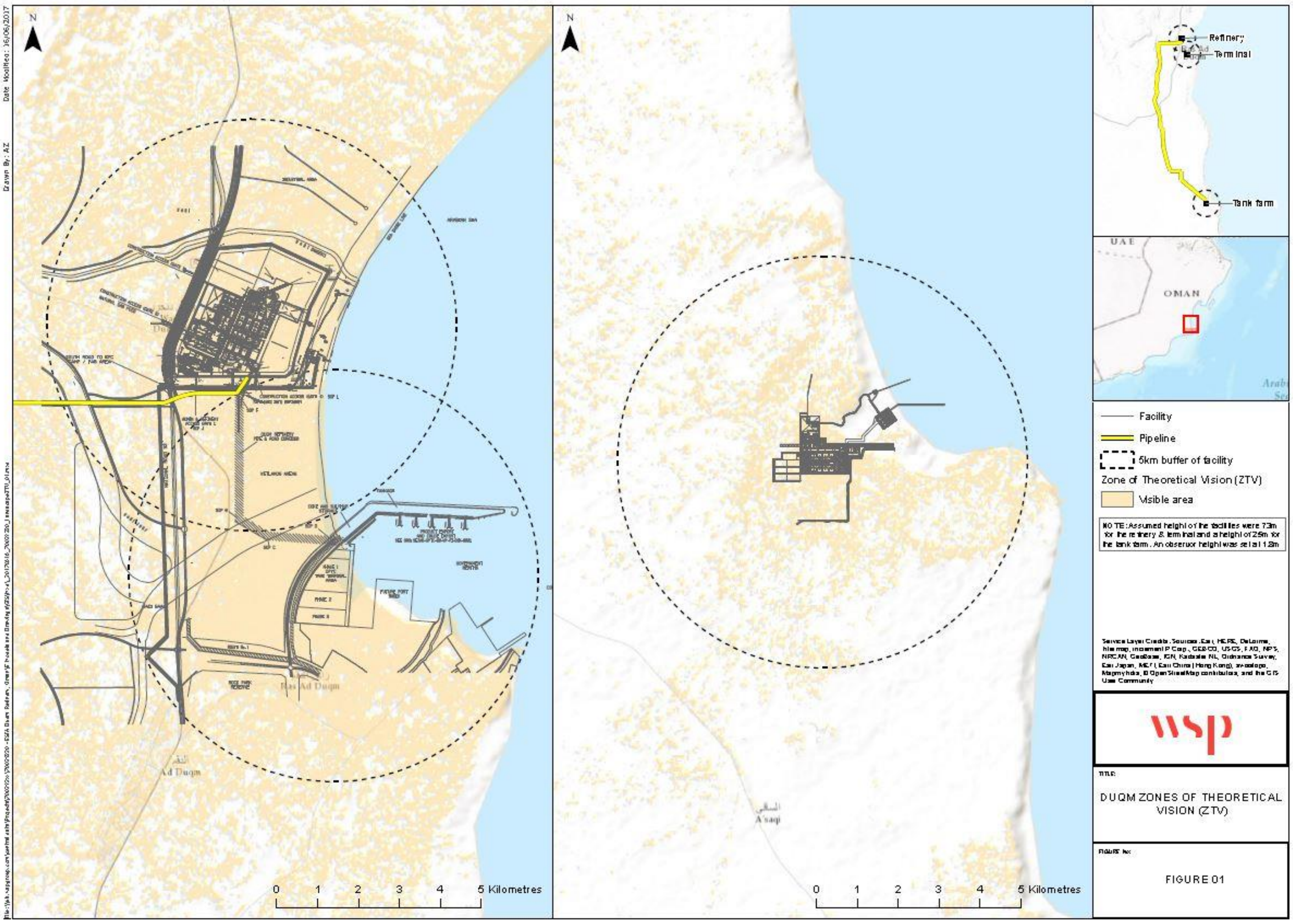

Figure iii: Landscape Character Areas

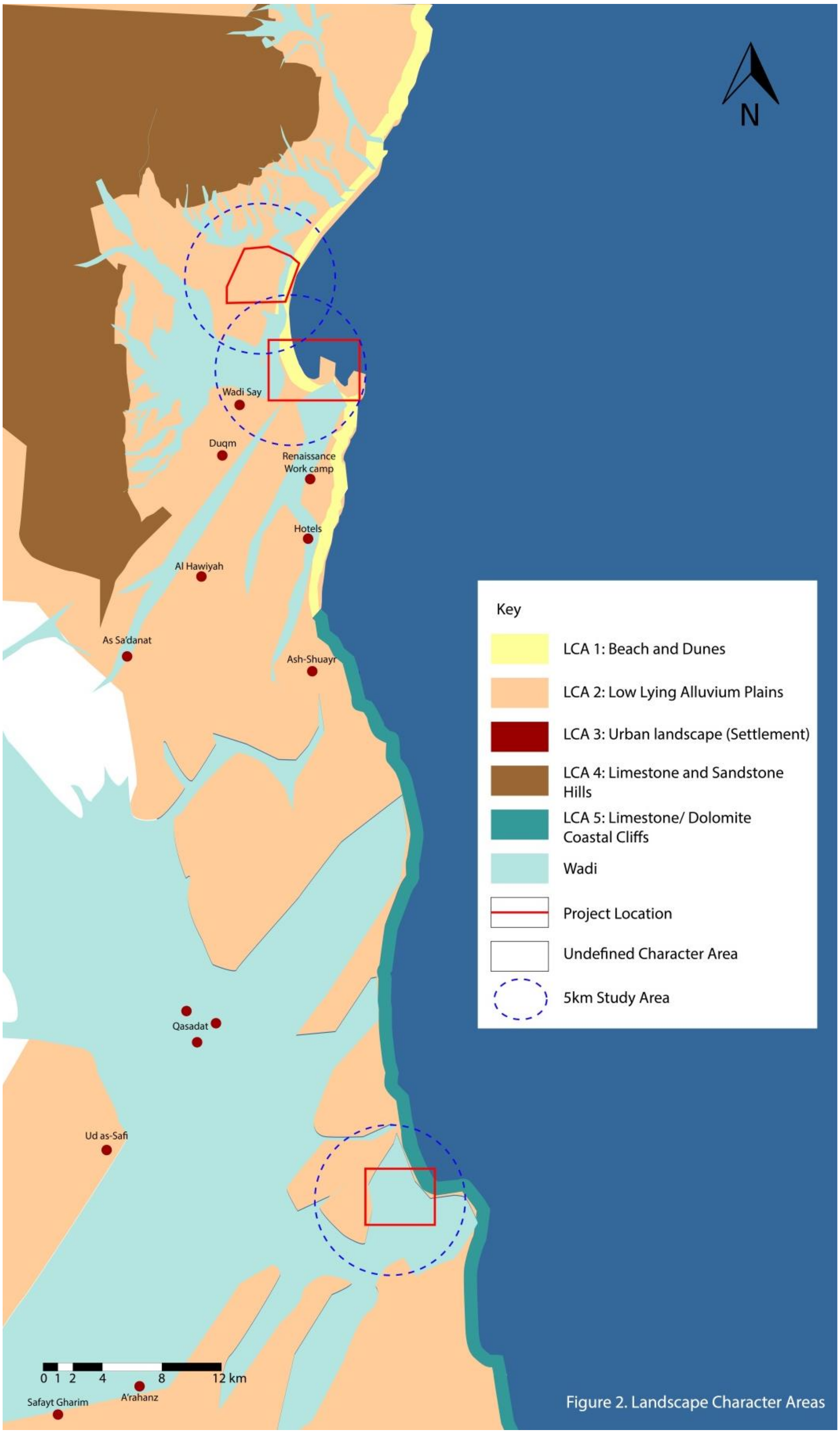

Figure 2. Landscape Character Areas

Appendix D

APPENDICES FOR SECTION 7 - BIODIVERSITY

APPENDIX D-1

APPENDIX 7.1: TERRESTRIAL ECOLOGY SURVEY RECORD

Survey point	Location	Northing	Easting	Habitat description	Plants notes	Other notes
Start of pipeline route from Ras Markaz storage area heading north						
PL 0	Pipeline exits storage area	19.172059	57.749412	Rocky plateau above sea cliffs	*Blepharis ciliaris*, *Pulicaria omanensis*	Group of 6 donkeys
PL 1	Pipeline markers found	19.176830	57.745228	Rocky plateau above sea cliffs	*Blepharis ciliaris*, *Pulicaria omanensis*	
PL 2	Scarp edge	19.184412	57.734829	Scarp edge, rocky	*Tetraena qatarensis*	
PL 3		19.194498	57.722103	Sandy-gravel plain	*Blepharis ciliaris*, *Pulicaria omanensis* –in runnels	
PL 4		19.208212	57.715919	Broad wadi, outflow area	*Acacia* sp. Likely *A.tortilis*, *Blepharis ciliaris*, *Tephrosia apollinea*	Donkey & Camel droppings, small carnivore partial skull (Viverrid or Mustelid?)
PL 5		19.231171	57.671139	Sandy plain, lightly wooded	*Acacia tortilis*, *Blepharis ciliaris*, *Poaceae* sp, *Rhazya stricta*	
PL 6		19.246351	57.656273	Sandy-gravel plain	*Blepharis ciliaris*	
PL 7	In village	19.263441	57.633442	Urban		
PL 8		19.277147	57.616642	Sandy-gravel plain	Scattered *Acacia tortilis*, *Blepharis ciliaris*, *Pulicaria omanensis*, *Convolvulus* sp.	Pipeline route & Duqm Special Economic Zone concrete marker pillar photos 54-55
PL 9		19.295979	57.608273	Sandy-gravel plain	*Pulicaria omanensis* *Acacia tortilis*, Dried stem - *Blepharis ciliaris*?	Paired Line marker photo 60.
PL 10		19.315599	57.598553			Borrow pits photo 63
PL 11		19.358812	57.591915	Sandy-gravel plain	*Blepharis ciliaris*, *Pulicaria omanensis*, *Rhazya stricta*, Euphorb?, *Tephrosia apollinea*	
PL 12		19.379986	57.590813	In *Acacia tortilis* woodlands		
PL 13		19.424900	57.588345	Sandy-gravel plain	scattered *Acacia tortilis*, *Pulicaria omanensis*, little else	
PL 14	After crossing to W of main road	19.424714	57.581136	Sandy-gravel plain	Unvegetated	
PL 15	Flash flood pan	19.456619	57.579941	Sandy-gravel plain	Many tiny seedlings, *Pulicaria omanensis*, *Cyperus* sp, *Tetraena qatarensis*, *Schweinfurthia* sp., *Helianthemum* sp.	
PL 16	End day's work at Hayma road crossing	19.477003	57.573147	Damaged habitat through road construction		
Continuation of Pipeline route heading north down scarp and across wadi and plains area to north						
PL 17	start at Hayma	19.479069	57.574692	Damaged		

Survey point	Location	Northing	Easting	Habitat description	Plants notes	Other notes
	road crossing			habitat through road construction		
PL 18	Edge of scarp beside house & compound	19.486675	57.570545	Sandy-gravel plain	No vegetation	scarp is major habitat boundary
PL 19	Below scarp in major wadi system	19.488495	57.563995	Vegetated wadi, extensive system	*Convolvulus* sp., *Pulicaria omanensis*, *Rhazya stricta*, *Poaceae* sp., *Acacia tortilis*, "euphorb"	Very wide braided wadi system verging on sandy gravelplain
PL 20		19.492279	57.567898	Vegetated wadi, extensive system	*Convolvulus* sp., *Pulicaria omanensis*, *Poaceae* sp., *Acacia tortilis*, "euphorb" sp.	
PL 21		19.496716	57.568428	Wadi edge, against piedmont foothills of scarp	*Convolvulus* sp, *Pulicaria omanensis,* *Poaceae* sp., *Acacia tortilis*, "euphorb" sp. *Fagonia* sp.	Wadi edge, site footprint will determine impact on wadi, settlement nearby
PL 22		19.499197	57.566013	Wooded sandy gravel plain	*Acacia tortilis*, *Rhazya stricta*, *Pulicaria omanensis*, *Nanorrhops ritchieana*	
PL 23		19.509232	57.572632	Wooded sandy gravel plain	*Blepharis ciliaris* (desiccated), *Acacia tortilis*, *Convolvulus* sp., *Heliotropium kotschyi*, *Rhazya stricta*, *Pulicaria omanensis*	
PL 24		19.522366	57.560303	Wooded sandy gravel plain	*Pulicaria omanensis*, *Acacia tortilis*, Dried stem - *Blepharis ciliaris* ?	
PL 25		19.549030	57.570415	Rocky hills, scarp base	*Acacia tortilis*, *Poaceae* sp., *Limonium* sp.	
PL 26		19.556787	57.566040	Wadi in Sandy-gravel plain	*Acacia tortilis*, *Pluchea dioscoridis*, *Salvadora persica*, *Echiochilon jugatum*	Gazelle midden 3 photos, very fresh dung
PL 27		19.571968	57.567287	Sandy-gravel plain, many small wadis/runnels	*Pulicaria omanensis*, *Acacia tortilis*, Dried stem - *Blepharis ciliaris*?, *Limonium* sp	Pristurus carteri gecko
PL 28	Large wadi, small cliffs	19.575554	57.562035	Wadi crossing	*Acacia tortilis* prominent (large trees)	
PL 29		19.588905	57.570449	Sandy-gravel plain, beside small wadi	*Acacia tortilis*, *Pulicaria omanensis* , lichens on small rocks at surface	

Survey point	Location	Northing	Easting	Habitat description	Plants notes	Other notes
PL 30	Point at which overlapping with 5OES (2011) survey to north	19.612886	57.570431	Sandy-gravel plain	Dried stem - *Blepharis ciliaris*?, *Pulicaria omanensis* *Acacia tortilis*	
Following line of the between N breakwater land end and Refinery area						
R 1	IBA area over-view, from end of Route no. 1 road where adjoins landward end of the port northern breakwater.	19.677883	57.675755	Sabkha, wet & dry	Unvegetated apart from marine algae.	S of northern port breakwater (the Lee Breakwater), significant area of tidally inundated sabkha/mudflats occurs, channel along N edge road bund, some 300 odd-birds present, including Reef Heron (white phase), 6 Greater Flamingo, numbers of small waders from small & larger plovers to larger Whimbrel. Numerous Grey (& Purple?) Heron seen on 25th on N side of this road bund. Evident that along the initial (port end) of Port Road Number 5 acting as a dam to water movement, so water trapped that side cannot drain to sea but evaporating creating salf flats area. The area trapped between the two parallel road bunds however, still wet and seemingly connected with the larger port area wetland within IBA.
R 2	Wetland overview	19.659540	57.671135	Mudflats, linked to the sea	Unvegetated apart from marine algae.	
R 3		19.665401	57.644207	Mudflats, linked to the sea	Unvegetated apart	
R 4	Junction of roads	19.687019	57.655815	Modified habitat across sabkha due to roads construction.	Unable to stop and study due to construction traffic	
R 5	Refinery fence	19.718637	57.642082	Sandy-gravel plain	Sparse *Tetraena qatarensis, Pulicaria omanensis*	Port Road 5 crosses Sandy-Gravel Plain area W of main road, as well as some vegetated & unvegetated sabkha areas.
Start of Pipeline route from Refinery heading west						
PL 31	Refinery cleared area, fenced	19.715330	57.640949	Modified cleared area & road	Sparse *Tetraena qatarensis*, *Pulicaria omanensis*, *Heliotropium* sp., *Salsola rubescens*	Pipeline enters Refinery area to E
PL 32	W of main road	19.714930	57.629303	Sandy-Gravel plain	*Tetraena qatarensis*, *Limonium* sp., *Acacia ehrenbergiana*	
	stuck in sand W of main road				*Tamarix* sp., *Tavernieria* sp.	Became bogged in sand, no further observations. Spiny-tailed lizard dropping found here.

APPENDIX D-2

APPENDIX 7.2: HARMONIZED HABITAT MAPPING

TECHNICAL APPENDIX: HARMONISED HABITAT MAPPING

1. METHOD

A pre-fieldwork biodiversity workshop was held on 24 April 2017 involving representatives from WSP and 5OES. It was determined that the most appropriate method for creating a habitat map covering the wider Duqm area was to integrate the mapping produced for the Duqm Industrial Development Zone (IDZ) EIA (5OES, 2011) and Port of Duqm EBS (5OES, 2015) with the mapping generated by the 2017 field visit (Figure B-1). To that end the harmonised habitat mapping for the Duqm Refinery Project and Associated Facilities (AF) was conducted in a phased approach that is outlined below.

1. Preliminary habitat mapping of the Project footprint

Preliminary habitat polygons were delineated following a review of Google Earth 2015 satellite imagery. Habitat units were principally based on the Brown and Boër's interpretation manual of the major terrestrial natural and semi-natural types of Abu Dhabi emirate (2004). Where appropriate, the nomenclature has been modified to reflect the local environmental conditions (see Appendix 1). A 250 m buffer zone was mapped either side of the Project footpring to account for the potential impact of Project construction works and DRPIC Crude Pipeline maintenance.

2. Rapid drive-over/walk-over of the Project footprint

A rapid ground-truthing exercise (24-26th April 2017) was conducted by Dr Chris Hillman (5OES) and Mr Richard Gowing (WSP) in order to refine the preliminary mapping and gather further information about the fauna and flora present in the Project area. Each of the Project components were visited as far as safe access was possible (e.g. the Refinery site was fenced off but could be observed from the fenceline). For the import DRPIC Crude Pipeline, as far as possible the team attempted to follow the DRPIC Crude Pipeline route and noted changes in habitat as they progressed. However, greater emphasis was placed on collecting information at pre-determined survey locations, including DRPIC Crude Pipeline turning points. In the event that an unplanned point was surveyed, its location was recorded using a handheld GPS device. The ground truthing survey did not include the location where AF's are being constructed, habitat information presented in the EIA's corresponding to each AF is relied upon. The terrestrial habitat around the breakwater at Duqm Port was similarly excluded as all terrestrial environments at this location have already been developed by third parties and no natural terrestrial vegetation remains.

A brief walkover was conducted at each survey point in order to document the presence of wildlife (including direct observations, tracks, signs and calls) and flora in the area. The flora component focused on recording the dominant species and those of conservation interest including woodland areas (woodland in the context of the Duqm environment is defined as scattered assemblages of woody shrubs/small trees such as *Prosopis cineraria* and *Acacia tortilis*). In addition, photos were taken in the direction of the four cardinal compass points at each survey point. The survey field notes are presented in Appendix 2.

3. Revision of preliminary habitat mapping and integration with existing mapping

Following the completion of the fieldwork the preliminary habitat map was updated through the integration of ground observations and imagery (Google Earth 2015 and 2017 Sentinel map medium resolution satellite imagery) to reflect current environmental conditions. Thereafter, the habitat mapping conducted by 5OES in 2010 for the Duqm IDZ masterplan EIA (5OES, 2011) and in 2015 for the Port of Duqm winter Ecological Baseline Survey (EBS) (5OES 2015) was revised so that the nomenclature of the habitat units is consistent with those used in 2017. It should be noted that the 5OES 2015 map represents an expansion and revision of earlier mapping produced by another organisation.

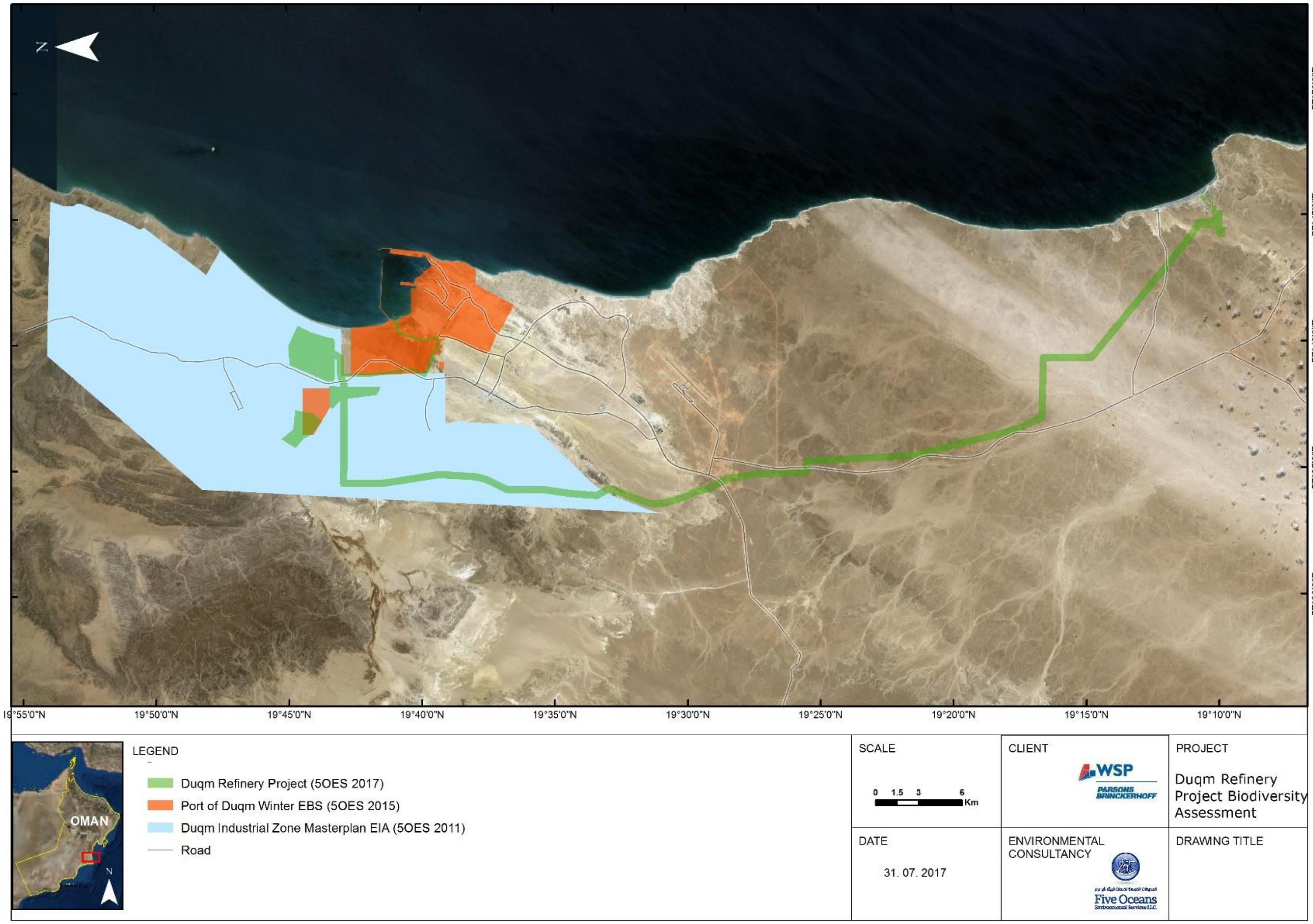

Figure B-1: Areas mapped by 5OES in 2011, 2015 and 2017

4. Delineation of natural, modified and critical habitats

The following paragraphs have been extracted from Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC 2012):

Modified, natural and critical habitat refers to the biodiversity value of the area as determined by species, ecosystems and ecological processes. In practice, natural and modified habitats exist on a continuum that ranges from largely untouched, pristine natural habitats to intensively managed modified habitats. In reality, project sites will often be located among a mosaic of habitats with varying levels of anthropogenic and/or natural disturbance. Clients (i.e. project proponents) are responsible for delineating the Project site as best as possible in terms of modified and natural habitat. This determination is made based on the level of human-induced disturbance (e.g. presence of invasive species, level of pollution, extent of habitat fragmentation, viability of existing naturally-occurring species assemblages, resemblance of existing ecosystem functionality and structure to historical conditions, degree of other types of habitat degradation, etc.) and the biodiversity values of the site (e.g. threatened species and ecosystems, culturally important biodiversity features, ecological processes necessary for maintaining nearby critical habitats). When delineating modified and natural habitats, clients should not focus on the Project site in isolation. The level of anthropogenic impact should be determined with respect to the greater landscape/seascape in which the project is located. In other words, is the project site (or parts of it) located in a disturbed area amidst an otherwise intact landscape? Is the project site (or parts of it) an island of natural habitat within a heavily disturbed or managed landscape? Is the project site located near areas of high biodiversity value (e.g. wildlife refuges, corridors or protected areas)? Or, is the project site located in a mosaic of modified and natural habitats that contain various degrees of biodiversity values of importance to conservation? The client should be prepared to define its project site in these terms as part of the risks and impacts identification process.

Both natural and modified habitats may contain high biodiversity values, thereby qualifying as critical habitat. IFC PS 6 does not limit its definition of critical habitat to critical natural habitat. An area may just as well be critical modified habitat. The extent of human-induced modification of the habitat is therefore not necessarily an indicator of its biodiversity value or the presence of critical habitat.

Critical habitats are areas with high biodiversity value, including:

i. Habitat of significant importance to Critically Endangered and/or Endangered[1] species;

ii. Habitat of significant importance to endemic and/or restricted-range species;

iii. Habitat supporting globally significant concentrations of migratory species and/or congregatory species;

iv. Highly threatened and/or unique ecosystems; and/or

[1] As listed on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The determination of critical habitat based on other listings is as follows: (i) If the species is listed nationally / regionally as critically endangered or endangered, in countries that have adhered to IUCN guidance, the critical habitat determination will be made on a project by project basis in consultation with competent professionals; and (ii) in instances where nationally or regionally listed species' categorizations do not correspond well to those of the IUCN (e.g., some countries more generally list species as "protected" or "restricted"), an assessment will be conducted to determine the rationale and purpose of the listing. In this case, the critical habitat determination will be based on such an assessment.

v. Areas associated with key evolutionary processes.

The determination of critical habitat however is not necessarily limited to these criteria. Other recognized high biodiversity values might also support a critical habitat designation, and the appropriateness of this decision would be evaluated on a case-by-case basis.

In general, internationally and/or nationally recognized areas of high biodiversity value will likely qualify as critical habitat; examples include the following:

- Areas that meet the criteria of the IUCN's Protected Area Management Categories Ia, Ib and II, although areas that meet criteria for Management Categories III-VI may also qualify depending on the biodiversity values inherent to those sites.
- Majority of Key Biodiversity Areas (KBAs), which encompass *inter alia* Ramsar Sites, Important Bird Areas (IBA), Important Plant Areas (IPA) and Alliance for Zero Extinction Sites (AZE).

IFC PS6 requires areas of critical habitat to be further defined as Tier 1 or Tier 2 critical habitat according to criteria listed in Table B-1. Tier 1 and Tier 2 habitats are not mapped as part of the harmonised habitat mapping exercise as for each different species, these differ). A full discussion of which Tier 1 and Tier 2 habitats occur in the Project area is provided in Technical Appendix C: Critical Habitat Assessment.

The following abbreviations are used in Table B-1, relating to the IUCN red data book categories: Critically Endangered (CR); Endangered (EN), Vulnerable (VI) and Near Threatened (NT).

Table B-1: Quantitative thresholds for Tiers 1 and 2 of Critical Habitat Criteria 1 through 3

CRITERIA	TIER 1	TIER 2
1.Critically endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species. (b) Habitat with known, regular occurrences of Critically Endangered (CR) or Endangered (EN) species where that habitat is one of 10 or fewer discrete management sites globally for that species.	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/ subspecies. (d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
2. Endemic/ Restricted Range Species	(a) Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that

Criteria	Tier 1	Tier 2
	unit for that species.	species, where adequate data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 percent of the global population of recruits.

2. CRITICAL HABITAT ASSESSMENT STEPPED PROCESS

The CHA involves a three-step process:

- Step 1 – Stakeholder consultation/initial literature review involving In-field consultation exercises and desktop research;
- Step 2 – In-field data collection and verification of available information through engaging qualified specialists to collect field data as necessary both within and outside of the project area/discrete management unit; and
- Step 3 – Critical Habitat Determination through the analysis and interpretation of the desktop and field data.

A detailed account of how critical habitat was assessed and has been determined is provided in Technical Appendix C: Critical Habitat Assessment. For the purposes of this Project a single terrestrial (excluding beach and coastal zone habitats) critical habitat has been identified:

Habitat supporting two endemic plant namely *Salsola omanensis* and *Ochradenus harsusiticus*. The three species were selected in favour of other endemics on account of having been recorded in the four quarter degree grid squares between 19.0° - 20.0° N and 57.0° - 58.0° E that include or surround the SEZAD area (Patzelt 2014) and been documented during other baseline surveys related to the SEZAD area (e.g. 5OES 2011 and 5OES 2015). In addition these three species also have an elevated global conservation status - vulnerable as opposed least concern or near threatened. Further details are provided in the critical habitat assessment chapter. *Ochradenus harsusiticus* was recorded in the Refinery footprint during the historic EIAs conducted by HMR. *Salsola omanensis* was recorded in the Port of Duqm footprint in 2015.

3. LIMITATIONS

Three key limitations have been identified:

1. The ground truthing survey was designed to confirm or evaluate the findings of previous ecological survey work and not to investigate the fauna and flora comprehensively.
2. As far as practical the team attempted to follow the DRPIC Crude Pipeline route but this was not always possible due to the presence of sand accumulations, wadis and escarpments. The broken terrain of the escarpment and hills especially slowed progress and required extensive deviation.

3. The habitat mapping conducted by 5OES in 2010 as part of the Duqm IDZ EIA (5OES 2011) is now out of date as some areas have been significantly modified in the intervening years. The same issue, albeit to a lesser extent, has been identified with the Port of Duqm habitat mapping (5OES 2015). Mapping the new infrastructure outside of the Project and Associated Facilities footprint is beyond the scope of this project and therefore these developments are not reflected in the harmonised habitat map.

4. RESULTS

COVERAGE OF EACH DIFFERENT HABITAT IN THE FIELD STUDY AREA

Table B-2. Habitat coverage within the Project footprint

HABITAT TYPE	AREA IN KM^2	DISTRIBUTION WITHIN THE PROJECT FOOTPRINT
Borrow pit areas, quarries and construction sites	10.16	Principally the Refinery site which is entirely modified but also along DRPIC Crude Pipeline to the west of construction camp 1 plot and at the junction of the Hayma road
Gravel & sand plains with dwarf shrub cover	31.28	Along the length of the DRPIC Crude Pipeline, dominant habitat at both construction camps and along part of service corridor close to refinery. Co-dominant habitat at Ras Markaz crude oil park
Gravel & sand plains with trees	2.23	Scattered locations along the DRPIC Crude Pipeline
Industry and infrastructure	1.37	Scattered locations along the DRPIC Crude Pipeline, construction camp 2 plot, the services corridor
Rocky mountain & escarpment	0.96	A few locations along DRPIC Crude Pipeline north of Hayma road junction
Rocky outcrops & gravel hills	5.97	Scattered locations including service corridor, construction camp 2, Ras Markaz crude oil park and along the length of the DRPIC Crude Pipeline
Settlements	0.03	Two locations within 0.25 km of the the DRPIC Crude Pipeline but outside of the construction Right of Way (ROW).
Vegetated dune	0.05	Ras Markaz crude oil park (shore)
Vegetated sabkha	1.73	Co-dominant habitat along the service corridor. Also present where DRPIC Crude Pipeline turns east and heads towards construction camp 1 plot.
Wadis in close association with mountains	0.3	250 m north of Hayma road junction
Wadis in open terrain	5.3	Scattered along length of the DRPIC Crude Pipeline. Also in NE corner of construction camp 2 plot.

The gravel and sand plains with dwarf shrub cover habitat is by far the most prevalent habitat type within the project footprint, accounting for nearly 53% of the total surface area (Figure B-2). The next most abundant habitat type are borrow pit areas, quarries and non-Project related construction sites that comprise approximately 17% of the project footprint. Although much of that area is attributed to the construction taking place near the refinery (not Project related), other areas of excavation can be found to the west of construction camp 1 plot and at the junction of the Haima road.

DESCRIPTION OF THEIR RELATIVE ABUNDANCE IN THE DUQM AREA

When the habitat mapping was conducted for the 5OES 2011 and 5OES 2015 reports, the two gravel and sand plains habitat categories were considered as a single entity. Nevertheless, that habitat type was estimated to comprise approximately 30% or $119km^2$ of the total IDZ project area ($395km^2$) and 12% of the overall Port of Duqm project footprint ($56.3km^2$). It is therefore considered to be a common habitat in the wider area (Figure B-3).

Together the rocky mountain & escarpment and rocky outcrops & gravel hills only comprise just over 11.5% of the Refinery and AF footprint. In contrast those habitats coupled with the piedmont and foothills (another rocky habitat type but one absent from the current project area) comprise 190km^2 or 48% of the overall IDZ project area.

The percentage area covered by the wadis in open areas is similar across the current project (approximately 9%) and the IDZ (nearly 10%), both of which are slightly higher (proportionally) compared to the Port of Duqm (6.5%). As is to be expected the area covered by wadis in association with mountainous terrain is much lower than in open areas and estimated to only cover 0.26km^2 of the current project area and approximately 4% of the IDZ.

Vegetated sabkha, which is restricted to the services corridor and DRPIC Crude Pipeline areas of this project, covers approximately 1.73km^2 or 3% of the total area. No distinction was made between vegetated and unvegetated sabkha in 5OES 2011 mapping, however, that habitat type was estimated to cover 3.20km^2 or approximately 5.5% of the Port of Duqm area.

A small area of vegetated dunes (0.05km^2) was mapped within the footprint of the Ras Markaz facility and a similarly small area was noted on the Port of Duqm habitat map (0.17km^2). All coastal habitats were grouped together for the 5OES 2011 mapping so it is not possible to make meaningful comparisons.

In conclusion, with the possible exception of the vegetated dunes all the habitat types documented within the current project footprint are assessed to be relatively common within the wider Duqm area.

DELINEATION OF MODIFIED AND NATURAL HABITATS AS PER PS6

Although natural and modified habitats exist on a continuum (as described in PS6 extract above) for the purposes of this study, in the absence of more detailed information, it has been agreed with WSP that modified habitat will be defined as that habitat which is irrevocably transformed and cannot realistically be returned to its natural state. Examples include quarries, borrow pits as well as areas where non-Project related infrastructure has been built or is in the process of being built (i.e. construction sites). In contrast, areas that have been subjected to livestock grazing or that exhibit signs of off-road driving but are otherwise not significantly degraded are still classified as natural. On that basis the natural habitats are estimated to cover 47.0 km^2 (79%) of the current project area. The majority of the modified habitat (12.3 km^2) is attributed to the Refinery site, which has already undergone site preparation and the surroundings, which are being developed by third parties (Figure B-4).

5. DISCUSSION

IDENTIFICATION OF PRESSURES AND THREATS OBSERVED ON HABITATS

- Grazing and fuelwood collection, especially near habitation and dispersed livestock compounds were identified as possible factors reducing the abundance of natural vegetation cover;
- Vehicle tracking over much of the area, concentrated at wadi crossings, narrow defiles and places where escarpment can be ascended/descended are sources of localised disturbance/erosion of natural vegetation;
- Construction activity in the wider SEZ in many places especially ancillary exercises, such as fill scraping and collection and removal to port area account for the modification of natural desert habitats;
- Changes to hydrology through drainage impedance by bund construction to carry roads through sabkha and tidal flats. If balance drainage is not provided, then water will

accumulate and then evaporate. One location on the Port Road Numbber 5 already noted and photographed. Two major wadi outflows came together at the port area, now compromised by the developments and the northern breakwater. There is still some exchange with the sea and this should be enhanced and maintained to protect and further develop the Duqm Important Bird Area (IBA) wetland area for shore birds use during migratory periods in mitigation;

- There may also be some small local changes to surface water flow in wadi habitats, especially during rare but heavy rain, by any alteration to the surface topography through DRPIC Crude Pipeline burial and the construction process;
- Dust generation by vehicles during construction phases may smother natural vegetation. This affect was noted in the direct vicinity of third party construction activities around the port. Seawater could be used to supress dust from Project construction sites particularly since it develops a hardcore-like crust. However, it also introduces salt to areas with otherwise low salinity. Use of sea water for dust suppression should only be done in sabkha areas (i.e. in the coastal zone near the Refinery)) during construction, and later if not tarmac-surfaced;
- Access to and travel along tracks to reach the DRPIC Crude Pipeline or travel along it during construction and future operational phases will further fragment habitat areas and increase tracking if not controlled. These will also permit increased incursions by local people by vehicle to harvest vegetation and other resources, possibly beyond natural replacement rates; and
- Depending on the profiling of the buried DRPIC Crude Pipeline around wadis crossings the water flow and sediment/erosion dynamics may be affected leading to loss or smothering of natural vegetation. It should be possible to design-out this impact through careful post construction landscaping.

RECOMMENDATIONS

The following recommendations have been divided into two categories:

1. Project related recommendations – factors that DRPIC has direct influence or control over. Factors relating to significant ecological impacts identified in ecological impact assessment.

2. Strategic recommendations – factors and conservation issues which the Project may effect in a cumulative way but relating more to landscape scale management and planning directed by SEZAD.

In the former category, DRPIC will seek to mitigation for these issues through implementation of the Biodiversity Management Plan

<u>Project Related Recommendations</u>

- A detailed log of ‘hot spots’ where critical habitat for endemic plant species or vegetated wadi crossings may occur (see Technical Appendix C: Critical Habitat Assessment) will be provided in the BMP to enable pre-construction survey work and eventual micro-siting and minimisation of the Project working area to avoid impacts or to inform translocation strategies.
- In accordance with legislation and the Project ESMP, minimise the removal of trees during Project construction.
- An inventory of areas where the DRPIC Crude Pipeline crosses a wadi should be produced to inform ‘narrowing’ of the DRPIC Crude Pipeline construction working area.
- Use local trees, including *Prosopis cineraria*, *Acacia tortilis* and *Nannorrhops ritcheana* (dwarf palm) instead of exotic species in greenbelt planting. Integrate with SEZAD

strategic greenbelt strategy. The ESPM contains a requirement to utilise permit based greenbelt planting to ensure adoption.

- Conduct targeted pre-construction botanical survey work of key locations in the Project footprint likely to support endemic plant species (e.g. a 0.5 km radius of previous records) and at wadi/DRPIC Crude Oil Pipeline crossings. Evaluate the feasibility of translocating flora species of conservation concern, in particular rare and threatened endemic species. Surveys and mitigation initiatives of this nature could be conducted in partnership with the Oman Botanical Gardens.
- Mitigate for accidental transgression from access tracks and unofficial use of access tracks by non-Project related vehicle traffic by closing off and securing tracks.

Strategic Recommendations

- Encourage SEZAD and Port of Duqm to re-survey the Duqm IDZ and Port area in order to update the habitat map and ecological findings reported by 5OES in 2011 and 2015 respectively. The focus of the survey should be to identify populations of endemic or threatened plant species such as those listed in the Technical Appendix C: Critical Habitat Assessment, and to coordinate a strategic conservation approach to protect and enhance these populations through sensitive development planning, provision of appropriate 'nature reserve' areas which are protected from development and habitat enhancement.

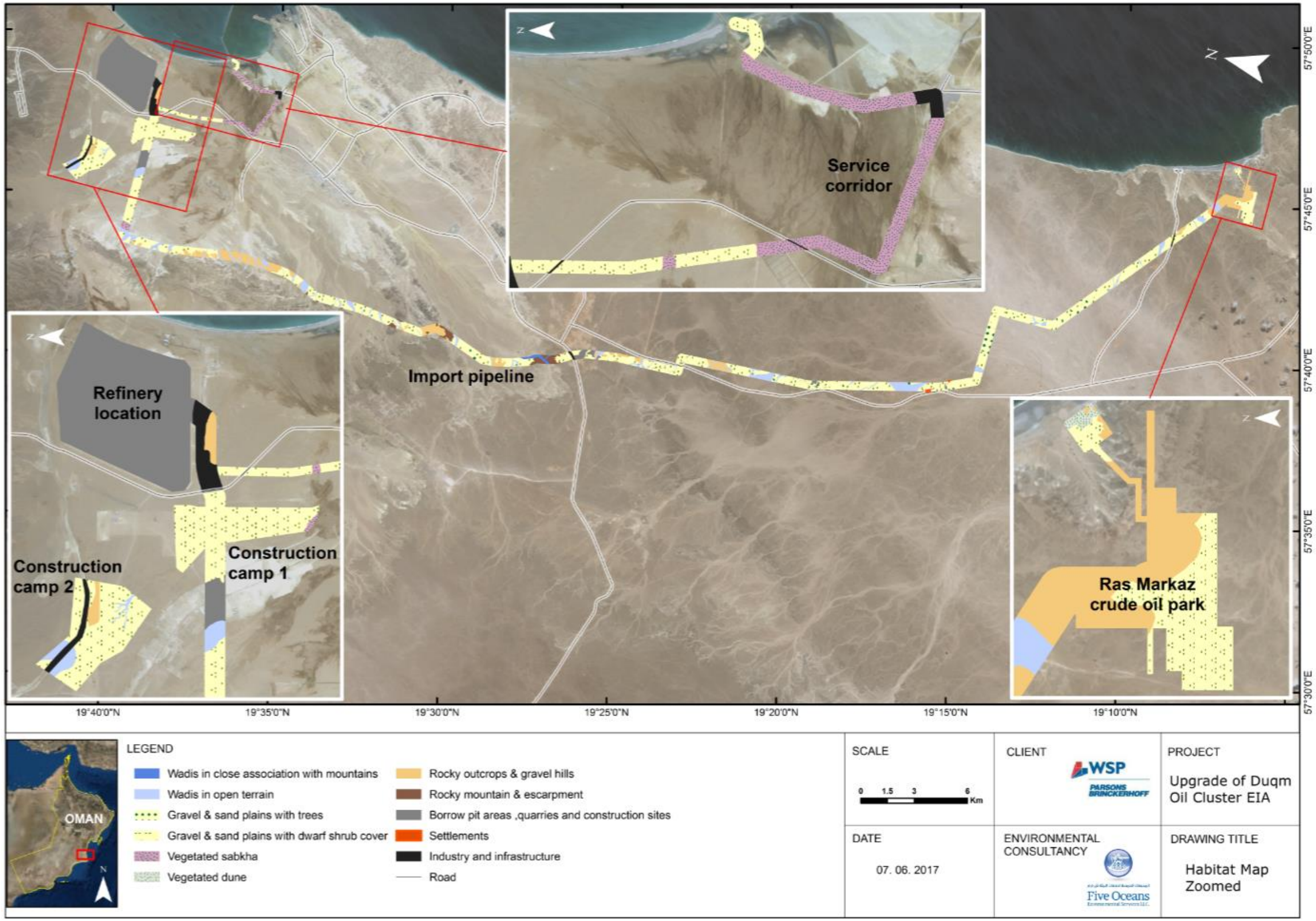

Figure B-2. Habitat map for the Duqm Refinery and AFs

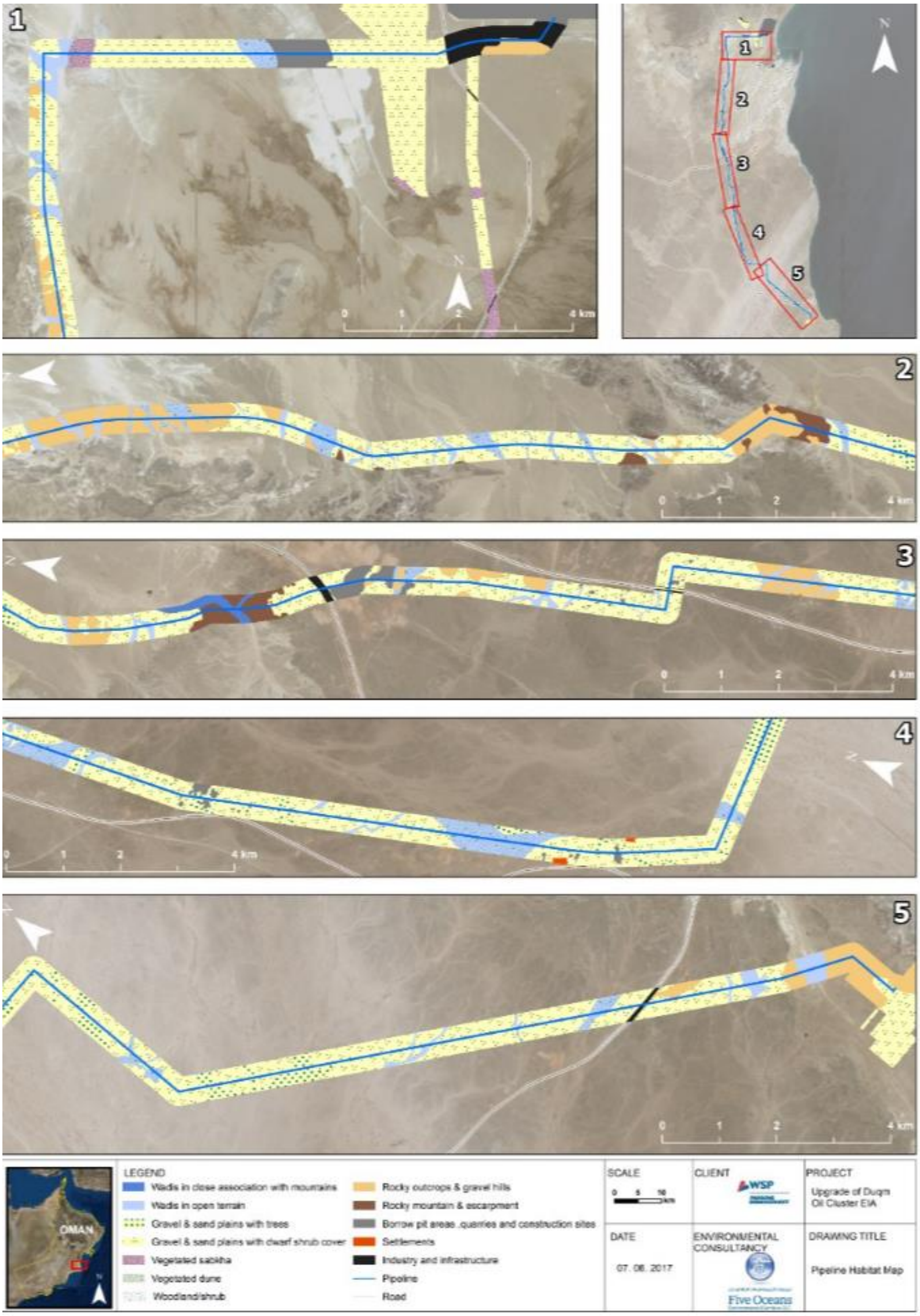

Figure B-3. A zoomed in view of DRPIC Crude Pipeline habitat mapping

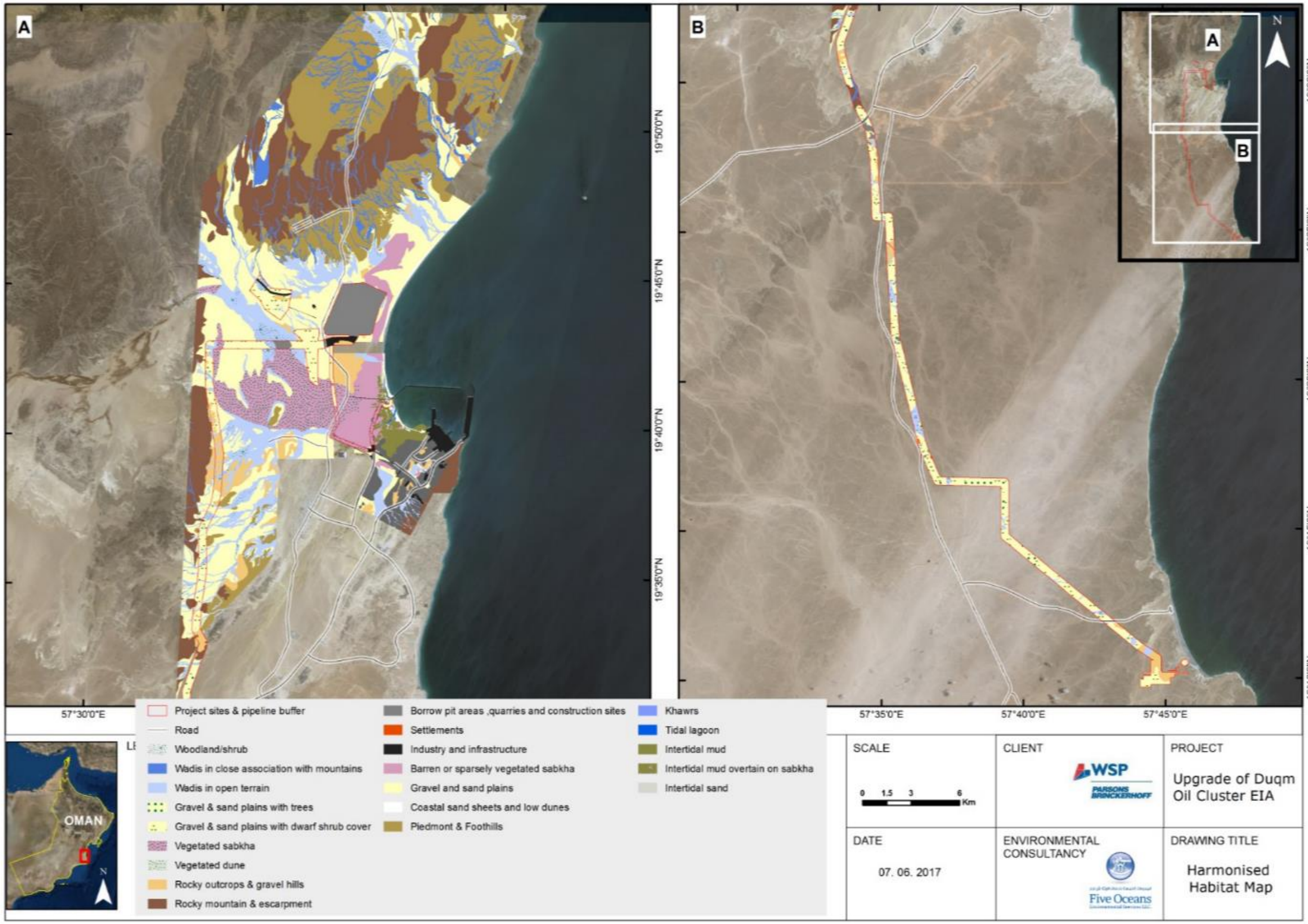

Figure B-4. Harmonised habitat map; integrated mapping from IDZ (5OES 2011), Port (5OES 2015) and Refinery and AFs

Figure B-5. An overview of natural and modified habitats within the Duqm Refinery and AFs footprint

ANNEX 1 – COMPARISON OF HABITAT UNITS

MAJOR TERRESTRIAL NATURAL AND SEMI-NATURAL HABITAT TYPES OF ABU DHABI (BROWN & BOER 2004)				DUQM OIL REFINERY AND ASSOCIATED FACILITIES HARMONISED HABITAT MAPPING UNITS (2017)	PORT OF DUQM HABITAT UNITS (5OES 2015)	DUQM IDZ HABITAT UNITS (5OES 2011)
UNIT CODE						
1000			**MUDFLATS, BEACHES AND ROCKY COASTAL HABITATS**	**COASTAL HABITATS INCL MUDFLATS, SANDS AND LAGOONS**	**COASTAL HABITATS INCL MUDFLATS, SANDS AND LAGOONS**	**COASTAL HABITATS INCL MUDFLATS, SANDS AND LAGOONS**
	1010		Mudflats and sand flats exposed at low tide	Khawr	Intertidal sands (fine, bivalve dominated)	Coastal zone
	1020		Sheltered tidal flats with cyanobacterial mats		Intertidal sand (thixotrophic, fine, bivalve and polychaete dominated)	
	1030		Intertidal mudflats and lagoons with coastal marshland	Tidal lagoon	Intertidal sand partially covered in green algae (polychaetes/bivalves)	
	1040		Intertidal mudflats and lagoons with mangroves		Intertidal mud (anoxic dominated by polychaetes and crabs)	
	1050		Storm beach ridges	Intertidal mud	Infralittoral mud covered in green algae/seagrass	
	1060		Non-vegetated, exposed sandy beaches		Supralittoral sand dominated by ghost crabs	
	1070		Vegetated sandy beaches	Intertidal mud overlain on sabkha	Tidal lagoon	
	1080		Rocky and gravelly beaches		Infralittoral sand	
	1090		Coastal cliffs and headlands	Intertidal sand	Intertidal sands covered in green algae	
	1095		Maritime rocky slopes		Intertidal mud/tidal lagoon	
	1098		Wadis in coastal situations		Supralittoral/intertidal mud overlain on sabkha	
					Intertidal upper coarse sand/deeper mud layers with crabs and bivalves	
2000			**COASTAL PLAINS, SAND SHEETS AND LOW DUNES**	**COASTAL PLAINS AND DUNES**	**COASTAL DUNES**	**COASTAL DUNES**
	2010		Coastal plains on well-drained ground	Coastal sand sheets and low dunes	Barren dune	Coastal zone
		2011	On sandy ground			

MAJOR TERRESTRIAL NATURAL AND SEMI-NATURAL HABITAT TYPES OF ABU DHABI (BROWN & BOER 2004)				DUQM OIL REFINERY AND ASSOCIATED FACILITIES HARMONISED HABITAT MAPPING UNITS (2017)	PORT OF DUQM HABITAT UNITS (5OES 2015)	DUQM IDZ HABITAT UNITS (5OES 2011)
		2012	On rocky or gravelly terrain	Vegetated dune	Vegetated dune	
	2020		Coastal sand sheets and low dunes			
3000			**COASTAL SABKHA AND SABKHA MATTI (LARGELY UNVEGETATED)**	**COASTAL SABKHA**	**COASTAL SABKHA**	**COASTAL SABKHA**
3100			Coastal sabkha	Barren or sparsely vegetated sabkha	Barren or sparsely vegetated sabkha	Sabkha
3200			Sabkha matti	Vegetated sabkha	Vegetated sabkha	
5000			**PLAINS (ALLUVIAL AND INTERDUNAL)**	**GRAVEL AND SAND PLAINS**	**GRAVEL & SAND PLAINS**	**GRAVEL & SAND PLAINS**
5100			Alluvial plains			
	5110		Alluvial plains with distinct tree vegetation	Gravel & sand plains with trees	Gravel & sand plains	Gravel & sand plains
	5120		Alluvial plains with dwarf shrub vegetation	Gravel & sand plains with dwarf shrub cover		
		5121	with *Haloxylon salicornicum*			
		5122	with *Rhazya stricta*			
6000			**MOUNTAINS, ROCKY TERRAIN AND WADIS**	**MOUNTAINS AND ROCKY TERRAIN**	**MOUNTAINS AND ROCKY TERRAIN**	**MOUNTAINS AND ROCKY TERRAIN**
6100*			Mountain slopes and scree	Rocky mountain & escarpment	Mountain	Rocky Mountain & escarpment
6200			Other rocky habitats	Rocky outcrops & gravel hills	Rocky outcrops, plateaux & slopes	Rocky outcrops & gravel hills
	6210		'Jebels'	Piedmont & foothills		Piedmont & foothills
	6220		Escarpments, lithified sand dunes, rocky exposures			
				WADIS AND OTHER TEMPORARY WATERCOURSES	**WADIS AND OTHER TEMPORARY WATERCOURSES**	**WADIS AND OTHER TEMPORARY WATERCOURSES**
6300			**Wadis and other temporary watercourses**		Wadis & runnels	Wadi courses
	6310		Wadis in close association with mountains	Wadis in close association with mountains		
	6320		Wadis in open terrain	Wadis in open terrain		
	6330		Drainage channels	Drainage channels (too small to map)		
8000			**OASES, FARMLAND AND FORESTRY**	**DEGRADED OR TRANSFORMED LAND**	**DEGRADED OR TRANSFORMED LAND**	
				Settlements	Degraded and/or transformed land	
				Industry and infrastructure		

MAJOR TERRESTRIAL NATURAL AND SEMI-NATURAL HABITAT TYPES OF ABU DHABI (BROWN & BOER 2004)				DUQM OIL REFINERY AND ASSOCIATED FACILITIES HARMONISED HABITAT MAPPING UNITS (2017)	PORT OF DUQM HABITAT UNITS (5OES 2015)	DUQM IDZ HABITAT UNITS (5OES 2011)
9000			**URBAN HABITAT TYPES**	Borrow pit areas and quarries		
				Construction sites		

ANNEX 2 – 2017 DUQM OIL REFINERY AND ASSOCIATED FACILITIES FIELD NOTES

SURVEY POINT	LOCATION	NORTHING	EASTING	HABITAT DESCRIPTION	PLANT NOTES	OTHER NOTES
Start of DRPIC Crude Pipeline route from Ras Markaz storage area heading north						
PL 0	DRPIC Crude Pipeline exits storage area	19.172059	57.749412	Rocky plateau above sea cliffs	*Blepharis ciliaris*, *Pulicaria omanensis*	Group of 6 donkeys
PL 1	DRPIC Crude Pipeline markers found	19.176830	57.745228	Rocky plateau above sea cliffs	*Blepharis ciliaris*, *Pulicaria omanensis*	
PL 2	Scarp edge	19.184412	57.734829	Scarp edge, rocky	*Tetraena qatarensis*	
PL 3		19.194498	57.722103	Sandy-gravel plain	*Blepharis ciliaris*, *Pulicaria omanensis* in runnels	
PL 4		19.208212	57.715919	Broad wadi, outflow area	*Acacia* sp. Likely *A.tortilis*, *Blepharis ciliaris*, *Tephrosia apollinea*, *Calligonum* sp., *Crotalaria aegyptiaca*	Donkey & Camel droppings, small carnivore partial skull (Viverrid or Mustelid?)
PL 5		19.231171	57.671139	Sandy plain, lightly wooded	*Acacia tortilis*, *Blepharis ciliaris*, *Poaceae* sp, *Rhazya stricta*	
PL 6		19.246351	57.656273	Sandy-gravel plain	*Blepharis ciliaris*	
PL 7	In village	19.263441	57.633442	Urban		
PL 8		19.277147	57.616642	Sandy-gravel plain	Scattered *Acacia tortilis*, *Blepharis ciliaris*, *Pulicaria omanensis*, *Convolvulus* sp.	DRPIC Crude Pipeline route & Duqm Special Economic Zone concrete marker pillar photos 54-55
PL 9		19.295979	57.608273	Sandy-gravel plain	*Pulicaria omanensis* *Acacia tortilis*, Dried stem - *Blepharis ciliaris*?	Paired Line marker photo 60.
PL 10		19.315599	57.598553			Borrow pits photo 63
PL 11		19.358812	57.591915	Sandy-gravel plain	*Blepharis ciliaris*, *Pulicaria omanensis*, *Rhazya stricta*, Euphorb?, *Tephrosia apollinea*	

SURVEY POINT	LOCATION	NORTHING	EASTING	HABITAT DESCRIPTION	PLANT NOTES	OTHER NOTES
PL 12		19.379986	57.590813	In *Acacia tortilis* woodlands		
PL 13		19.424900	57.588345	Sandy-gravel plain	scattered *Acacia tortilis*, *Pulicaria omanensis*, little else	
PL 14	After crossing to W of main road	19.424714	57.581136	Sandy-gravel plain	Unvegetated	
PL 15	Flash flood pan	19.456619	57.579941	Sandy-gravel plain	Many tiny seedlings, *Pulicaria omanensis*, *Cyperus* sp, *Tetraena qatarensis*, *Schweinfurthia* sp., *Helianthemum* sp.	
PL 16	Hayma road crossing	19.477003	57.573147	Damaged habitat through road construction		
Continuation of DRPIC Crude Pipeline route heading north down scarp and across wadi and plains area to north						
PL 17	Start at Hayma road crossing	19.479069	57.574692	Damaged habitat through road construction		
PL 18	Edge of scarp beside house & compound	19.486675	57.570545	Sandy-gravel plain	No vegetation	scarp is major habitat boundary
PL 19	Below scarp in major wadi system	19.488495	57.563995	Vegetated wadi, extensive system	*Convolvulus* sp., *Pulicaria omanensis*, *Rhazya stricta*, *Poaceae* sp., *Acacia tortilis*, "euphorb"	Very wide braided wadi system verging on sandy gravel plain
PL 20		19.492279	57.567898	Vegetated wadi, extensive system	*Convolvulus* sp., *Pulicaria omanensis*, *Poaceae* sp., *Acacia tortilis*, "euphorb" sp.	
PL 21		19.496716	57.568428	Wadi edge, against piedmont foothills of scarp	*Convolvulus* sp, *Pulicaria omanensis, Poaceae* sp., *Acacia tortilis*, "euphorb" sp. *Fagonia* sp.	Wadi edge, site footprint will determine impact on wadi, settlement nearby
PL 22		19.499197	57.566013	Wooded sandy gravel plain	*Acacia tortilis*, *Rhazya stricta*, *Pulicaria omanensis* spp TBC, *Nanorrhops ritchieana*	
PL 23		19.509232	57.572632	Wooded sandy gravel plain	*Blepharis ciliaris* (desiccated), *Acacia tortilis*, *Convolvulus* sp.,	

SURVEY POINT	LOCATION	NORTHING	EASTING	HABITAT DESCRIPTION	PLANT NOTES	OTHER NOTES
					Heliotropium kotschyi, *Rhazya stricta*, *Pulicaria omanensis*	
PL 24		19.522366	57.560303	Wooded sandy gravel plain	*Pulicaria omanensis* *Acacia tortilis*, Dried stem - *Blepharis ciliaris*?	
PL 25		19.549030	57.570415	Rocky hills, scarp base	*Acacia tortilis*, *Poaceae* sp., *Limonium* sp.	
PL 26		19.556787	57.566040	Wadi in Sandy-gravel plain	*Acacia tortilis*, *Pluchea dioscoridis*, *Salvadora persica*, *Echiochilon jugatum*	Gazelle midden 3 photos, very fresh dung
PL 27		19.571968	57.567287	Sandy-gravel plain, many small wadis/runnels	*Pulicaria omanensis*,. *Acacia tortilis*, Dried stem - *Blepharis ciliaris*?, *Limonium* sp	Pristurus carteri gecko
PL 28	Large wadi, small cliffs	19.575554	57.562035	Wadi crossing	*Acacia tortilis* prominent (large trees)	
PL 29		19.588905	57.570449	Sandy-gravel plain, beside small wadi	*Acacia tortilis*, *Pulicaria omanensis*, lichens on small rocks at surface	
PL 30	Point at which overlapping with 5OES (2011) survey to north	19.612886	57.570431	Sandy-gravel plain	Dried stem - *Blepharis ciliaris*?, , *Acacia tortilis*	
Following line of the road for solid byproducts between N breakwater land end and Refinery area						
R 1	IBA area over-view, from end of the road from refinery where adjoins landward end of the port northern breakwater.	19.677883	57.675755	Sabkha, wet & dry	Unvegetated apart from marine algae.	S of northern port breakwater, significant area of tidally inundated sabkha/mudflats occurs, channel along northern edge road bund, some 300 odd-birds present, including Reef Heron (white phase), 6 Greater Flamingo, numbers of small waders from small & larger plovers to larger Whimbrel. Numerous Grey (& Purple?) Heron seen on 25th on northern side of this road bund. Evident that along the initial (port end) of the haul road to refinery acting as a dam to water movement, so water trapped that side cannot drain to sea but evaporating creating salt flats area. The area trapped between the two parallel road bunds however, is still wet and seemingly connected with the larger port area wetland within IBA.
R 2	Wetland overview	19.659540	57.671135	Mudflats, linked to the sea	Unvegetated apart from marine algae.	

SURVEY POINT	LOCATION	NORTHING	EASTING	HABITAT DESCRIPTION	PLANT NOTES	OTHER NOTES
R 3		19.665401	57.644207	Mudflats, linked to the sea	Unvegetated apart	
R 4	Junction of roads	19.687019	57.655815	Modified habitat across sabkha due to roads construction.	Unable to stop and study due to construction traffic	
R 5	Refinery fence	19.718637	57.642082	Sandy-gravel plain	Sparse *Tetraena qatarensis, Pulicaria omanensis*	Haul Road will cross sandy-gravel plain area W of main road, as well as some vegetated & unvegetated sabkha areas.
Start of DRPIC Crude Pipeline route from Refinery heading west						
PL 31	Refinery cleared area, fenced	19.715330	57.640949	Modified cleared area & road	Sparse *Tetraena qatarensis*, *Pulicaria omanensis*, *Heliotropium* sp., *Salsola rubescens*	DRPIC Crude Pipeline enters refinery area to the east
PL 32	West of main road	19.714930	57.629303	Sandy-Gravel plain	*Tetraena qatarensis*, *Limonium* sp., *Acacia ehrenbergiana*	
	Stuck in sand west of main road				*Tamarix* sp., *Tavernieria* sp.	Became bogged in sand, no further observations. Spiny-tailed lizard dropping found here.

APPENDIX D-3

APPENDIX 7.3: CRITICAL HABITATS' ASSESSMENT (CHA)

TECHNICAL APPENDIX: CRITICAL HABITAT ASSESSMENT

DUQM REFINERY PROJECT, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

CONFIDENTIAL

AUGUST 2017

CRITICAL HABITAT ASSESSMENT

DUQM REFINERY PROJECT, OMAN

Duqm Refinery & Petrochemical Industries Company

Confidential

Project no: 70029220
Date: July 2017

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QUALITY MANAGEMENT

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1 INTRODUCTION

1.1 OVERVIEW AND PERFORMANCE STANDARDS

The International Finance Corporation's (IFC)'s Policy on Environmental and Social Sustainability describes commitments, roles, and responsibilities related to environmental and social sustainability[1]. The requirement for a Critical Habitat Assessment (CHA) is set out in IFC Performance Standard 6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources. (PS6[22]):. Critical habitat is defined as:

> *"areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered[3] species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes."*

IFC PS6 is guided by the Convention on Biological Diversity (CBD) including the CBD's Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets. Full details of the method and process for CHA are provided on pages 19-26 of the IFC6 Guidance Note (GN) document[4].

For projects located in critical habitat, PS6 requires that specific CHAs are conducted. It is additionally recommended that if habitat is critical due to the presence of Critically Endangered and Endangered species, recognized species specialists must be involved (for example, including individuals from IUCN Species Survival Commission Specialist Groups). The CHA was undertaken by staff from Five Oceans Environmental Services (5OES) who are current members of relevant IUCN Species Survival Commission Specialist Groups, including both the Sea Turtle Specialist Group and the Cetacean[5] Specialist Group, and are appropriately qualified to undertake the assessments presented below.

Of the five criteria listed above that are included in the definition of critical habitat, three are relevant to this current assessment:

- → Criterion 1: Critically Endangered (CR) or Endangered (EN) Species.
- → Criterion 2: Endemic/Restricted Range Species.
- → Criterion 3: Migratory/Congregatory Species.

The ultimate outcome of the CHA is determined, against each of these criteria, the gradient of critical habitat or the continuum of degree of biodiversity value associated with critical habitats

[1] IFC (International Finance Corporation). 2012. IFC Performance Standards on Environmental and Social Sustainability. World Bank Group, Washington, DC. 66pp.
[2] IFC (International Finance Corporation). 2012. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. World Bank Group, Washington, DC. 7pp.
[3] As listed on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The determination of critical habitat based on other listings is as follows: (i) If the species is listed nationally / regionally as critically endangered or endangered, in countries that have adhered to IUCN guidance, the critical habitat determination will be made on a project by project basis in consultation with competent professionals; and (ii) in instances where nationally or regionally listed species' categorizations do not correspond well to those of the IUCN (e.g., some countries more generally list species as "protected" or "restricted"), an assessment will be conducted to determine the rationale and purpose of the listing. In this case, the critical habitat determination will be based on such an assessment.
[4] IFC (International Finance Corporation). 2012b. Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. World Bank Group, Washington, DC. 69pp.
[5] 'Cetacean' is the collective name given to whales and dolphins.

based on the relative vulnerability (degree of threat) and irreplaceability (rarity or uniqueness) of the site. Numerical thresholds are defined for the three critical habitat criteria (i.e., CR/EN species; endemic/restricted-range species; migratory/congregatory species) based on IUCN Best Practice Protected Area Guidelines (Langhammer et al., 2007)[6].

The thresholds form the basis of a tiered approach, in that numerical thresholds are used to assign Criteria 1 through 3 to a Tier 1 or a Tier 2 critical habitat designation. A summary of the tiers with respect to the thresholds for each criterion is provided in the table that follows paragraph GN89 in the PS and is repeated in Table 1.1. Paragraphs GN71–GN97 discuss each criterion with respect to the tiers in more detail. It should be emphasized that both the thresholds and associated tiers are indicative and serve as a guideline for decision-making only. There is no universally accepted or automatic formula for making determinations on critical habitat.

Section GN6 in the IFC PS6 guidance document provides specific guidance on how to determine critical habitat by criterion, including the basis for determination of the gradient of critical habitat i.e. Tier 1 or Tier 2. Details are available on page 23 through 28 of IFC GN6.

Importantly, the IFC GN6 states that both a Tier 1 and a Tier 2 habitat would qualify as critical but the likelihood of project receiving investment in a Tier 1 habitat is generally considered to be substantially lower than in a Tier 2 habitat. Recommendations are provided in this document (Section 4) that DRPIC brings this requirement to the attention of SEZAD for inclusion in strategic land allocation and mitigation planning.

Table 1.1: Quantitative thresholds for CHA Tiers 1 and 2 of Critical Habitat Criteria 1 through 3

CRITERIA	TEIR 1	TEIR 2
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species. (b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/ subspecies. (d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
2. Endemic/ Restricted Range Species	(a) Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.

[6] Langhammer, P.F. et al. 2007. Identification and Gap Analysis of Key Biodiversity Areas: Targets for Comprehensive Protected Area Systems. Best Practice Protected Area Guideline Series No. 15. IUCN, Gland, Switzerland.

CRITERIA	TEIR 1	TEIR 2
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 percent of the global population of recruits.

1.2 STRUCTURE OF THE CRITICAL HABITAT ASSESSMENT

This appendix is structured to provide an assessment of some key species in the Duqm area that meet Criteria 1, 2, 3 or some combination of these. It is divided into two main sections, namely a terrestrial section and a marine section. For each species assessed, background is presented based on knowledge of the species life history and ecology, conservation and population status and its distribution globally, nationally and within the Duqm area. Finally, conclusions are drawn with respect to the gradient of critical habitat that the area represents for each species, including assessment of whether the habitat can be defined within a Tier 1 or Tier 2 category.

1.3 LIMITATIONS AND ASSUMPTIONS

Sufficient data were available to enable firm conclusions to be drawn regarding the critical habitat designations presented in this document. However, subsequent mitigation and management recommendations, would be significantly improved if more data were available, and recommendations covering potential future survey work are presented in Section 4 of this technical appendix.

The study presented here was also limited by the nature and variety of third party data sets which were not all necessarily designed for use in CHA and were of variable quality.

The review and compilation of component EIA studies relating to the different Project and AF components has identified a number of species potentially triggering CHA which require some consideration at the SEZAD (regional) scale to inform future development planning in the region. Recommendations are provided in Section 4 of this technical appendix for future CHA studies.

2 METHOD

2.1 CRITICAL HABITAT DETERMINATION

The CHA was based on the broad pool of biodiversity data obtained as through consulting existing information sources (Table 2.1, below) and generating an inventory of marine species known to the area. This list was screened against the IUCN Red List of Threatened Species to determine listed species including Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least Concern (LC) and Data Deficient (DD) species, These species were then subject to assessment using critical habitat criteria and thresholds, as appropriate, as defined in PS6 and GN6. The analysis of this data was conducted with the overall scope of determining the relative irreplaceability and vulnerability of any biodiversity values that trigger Criteria 1 through 5 on a scale that is ecologically relevant as made explicit in footnote 12 of Performance Standard 6 (see also paragraph GN13). Most of the assessment was based on analysis of existing data and results of previous studies. In the event that new, secondary analysis was deemed necessary for this report, this was conducted as mentioned in the results sections where relevant.

Table 2.1: Main sources of data

ORGANISATION	REFERENCED DATA
Ministry of Environment and Climate Affairs	CBD Biodiversity List Cetacean strandings data
Ministry of Fisheries and Agriculture	Fisheries species data
Environment Society of Oman	Cetacean and turtle data (Oman Cetacean Database)
Emirates Wildlife Society	Green turtle and hawksbill telemetry data. Turtle foraging ecology data
Five Oceans Environmental Services	Cetacean. turtle and baseline ecology data
	Previous ecology surveys in Duqm and the Gulf of Masirah
HMR Environmental Engineering Consultants	Previous marine and terrestrial ecology surveys in the Gulf of Masirah
Royal Haskoning DHV	Previous marine and terrestrial ecology surveys in the Gulf of Masirah

The Lenders' Independent Environmental and Social Consultant (IESC) identified the following species as a priority requiring CHA, which are accordingly used as the starting point in this report to which other eligible species have been added:

Terrestrial Species:

- Egyptian Vulture (*Neophron percnopterus*);
- Sociable Lapwing (*Vanellus gregarius*)
- *Salsola omanensis* (Plant); and
- *Ochradenus harsusiticus* (Plant).

Marine Species:

- Arabian Sea humpback whale (ASHW; *Megaptera novaeangliae*);
- Sei whale (*Balaenoptera borealis*);
- Loggerhead turtle (*Caretta caretta*);
- Hawksbill turtle (*Eretmochelys imbricata*); and
- Green turtle (*Chelonia mydas*).

The Egyptian Vulture (*Neophron percnopterus*) occurs in the area of interest and was therefore included in the CHA. However, the findings of the assessment and expert opinion agree that this species occurs at such low density in the project area that habitats therein are not considered to be critical for this species at this time. The assessment concludes that the Egyptian Vulture should therefore be excluded as an important ecological feature of the project area, and no mitigation measures to ensure no net loss of this species is required in the biodiversity management plan.

The Sociable Lapwing (*Vanellus gregarius*) was also initially identified by the IESC as a priority species, but since it has not previously been recorded in the Duqm area (Jens Erikson pers. comm.[7]) it has been ruled out and is not given further consideration in the CHA.

Although vagrants cannot be ruled out, the weight of evidence (Robert Baldwin, pers comm.) indicates that it is unlikely that Sei whales commonly occur in the Arabian Sea. Unconfirmed reports from Oman are noted (Baldwin et al, 1999) but these anecdotal reports have been made in the absence of definitive, positive identification by cetacean experts, nor have they been verified by genetic or photographic evidence. No confirmed records are reported from Omani waters either from vessels, nor beach based surveys of the Sei whale are included in the Oman Cetacean Database (1985 - 2017). Furthermore the chief scientist of Soviet whaling vessels active in the area from 1963 to 1966 made no record of Sei whales in their capture of 2,385 baleen whales (Michalev et al, 2000). Their presence in the area of interest is therefore considered highly unlikely (Baldwin, 2003) and according to regional experts it is considered likely that reports of this species in the region are either vagrants or misidentifications (Dr G Minton, pers.comm, 23 July 2017).

However, during this assessment another endangered cetacean, the Indian Ocean humpback dolphin (*Sousa plumbea*), was identified as meeting the criteria for CHA and is included in the assessment below.

[7] Jens Erikson is a resident bird specialist managing the Oman Bird Records Database. The database reveals no records of Sociable Lapwing in the area. According to expert opinion there is no known suitable habitat for this species in the area or nearby.

3 RESULTS

3.1 TERRESTRIAL ENVIRONMENT

3.1.1 TERRESTRIAL CRITICAL HABITAT ASSESSMENT AREA

The Critical Habitat Assessment Area (CHAA) for terrestrial species is defined as all habitat potentially offering suitable ecological conditions for that species to breed, feed, shelter, commute, congregate or which contributes to any other element of its life history. The identification of potential suitable habitat is confined to habitat data presented in Technical Appendix B: Harmonised Habitat Mapping which is compiled from baseline information presented in the EIA studies listed in Table 2.1. The resulting CHAA encompasses all of the Project and Associated Facility (AF) footprint and a 0.25 km buffer zone around it. To this end the terrestrial CHAA is synonymous with the direct and indirect Areas of Influence (AoI) as described in the main assessment.

3.1.2 DISCRETE MANAGEMENT UNITS (DMU)

The delineation of discrete management units within the Duqm Special Economic Zone (Duqm SEZ) is based on ecological units that have more in common with each other than they do with those in adjacent areas. For further information refer to the harmonised habitat mapping (Technical Appendix B).

Table 3.1: Terrestrial discrete management units and associated biodiversity features

DMU	KEY BIODIVERSITY FEATURES[8]
Coastal habitats including mudflats, sand and lagoons	Important area for wading and migratory bird species
Coastal plains and dunes	Reptiles and the Oman-endemic plant, *Salsola omanensis*. Striped hyena may scavenge along the coastal belt
Coastal sabkha[9]	Scattered areas of vegetation supporting small mammals and reptiles
Gravel and sand plains	Highest diversity of reptiles including endemic Thomas' spiny-tailed lizard and regionally endemic Egyptian spiny-tailed lizard
Mountains and rocky terrain	Diversity of flora and important wildlife corridor for larger species such as gazelle and ibex. The Oman-endemic plant, *Salsola omanensis* may be present. Cliffs may be used by nesting Egyptian Vultures (in the future)
Wadis and other temporary watercourses	Higher diversity of flora including mature stands of *Prosopis cineraria* and *Acacia tortilis*, habitat for the Oman-endemic plant *Ochradenus harsusiticus*. Important habitat for wildlife including arthropods, reptiles, birds and mammals
Degraded or transformed land	Generally of limited biodiversity value

3.1.3 SCREENING OF BIODIVERSITY FEATURES

The terrestrial CHA has been restricted to consideration of a single bird species, the Egyptian Vulture and two endemic plant species. Table 3.2 below highlights the species included in the CHA and justification for their inclusion.

[8] For species, common and scientific names are tabulated in the results section of this report.
[9] Sabkah - an area of coastal flats subject to periodic flooding and evaporation which result in the accumulation of aeolian clays, evaporites, and salts, particular to North Africa and Arabia.

Table 3.2 also highlights a number of additional biodiversity features that potentially warrant CHA consideration at a strategic (SEZAD) scale. In the case of the plants listed in Table 3.2 many have not been recorded in the project area but are known to occur in central Oman and more specifically in the four quarter degree grid squares between 19.0° - 20.0° N and 57.0° - 58.0° E that includes or surrounds the SEZAD area. More detailed surveys would be required to accurately map the distribution of many of the species listed as detailed botanical survey data is not available. Information on species conservation statuses is based on the following sources (Fisher *et al* 1999; Mallon & Budd 2011; IUCN 2017; Patzelt 2014). With reference to the five terrestrial mammal species – consultation with Omani mammal experts identified a possibility that these species occur in the Duqm area on the basis that habitats which are present in the CHAA may be suitable to support them (see the main biodiversity assessment for additional baseline information on these species).

IFC PS6 guidance requires that key biodiversity areas are also subject to CHA. Key biodiversity areas are identified as being sites of high nature conservation value, defined using internationally recognized standards. In the context of the Project, the Duqm Important Bird Area (IBA) and the Jiddat al Harasis IBA qualify as key biodiversity areas because they are designated according to international standards defined by Wetlands International. However, both IBA sites are not assessed in this CHA in order to keep individual species (rather than assemblages of species) the sole focus of this document. Potential impacts are fully considered in the main biodiversity assessment where detailed baseline information for these IBAs is also presented.

Table 3.2: Biodiversity screening for terrestrial environment

Species/Feature	Feature type	Endemism (Oman or regional)	Oman status	Regional status	Global status	Included/Excluded from this assessment	Justification for inclusion/exclusion
Egyptian Vulture *(Neophron percnopterus)*	Bird	N/A	NE	NE	En[3]	Included	Included in this CHA. Of global conservation concern. Requested by the Lenders' IESC.
Sociable Lapwing (*Vanellus gregarius*)	Bird	N/A	NE	NE	CR[3]	Excluded	Identified by the Lenders IESC but there are no records of this species occurring in the vicinity of Duqm. All Omani records for this species are restricted to Sohar and Dhofar.
Steppe Eagle (*Aquila nipalensis*)	Bird	N/A	NE	NE	En[3]	Excluded	Not identified by the Lenders IESC. Only one recorded sighting. Unlikely to warrant strategic CHA consideration in the Duqm region
Saker Falcon (Falco cherrug)	Bird	N/A	NE	NE	En[3]	Excluded	Not identified by the Lenders IESC. Only one recorded sighting. Unlikely to warrant strategic CHA consideration in the Duqm region
Salsola omanensis	Plant	Endemic	NE	NE	VU[4]	Included	Included in this CHA. Endemic species of global conservation concern. Recorded in Port of Duqm boundary (5OES 2015). Under threat from development, livestock farming and road construction
Ochradenus harsusiticus	Plant	Endemic	NE	NE	VU[4]	Included	Included in this CHA. Endemic species of global conservation concern. Recorded in SEZAD boundary (5OES 2011). Under threat from development, livestock farming and road construction
Pycnocycla sp. nov.	Plant	Endemic	Dd	NE	NE[4]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region.
Campylanthus sedoides	Plant	Endemic	NE	NE	NT[4]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region. Not under threat.
Convolvulus oppositifolius	Plant	Endemic	NE	NE	NT[4]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region. Under no immediate threat
Pulicaria pulvinata	Plant	Endemic	NE	NE	NT[4]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region. Under no immediate threat
Striped hyena *(Hyaena hyaena)*	Mammal	N/A	CR[1]	EN[2]	NT[3]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm

SPECIES/FEATURE	FEATURE TYPE	ENDEMISM (OMAN OR REGIONAL)	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/EXCLUDED FROM THIS ASSESSMENT	JUSTIFICATION FOR INCLUSION/EXCLUSION
							region.
Arabian wolf (*Canis lupus arabs*)	Mammal	N/A	EN[1]	EN[2]	LC[3]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region.
Rüppell's sand fox (*Vulpes rueppellii*)	Mammal	N/A	EN[1]	LC[2]	LC[3]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region.
Caracal (*Caracal caracal*)	Mammal	N/A	EN[1]	LC[2]	LC[3]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region.
Ibex (*Capra ibex)*	Mammal	N/A	EN[1]	NE	VU[3]	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration in the Duqm region.
Duqm Important Bird Area	Key Biodiversity Area	N/A	N/A	N/A	N/A	Excluded	Assessed in the main biodiversity impact assessment not in this CHA.
Jiddat Al Harasis Important Bird Area	Key Biodiversity Area	N/A	N/A	N/A	N/A	Excluded	Assessed in the main biodiversity impact assessment not in this CHA.

[1] Fisher et al 1999
[2] Mallon & Budd 2011
[3]IUCN 2017
[4]Patzelt 2014

3.1.4 EGYPTIAN VULTURE

LIFE HISTORY AND ECOLOGY

The Egyptian Vulture typically nests on ledges or in caves on cliffs, crags and rocky outcrops, but occasionally also in large trees, and exceptionally on the ground (Gangoso and Palacios, 2005). It forages in lowland and montane regions over open, often arid, country. It also scavenges at human settlements. The Egyptian vulture has a broad diet including carrion, tortoises, organic waste, insects, young vertebrates, eggs and even faeces (Margalida et al., 2012). It is usually solitary, but will congregate at feeding sites, such as rubbish tips.

CONSERVATION STATUS

The Egyptian Vulture is a medium-sized avian scavenger that is globally endangered (BirdLife International, 2017). Published information puts the Oman population of breeding Egyptian Vulture at around 100 pairs (Jennings, 2010). However, recent work on Masirah Island (about 110 km north-east of Duqm) estimated the population on that island alone to be 65-80 pairs (Angelov et al., 2013), suggesting a larger national breeding population. The previous estimate of the breeding Egyptian Vulture population on Masirah was of 12 pairs (Rogers, 1988). The new estimate makes Masirah the second-most dense known population of breeding Egyptian Vultures in the world. Only Socotra Island, Yemen, is more densely populated. It is not known whether the Oman population of Egyptian Vultures has increased, or whether higher recent population estimates are the result of better survey work. Generally speaking, information on numbers of breeding vultures in Oman is lacking.

Electrocution of Egyptian Vultures and other large birds is a conservation problem. The impact of electrocution on some bird species, especially endangered ones, can be significant. The risk and impact of this threat has increased over the years as electricity infrastructure has expanded. Electrocution events can also cause power outages, which affect end users and can increase transmission costs.

There is evidence that Egyptian Vultures are sometimes electrocuted in Oman, though the extent of the problem has not been quantified (http://egyptianvultureoman.blogspot.co.at/). Electrocution incidents are known to have occurred at oil production camps in Oman, resulting in damage to equipment, lost production time and death of birds (Petroleum Development Oman, unpublished data). Solutions have been found by power transmission and distribution companies, users and conservationists, and can be particularly cost effective, if implemented early in development (APLIC 2006, http://www.aplic.org/mission.php).

It appears that other threats to Egyptian Vultures are either not operative or not significant in Oman, including the Duqm area. Because there is apparently no breeding population near Duqm, nest disturbance and persecution of breeders is not an issue. Firearms are not widely used, though some poaching of wildlife is known to occur. Although Omanis have a generally negative view of Egyptian Vultures (local name: *Rahma*), this does not usually translate into direct persecution, poisoning or shooting. Low human populations across much of the country and local animal husbandry methods suggest that inadvertent or targeted poisoning may be low.

Increasing human population at Duqm will mean a larger volume of organic waste, which the government will want to dispose of in a manner that promotes human health. A larger volume of waste, if available to vultures, will be an attractant, and may provide a foothold for future breeding birds or the regular use of rubbish dumps at Duqm by non-breeding birds. At the very least, an increase in biological waste might attract small numbers and single transient birds.

In recent decades global Egyptian Vulture populations have suffered huge declines. The main causes for the declines are targeted and inadvertent poisoning, electrocution, hunting/persecution, and changes in food availability. As a group, vultures are under threat.

Declines have occurred in 15 of the 16 vulture species in Europe, Asia and Africa, a situation which is driving the urgent development of a multi-species conservation action plan being coordinated by the Convention on Migratory Species (CMS). At a recent regional workshop to develop that action plan (Sharjah, February 2017), Oman was identified by local and international experts as particularly important because of its breeding population, its large wintering population, and that it is apparently fairly benign in terms of the main threats being faced by vultures.

GLOBAL AND NATIONAL DISTRIBUTION

The species has a huge global distribution, extending from the Iberian Peninsula across to central Asia, south to India, Arabia and large parts of Africa, mostly north of the equator. In southern areas Egyptian Vultures are year-round residents; in the north, they are migratory. Migratory birds winter mostly in Arabia and Africa. Young Egyptian Vultures from migratory populations will spend at least their first 1.5 years in southern areas (i.e. they do not undertake migration in their first spring, at least) (Oppel et al 2015, BirdLife International 2017, Vulture Conservation Foundation https://www.4vultures.org/2017/04/19/egyptian-vulture-rupis-is-home/).

DISTRIBUTION WITHIN CHAA

There is no published information that suggests the Duqm area to be currently important to Egyptian Vultures, either as a place to nest or as an area that might support pre-breeding or migratory birds. Masirah Island, approximately 125 km from Duqm, is the nearest concentration of breeders, and breeding has been confirmed (probably of a single pair) at Jaaluni (about 70 km west) (Eriksen & Victor 2013). Although no vultures seem to breed nearby, cliffs in the Duqm area are probably suitable for Egyptian Vulture nesting. It is important to note that changes resulting from the development of Duqm may attract Egyptian Vultures and other scavenging birds, and so the potential for impact may change over time. Resident species attracted to Duqm (i.e. Egyptian Vulture and Lappet-faced Vulture) could potentially set up territories and attempt to breed.

Egyptian Vultures breed on ledges and in holes in cliffs. Nesting cliffs need not be very high. The main breeding areas in Oman are where cliffs exist on Masirah Island and in the mountains in northern Oman (Eriksen & Victor 2013). Egyptian Vultures may nest in other parts of Oman, but if so at low densities, reflecting the lack of food and the absence of cliffs in which to nest and roost. Nesting Egyptian Vultures are territorial. In high density areas Egyptian Vulture territories may be separated by hundreds of meters, in low density areas there could be tens of kilometers between nests.

Like most scavengers, Egyptian Vultures can forage over huge areas, especially when not tied to a nest during breeding. This allows them to survive in areas where food availability is unpredictable. Egyptian Vultures in Oman tracked via satellite used an area that extended over more than 11,000 square km in the course of a year (Dr. Mike McGrady unpubl. data).

In places across their global distribution, Egyptian Vultures are commensal with humans. They are often associated with nomadic camps, and forage at abattoirs and rubbish dumps in villages and towns. In southern areas (i.e. Arabia, Africa and India) during the non-breeding season, (sometimes very large) aggregations of migrant and resident Egyptian Vultures gather at rubbish dumps. In recent decades such aggregations have occurred at rubbish dumps and landfills in Oman, and some landfills in the sultanate are internationally recognized as important to Egyptian Vultures and other scavenging birds (eagles and vultures) of conservation concern (Al Fazari and McGrady 2016).

KNOWLEDGE GAPS

It is not known whether the Oman population of Egyptian Vultures has increased, or whether higher recent population estimates are the result of better survey work. Generally speaking, information on numbers of breeding vultures in Oman is lacking, including specific numbers for the Duqm area, if any. The national (Omani) Egyptian Vulture survey that is currently run in partnership with the Environment Society of Oman (since 2012) is designed to fill this knowledge gap.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

Although Egyptian Vultures are listed globally, at present Duqm is not assessed to be an important area for the species. On that basis it is difficult to designate the natural (cliffs for nesting) or modified habitats (waste disposal sites and settlements for foraging) in the Duqm region as meeting either Tier 1 or Tier 2 critical habitat criteria. This species has therefore been excluded from further consideration in the management of critical biodiversity.

In the future landfill sites catering for a larger volume of waste (if available to the birds) may act as an attractant for breeding or non-breeding birds. With this in mind landfill sites and the mountainous and rocky terrain, especially that between Duqm and Ras Madrakah and further inland (in particular cliffs of the rocky mountain and escarpment) could meet critical habitat for this species in the future.

3.1.5 SALSOLA OMANENSIS

LIFE HISTORY AND ECOLOGY

Salsola omanensis is a shrub that grows to a height of 50 cm (Ghazanfar, 2003). It occurs on limestone plateau, limestone cliffs and coastal plains ranging from 50-300m above sea level (Patzelt, 2014). It flowers/fruits in October (Ghazanfar, 2003). Little else is known about the ecology of the species.

CONSERVATION STATUS

The species is listed as by the IUCN Red List as Vulnerable with an observed, estimated, inferred, projected or suspected population reduction. Detailed information pertaining to the Omani status of this species is lacking. Key threats include development, agriculture (in particular livestock farming) and recreational activities that may lead to habitat destruction/degradation (Patzelt, 2014). Loss of habitat resulting from infrastructure development is listed as a key concern (*ibid*.).

GLOBAL AND NATIONAL DISTRIBUTION

Salsola omanensis is endemic to Oman. It reportedly occurs throughout the country including central Oman, the offshore island of Al Hallaniyah and the Sahil al Jazir coast but its abundance is classified as not common (Ghazanfar, 2003; Patzelt, 2014). It inhabits limestone plateaux, limestone cliffs and coastal plains (Patzelt, 2014).

DISTRIBUTION WITHIN CHAA

The presence of *Salsola omanensis* within the CHAA was not documented in the Duqm Refinery Project and Associated Facilities EIAs or the Industrial Development Zone (IDZ) EIA (5OES 2011). However, specimens were encountered during the Port of Duqm winter ecological baseline survey (5OES, 2015) around N19.644106 E57.694306. These specimens were positively identified as *S. omanensis* (J. Henrot pers. comm. 2015). This area in the Port has been earmarked for development and was already surrounded by modified habitat at the time the 2011 survey was conducted.

KNOWLEDGE GAPS

Little information is currently available relating to the ecology and distribution of the species. Detailed surveys would be required to identify the population size, distribution and conservation measures (Patzelt 2014).

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

Only limited information exists regarding the presence of *Salsola omanensis* in the CHAA. However, the limestone cliffs and plateaux of the mountains and rocky terrain DMU together with coastal plains may potentially qualify as Tier 2 critical habitat on the basis that they are likely to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement.

3.1.6 OCHRADENUS HARSUSITICUS

LIFE HISTORY AND ECOLOGY

Ochradenus harsusiticus is a spiny shrub that grows to a height of 50cm (Ghazanfar, 2003). It occurs in open *Acacia tortilis* - *Prosopis cineraria* woodland of sandy and gravelly depressions and wadi habitats (Ghazanfar, 2003; Patzelt, 2014). It fruits and flowers between November and April (Ghazanfar, 2003).

CONSERVATION STATUS

The species is listed as globally Vulnerable by the IUCN Red List reflecting continuing decline in the area of occupancy and area, extent and/or quality of habitat. Detailed information pertaining to the Omani status of this species is lacking (Patzelt, 2014).

Key threats include infrastructure development, agriculture (in particular livestock farming) and road construction that may lead to habitat destruction/degradation (Patzelt, 2014). The wadis are already subject to some modification but are resilient and will recover if stress factors are limited. However, this habitat will not recover if large swathes are destroyed through the removal of mature stands of vegetation and/or alteration to natural drainage patterns and hydrology..

GLOBAL AND NATIONAL DISTRIBUTION

Ochradenus harsusiticus is endemic to Oman and more specifically the sandy and gravelly soils of central Oman (including the limestone plateau of the Jiddat Al Harasis) (Ghazanfar 2003; Patzelt 2014).

DISTRIBUTION WITHIN CHAA

Ochradenus harsusiticus was noted during the refinery and service corridor studies (referenced as HMR 2015a and HMR 2015e, respectively in the Biodiversity chapter), however, details of where the species occurred were not provided. Since the refinery footprint is now entirely modified it is extremely unlikely that the species is still present if they were located on the prepared ground. A few specimens of this species were also recorded in a shallow wadi less than 1 km from the sea between two areas of dense vegetation (N19.78598 E57.71176) approximately 5.8 km north-north-east of the refinery boundary during the IDZ survey (5OES 2011).

KNOWLEDGE GAPS

Little information is currently available relating to the ecology and distribution of the species. Detailed surveys would be required to identify the population size, distribution and conservation measures (Patzelt, 2014).

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

Only limited information exists regarding the presence of *Ochradenus harsusiticus* in the CHAA. However, the sandy and gravelly wadis associated with open terrain populated by *Acacia tortilis* and *Prosopis cineraria* could potentially support populations of this species, and on this basis, they could qualify as Tier 2 critical habitat because they might sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement. 5OES (2011) concluded that the wadi habitats within the SEZAD area support the most diverse array of fauna and flora including mature stands of *Prosopis cineraria* and *Acacia tortilis* and are most likely to support this species.

3.1.7 TERRESTRIAL ENVIRONMENT CRITICAL HABITAT SUMMARY

Tier 2 critical habitat for the two Oman-endemic plant species assessed in this CHA may occur in the CHAA on the basis that the CHAA could sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement. Detailed academic research on the habitat preferences of the two assessed plant species is not available, however, available evidence suggests that their critical habitat comprises the following DMUs in the CHAA:

- *Salsola omanensis* - limestone plateau, limestone cliffs and coastal plains ranging from 50 - 300m above sea level (likely to best correspond to the mountains and rocky terrain and coastal plains and dunes DMUs);
- *Ochradenus harsusiticus* - sandy and gravelly depressions and wadi habitat in association with *Acacia tortilis* - *Prosopis cineraria* woodland (likely to best correspond to the wadis and other temporary watercourses DMU); and

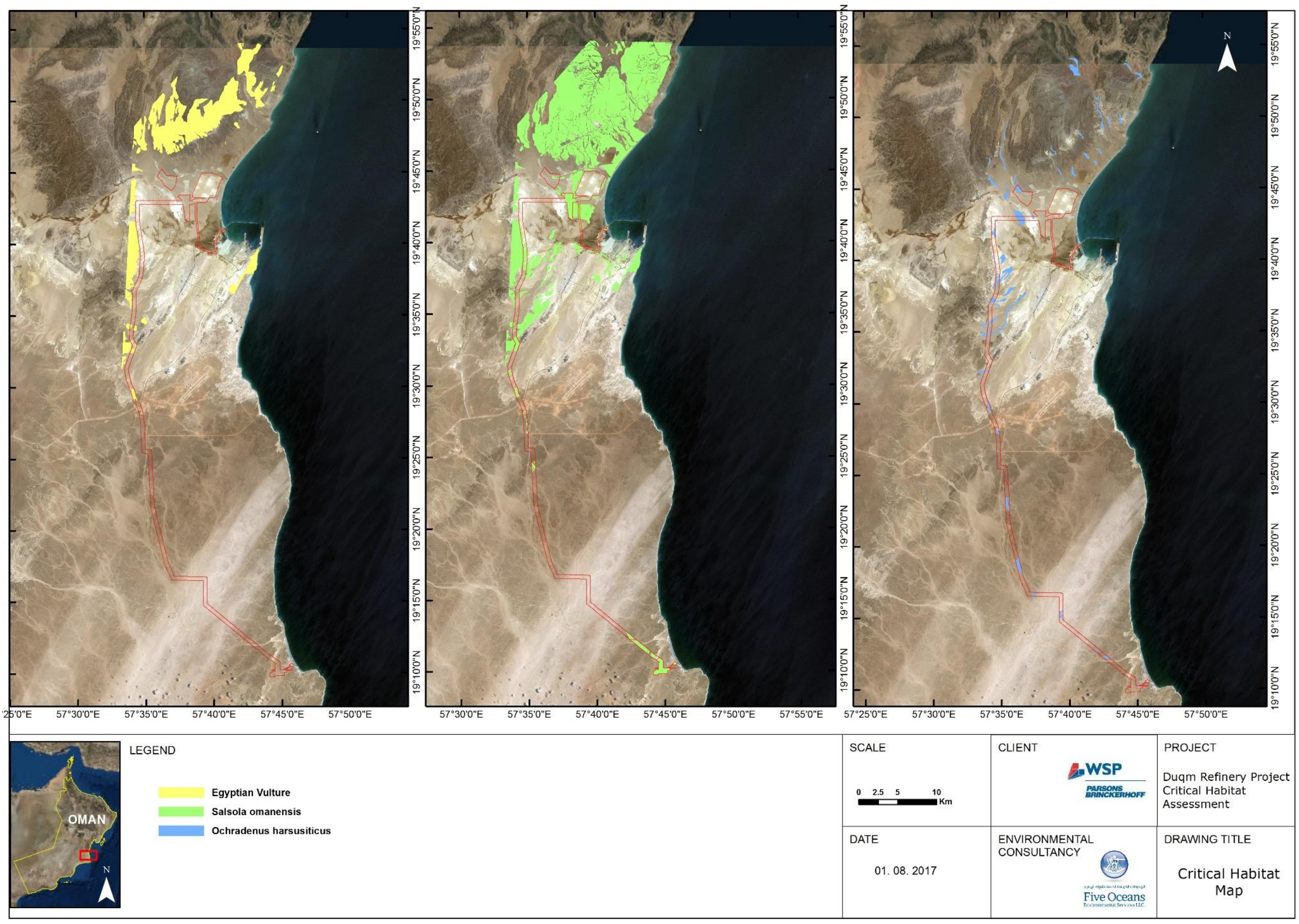
In the case of the Egyptian Vulture, although this species is listed globally as Vulnerable, at present Duqm is not assessed to be an important area for the species and the CHAA is unlikely to contain either Tier 1 or Tier 2 critical habitat. It is noted that, in the future the species could colonise the area in association with increased scavenging opportunities associated with refuse disposal facilities. Suitable nesting habitat could, in the future, comprise cliffs in the mountains and rocky terrain DMU – although there is no evidence of nesting in the CHAA at present.

Using information on likely habitat preferences of the three assessed species and their corresponding DMUs, Figure 3.1 shows the distribution of potential critical habitat for the four assessed species in the CHAA. The distribution of critical habitat represents has been inferred based on potential habitat suitability for these species and not their actual distribution. The critical habitat mapping is restricted to areas for which prior habitat mapping is available namely the CHAA which is informed by the Duqm Industrial Zone IEA (5OES 2011), the Port EIA (50ES 2015) and Duqm Refinery and Associated Facilities EIA. The habitat mapping methodology and findings, which form the basis of the DMU mapping, is provided in Technical Appendix B: Harmonised Habitat Mapping).

Figure 3.2 shows the combined critical habitat for the four assessed species. In the legend for Figure 3.2 - low refers to areas where one of the species may potentially occur; medium for areas where two of the species may overlap; and high for areas where three species may overlap. No area exists where all four may possibly occur. Critical habitats within the footprint are predominantly assessed to be low or medium. As can be seen from Figure 3.2, the majority of potential critical habitat – four the three plant species and Egyptian vulture - lies outside the footprint of the Duqm Refinery and the Associated Facilities footprint.

There are 163 locations where the Project footprint overlaps an area of potential critical habitat for the two assessed plant species – the list of locations is provided at the end of this document.

Egyptian vulture is omitted from Table 3.3 as there is no evidence that it is currently present in the CHAA.



3.1.8

Figure 3-1: Distribution of critical habitat for the three terrestrial species assessed.

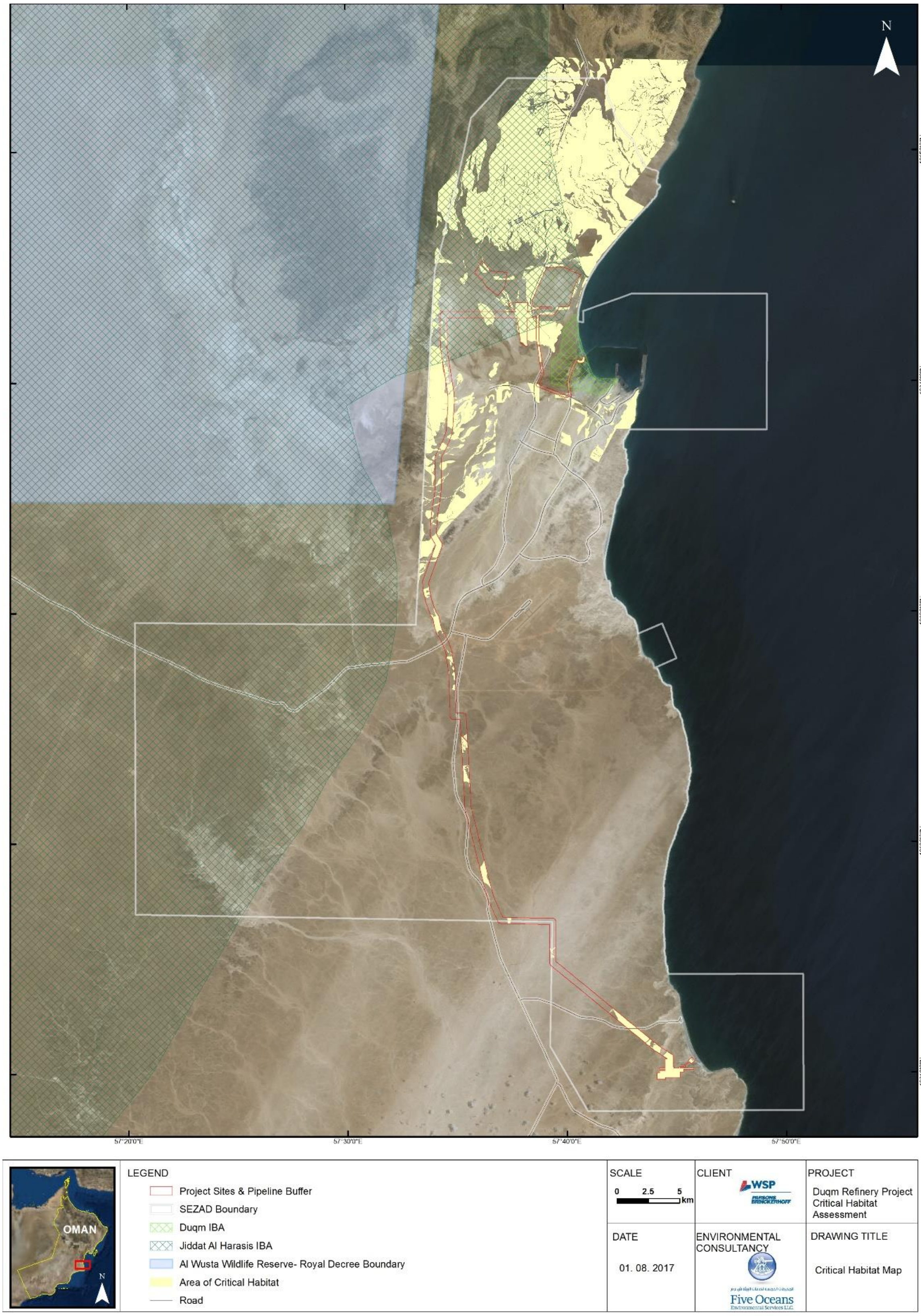


Figure 3-2: Combined critical habitat mapping for the three species included in the assessment.

3.2 MARINE ENVIRONMENT

3.2.1 MARINE CRITICAL HABITAT ASSESSMENT AREA

For assessment of the marine environment an initial step in the process was to define the CHAA using GIS analysis of data presented in previous EIA studies listed in Table 2.1. The relevance of project elements in defining the CHAA was directed by GN5 of PS6 that states:

> "*At a minimum, the client should screen and assess the risks to and potential impacts on biodiversity and ecosystem services in the project area of influence, taking into account the following: (i) the location and scale of project activities, including those of associated facilities; (ii) its supply chains (as required in paragraph 30 of Performance Standard 6); (iii) the project's proximity to areas of known biodiversity value or areas known to provide ecosystem services; and (iv) the types of technology that will be used…"*

The maximum extent of the CHAA from information available was ultimately defined by the ESIA dated October 2015 for the OTTCO Ras Markaz Crude Park, an Associated Facility, It should be noted that only eight tanks at the Ras Markaz facility will be used exclusively for the Project and therefore liability for spills arising from the facility are shared between the project owner and third parties. However, as no specific oil spill scenario for the eight dedicated project tanks was provided in the ESIA the precautionary principle was applied and the worst case presented in the EIA was used to define the area of influence for the project. It should be noted that adopting a Project focussed assessment, the 'worst case' scenariois potentially unrealistic given that the DRPIC crude oil storage tanks are approximately 1.7 km from the coast and the chances of oil spilling directly from the DRPIC part of the tank storage facility is low. However, to ensure a robust assessment available modelling for the whole tank storage facility (including the majority of the site which will be managed by OTTCO) has been used.

Annex 13 of the Ras Markaz ESIA presents a Tier 3 oil spill model (60,000 m^3) which suggests potential impacts covering a wide geographic area which represents the area of influence since it encompasses the footprint of all other potential impacts. **Error! Reference source not found.** shows the combined winter and summer oil dispersion models based on a 60,000m^3 spill from the Ras Markaz tanker terminal single point mooring (SPM) (OTTCO, 2015). The full extent ranges over 250 km to the north, 170 km to the south and a maximum offshore distance of 85 km. The seaward extent of the spill model aligns approximately with the 200 m depth contour, which also coincides with DMU boundaries described in the section below. At least one SPM will have the capacity to receive oil from Ultra Large Crude Carriers OTTCO, 2015) which can transport over 550,000 m^3 (Evanelista 2002), and therefore the spill model used for this exercise does not represent the very worst case scenario of a spill from a single vessel at the Ras Markaz site.

Fully developed impact scenario assessments that account for noise, wildlife strikes and spills from ships in transit through the Gulf of Masirah (associated with AFs) were not available to inform this CHA. The potential oil spill area has been adopted as a pragmatic CHAA which is likely to capture the spatial extent of the majority of other potential direct and indirect impacts associated with the Refinery, the off-site facilities or the AFs. This approach confers with paragraph GN64 in the IFC GN6 guidance document which recommends that CHAs extend beyond the immediate project site where biodiversity attributes and ecological processes dictate. This approach was also adopted to define the maximum direct and indirect Area of Influence (AoI) for the marine environment which is outlined in the main assessment.

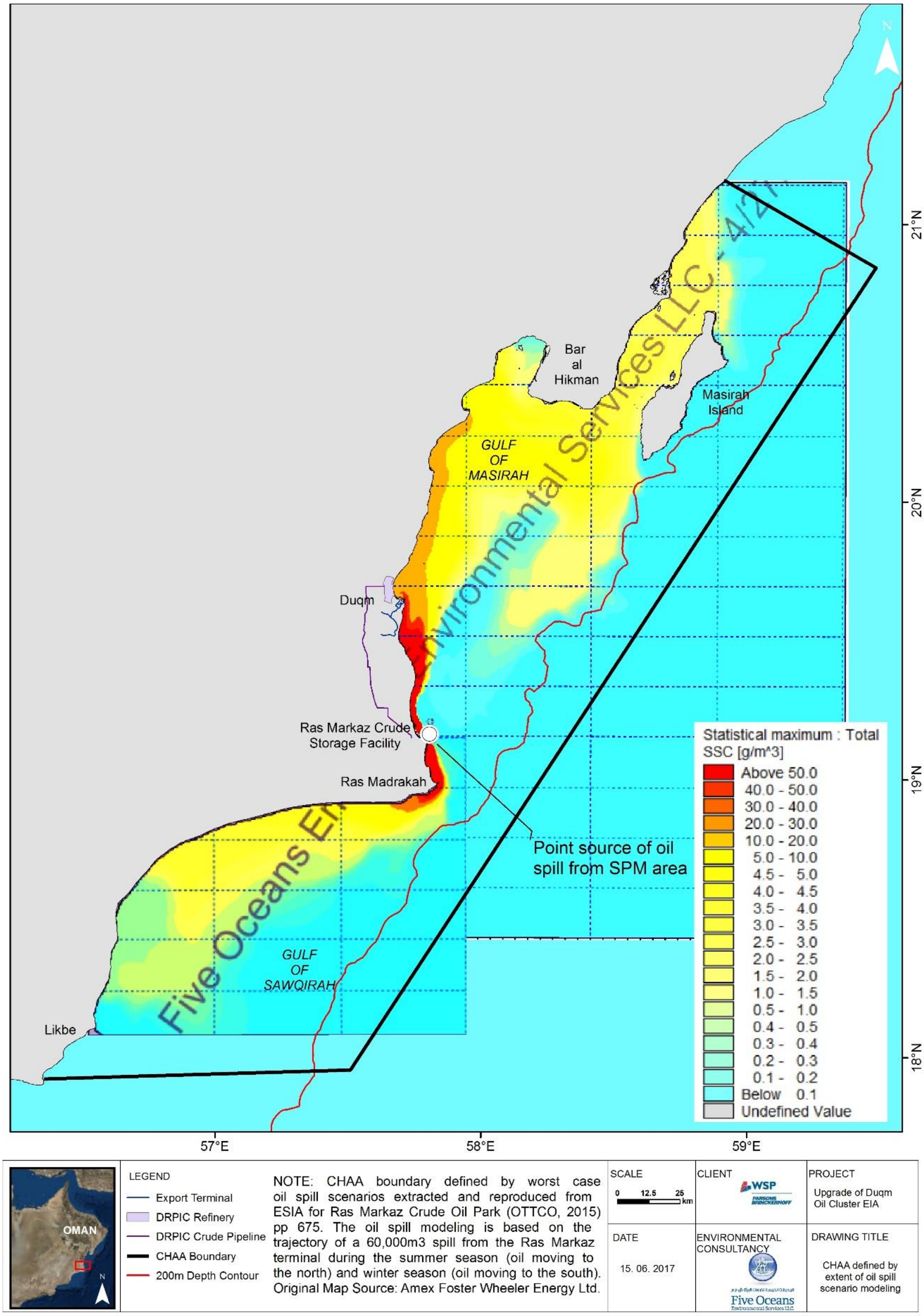


Figure 3-3: Geographic extent of marine CHAA as defined by 60,000 m^3 oil spill from SPM at Ras Markaz.

3.2.2 Discrete Management Units

Discrete management units (DMUs) are defined by the spatial extent of physical and biological features within the CHAA. DMU's were thematically defined through preliminary screening of the ecology of specific biodiversity features within the CHAA including an overlap with terrestrial DMUs in the nearshore and intertidal zone, as well as shallow coastal waters, deep water over shelf areas and oceanic water as detailed in Table 3-3. The spatial extent of DMUs is defined by bathymetry which is natural biogeographic feature delineating changes in ecological features in the marine environment. Enclosed within the CHAA boundary, the marine DMUs follow depth contours as depicted in **Error! Reference source not found.** below.

Table 3-3: Marine discrete management units and associated biodiversity features

DESCRIPTION	DEPTH	POTENTIAL MARINE BIODIVERSITY FEATURES[10]
Nearshore and intertidal habitat	Lowest Astronomical Tide (LAT) 0m	• Turtle nesting sites • High biomass and high biodiversity mudflats • Bird wading and foraging
Shallow coastal habitat	0 - 20m	• Sea-grass beds • Hard coral reef environments • Green, hawksbill and loggerhead turtle foraging areas and/or interesting habitat • Reef associated demersal (bottom-dwelling) fish resources • Coastal dolphin habitat • Humpback whale potential nursery habitat
Deep water shelf habitat	20 – 200m	• Deep water benthic habitats including soft corals (octocorals) • Principle humpback whale habitat • Pelagic fish resources • Turtle migratory habitat
Oceanic habitat	>200m	• Oceanic cetacean species • Humpback whale migratory habitat • Pelagic fish resources • Turtle migratory habitat

[10] Many of the habitats listed are in the wider CHAA. They are not present in the Project footprint.

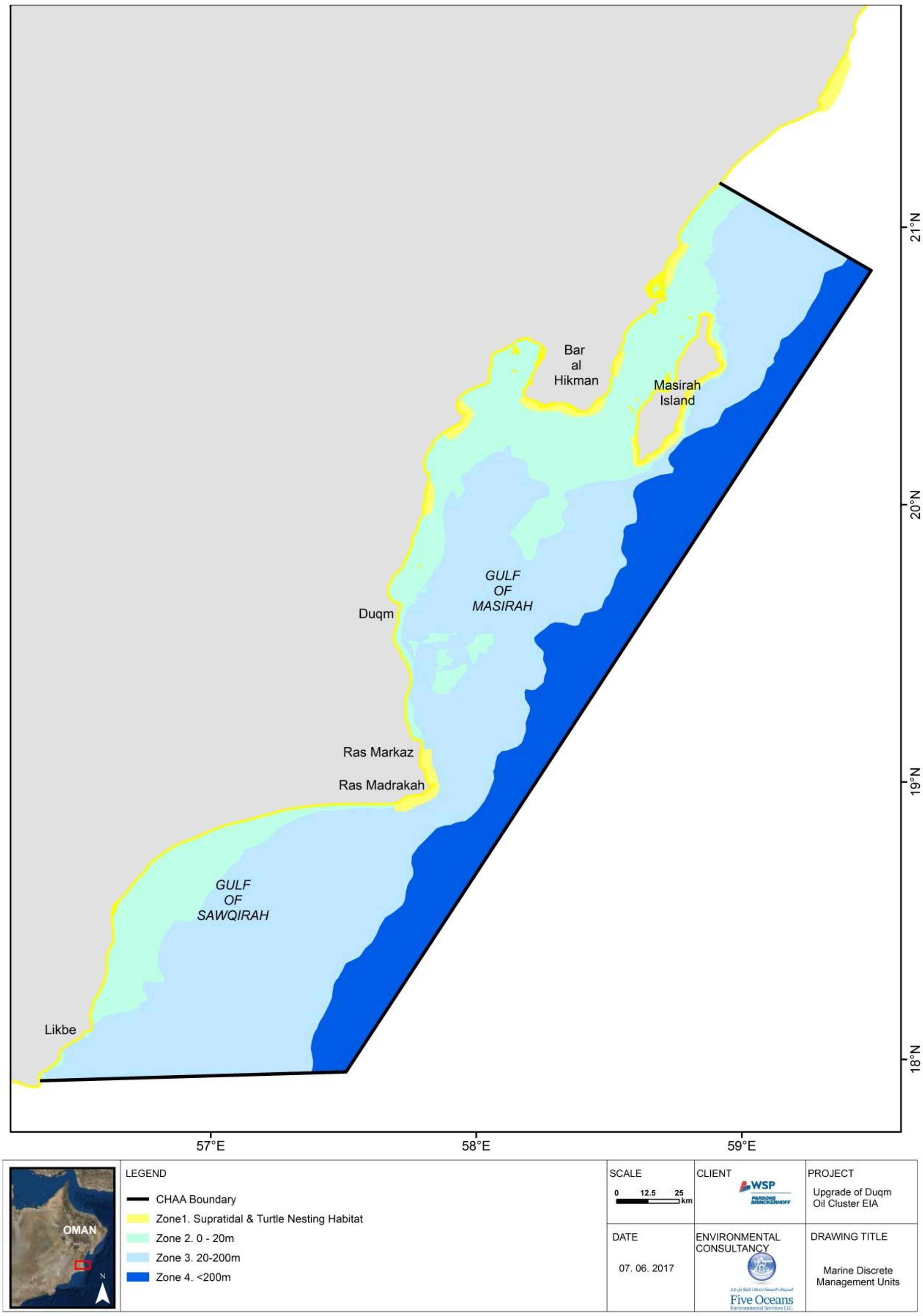


Figure 3-4: Marine Discrete Management Units (DMUs)

3.2.3 Screening of Biodiversity Features

The marine CHA was limited to the two cetacean species (ASHW and Indian Ocean humpback dolphin) and three turtle species (hawksbill, loggerhead and green turtles). Table 3-4 also presents other species of high biodiversity value, extracted from EIA reports for the project and associated facilities (Table 2.1), that potentially warrant CHA consideration at a wider scale than the Project (e.g. the Gulf of Masirah scale). More detailed field surveys are required to enable CHA for many of the listed species as they remain data deficient. Additionally other important taxa not considered within relevant EIAs but which are relevant to the CHA include the scalloped hammerhead (*Sphyrna lewini*), great hammerhead (*Sphyrna mokarran*) and the narrow sawfish (*Anoxypritis cuspidate*). These three species are all noted on the IUCN Red List as Endangered (Jedabo and Ebert, 2015) and highlights the requirement to ensure marine species are given opportunity for more detailed review beyond findings of previous EIAs. Insufficient data on these biodiversity features is available at the present time to develop appropriate and effective mitigation (if required), noting that these issues sit largely outside the scope of the Present scope and relate to wide-scale commercial use of the marine zone (e.g. fishing).

Table 3-4: Biodiversity screening for marine environment

SPECIES	FEATURE TYPE	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/ EXCLUDED	JUSTIFICATION FOR INCLUSION/ EXCLUSION
Arabian long-beaked common dolphin *Delphinus capensis tropicalis*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Blue Whale *Balaenoptera musculus*	Cetacean	NE	NE	EN	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Bryde's Whale *Balaenoptera edeni*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Cuvier's beaked whale *Ziphius cavirostris*	Cetacean	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Dwarf sperm whale *Kogia sima*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
False killer whale *Pseudorca crassidens*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Humpback whale *Megaptera novaeangliae*	Cetacean	NE	EN	LC	Included	Identified by the Lender's IESC Regional population Endangered IUCN Red List
Indian Ocean humpback dolphin *Sousa plumbea*	Cetacean	NE	NE	EN*	Included	Not identified by the Lenders IESC but included in the CHA as a representative species subject to potential impacts arising from the Project and AFs. Global population assessed as Endangered (*in review)

SPECIES	*FEATURE TYPE*	*OMAN STATUS*	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/ EXCLUDED	JUSTIFICATION FOR INCLUSION/ EXCLUSION
Indo-pacific bottlenose dolphin *Tursiops aduncus*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Orca *Orcinus orca*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Pygmy killer whale *Feresa attenuata*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Risso's Dolphin *Grampus griseus*	Cetacean	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Rough toothed dolphin *Steno bredanensis*	Cetacean	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Sperm Whale *Physeter macrocephalus*	Cetacean	NE	NE	VU	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Spinner Dolphin *Stenella longirostris*	Cetacean	NE	NE	DD	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Pantropical Spotted Dolphin *Stenella attenuata*	Cetacean	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Hawksbill turtle *Eretmochelys imbricata*	Turtle	NE	NE	CR	Included	Identified by client. Global population Critically Endangered IUCN Red List

SPECIES	FEATURE TYPE	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/ EXCLUDED	JUSTIFICATION FOR INCLUSION/ EXCLUSION
Green turtle *Chelonia mydas*	Turtle	NE	NE	EN	Included	Identified by client. Global population Endangered IUCN Red List
Leatherback turtle *Dermochelys coriacea*	Turtle	NE	CR	VU	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Loggerhead turtle *Caretta caretta*	Turtle	NE	CR	VU	Included	Identified by client. Regional population Critically Endangered IUCN Red List
Olive Ridley turtle *Lepidochelys olivacea*	Turtle	NE	NE	VU	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Oman Butterflyfish *Chaetodon dialeucos*	Fish	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Yellow-bellied sea snake *Pelamis platura*	Snake	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Diploastraea favus*	Hard coral	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Favites pentagona*	Hard coral	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Cabage Coral *Montipora foliosa*	Hard coral	NE	NE	NT	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.

SPECIES	FEATURE TYPE	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/ EXCLUDED	JUSTIFICATION FOR INCLUSION/ EXCLUSION
A coral species *Platygyra daedalea*	Hard coral	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Plesiastrea versipora*	Hard coral	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Porites lobata*	Hard coral	NE	NE	NT	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Stylophora pistillata*	Hard coral	NE	NE	NT	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Turbinaria mesenterena*	Hard coral	NE	NE	VU	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A coral species *Turbinaria peltata*	Hard coral	NE	NE	VU	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Cabbage leather coral *Sinularia brassica*	Soft Coral	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Arabian cushion star *Culcita coriacea*	Marine Fauna	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Spiny cushion star *Culcita schmideliana*	Marine Fauna	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Indian Sea Star	Marine Fauna	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species

SPECIES	FEATURE TYPE	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS	INCLUDED/ EXCLUDED	JUSTIFICATION FOR INCLUSION/ EXCLUSION
Fromia indica						potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
A starfish *Linckia multifora*	Marine Fauna	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Lollyfish *Holothuria atra*	Marine Fauna	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Tiger-tail sea cucumber *Holothuria hilla*	Marine Fauna	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
White thread fish *Holothuria leucospilota*	Marine Fauna	NE	NE	LC	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.
Macroalgae *Nizamuddinia zanardinii*	Macroalga	NE	NE	NE	Excluded	Not identified by the Lenders IESC but species potentially requiring strategic CHA consideration, considering all commercial and non-commercial uses of the marine zone.

3.2.4 ARABIAN Sea Humpback Whale

LIFE HISTORY AND ECOLOGY

The high primary productivity associated with the monsoon-driven upwelling in the Arabian Sea creates conditions suitable for feeding by large whales at latitudes more typically associated with breeding (Reeves et al. 1991; Mikhalev 1997; Papastavrou & Van Waerebeek 1997; Baldwin 2000). Whaling data and recent scientific research confirm that this includes a small and isolated subpopulation of humpback whales (Minton et al. 2008, Minton et al. 2011). Recent genetic analyses confirm that this subpopulation is significantly distinct from other humpback whale populations, and has been isolated for an estimated 70,000 years (Pomilla et al., 2014).

CONSERVATION STATUS

The IUCN Red list classifies Humpback whales globally as Least Concern. In the northern Indian Ocean (NIO), however, they are recognised by the IUCN Red List as geographically, demographically and genetically isolated (Minton et al. 2008) and are referred to as ‘Arabian Sea humpback whales’. This subpopulation is officially listed as ‘Endangered’ (Minton et al., 2008).

The global population abundance of humpback whales is currently undefined by IUCN status assessments (Reilly et al., 2008), but is estimated at over 80,000 individuals. The most recent assessment of the Arabian Sea population in Oman indicates a population of ASHWs of just 82 individuals (95% CI 60-111) and it has been speculated that this sub-population may be in decline (Minton et al., 2008).

Threats to whales in the region are well documented, and include accidental entanglement in fishing gear (Minton et al., 2011; Anderson, 2014; Sutaria et al., 2017; and Moazzam & Nawaz, 2017), ship strike and disturbance from underwater noise created by the shipping and transport industries, as well as coastal and offshore construction, seismic exploration and offshore oil and gas production (Baldwin et al., 2016b). Images of whales photo-identified in Oman between 2000 and 2003 demonstrate that 30-40% have scarring consistent with entanglement in fishing gear (Minton et al., 2011) and fishing effort, particularly that using gillnets, the gear known to cause the greatest risk to humpback whales (Johnson et al., 2005), is on the rise in Oman and many other parts of the region (Oman Department of Statistics, 2013; FAO, 2016; Anderson, 2014).

Globally, humpback whales are the cetacean species second most at risk from ship strike (Vanderlaan & Taggert, 2007). This is pertinent as the Arabian region hosts some of the busiest shipping lanes in the world. A threefold increase of container shipping traffic has been noted from the Arabian Sea between 2004 and 2014 (Willson et al., 2016b).

ASHWs may also be more susceptible to disease: nearly 70% of examined whales from Soviet whaling catches in the Arabian Sea in the 1960’s showed liver anomalies (Mikhalev, 2000b) and over 20% of examined whales from Oman displayed signs of Tattoo-like skin disease, with a significantly increasing trend between 2000 and 2011 (Van Bressem et al., 2014). This regionally resident population of whales may also be more vulnerable to climate change if shifts in oceanographic conditions affect productivity in their restricted Northern Indian Ocean range (Thomas et al., 2015).

The International Whaling Commission’s (IWC) Scientific Committee has repeatedly reiterated that this population is at great risk and requires significant collaborative conservation efforts to both prevent further decline and to promote recovery of the population (e.g. IWC, 2016b). Despite these designations and recommendations, conservation efforts to date have been minimal, piecemeal and lacking coordinated government support.

GLOBAL AND NATIONAL DISTRIBUTION

Humpback whales are found in all major oceans and noted as a cosmopolitan species (Clapham and Mead 1999) and are divided into separate management units by IUCN (also referred to as 'stocks' by the IWC).

The current known distribution of the ASHW includes the waters of Oman, Yemen, Iran, Pakistan and India with potential for occurrence in other states of the NIO region. Almost all data to date, however, has come from the results of research in Oman (Brown, 1957; Mikhalev, 2000; Minton et al. 2008; Reeves et al., 1991; Slijper et al., 1964; Wray and Martin, 1983; Yukhov, 1969; Baldwin 2003, and others).

Species distribution modelling and ecological niche modelling derived from Oman-based studies indicates a distribution around the periphery of the Arabian Sea with a core area along the central and southern coastline of Oman (Willson et al., 2017). Models were run using vessel based sightings data and satellite telemetry with the output of three separate model algorithms combined into an 'ensemble model' using environmental covariate data. The distribution models fit broadly with distribution of whale capture by Soviet whaling fleets between 1962 and 1966 (Figure 3-5) allowing for the fact that no information is available on the relativel effort spend whaling in different areas hence the catch density off the Pakistani coast may be biased. This information was reviewed by the IWC Scientific Committee in 2017 (IWC, 2017).

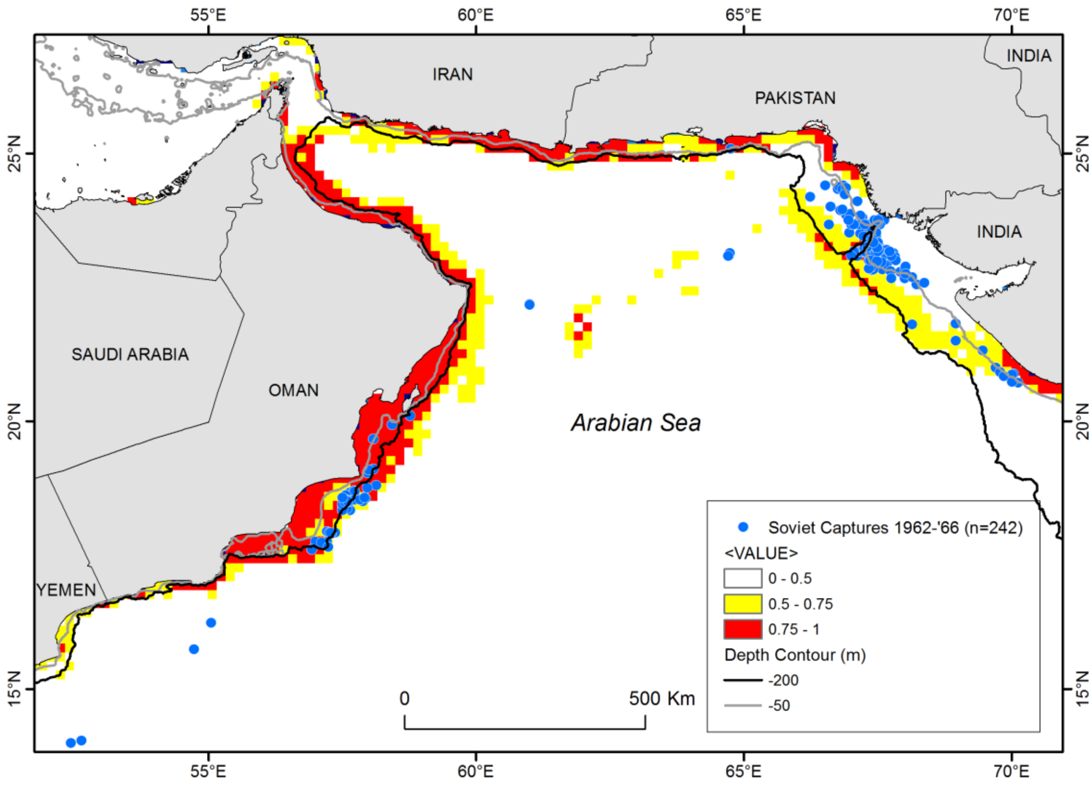


Figure 3-5: Average of sightings and satellite telemetry ensemble ecological niche models with overlay of historical takes of humpback whales in the Northern Indian Ocean between 1962 and 1966, (Mikhalev, 2000; IWC Catch Database, extracted 25 October 2013). (Source: Willson et al. 2017)

Vessel-based research surveys conducted in Oman since 2000, as well as the results of satellite telemetry studies (Willson et al 2017), demonstrate the Gulf of Masirah, to be one of the most important habitats yet identified for the ASHW. Minton (2011) reports humpback whale group sightings of 0.15/ hour for small vessel surveys in the Gulf of Masirah and 0.2/ hour from shore based observations at Duqm during surveys conducted between 2000 and 2004. These are noted as the highest encounter rates of all study areas within Oman, with the other main high-density area being the Hallaniyats Bay (Dhofar region). Habitat modelling using Eigenvector Linear Models was performed on the same dataset (Corkeron et al., 2011) and resulted in the same conclusions. More recent analysis of vessel-based surveys conducted up to 2012 (Figure 3-6) continues to confirm the Gulf of Masirah as a critically important area (Willson et al. in prep).

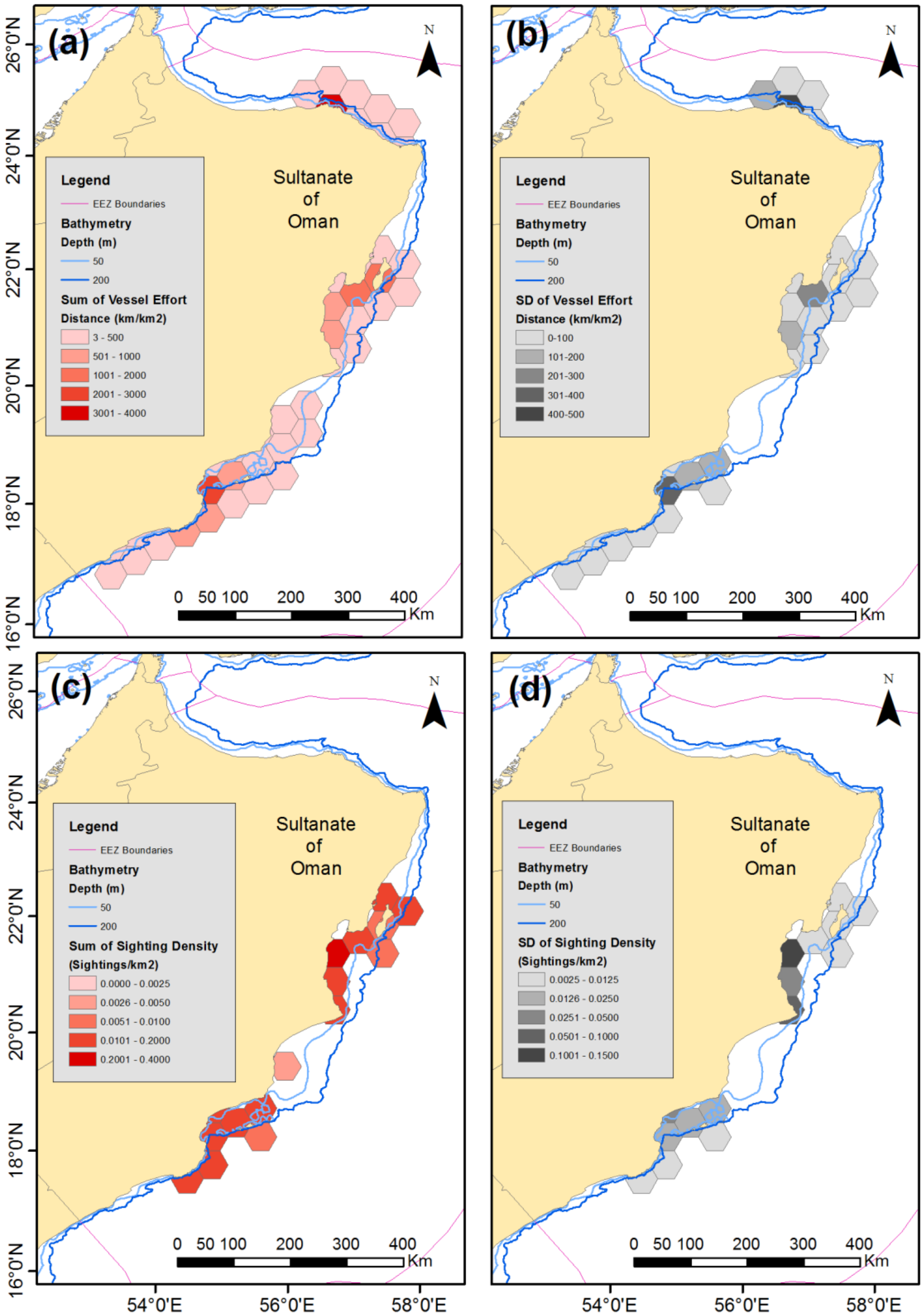


Figure 3-6: Density plots of total vessel effort (a) vessel effort standard deviation (b) sum of ASHW sightings density (c) and standard deviation of sightings density (Source: Willson et al, in prep)

3.2.5

Satellite telemetry studies conducted in Oman between 2014 and 2016 to model the movements of ASHWs revealed migratory movements within a 1,150 km corridor between central Oman and Northern Yemen (n=9) (Willson et al, 2016). Whales in this study spent the majority of their time (72%) over shelf waters in depths of <200m.

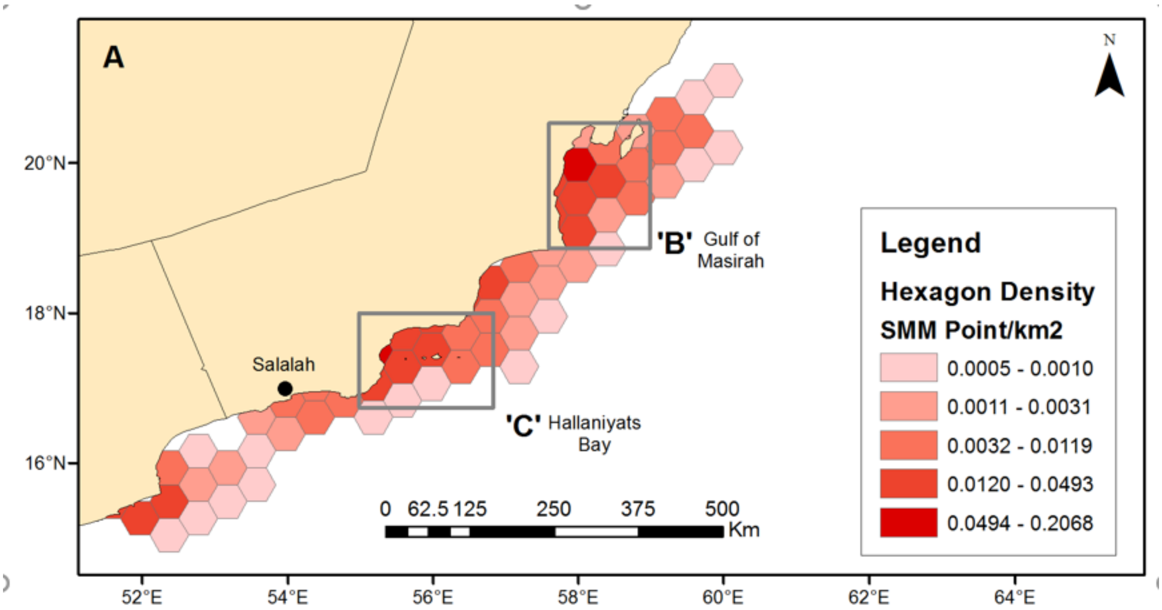


Figure 3-7: Habitat utilization derived from counts of Static Space State Model (SSSM) locations within a hexagon grid network. Full extent of the study area defined by whale movement (upper panel; this should be A; cell size 25 km min. radius) and selected high-use areas (bottom plots 'B' and 'C'; cell size 15 km min. radius). (Willson et al., 2016).

DISTRIBUTION WITHIN AREA OF INFLUENCE

Results of the 2014 to 2016 telemetry studies revealed that whales spent 35% of their time in the Gulf of Masirah (Willson et al. 2016) with the range included in this analysis determined by the extent of the area shown in

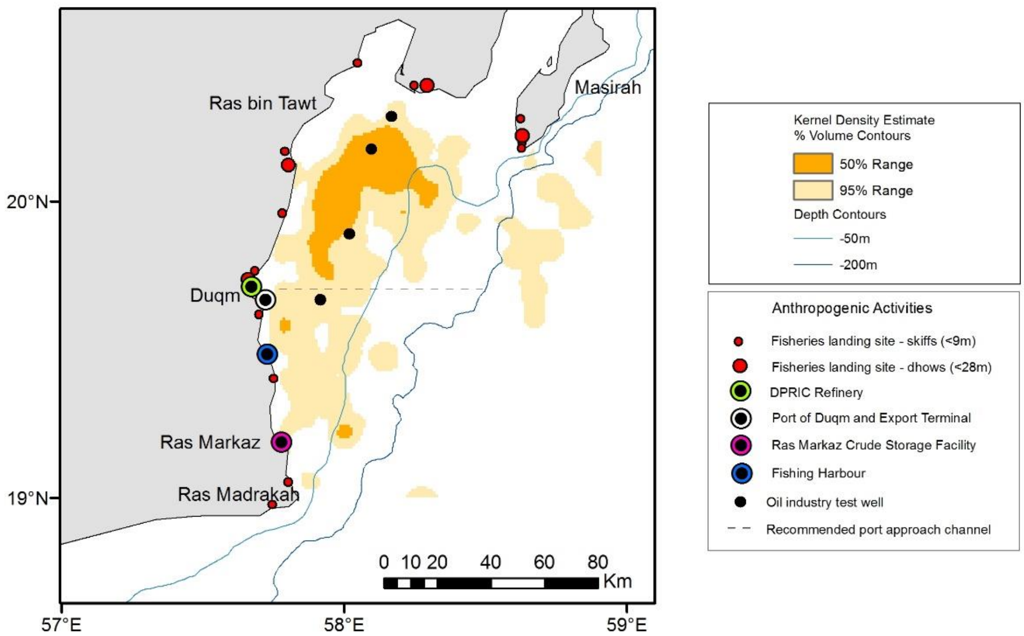


Figure 3-8. The results reveal that the 95% habitat range within the Gulf of Masirah is broadly distributed throughout the area, whilst the 50% range is found towards the north of the Gulf. Six satellite tags fitted with dive profile sensors revealed that whales spent 83% of their time within the top 20 m of the water column, with the most frequent dive duration lasting between 5-10 minutes (Willson et al. 2016).

Secondary analysis of the same data modelled using space state techniques for the specific purpose of the current report reveals that whales spent 54% of time within the defined CHAA between the months of November and July.

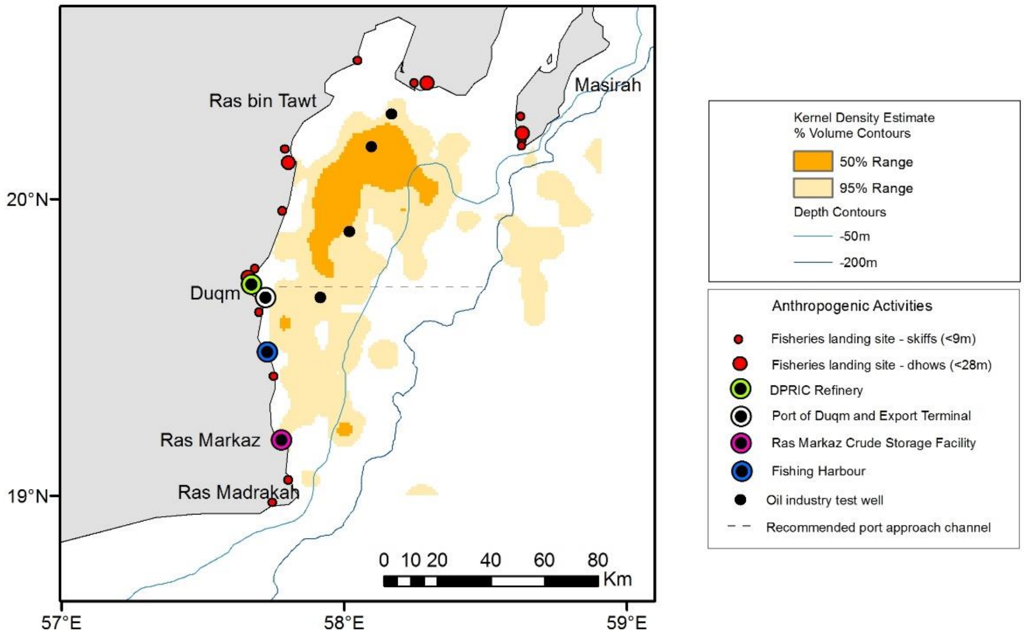


Figure 3-8: Kernel Density Estimate of ASHW habitat utilisation derived from Static Space State Model locations from satellite telemetry studies 2014-'16 within the Gulf of Masirah.

Ongoing vessel-based surveys in the area prioritise the collection of photographic data during encounters with humpback whales. Photographic records include the cataloguing of tail fluke and dorsal images together with location and behaviour data. Simultaneously genetic samples are taken that enable the same catalogue to match individual fluke and dorsal records with the sex derived from laboratory based DNA analysis. Recent review of the photographic database indicates that encounters have resulted in a total of 354 occasions where individual identifications could be made across study sites in Oman (Table 3.5).

Photographic records also reveal that over 52% of individuals registered in the database have been observed within the CHAA, thus making it the most important habitat within the known range of this endangered population (Willson et al. in prep).

Table 3.5: Occurrence of identified ASHWs within different study areas within Oman (Willson et al. in prep)

STUDY AREAS	TOTAL NUMBER OF INDIVIDUAL IDENTIFICATIONS	NUMBER OF INDIVIDUALS IDENTIFIED	OVERALL PERCENTAGE OF INDIVIDUALS IDENTIFIED WITHIN EACH STUDY AREA
Azaiba	1	1	0.6

Study Areas	Total number of individual identifications	Number of individuals identified	Overall Percentage of individuals identified within each study area
Duqm	3	3	1.7
Duqm Port	2	2	1.2
Gulf of Masirah	117	75	43.6
Hadbin	3	2	1.2
Hallaniyats	35	26	15.1
Hasik	144	39	22.7
Likbe	3	3	1.7
Masirah	14	11	6.4
Mirbat	5	5	2.9
Muscat Area	1	1	0.6
Sadh	2	2	1.2
Salalah	4	2	1.2
Grand Total	334	172	100

The foraging ecology of the ASHW remains poorly understood, and is of interest given the population's unique regional status (Minton et al., 2008; Pomilla Amaral et al. 2014). Minton (2011) and Reeves (1991) hypothesised that energy requirements within the Arabian Sea may be met by increased productivity generated by nutrient rich upwelling water off the southern Arabian Peninsula during the summer monsoon period.

Sardines and euphasiids were found in the stomachs of whales examined in the Soviet catch (n=85) (Mikhalev, 1997). Both of these prey items occupy different habitats. Sardine species found in Oman predominantly feed on phytoplankton (Randal, 1995). Piontkovski (2014) identified monthly fluctuations in sardine landings associated with remotely sensed chlorophyll-a concentration from MODIS-Aqua and SeaWIFS archives off the northern coast of Oman. Spatial distribution modelling of ASHW revealed that net primary productivity was the strongest environmental co-variate associated with distribution, with primary productivity a noted feature of the Gulf of Masirah (Willson et al. 2017).

High densities of euphausids (shrimp-like krill) are typically associated with proximity to shelf edge (Harris et al. 2014). Dive behaviour of whales off Masirah Island bordering on the eastern extent of the CHAA has indicated repeated dives over 200m (Figure 3.9) and of equivalent depth to where high densities of myctophids (lantern fish) have been detected. The historical whaling records and evidence from telemetry work suggest behavioural plasticity in foraging strategies between coastal and offshore waters (Willson et al. 2016).

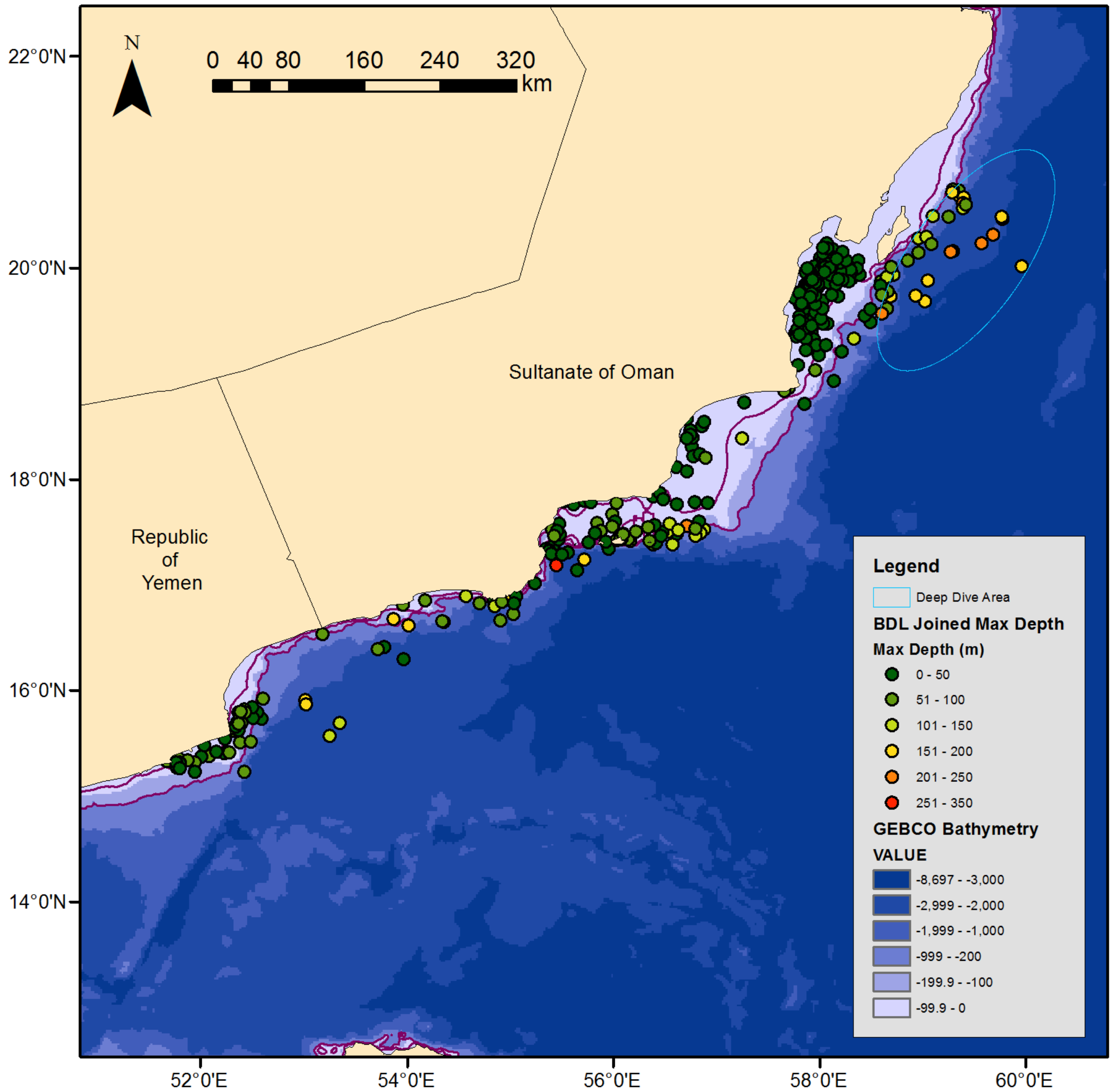


Figure 3.9: Best Daily Locations (BDL) of telemetry plots combined with maximum depths for each day (Source: Willson et al. 2016)

Of a total of 162 sightings within the CHAA the Oman Cetacean Database (OMCD) describes 11 encounters where feeding has been observed (OMCD 2016). These are defined by events during which surface lunge feeding is visible. It is possible that feeding behaviour often goes undetected given that dive profile information (recorded by satellite telemetry units) shows that dive duration of whales ranges between 2 – 35 minutes, with the most frequent average dive duration for all animals lasting between 5 to 10 minutes (Willson et al., 2016).

There are various lines of evidence to indicate that the Gulf of Masirah is important during the reproduction process of ASHW. Mating has not been directly observed anywhere in Oman. However, the breeding season for the ASHW population is estimated to commence in January, peak in March and end in late May based on inspection of foetus development during Soviet whaling activities (Mikhalev, 1997). A combined genetics and photographic study programme (Minton et al., 2011) has demonstrated that the Gulf of Masirah has an equal ratio of sightings of males and females over the winter/ spring period in contrast to male dominated ratios recorded elsewhere in Oman, thus providing the opportunity for mating to take place. Mating is also likely to be associated with locations where male humpback song is detected. Deployment of bottom mounted passive acoustic monitoring units between 2012 and 2013 revealed the presence humpback whale song in the Gulf of Masirah from early December through to late June (Cerchio et al. 2016).

As with mating, calving of ASHW has not been directly observed. The Oman Cetacean Database (OMCD) reveals that 27% (n=37) of individuals that have been observed and biopsied in the Gulf of Masirah have been females, (39%= male and 33% unknown) (OMCD 2016). Based on the occurrence of adult females in the area during the breeding and calving season it is hypothesised that these are either recently pregnant or in late pregnancy stages. Further interrogation of sightings data in the OMCD reveals that mother-calf pairs have been observed on 15 separate occasions in Oman waters. Seven of these occurred within the boundary of the CHAA, and specifically within the Gulf of Masirah, indicating that the area has ecological function as nursery habitat (OMCD 2016). On one occasion, in March 2012, a mother-calf pair is known to have entered the confines of the Port of Duqm port basin (Port of Duqm Company in lit. to R. Baldwin. March 2012).

Plates 1 and 2: Mother and calf humpback sighted within the Duqm port basin in March 2012 (source: Port of Duqm Company).

KNOWLEDGE GAPS

Detailed information on the ASHW is available as a result of systematic study conducted since 2000 (e.g. Baldwin 2000; Minton et al 2008; Willson et al. 2017; ESO and MECA unpubl. Data; and others). These studies have also revealed information about threats. Still relatively little is known about breeding and feeding behaviours and habitats, and there remain gaps in knowledge of distribution and seasonality of movements. The recent EIAs in the Duqm area have provided little new information. The gaps in our knowledge hinder definition of thorough and comprehensive mitigation and management measures.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

IFC's PS6 defines critical habitat as areas of high biodiversity value that satisfy one or more of five Critical Habitat Criteria. PS6 also defines gradients of critical habitat based on the vulnerability and irreplaceability of the site. For the first three criteria numerical thresholds are used to assign a Tier 1 or Tier 2 critical habitat designation. For ASHWs, three of the five critical habitat criteria are relevant (Criteria 1, 2 and 3) the first of which meets the Tier 1 level designation, whist the second and third meet the Tier 2 level designation, as described below:

Criterion 1: Critically Endangered (CR) or Endangered (EN) Species. The CHAA is a centre for distribution of the Endangered ASHW. Tier 1 criterion (a) is met because the habitat sustains more than 10% of the global population of the 'species', the later termed a discrete 'subpopulation' in this case.

Criterion 2: Endemic/Restricted Range Species. Tier 2 is assigned in this case as the AoI is known to sustain more than 1%, but less than 95%, of the global population of this restricted range species.

Criterion 3: Migratory/ Congregatory Species. The assignation of Tier 2 in this case relates to the CHAA sustaining, on a cyclical or otherwise basis, more than 1%, but less than 95%, of the global population of this migratory species.

Based on these conclusions, there is a requirement to adhere to paragraphs 17-19 of PS6, which includes reference to study of alternative sites, assessment of impacts on the biodiversity values for which the critical habitat was designated, a robust monitoring programme and a mitigation strategy within the context of a Biodiversity Action Plan, including identification of biodiversity offsets if required. Such plans require advance preparation in considerable detail in order to assess whether the necessary requirements can be satisfied for a species meeting the Tier 1 critical habitat designation.

3.2.6 Indian ocean humpback dolphin

LIFE HISTORY AND ECOLOGY

Indian Ocean humpback dolphins are usually seen within a narrow strip of shallow near-shore waters (Ross et al. 1994, Jefferson and Karczmarski 2001), seldom in water deeper than 20-30 m (Karczmarski et al. 2000). Seasonality of occurrence, movements, group sizes, and reproduction has been reported in several studies (e.g. Durham 1994, Karczmarski et al. 1999a, 1999b, Guissamulo 2007). The dolphins appear to be selective in their habitat choice (e.g. Karczmarski et al. 2000; Stensland et al. 2006). Dependence on shallow-water habitats as feeding grounds is often evident throughout the year (Karczmarski and Cockcroft 1999; Karczmarski et al. 2000), although the details of the preferred key habitats may differ between groups and locations (Jefferson and Karczmarski 2001; Atkins et al. 2004; Stensland et al. 2006).

In Oman, identification of fish otoliths (inner ear bones) taken from the stomach contents of this species from the Gulf of Masirah (Ponnampalam et al., 2012) reveals prey to often include fishes of the family Sciaenidae (drums and croakers), demersal species associated with shallow rocky, sand and mud substrate. Similar studies from the south of Oman have also revealed a high incidence of cephalapods and crustaceans in the diet (Baldwin et al., 2004).

Little is known about the life history of this species. Studies in South Africa suggest gestation is 10-12 months (Cockcroft, 1989), with mother-calf association continuing for three to four years (Karczmarski et al., 1999). In Oman, social and/or mating behaviour has been observed in the months of April and May, and the presence of calves has been recorded in April through June, and in October through December (Baldwin et al. 2004).

CONSERVATION STATUS

Humpback dolphins found within the Indian Ocean have recently been taxonomically separated are and now considered a separate species distinct from the Indo-Pacific humpbacked dolphin ((Jefferson and Rosenbaum, 2014). This status has not yet been formally incorporated by the IUCN Red List. However, the conservation status of this species has been reviewed using the Red List criteria in recognition of diminishing abundance and degradation of habitat throughout much of the Indian Ocean (Braulik et al 2016). This recent assessment considers the species to be Endangered (Braulik et al. 2016) based on an estimated decline of at least 50% across its range over three generations.

Abundance estimates exist for South Africa and Southwest Indian Ocean, but no-where else within the range. All those that have been quantitatively evaluated have been small in size, always less than 500 and usually fewer than 200, and the evidence suggests that the species is not abundant anywhere within its range (Braulik et al. 2015).

The nearshore distribution of this species puts it within range of artisanal fisheries with gill nets posing a high risk of bycatch. Within Oman a high incidence of beach cast specimens results from interactions with fisheries (Collins et al. 2002). Loss of nearshore habitats due to coastal development is also a noted feature of the Arabian region in general (Baldwin et al. 2004), with dredging, land reclamation, construction blasting, port and harbour construction, vessel traffic, oil and gas exploration related activities, and other activities, all occurring in humpback dolphin habitat (IWC, 2002). Range wide mortality from bycatch alone is several orders beyond the limit for a sustainable population and leads experts to conclude the species is almost certainly decreasing (Friedmann and Daly, 2004; Reeves et al., 2008).

GLOBAL AND NATIONAL DISTRIBUTION

Indian Ocean humpback dolphins occur along the western periphery of the Indian Ocean from False Bay in South Africa in the south west of the range through to the most southern tip of India in the north west of the range (

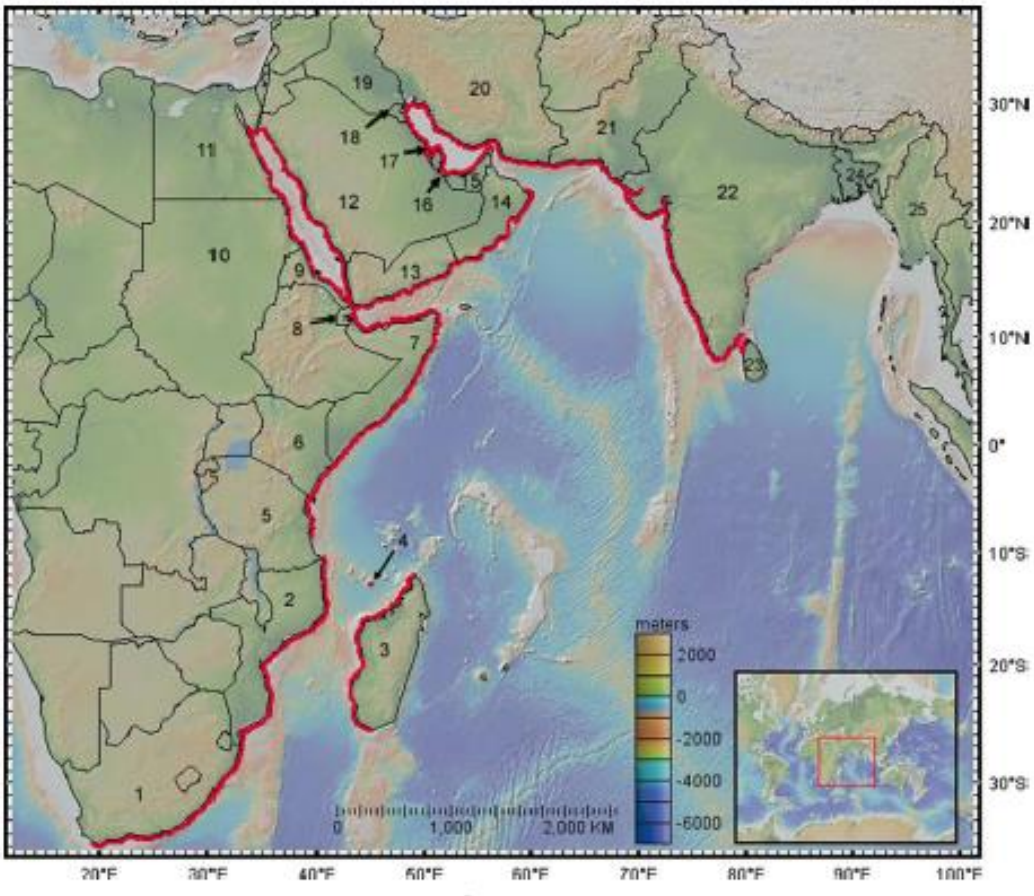


Figure 3.10). Distribution covers south and east Africa, the Middle East and South Asia with this range including the west coast of Madagascar, Red Sea, Arabian Sea and Arabian Gulf. The level of knowledge is greatest in the South West Indian Ocean, South Africa and Oman (Braulik et al. 2015). Existence of pockets of suitable habitat, local extirpation and range reductions are most likely the key factors accounting for their disjunct distribution (IWC, 2002). Within the western Indian Ocean genetic data suggests significant population segregation between Oman, Zanzibar and South Africa that is correlated with large scale oceanographic regimes.

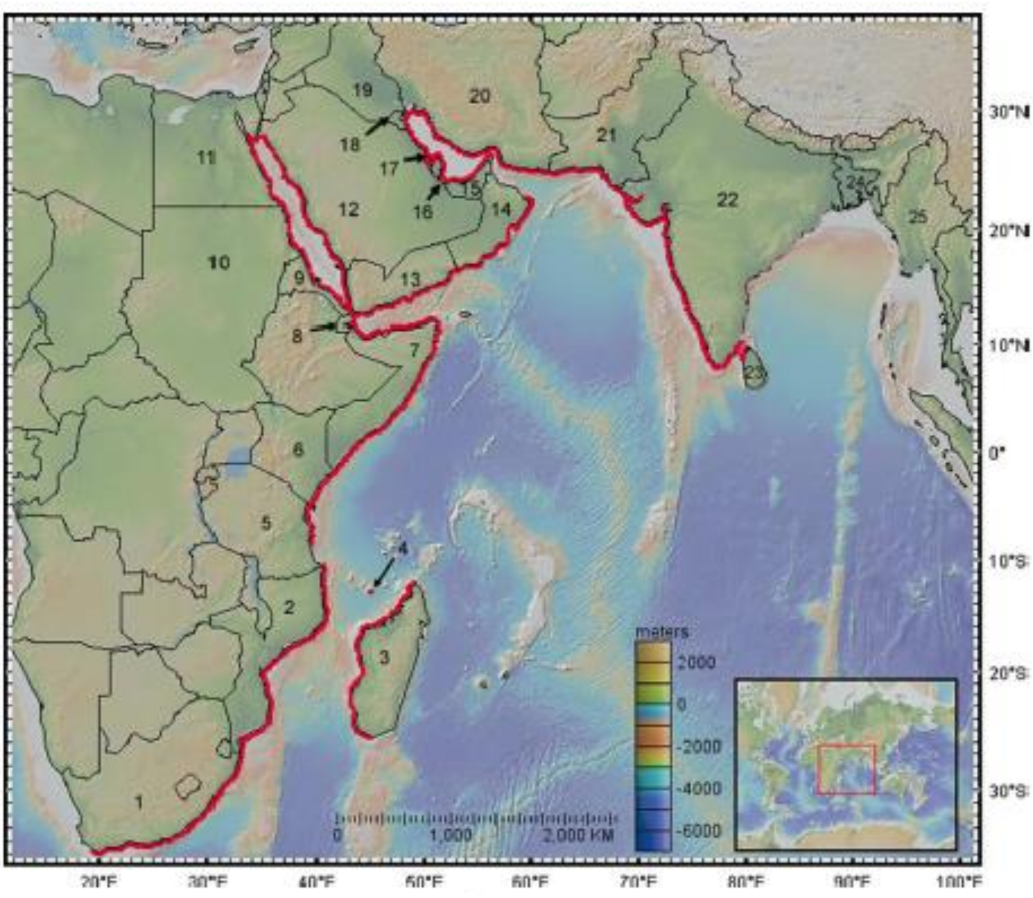


Figure 3.10: The assumed distribution of the Indian Ocean humpback dolphin (*Sousa plumbea*). (Source: Braulik et al. 2016).

Indian Ocean humpback dolphins are one of the most commonly encountered cetacean species in Oman, and its distribution, while seemingly absent from the Gulf of Oman, appears to be continuous along the Arabian Sea coast of the Sultanate (Salm et al. 1993; Baldwin & Salm 1994; Baldwin et al. 2004; Minton 2004).

Humpback dolphins are known for their narrow habitat preference. Results of surveys in 2000-2003 in Oman confirmed that sighting rates for this species increase with proximity to the shore (Minton et al., 2011). Although usually found in water depths of 20m or less, this species has been sighted in Oman in water depths greater than 40m in certain, restricted locations (Baldwin et al. 2004). The migration and movements of animals in Oman have not yet been studied, but elsewhere in its range *S. plumbea* populations are apparently comprised of long-term residents that show a limited home range, in the order of tens to hundreds of kilometres (Guissamulo and Cockroft, 2004; Karczmarski et al., 1999; Keith et al., 2002; Parsons, 1998).

Very strong population structure has been defined from genetic study of this species in Oman, including animals sampled from the Gulf of Masirah (Mendez et al., 2013). The study also showed that the population sampled in Oman has the highest genetic diversity in the Western Indian Ocean region (Mendez et al., 2011).

DISTRIBUTION WITHIN CHAA

A total of 40 sightings of humpback dolphins have been recorded from incidental and dedicated sightings from vessel surveys between 1986 and 2006 within the AoI. Group sizes range between one and one hundred individuals (OMCD 2016). Most sightings (n=22) were of groups of 10 animals or less, with 16 sightings of between 11 and 50 individuals and two sightings made up of group numbers between 60 and 100 animals (OMCD).

Within the Gulf of Masirah, Indian Ocean humpback dolphins have been sighted off the west coast of Masirah, Bar al Hikman, the Ghabbhat Hashish and in several locations between Ras bin Tawt and Ras Madrakah, including around the Port of Duqm (OMCD). This indicates a near continuous coastal distribution in the area (Figure 3-11). Frequent year round sightings have been made from shore-based observations from Duqm south to Ras Markaz. A key habitat identified in 2002 was the northern part of Duqm bay (now the central location of the port itself) (Minton, 2004).

Based on the fact that Indian Ocean humpback dolphins typically exhibit limited home ranges (Baldwin 2003) it can be inferred that all ecological requirements for the species are likely to be available within the CHAA.

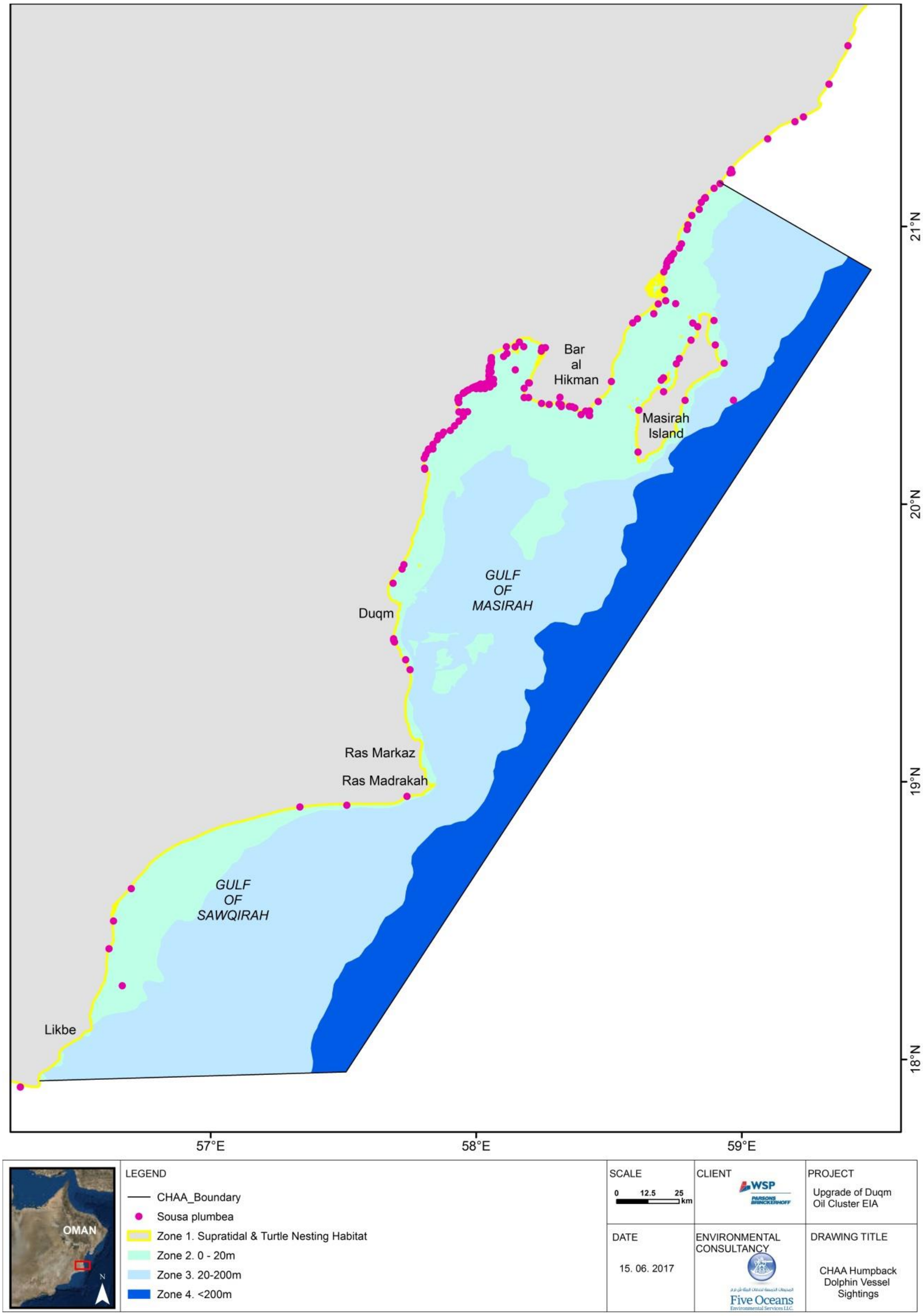


Figure 3-11: Distribution of Indian Ocean humpback dolphin based on sightings and strandings records

KNOWLEDGE GAPS

There is very little information available on the Indian Ocean humpback dolphin. Most of the information is dated and little of it is detailed. No dedicated study of this species has been conducted in Oman and most records are therefore incidental. The gaps in our knowledge hinder definition of thorough and comprehensive mitigation and management measures.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

IFC's Performance Standard 6 defines critical habitat as areas of high biodiversity value that satisfy one or more of five Critical Habitat Criteria. PS6 also defines gradients of critical habitat based on the vulnerability and irreplaceability of the site. For the first three criteria numerical thresholds are used to assign a Tier 1 or Tier 2 critical habitat designation. For Indian Ocean humpback dolphin, two of the five critical habitat criteria are relevant (Criteria 1 and 2), both of which meet the Tier 2 level designation, as described below:

Criterion 1: Critically Endangered (CR) or Endangered (EN) Species. The AoI is known to be populated by the Endangered Indian Ocean humpback dolphin. Tier 2 criterion (c) is met because the habitat supports regular occurrence of one or more individuals.

Criterion 2: Endemic/Restricted Range Species. Tier 2 (b) is assigned in this case as the CHAA is considered to sustain more than 1%, but less than 95%, of the global population of this restricted range species.

Based on these conclusions, there is a requirement to adhere to paragraphs 17-19 of PS6, which includes amongst other requirements includes reference to the assessment of impacts on the biodiversity values for which the critical habitat was designated, a robust monitoring programme and a mitigation strategy within the context of a Biodiversity Action Plan, including identification of biodiversity offsets, if required.

3.2.7 Hawksbill turtle

LIFE HISTORY AND ECOLOGY

Hawksbill turtles mature very slowly, taking 20 to 40 years, and so are long-lived (Chaloupka and Musick 1997). Age to maturity in the Indo-Pacific is at the upper end of this scale, requiring a minimum of 30-35 years (Limpus 1992; Limpus and Miller 2000; Mortimer et al. 2002, 2003). This makes populations more sensitive to potential decline as juveniles face the threat of mortality for many years before they are able to reproduce. Once mature, active nesting by females continues over a period of at least 17-20 years in the Indo-Pacific (Mortimer and Bresson 1999; Limpus 1992). Data specific to Oman on this topic are not available.

Hawksbills nest on insular (island) and mainland sandy beaches throughout the tropics and subtropics. They are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (for review see Witzell 1983). Available data indicate that newly emerged hatchlings enter the sea and are carried by offshore currents into major gyre systems where they remain until reaching a carapace length of some 20 to 30 cm. At that point they recruit into a neritic (coastal) developmental foraging habitat that may comprise coral reefs or other hard bottom habitats, sea grass, algal beds, such as that found in the Gulf of Masirah.

Once sexually mature, hawksbills undertake breeding migrations between foraging grounds and breeding areas at intervals of several years (Witzell 1983, Dobbs et al. 1999, Mortimer and Bresson 1999). In Oman these migrations are known to have both a local component (e.g. nesting on Masirah Island and feeding in the Gulf of Masirah) and a wider, national component (e.g. nesting at the Daymaniyat Islands and, again, foraging in the Gulf of Masirah) as demonstrated by satellite tracking studies.

Global population genetic studies have demonstrated the tendency of female sea turtles to return to breed at their natal rookery (Bowen and Karl 1997), even though as juveniles they may have foraged at developmental habitats located hundreds or thousands of kilometers from the natal beach. While hawksbills undertake long migrations, some portion of immature animals may settle into foraging habitats near their beaches of origin (Bowen et al. 2007). In Oman, all adult females tagged to date have remained in Omani waters, often using the Gulf of Masirah for foraging as described above.

Hawksbills are known to be important components of healthy coral reef ecosystems and are primarily omnivorous in the Indo-Pacific (Bjorndal and Jackson 2003). In Oman they are thought to consume a combination of forage including sponges, soft corals and other benthic reef organisms (Salm 1991).

CONSERVATION STATUS

The global status of hawksbill turtles, as listed by the IUCN Red List is Critically Endangered, reflecting a low population size in decline (Mortimer and Donnelly, 2008). With respect to IFC GN6 guidance document, this means that it is facing an extremely high risk of extinction in the wild. It is the highest risk category assigned by the IUCN Red List for wild species.

Analysis of historic and recent published and unpublished global accounts indicate extensive subpopulation declines of hawksbill turtles in all major ocean basins over the last three generations as a result of over-exploitation of adult females and eggs at nesting beaches, degradation of nesting habitats, take of juveniles and adults in foraging areas, incidental bycatch mortality relating to fisheries, and degradation of marine habitats (Mortimer and Donnelly, 2008). Today, some protected populations are stable or increasing, but the overall decline of the species, when considered over a period of three generations, has been in excess of 80%. The greatest decline has occurred in the Indian Ocean, where a decline of 93.8% over the past three generations has been calculated (Mortimer and Donnelly, 2008).

Almost all of the threats described above apply in Oman, where degradation of nesting habitat due to coastal development and incidental mortality as a result of fisheries are thought to be the most important impacts (Pilcher et al., 2014). The hawksbill turtle population of Oman has been recognised as a globally significant population of high conservation priority (IUCN 1991). Oman is one of few countries in the world that still has large populations of turtles (Baldwin, 1999). However, the current status, and trend, of hawksbill turtle populations in Oman is not known. Indeed, such figures are available only for the loggerhead turtle (see below) which reveal a significant and very substantial decline (over 70%) in the nesting female population over the past three decades.

GLOBAL AND NATIONAL DISTRIBUTION

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic Ocean, Indian Ocean, and Pacific Ocean. Hawksbills are migratory and individuals undertake complex movements through geographically disparate habitats during their lifetimes. Hawksbill nesting occurs in at least 70 countries, although much of it now only at low densities. Their movements within the marine environment are less understood, but hawksbills are believed to inhabit coastal waters in more than 108 countries (Groombridge and Luxmoore 1989, Baillie and Groombridge 1996).

In Oman, hawksbills nest on beaches in Musandam in the very north, to as far south as Dhofar, though nesting here is in very low numbers. The main concentrations of nesting females occur at the Daymaniyat Islands, where between 250-350 females nest annually (making this small site one of the densest nesting locations by this species in the world) (Salm 1991; Baldwin 1999), and at Masirah Island, where upwards of 125 females nest annually (Ross and Barwani 1982). Other key nesting sites include the Muscat area around Bandar Jissah and Bandar Khayran and in the Gulf of Masirah at Bar al Hikman and between Ras bin Tawt and Ras Madrakah (IUCN, 1991). Nesting peaks in April-May (Baldwin 1999) but at hawksbills have been recorded nesting year round at some locations in Oman (MECA unpubl. data).

Foraging largely occurs in the Gulf of Masirah (Pilcher et al. 2014), but has been observed in other parts of Oman, such as around reefs off Muscat to the north (Salm and Salm 1991).

DISTRIBUTION WITHIN CHAA

As described above, hawksbills nest at Masirah Island and in the Gulf of Masirah at Bar al Hikman and between Ras bin Tawt and Ras Madrakah (IUCN, 1991) (

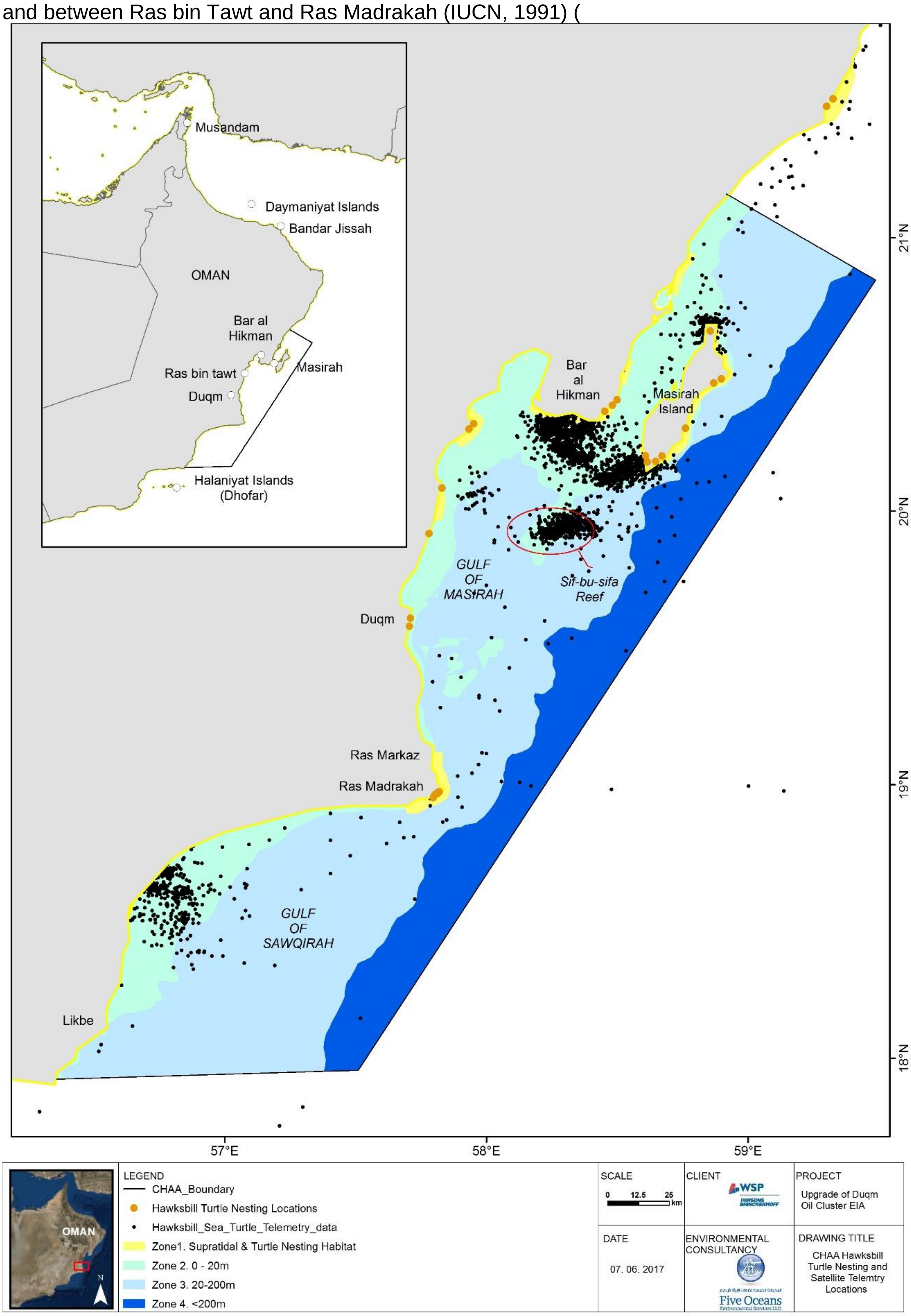


Figure 3-12). Nesting is still known at all of these sites (ESO unpubl. data) and was recorded during the EIA studies for Duqm Refinery Project and some of the Associated Facilities. Nesting occurs at many different types of beaches in the CHAA, including pocket beaches in bays and along open shoreline. Nesting is disparate and not enough intensive, long-term study has been conducted to determine all nesting locations or the seasonality of nesting. It is interesting to note, however, that in at least two locations in Oman where continuous monitoring has been undertaken for multiple years (Daymaniyat Islands and Bar al Jissah) nesting has been found to occur year round, every year (MECA unpubl. data).

At Masirah, the numbers of nesting females appears to have remained similar to that recorded in the late 1970s, although the population trend is impossible to verify without long-term monitoring as there is a very high inter-annual variation in nesting (ESO unpubl. data). It is possible, however, that Masirah Island is more important to nesting hawksbills than has previously been thought; an estimated 405 females nested there in 2016 (ESO unpubl. data).

Hawksbills also use the Gulf of Masirah as a foraging habitat. This part of Oman appears to be favoured for foraging by hawksbills that nest both nearby (e.g. at Masirah Island) and further away (e.g. Daymaniyat Islands) as revealed by results of satellite tracking.

Satellite telemetry studies were undertaken on a total of 27 hawksbills between 2010 and 2013, with 15 turtles tagged from the Daymaniyat Islands (to the north of Muscat) and 12 turtles from Masirah

Island (Pilcher et al., 2014). Plotted locations of final foraging areas are shown in

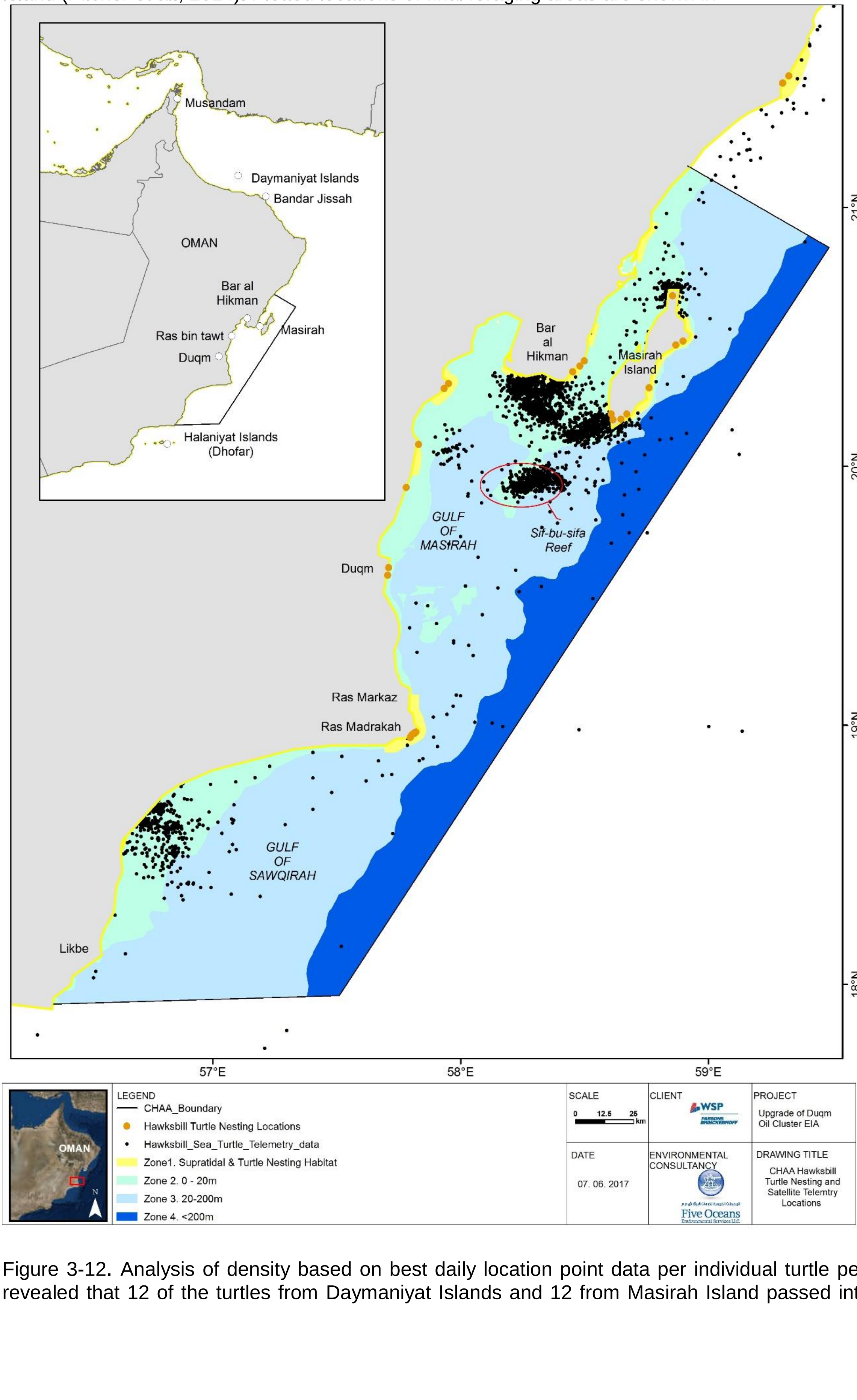


Figure 3-12. Analysis of density based on best daily location point data per individual turtle per day revealed that 12 of the turtles from Daymaniyat Islands and 12 from Masirah Island passed into the

Gulf of Masirah post nesting. The data also show that there is activity in this area year-round. Core habitats were noted from the southern tip of Masirah (in close proximity to nesting areas) and in the reef shallows of Bar al Hikman and Sif-bu-Sifa offshore reefs northeast of Duqm. All individuals demonstrated high site fidelity over foraging grounds.

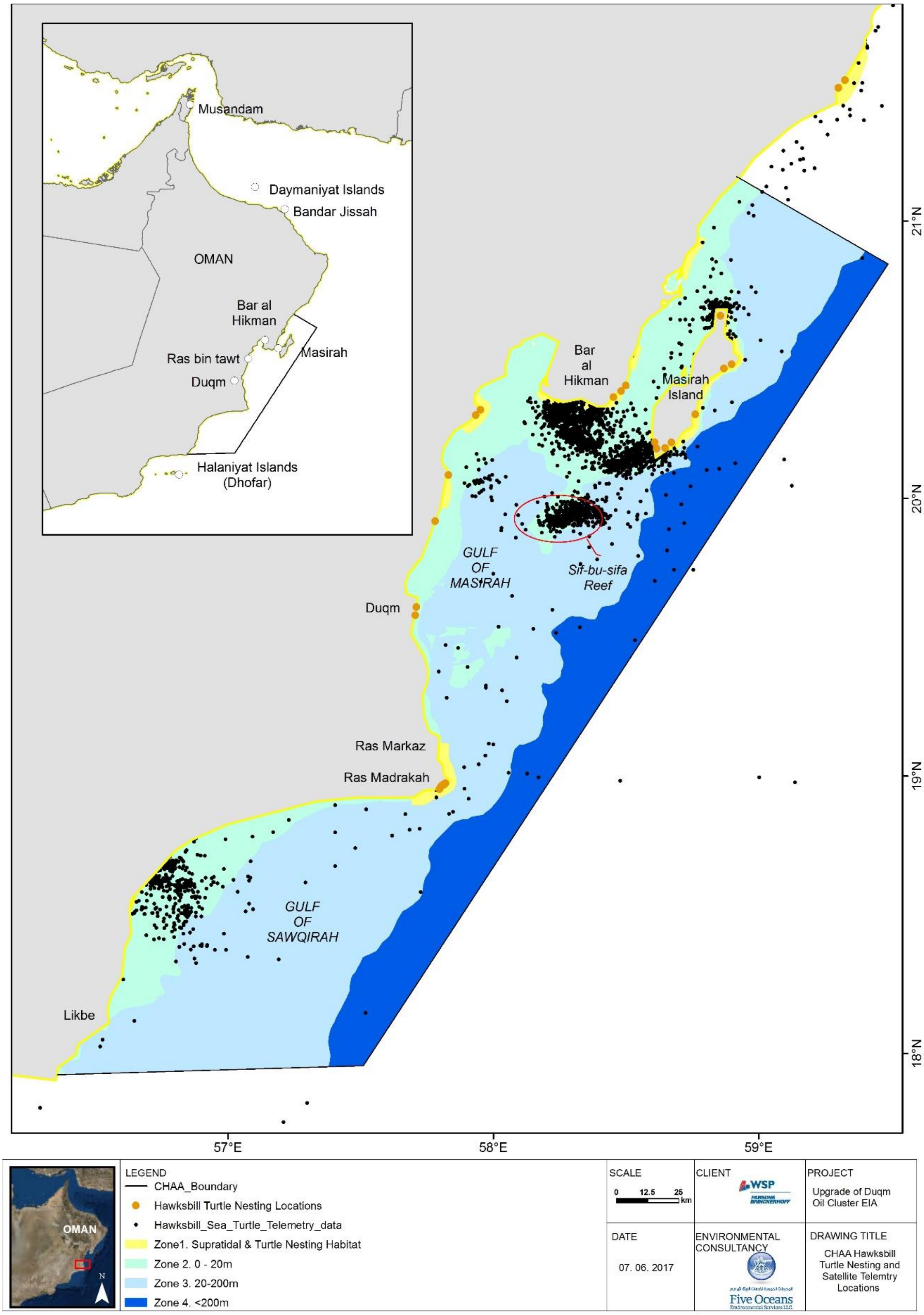


Figure 3-12: Distribution of hawksbill turtles including nesting locations and post-nesting migrations obtained using satellite telemetry studies

Migratory routes to and from other breeding and foraging areas are likely to cross many parts of the CHAA and hatchlings and juveniles can be expected to disperse widely throughout the area from widely separated nesting sites.

KNOWLEDGE GAPS

Relatively little is known about hawksbill turtles in the CHAA and in Oman in general. Most information comes from studies conducted around Masirah Island, Daymaniyat Islands and the Muscat area and is limited to basic monitoring data of nesting turtles only (MECA and ESO unpubl. data.). The recent EIAs in the Duqm area have provided some new information, but this is limited to records of nesting inferred from tracks on beaches. The only other recent available data is from satellite tracking studies (Pilcher et al. 2014) which provides some insight into migratory routes and foraging habitats for a small sample of the population. All other data, largely limited to nesting records, is over 20 years old. Current knowledge gaps hinder definition of thorough and comprehensive mitigation and management strategy for this species.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

IFC's Performance Standard 6 defines critical habitat as areas of high biodiversity value that satisfy one or more of five Critical Habitat Criteria. PS6 also defines gradients of critical habitat based on the vulnerability and irreplaceability of the site. For the first three criteria numerical thresholds are used to assign a Tier 1 or Tier 2 critical habitat designation. For hawksbill turtles, two of the five Critical Habitat Criteria are relevant (Criteria 1 and 3) both of which meet the Tier 2 level designation, as described below:

Criterion 1: Critically Endangered (CR) or Endangered (EN) Species. The CHAA contains breeding and foraging habitat used by the Critically Endangered hawksbill turtle. Tier 2 criterion (c) is met because the habitat supports the regular occurrence of one or more individuals of this CR species.

Criterion 3: Migratory/Congregatory species. The assignation of Tier 2 in this case relates to the CHAA sustaining, on a cyclical or otherwise basis, more than 1% of the global population of this migratory species.

3.2.8 Loggerhead Turtle

LIFE HISTORY AND ECOLOGY

The loggerhead turtle (*Caretta caretta*) nests on insular and mainland sandy beaches throughout the temperate and subtropical regions worldwide. Like most turtles, loggerheads are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (Bolten and Witherington 2003). Upon leaving the nesting beach, hatchlings begin an oceanic phase in major current systems (gyres) that serve as open-ocean developmental grounds (Bolten and Witherington 2003; Putman and Mansfield, 2015). After 4-19 years in the oceanic zone, loggerheads recruit to neritic developmental areas rich in benthic prey or epipelagic prey where they forage and grow until maturity at 10–39 years (Avens and Snover, 2013). In Oman, on reaching sexual maturity loggerhead turtles undertake breeding migrations between foraging grounds (distributed throughout the region, but centered off Oman and Yemen), and nesting areas, primarily at Masirah Island. Remigration intervals of loggerhead turtles are of one to several years with a mean of 2.5–3 years for females (Schroeder et al., 2003) while males would have a shorter remigration interval (e.g., Hays et al. 2010, Wibbels et al., 1990). On Masirah Island, females nest on average 5.5 times per year (Tucker et al. 2013). Migrations are carried out by both males and females and may traverse oceanic zones spanning hundreds to thousands of kilometres (Plotkin 2003). During non-breeding periods adults reside at coastal neritic feeding areas that sometimes coincide with juvenile developmental habitats (Bolten and Witherington, 2003).

CONSERVATION STATUS

The loggerhead turtle is considered globally as Vulnerable under current IUCN Red List Criteria (criterion A2b). However, it is recognised that the loggerhead turtle comprises 10 subpopulations that vary widely in population size, geographic range, and population trends, and are the appropriate units for assessment of global conservation status for this species (Wallace et al., 2010, 2011). Each of these 10 subpopulations have been formally assessed and given their own status listing. The IUCN Red List specifically states the following:

"the global listing is not an appropriate representation of the conservation status of the biologically relevant subpopulations that make up the global Loggerhead Turtle population. Subpopulation assessments demonstrated wide variation not only in status of individual subpopulations (as indicated by IUCN Red List Categories), but also in the criteria under which the individual subpopulations qualified for a threatened category. For these reasons, the subpopulation-level assessments for the Loggerhead Turtle should be given priority in evaluating the true global conservation status of this species." (Casale, 2015).

One of the 10 subpopulations is the Northwest Indian Ocean loggerhead turtle subpopulation which nests in Oman and Yemen. Genetic markers indicate that this subpopulation represents a distinct subpopulation or regional management unit (Shamblin *et al*., 2014, Wallace *et al*. 2010). The Masirah island stock probably represents over 90% of the subpopulation and has experienced a massive decline in the past few decades, which has recently accelerated. Based largely on this, the Northwest Indian Ocean loggerhead turtle subpopulation qualifies for the category Critically Endangered according to IUCN Red List criterion A4, sub-criterion (b). According to the IFC GN6 guidance document, this means that it is facing an extremely high risk of extinction in the wild. It is the highest risk category assigned by the IUCN Red List for wild species.

Threats to loggerhead turtles in the CHAA and in Oman in general have been documented (ESO unpubl. report to MECA) and are summarised below.

Threats in the beach environment:

- Light pollution;
- Coastal construction;
- Vehicle traffic;
- Fisheries activities on beaches;
- Harvest of eggs;
- Beach recreation;
- Beach pollution (including that from oil spill);
- Overgrazing;
- Vegetation removal/planting;
- Erosion;
- Sand mining and beach nourishment;
- Predation; and
- Climate change.

Threats in the marine environment:

- Fisheries bycatch;
- Habitat degradation by fisheries;

- Harvest of adult sea turtles;
- Pollution at sea (including that from oil spill);
- Vessel collision;
- Dredging and other marine construction works;
- Disease/pathogens; and
- Changes in trophic dynamics.

The impacts of fisheries activities on loggerheads have been a more recent focus of study at Masirah Island and the Gulf of Masirah (Willson et al., 2015). This involved telemetry studies combined with mapping of fisheries effort to reveal co-occurrence as well as interviews with fishermen. The results revealed a preliminary estimate of 1,640-1,770 loggerheads bycaught every year in the skiff gill net fishery alone. The bycatch from dhow fisheries is not known, but currently under study (ESO, unpublished data), and is likely to be higher given the increased effort, endurance and range of this fleet.

GLOBAL AND NATIONAL DISTRIBUTION

The loggerhead turtle is globally distributed throughout the subtropical and temperate regions of the Mediterranean Sea and Pacific, Indian, and Atlantic Oceans (Wallace et al. 2010). Within its range, 10 different genetic stocks are recognised including those in: North West Atlantic Ocean, North East Atlantic Ocean, South West Atlantic Ocean, Mediterranean Sea, North East Indian Ocean, North West Indian Ocean, South East Indian Ocean, South West Indian Ocean, North Pacific Ocean, and South Pacific Ocean. The IUCN Red List evaluation notes the global population size is unknown although estimates the number of females nesting annually is between 36,000 and 67,000 (Casale et al, 2015).

In Oman, loggerhead turtles are widely distributed, having been documented from Musandam, in the far north to the Oman/Yemen border in the south (Salm, 1991; Baldwin, 1999). The centre of their distribution, however, is around Masirah Island and in the Gulf of Masirah. Over 90% of females (approx. 10,000-14,000 individuals annually (Wilson et al., 2015)) nest in this location, with much smaller numbers nesting primarily at the Hallaniyat Islands and mainland Dhofar.

Foraging habits and locations of loggerhead turtles are not well known, but telemetry studies (ESO unpubl. data) reveal that adult females range mostly within Omani and Yemeni waters (Figure 13-3), spending most of their time in deep, offshore waters. However, significant amounts of time are also spent migrating along shorelines, including through the CHAA. Juvenile loggerhead turtles from Oman have been documented as far afield as La Reunion and Western Australia, indicating that hatchling dispersal and juvenile ranging are much more extensive than during the adult phase (ESO unpubl. data).

DISTRIBUTION WITHIN CHAA

At least 40% of global loggerhead turtle nesting activity was previously thought to occur on Masirah Island (Environment Society of Oman (ESO), unpublished data). Initial surveys conducted from 1978 (Ross and Barwani, 1982) estimated 30,000 or more female loggerheads nesting at Masirah island. A comparison of equivalent historical and recent nesting trend data of index beaches at Masirah Island indicates current nesting is now at one third (10-14,000 females annually) of the original number estimated in the 1970’s and 1980’s (Witherington et al., 2015). Marginal loggerhead nesting habitat is also known to occur between Ras Madrakah and Ras bin Tawt with estimates of 100 nests/year reported by Salm (1991). With a global estimate from 36- 67,000 nesting females and Masirah estimate at 10-14,000 it is estimated that 15 - 38% of the global population of adult females nest on the island and the same proportion of males and females originate from this rookery.

Nesting by loggerhead turtles at Masirah mostly occurs between the end of April and beginning of September with a peak in the first two weeks of June (Willson et al., 2015). The incubation period of 6-8 weeks implies that hatchlings will disperse to sea between June and November, which coincides with south west monsoon currents that will take them in a northeasterly direction, away from the Gulf of Masirah.

Movements of adult females in the inter-nesting and post-nesting periods is described from a satellite telemetry study conducted on Masirah Island where 44 turtles were instrumented between 2006 and 2012 (Willson et al., 2015). The full regional extent of turtle movements post nesting is shown in

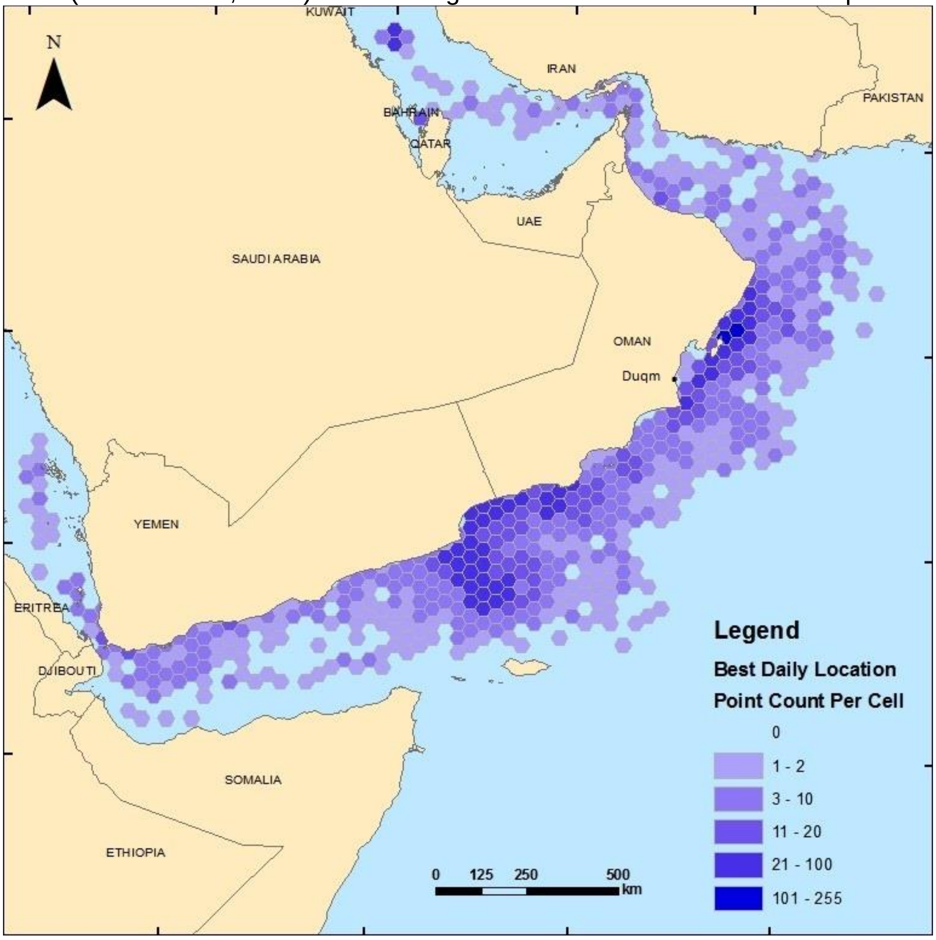


Figure 3-13, with turtles distributing as far as the Arabian Gulf and Red Sea, whilst the predominant area of post migration movement is to the Gulf of Aden between Yemen, Oman and Socotra.

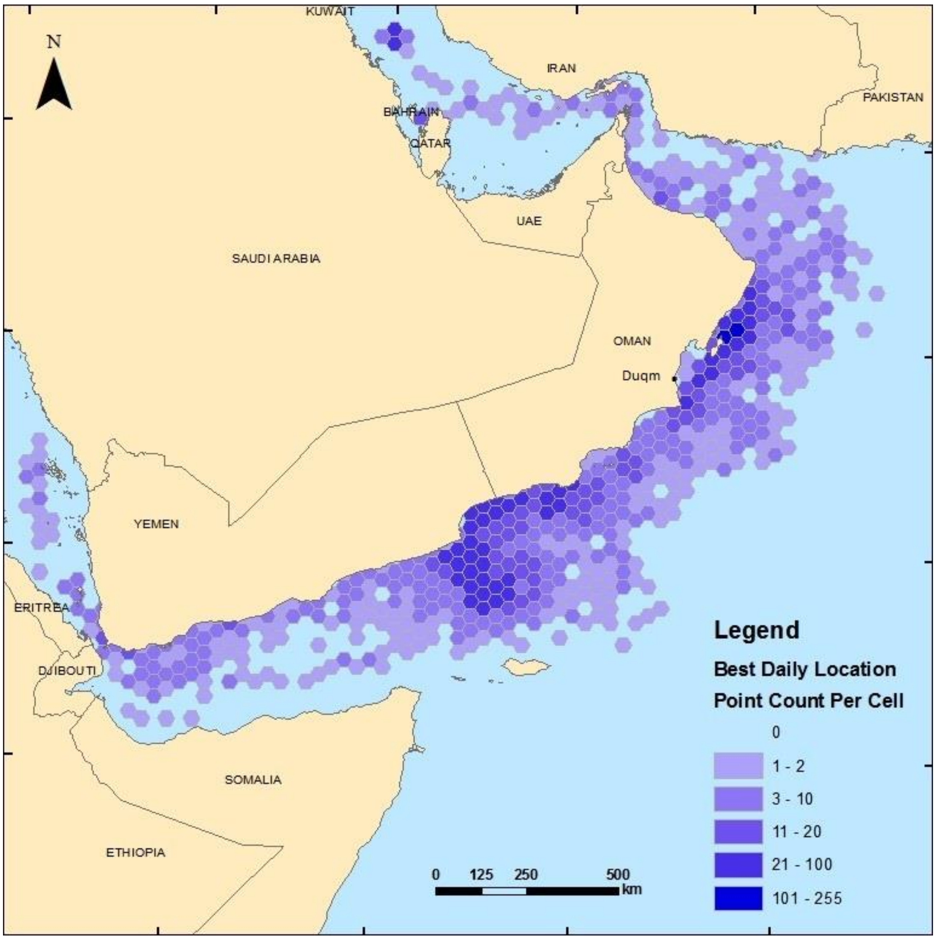


Figure 3-13: Adult female loggerhead turtle distribution based on telemetry studies conducted between 2006 and 2012 (ESO unpubl. data)

The results also reveal high density use of habitat within the CHAA (Figure 3-14). The results are temporally biased: they only show movements of those animals that have already arrived on the island (tagged on their first nesting event of the season), and exclude movements prior to the beginning of the season. Furthermore, females were only tagged from the north end of the island. Movement towards Masirah Island by females able to breed should be expected to occur at least two months prior to April, and is likely to include passage through the Gulf of Masirah from foraging grounds to the south. Females leave the island between July and September and head south. This route predominantly takes them along the eastern fringe of the Gulf of Masirah.

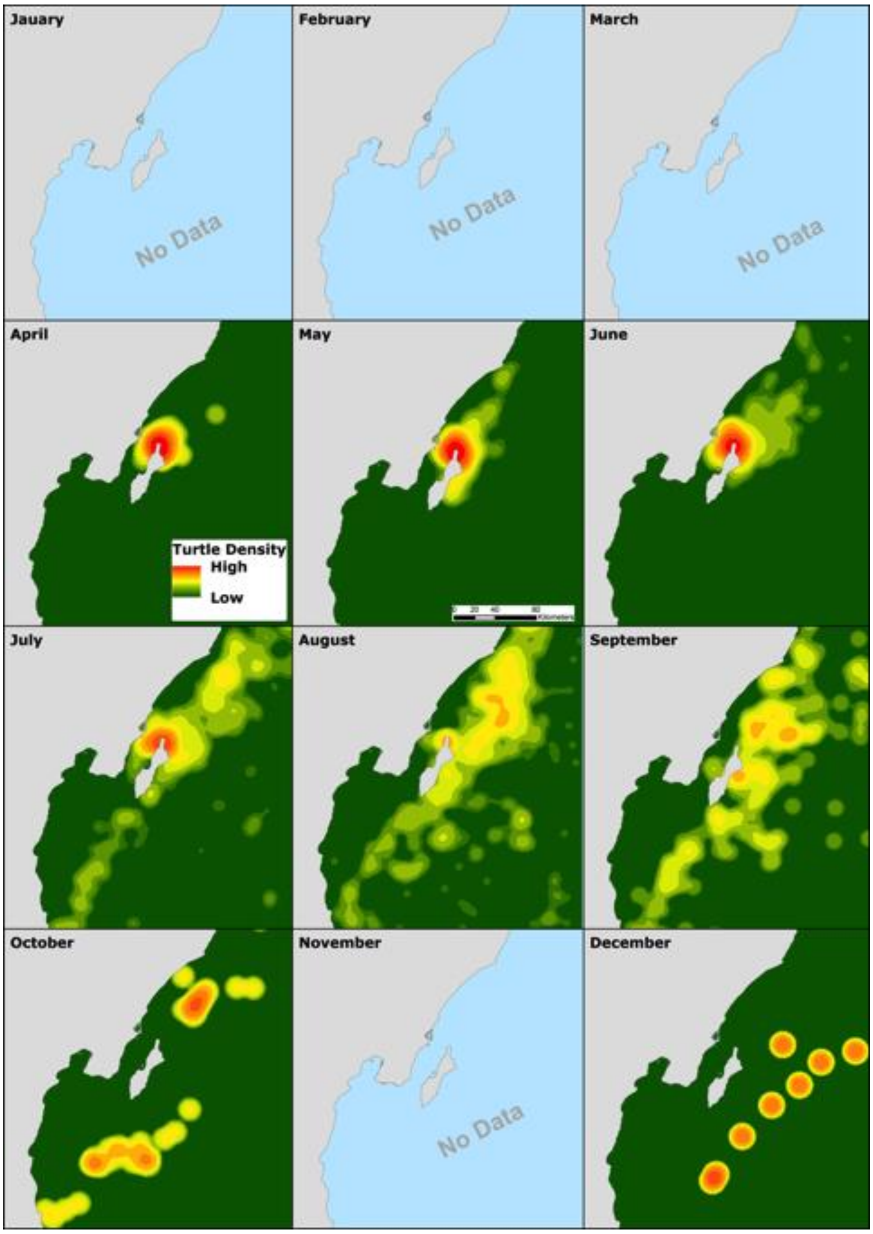


Figure 3-14: Kernel density plots of best daily locations from telemetry studies, showing monthly distribution of adult female loggerhead turtles in the CHAA between 2006 and 2012 (ESO unpubl. data)

Habitat utilisation by this species is understood to be predominantly seasonal based on results of telemetry data. This is expected to relate to turtles transiting through the area on migration to and from nesting at Masirah Island (Willson et al., 2015). Although an important migration route, the Gulf of Masirah is not expected to be an important foraging destination for adult female turtles based on these results. However, the occurrence of male turtles or sub-adults in the area is not well known, due to a lack of study on these population segments.

Overall distribution of loggerheads in the CHAA is depicted in

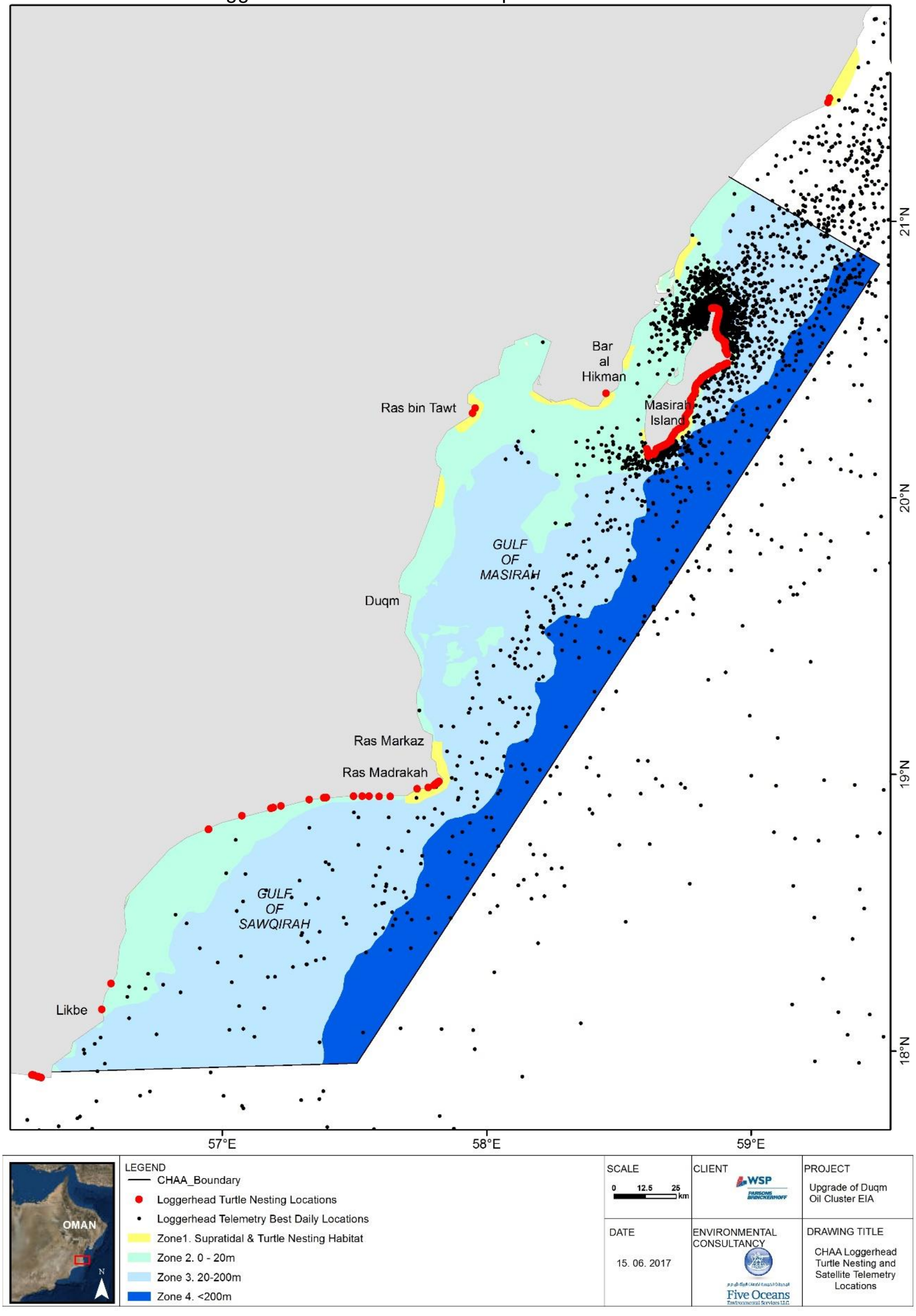


Figure 3-15 below.

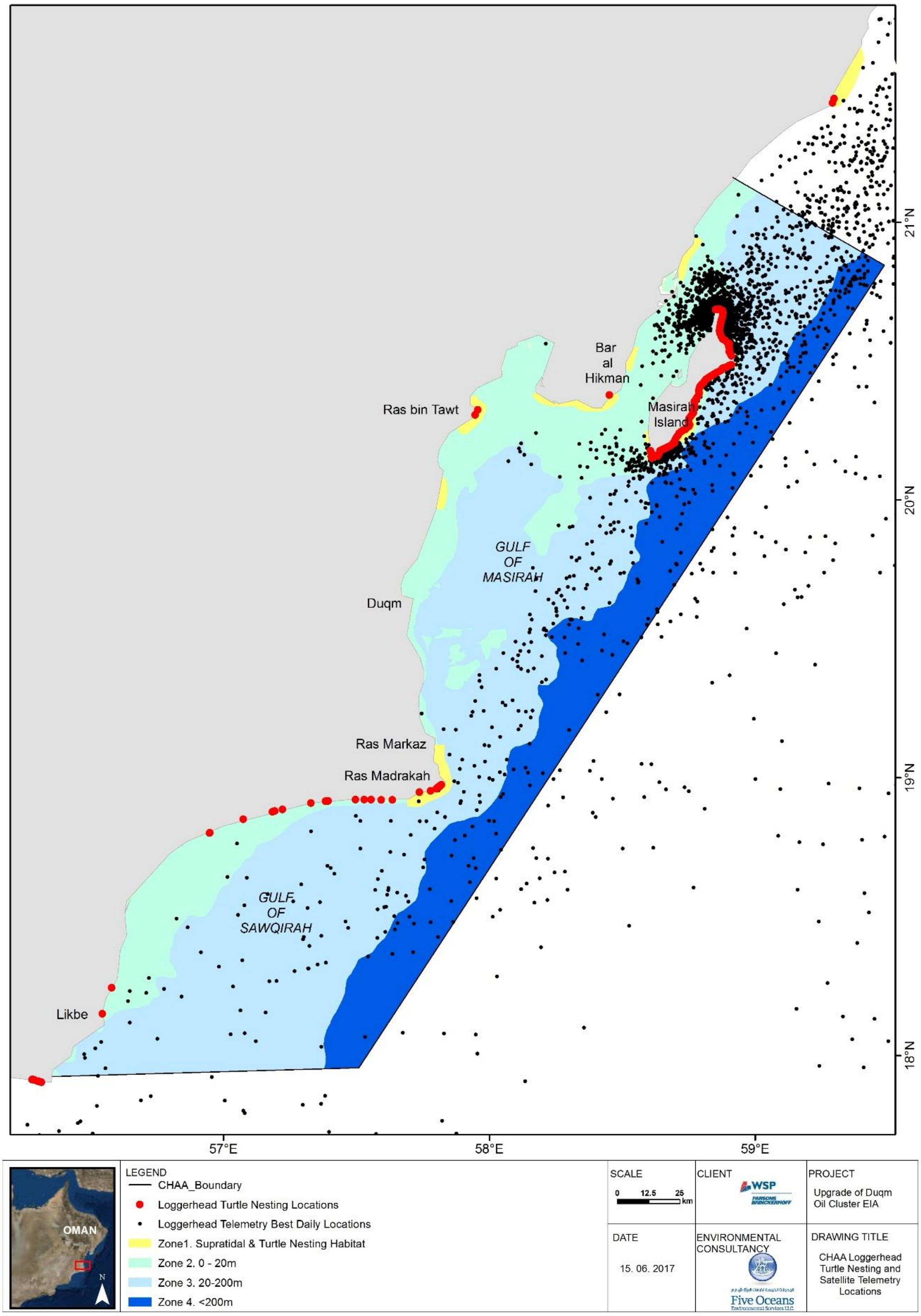


Figure 3-15: Distribution of loggerhead turtles in the CHAA including nesting locations and post-nesting migrations obtained using satellite telemetry studies.

KNOWLEDGE GAPS

Detailed study of the Masirah Island nesting population of loggerhead turtles is available as a result of systematic study conducted since 2006 (Casale, 2015; Willson et al., 2015; ESO and MECA unpubl. data). Much less is known about foraging habitat except for that generated during investigation of post-nesting migrations of adult female loggerheads during satellite tracking studies (Casale 2015; Willson et al. 2015; ESO and MECA unpubl. data). These studies have also revealed information about threats to loggerhead turtles, although this knowledge is largely confined to Masirah Island. Almost nothing is known about the pre--adult life history stage of loggerhead turtles or about males. The EIAs in the Duqm area have provided no new information. All other data on loggerhead turtles (which is limited) comes mostly from IUCN Coastal Zone Management studies conducted in the late 1980s/early 1990s (Salm 1991). Knowledge gaps are a constraint on definition of a thorough and comprehensive mitigation and management strategy for this species.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

IFC's PS6 defines critical habitat as areas of high biodiversity value that satisfy one or more of five Critical Habitat Criteria. PS6 also defines gradients of critical habitat based on the vulnerability and irreplaceability of the site. For the first three criteria numerical thresholds are used to assign a Tier 1 or Tier 2 critical habitat designation. For loggerhead turtles, two of the five Critical Habitat Criteria are relevant (Criteria 1 and 3) the first of which meets the Tier 1 level designation, whist the second meets the Tier 2 level designation, as described below:

Criterion 1: Critically Endangered (CR) or Endangered (EN) Species. The CHAA contains breeding and foraging habitat used by the Critically Endangered loggerhead turtle. Tier 1 criterion (a) is met because the habitat sustains more than 10% of the global population of the species, and 90% of the relevant regional management unit/subpopulation (North West Indian Ocean subpopulation), which is Critically Endangered.

Criterion 3: Migratory/Congregatory species. The assignation of Tier 2 in this case relates to the CHAA sustaining, on a cyclical or otherwise basis, more than 1%, but less than 95%, of the global population of this migratory species.

Based on these conclusions, there is a requirement to adhere to paragraphs 17-19 of PS6, which includes reference to assessment of impacts on the biodiversity values for which the critical habitat was designated, a robust monitoring programme and a mitigation strategy within the context of a Biodiversity Action Plan, including identification of biodiversity offsets if required. Recommendations for formulation of such a Biodiversity Action Plan are provided under 'Strategic Recommendations' in Section 4. It is key to note that these requirements sit beyond the sphere of direct Project control and impacts driving this requirement are only partly related to the Project.

It should, however, be noted that the AF influence on loggerhead turtle nesting sites is largely limited to crude oil spill, which under worst case modelled scenarios would reach nesting beaches to the south of Ras Markaz. This should be taken into consideration when evaluating the implications of the CHA and in defining mitigation and/or offset action.

3.2.9 Green Turtle

LIFE HISTORY AND ECOLOGY

Green turtles are among the most highly migratory of all the turtles and use a wide range of broadly separated localities and habitats during their lifetimes (for review see Hirth, 1997). Upon leaving the nesting beach, it has been hypothesized that hatchlings begin an oceanic phase (Carr 1987), perhaps floating passively in major current systems (gyres) that serve as open-ocean developmental grounds (Carr and Meylan, 1980; and Witham, 1991). After a number of years in the oceanic zone, these turtles recruit to neritic developmental areas rich in seagrass and/or marine algae where they forage and grow until maturity (Musick and Limpus, 1997). Upon attaining sexual maturity green turtles commence breeding migrations between foraging grounds and nesting areas that are undertaken every few years (Hirth 1997). Age to maturity for the species appears to be the longest of any sea turtle (Hirth 1997) sometimes requiring 50 years. Estimates of reproductive longevity range from 17 to 23 years (Carr et al. 1978, Fitzsimmons et al. 1995). Migrations are carried out by both males and females and may traverse oceanic zones, often spanning thousands of kilometers (Carr, 1986; Mortimer and Portier, 1989). During non-breeding periods adults reside at coastal neritic feeding areas that sometimes coincide with juvenile developmental habitats (e.g., Limpus et al., 1994, Seminoff et al., 2003). In Oman, juveniles/sub-adults are commonly seen in shallow waters along rocky shorelines where they forage (Baldwin 1995).

CONSERVATION STATUS

The green turtle is currently categorized as Endangered by the IUCN Red List of Threatened Species (Seminoff, 2004). On-going revision of the IUCN Red List will segregate the population into discrete management units one of which is likely to be the Northern Indian Ocean management unit. According to the IFC GN6 guidance document the Endangered listing means that it is facing a very high risk of extinction in the wild. It is the second highest risk category assigned by the IUCN Red List for wild species.

Analysis of historic and recent published accounts indicate extensive subpopulation declines in all major ocean basins over the last three generations as a result of overexploitation of eggs and adult females at nesting beaches, juveniles and adults in foraging areas, and, to a lesser extent, incidental mortality relating to marine fisheries and degradation of marine and nesting habitats. Analyses of subpopulation changes at 32 Index Sites distributed globally show a 48% to 67% decline in the number of mature females nesting annually over the last three generations.

In Oman, data from nesting beach monitoring at Ras al Hadd (350 km to the north east of Duqm) collected over the past 30 years (MECA unpubl. data) have yet to be analysed and the trend of the population is therefore unknown. However, the population abundance of green turtles has been previously estimated at between 12-20,000 females based on annual nest counts at Ras al Hadd alone. This constitutes a relatively high proportion (14-23%) of the total global adult female population, which has been estimated at 88,520 nesting females (Spotila, 2004). Oman therefore has an important role to play in the conservation of this species.

Up to 8,000 green turtles per year are bycaught in the area around Masirah Island and in the Gulf of Masirah, mostly in gill nets deployed by the artisanal skiff fishery (Willson et al., 2015). Ministry of Agriculture and Fish Wealth annual statistics show the artisanal skiff gill net fishery to be prevalent throughout the Gulf of Masirah for much of the year (MAFW, 2013) and as such it is likely this activity has been exerting a significant population level threat to green turtles in the region since the motorization of the artisanal fishery in the mid to late 1980's (IUCN, 1991). Siddeek and Baldwin (1996) projected simulated fishing related mortality and directed hunting captures using a stage class matrix model for green turtles in Oman. The study concluded a maximum take and accidental drowning rate of 268 female turtles per year for a positive population growth rate. The study indicates that the existing accidental and targeted takes of green turtles in Oman far exceeds a sustainable level for a viable population.

Other threats to green turtles in Oman are similar to those listed above for loggerhead turtles, including both threats on nesting beaches and on the marine environment, although the severity and magnitude of threats differs for each species.

GLOBAL AND NATIONAL DISTRIBUTION

The green turtle has a circumglobal distribution, occurring throughout tropical and, to a lesser extent, subtropical waters (Atlantic Ocean – eastern central, northeast, northwest, southeast, southwest, western central; Indian Ocean – eastern, western; Mediterranean Sea; Pacific Ocean – eastern central, northwest, southwest, western central). Green turtles are highly migratory and they undertake complex movements and migrations through geographically disparate habitats. Nesting occurs in more than 80 countries worldwide (Hirth 1997). Their movements within the marine environment are less understood but it is believed that green turtles inhabit coastal waters of over 140 countries (Groombridge and Luxmoore 1989).

In Oman, green turtles are truly ubiquitous occurring from Musandam in the north to the Dhofar-Yemen border in the south and are a common sight in coastal waters (Baldwin, 1999). Nesting occurs on approximately 275 beaches in Oman from Musandam to Dhofar (Salm, 1991) though is centred at Ras al Hadd where approximately 90-95% of Oman's nesting occurs.

Foraging green turtles occur throughout shallow coastal waters in Oman wherever algae and seagrasses occur. Highest densities of foraging green turtles have been recorded in Dhofar and in the Gulf of Masirah (Salm 1991; and Ross, 1985).

DISTRIBUTION WITHIN CHAA

Salm (1991) documents nesting broadly spread around the periphery of the Gulf of Masirah at a relatively low to medium density for this species. Annual estimates for the number of nests at main nesting sites include 500/year at Ras Madrakah, between 240/year between Duqm and Ras bin Tawt, and 220/year at Bar al Hikman (Salm 1991). Further important green turtle nesting occur at the southern and eastern shores of Masirah island (n=200-500 nests/year) (MECA/ESO unpublished data). Combining these data provides a maximum estimate of 1,500 turtle nests per year on beaches of the CHAA. Although nesting occurs year round at Ras al Hadd, nesting is largely restricted to the period June-October at Masirah Island.

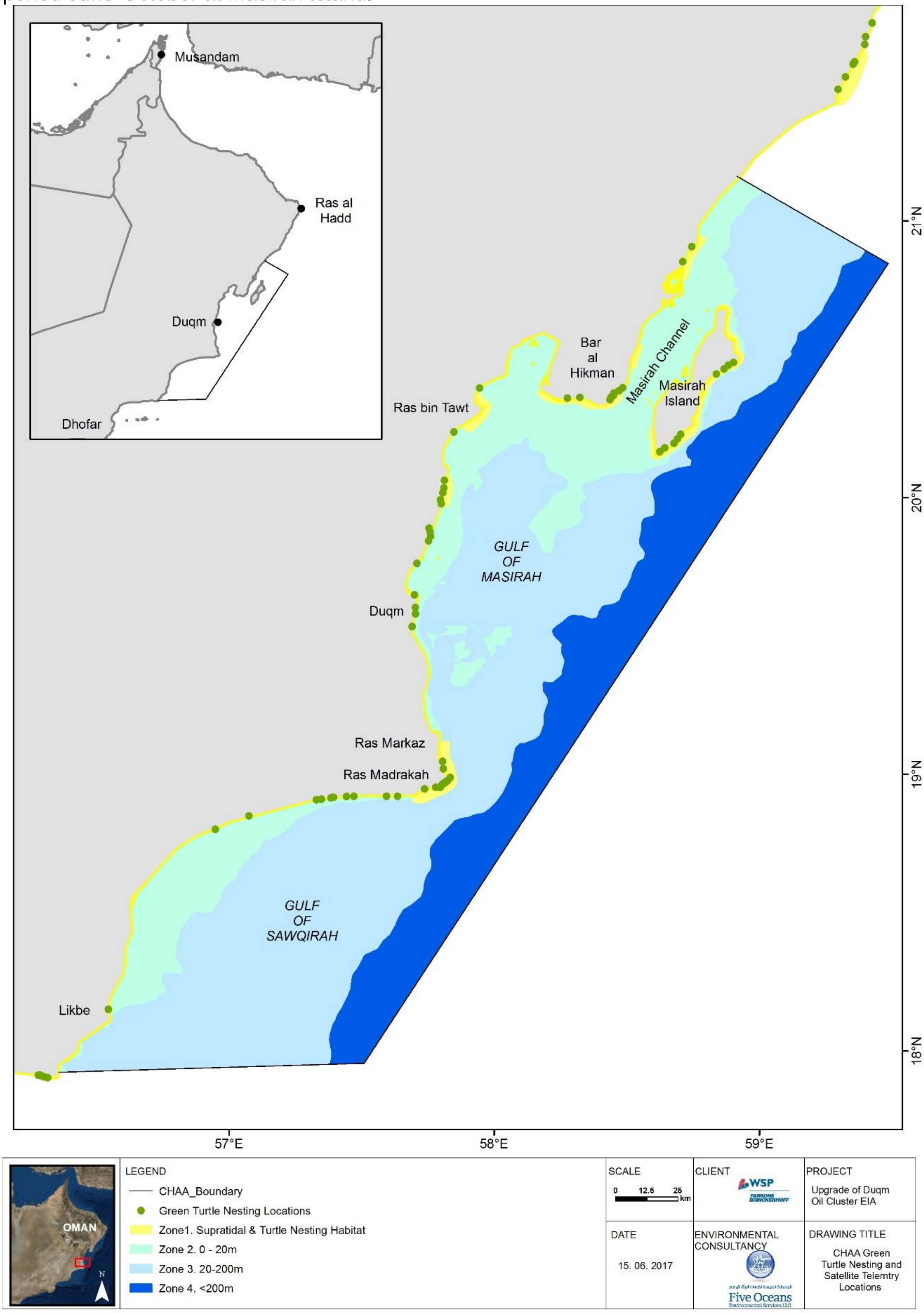


Figure 3-16 depicts the overall distribution of nesting green turtles in the CHAA.

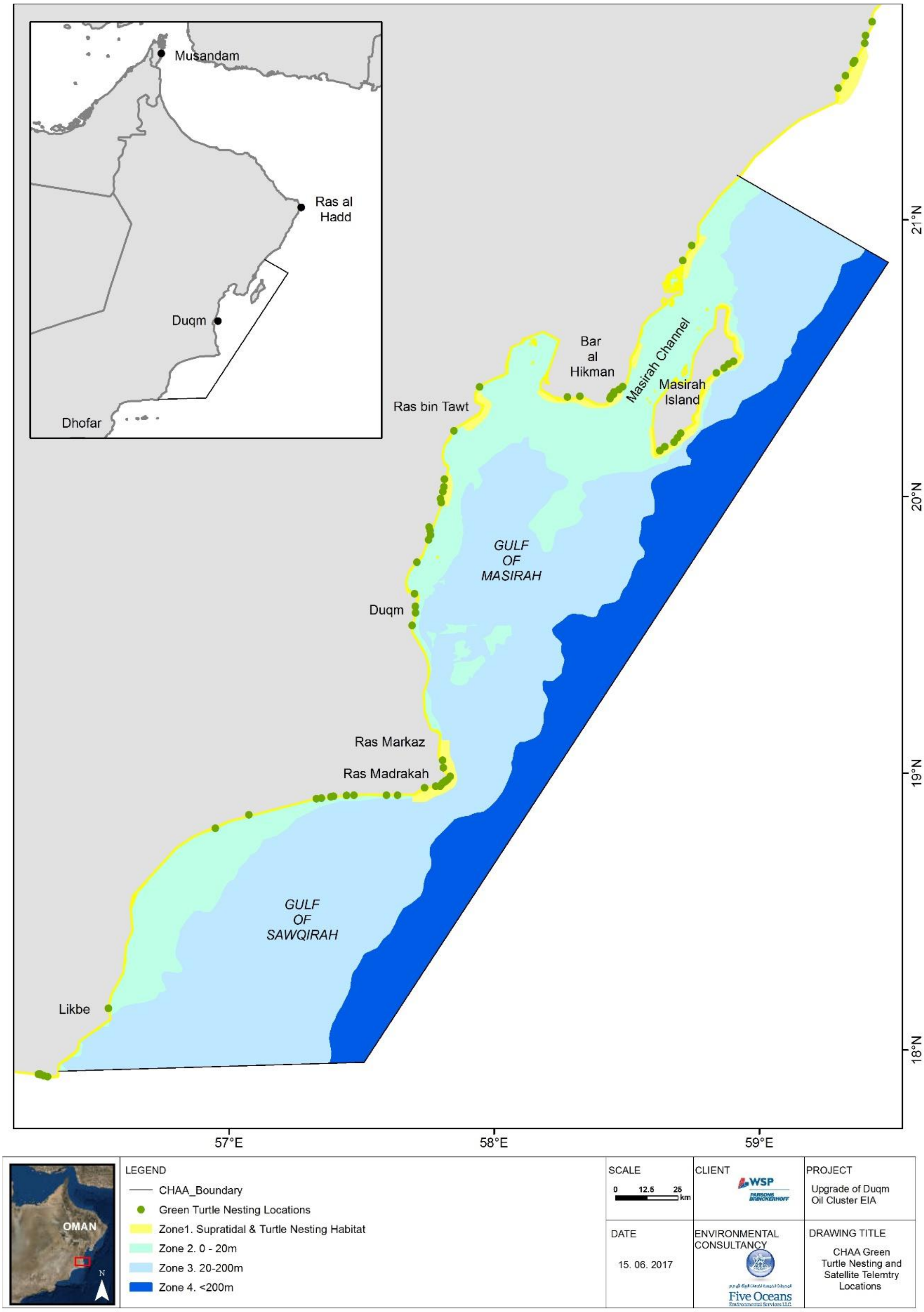


Figure 3-16: Distribution of green turtles nesting locations in the CHAA

Of six turtles tracked using satellite tags deployed in July 2016 at Ras al Hadd, three individuals passed through the CHAA on post-nesting migration (EWS-WWF unpubl. data). One remained in the CHAA for over three months are remained there until tag transmission terminated. This provides further indication of the importance of the area for foraging by green turtles.

Studies conducted in the Masirah channel (Ross 1985) document foraging items to include seagrasses (*Halophila ovalis, Halodule uninervis*) and algae (*Chaetomorpha aera* and *Sargassum illicifolium*). Within the Masirah channel alone, a conservative count from aerial surveys of green turtles in this area was estimated at 1,000-3,000 individuals equating to 100-300 turtles/km^2 (Ross, 1985). The sex ratio of turtles in this area was found to be equal with capture studies showing individuals had a two week residency period, suggesting high mobility during foraging.

Juveniles and sub-adults, as well as migrating adults, can be expected to occur in high numbers throughout the CHAA. Capture studies in the Masirah Channel encountered sizes from 30-110 cm (Ross, 1985). Beach surveys reveal high numbers of strandings of green turtles, especially juveniles), along beaches from Bar al Hikman to Duqm (ESO unpubl. data) including high densities along beaches south of Ras bin Tawt, where approximately 10 stranded green turtles were encountered per kilometre on average over a 5 kilometre stretch of shoreline in 2015 (Five Oceans Environmental Services, 2015).

KNOWLEDGE GAPS

Relatively little is known about green turtles in the CHAA and in Oman most recent data, restricted largely to nesting records, comes from Ras al Hadd (MECA and ESO unpubl. data.) or, at Masirah Island, from fisheries bycatch studies (Willson et al. 2015; ESO unpubl. data). The recent EIAs in the Duqm area have provided some new information, but this is mostly limited to records of strandings, nesting inferred from tracks on beaches and infrequent sightings at sea. The only other recent available data is from satellite tracking studies (EWS-WWF unpubl. data) which provides some insight into migratory routes and forgaing habitats for a very small sample of the population. All other data, which is predominantly results of nesting beach and foraging surveys, is over 20 years old. Knowledge gaps are a constraint on definition of a thorough and comprehensive mitigation and management strategy for this species.

CONCLUSIONS AND JUSTIFICATION FOR TIER SELECTION

IFC's PS 6 defines critical habitat as areas of high biodiversity value that satisfy one or more of five Critical Habitat Criteria. PS6 also defines gradients of critical habitat based on the vulnerability and irreplaceability of the site. For the first three criteria numerical thresholds are used to assign a Tier 1 or Tier 2 critical habitat designation. In the case of green turtles, two of the five Critical Habitat Criteria are relevant (Criteria 1 and 3) both of which meet the Tier 2 level designation, as described below:

- Criterion 1: Critically Endangered (CR) or Endangered (EN) Species. The CHAA contains breeding and foraging habitat used by the Endangered green turtle. Tier 2 criterion (c) is met because the habitat supports the regular occurrence of one or more individuals of this EN species; and

- Criterion 3: Migratory/Congregatory species. The assignation of Tier 2 in this case relates to the CHAA sustaining, on a cyclical or otherwise basis, more than 1% of the global population of this migratory species.

Based on these conclusions, there is a requirement to adhere to paragraphs 17-19 of PS6, which includes reference to assessment of impacts on the biodiversity values for which the critical habitat was designated, a robust monitoring programme and a mitigation strategy within the context of a Biodiversity Action Plan, including identification of biodiversity offsets if required.

3.2.10 Marine Environment Critical Habitat Summary

There are many marine species listed by IUCN's Red List that are known to occur within the CHAA. Of the five species evaluated as part of this assessment, two species, the Arabian Sea humpback whale and the loggerhead turtle, meet the Tier 1 critical habitat criteria whereas the other three are assessed to be Tier 2.

It should be noted that whilst the science and logic behind these results are thought to be comprehensive and robust, the extent of the CHAA has been determined largely by the results of oil spill modelling which implies a relatively expansive CHAA relative to the direct project risk. Some other impacts may extend to similar distances from the project site (e.g. noise, ship strikes) but most will be more localised. This should be taken into account when considering the implications of the results of this CHA and the focus of mitigation/offset actions required.

4 RECOMMENDATIONS

The following recommendations have been divided into two categories:

- Project and AF related recommendations – factors that DRPIC has direct influence or control over. Factors relating to significant ecological impacts on critical habitat triggering species identified in ecological impact assessment.

- Strategic recommendations – issues affecting critical habitat triggering species that the Project and AFs may affect in a cumulative way but which mainly relate to other industrial developments and wider spatial planning of the terrestrial and marine zone.

In practice, it is difficult to separate Project related from strategic issues. However it is understood a strategic approach to addressing impacts will take time to develop and there will be the requirement to address specific mitigation requirements impacts immediately, such as during the construction phase.

In the first category, DRPIC will seek mitigation for these issues through implementation of the Project ESMP. In the second category, DRPIC will seek to influence and address these issues through consultation and advocacy with a broad range of stakeholders. The CHAA of projects and AFs extends beyond the jurisdiction of SEZAD alone and are also shared with other industries and community activities within the area.

Project Related Recommendations

DRPIC should commission detailed pre-construction botanical surveys at each of the locations where the Project and AF footprint intersects with an area of potential suitable critical habitat for the endemic plant species identified in this CHA. The results shall form the basis for a mitigation plan that is compliant with the requirements of IFC PS6 and could be used to inform a net grain strategy (will require development of a suitable metric as recommended in Technical Appendix E: Biodiversity Offsetting Framework). An inventory of locations where the Project Footprint overlpas an area of potentially terrestrial habitat is provided at the end of this document and will also be listed in the Project Biodiversity Management Plan.

DRPIC should deploy construction phase and operational phase mitigation to address potential indirect disturbance associated with marine facilities under its direct control: the Refinery; the Ras Markaz Single Point Mooring facility; and the Product Export Terminal. Measures to address disturbance arising from artificial lighting, noise and vibration and visual disturbance associated with personnel and vehicles should be managed within thresholds which do not alter the behaviour or habitat use of species triggering CHA (further recommendations are provided in Section 5 of the main chapter).

DRPIC should agree a code of conduct for avoidance of marine mammal and turtle collisions and minimum safety standards relating to pollution for all vessels importing and exporting oil products to/from the Refinery.

Through biodiversity offsetting approaches (see Technical Appendix E: Biodiversity Offsetting Framework) DRPIC should contribute to primary research and management and mitigation of strategic biodiversity conservation issues associated with both marine and terrestrial zones (see below).

Strategic Initiative Approach

Although the project and AFs are challenged by specific elements of the IFC PS6 with respect to the CHAA overlap with critical habitat, an opportunity exists for DRPIC to front an industry lead approach to address strategic environmental management responsibilities. A mechanism such as an industry association and fund (representing proportional interests) would provide a direct means for companies such as DPRIC to guide resources directly into addressing associated impacts. CSR activities may be undertaken as a gesture to support local community projects but should not be considered a replacement for a coordinated and structured approach to environmental mitigation offset and monitoring activities.

It is intended tha that the strategic initiative would be comprised of key stakeholders including: MECA; and Office of the Conservation of the Environment (OCE, Diwan of the Royal Court); the Oman Botanic Garden; SEZAD; other Al Wusta local Govenrment agencies; the Port of Duqm Authority; all AF developers and DRPIC.

With respect to the marine environment, development of the strategic initiative approach could be supported by the IUCN whom have been active in formation of ‘advisory panels’ that guide mitigation and monitoring through linking industry together government, conservation and research interests, (Martin-Mehers, 2016). In the case of the Western Grey Whale, an IUCN advisory panel has contributed to the development of a Conservation Management Plan and an IFC guided approach to address environmental responsibilities of the developers of the Sakhalin oil field within an area of critical habitat.

Progress with the Western Grey Whale advisory panel and consideration of similar conservation concerns for the ASHW has previously resulted in members of the International Whaling Committee Scientific Committee advising for a similar initiative to address critical habitat in the Gulf of Masirah:

> *‘…consideration of the formation of an independent advisory panel along the lines of that developed for the western gray whale… to focus on key areas where threats are occurring concurrently and provide expert advice on conservation management and research’ (IWC, 2015).*

Other Strategic Recommendations

In addressing IFC PS6 conditions, DPRIC and lenders to evaluate financial framework for contribution towards a strategic initiative based environmental monitoring and mitigation approach (such as the industry association). Costings to include options, development and facilitation.

DPRIC to propose and present strategic initiative concept and strategic options to SEZAD, other Omani Government bodies and interested industries.

Formally establish the initiative or the agreed mechanism through which DPRIC will finance activities of strategic responsibility.

The strategic initiative should commission research to define likely impact scenario for noise, wildlife strikes and oil spills from ships in transit through the Gulf of Masirah associated with AFs and wider shipping operations. This information is essential to accurate define the CHAA for relevant marine species and ultimate to devise effective mitigation approaches. Information from ecological research should be made available to developers carrying out EIA studies in the Gulf of Masirah. SEZAD and Omani Government bodies (such as the authority responsible for coordinating spatial planning in the Sultanate, the Supreme Council for Planning) should develop a zoning strategy to guide developers to avoid critical habitat, this may require designation of marine protected areas where no development or commercial use is permitted.

The strategic initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas.

The strategic initiative including SEZAD and Omani Government bodies (principally MECA and Office of the Conservation of the Environment (OCE, Diwan of the Royal Court) in collaboration with the Oman Botanic Garden) should commission research to better understand the distribution and abundance of all endemic plant and mammal species identified in Table 3.2 which could potentially trigger CHA according to IFC PS6.

With reference to both the terrestrial and marine zones, the strategic initiative should consider offsetting approaches to address cumulative impacts on critical habitat for the species identified in this document (see Technical Appendix E: Biodiversity Offsetting Framework). Such an approach could be linked to a government lead region-wide/Gulf of Masirah wide zoning strategy with designated zones where different activities are prohibited or permitted. Implementation of an offsetting strategy may also offer a potential source of funding for conservation measures and would also provide a strategic framework to provide assurance to potential project funders (particularly those requiring compliance with IFC PS6) as implementation of the Duqm Special Economic Zone masterplan is progressed.

5 LOCATIONS WHERE THE PROJECT FOOTPRINT OVERLAPS AN AREA OF POTENTIAL CRITICAL HABITAT

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
1	1	19.71935325760	57.64452913060	Mountains and rocky terrain	*Salsola omanensis*
2	1	19.71950549830	57.64777543130	Mountains and rocky terrain	*Salsola omanensis*
3	1	19.71896797370	57.64780353580	Mountains and rocky terrain	*Salsola omanensis*
4	1	19.71881573310	57.64455724590	Mountains and rocky terrain	*Salsola omanensis*
5	2	19.69728197470	57.63843102180	Gravel and Sand Plains	*Salsola omanensis*
6	2	19.72229467790	57.63910630990	Gravel and Sand Plains	*Salsola omanensis*
7	2	19.72220527170	57.64279679300	Gravel and Sand Plains	*Salsola omanensis*
8	2	19.69719259820	57.64212093240	Gravel and Sand Plains	*Salsola omanensis*
9	3	19.72071252610	57.66018210770	Gravel and Sand Plains	*Salsola omanensis*
10	3	19.72070379680	57.66254880680	Gravel and Sand Plains	*Salsola omanensis*
11	3	19.71873480930	57.66254069430	Gravel and Sand Plains	*Salsola omanensis*
12	3	19.71874353770	57.66017402410	Gravel and Sand Plains	*Salsola omanensis*
13	4	19.66550124170	57.64541708730	Gravel and Sand Plains	*Salsola omanensis*
14	4	19.66445220870	57.64824679410	Gravel and Sand Plains	*Salsola omanensis*
15	4	19.66269253180	57.64751984250	Gravel and Sand Plains	*Salsola omanensis*
16	4	19.66374155290	57.64469016110	Gravel and Sand Plains	*Salsola omanensis*
17	5	19.66601799150	57.64571402790	Gravel and Sand Plains	*Salsola omanensis*
18	5	19.66610239410	57.64575603910	Gravel and Sand Plains	*Salsola omanensis*
19	5	19.66606409010	57.64584179460	Gravel and Sand Plains	*Salsola omanensis*
20	5	19.66597968750	57.64579978340	Gravel and Sand Plains	*Salsola omanensis*
21	6	19.18920556440	57.73303835220	Gravel and Sand Plains	*Salsola omanensis*
22	6	19.18574434130	57.73744069150	Gravel and Sand Plains	*Salsola omanensis*
23	6	19.18214284950	57.73430408940	Gravel and Sand Plains	*Salsola omanensis*
24	6	19.18560399760	57.72990177480	Gravel and Sand Plains	*Salsola omanensis*
25	7	19.18817152920	57.72663506000	Gravel and Sand Plains	*Salsola omanensis*
26	7	19.19165198780	57.72966533840	Gravel and Sand Plains	*Salsola omanensis*
27	7	19.18955574150	57.73233240770	Gravel and Sand Plains	*Salsola omanensis*
28	7	19.18607532670	57.72930211490	Gravel and Sand Plains	*Salsola omanensis*
29	8	19.20189605110	57.71663054310	Gravel and Sand Plains	*Salsola omanensis*
30	8	19.19162066440	57.72970516570	Gravel and Sand Plains	*Salsola omanensis*
31	8	19.18814020510	57.72667477390	Gravel and Sand Plains	*Salsola omanensis*
32	8	19.19841537680	57.71360022250	Gravel and Sand Plains	*Salsola omanensis*
33	9	19.21367824340	57.70163522100	Gravel and Sand Plains	*Salsola omanensis*
34	9	19.19904033140	57.72026473960	Gravel and Sand Plains	*Salsola omanensis*
35	9	19.19555973580	57.71723445460	Gravel and Sand Plains	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
36	9	19.21019734140	57.69860503800	Gravel and Sand Plains	*Salsola omanensis*
37	10	19.71310613780	57.63870119060	Gravel and Sand Plains	*Salsola omanensis*
38	10	19.69255854030	57.63899834870	Gravel and Sand Plains	*Salsola omanensis*
39	10	19.69245643420	57.63114126550	Gravel and Sand Plains	*Salsola omanensis*
40	10	19.71300404670	57.63084310360	Gravel and Sand Plains	*Salsola omanensis*
41	11	19.17213641960	57.73384852170	Gravel and Sand Plains	*Salsola omanensis*
42	11	19.17439853740	57.75164478420	Gravel and Sand Plains	*Salsola omanensis*
43	11	19.16337389730	57.75319617400	Gravel and Sand Plains	*Salsola omanensis*
44	11	19.16111188820	57.73540108490	Gravel and Sand Plains	*Salsola omanensis*
45	12	19.17579373420	57.75711406750	Gravel and Sand Plains	*Salsola omanensis*
46	12	19.17754228000	57.76152810780	Gravel and Sand Plains	*Salsola omanensis*
47	12	19.17450839280	57.76285917070	Gravel and Sand Plains	*Salsola omanensis*
48	12	19.17275987600	57.75844519960	Gravel and Sand Plains	*Salsola omanensis*
49	13	19.69406563460	57.64521654520	Gravel and Sand Plains	*Salsola omanensis*
50	13	19.70939274550	57.64550953250	Gravel and Sand Plains	*Salsola omanensis*
51	13	19.70936002830	57.64741693140	Gravel and Sand Plains	*Salsola omanensis*
52	13	19.69403292560	57.64712376270	Gravel and Sand Plains	*Salsola omanensis*
53	14	19.68200513560	57.67586450920	Gravel and Sand Plains	*Salsola omanensis*
54	14	19.68518589240	57.68198606130	Gravel and Sand Plains	*Salsola omanensis*
55	14	19.68200639470	57.68382736970	Gravel and Sand Plains	*Salsola omanensis*
56	14	19.67882569710	57.67770590620	Gravel and Sand Plains	*Salsola omanensis*
57	15	19.69252565730	57.64811153730	Gravel and Sand Plains	*Salsola omanensis*
58	15	19.68117590440	57.64971050720	Gravel and Sand Plains	*Salsola omanensis*
59	15	19.68093693700	57.64781988960	Gravel and Sand Plains	*Salsola omanensis*
60	15	19.69228667700	57.64622078780	Gravel and Sand Plains	*Salsola omanensis*
61	16	19.70907302720	57.64547019940	Gravel and Sand Plains	*Salsola omanensis*
62	16	19.71495812730	57.64558280590	Gravel and Sand Plains	*Salsola omanensis*
63	16	19.71492481380	57.64752342120	Gravel and Sand Plains	*Salsola omanensis*
64	16	19.70903971700	57.64741074390	Gravel and Sand Plains	*Salsola omanensis*
65	17	19.71749384730	57.62861260850	Gravel and Sand Plains	*Salsola omanensis*
66	17	19.71803713550	57.64230239990	Gravel and Sand Plains	*Salsola omanensis*
67	17	19.71302850190	57.64252382980	Gravel and Sand Plains	*Salsola omanensis*
68	17	19.71248521850	57.62883446510	Gravel and Sand Plains	*Salsola omanensis*
69	18	19.72439858360	57.62930794070	Gravel and Sand Plains	*Salsola omanensis*
70	18	19.72435389910	57.63912497720	Gravel and Sand Plains	*Salsola omanensis*
71	18	19.71748307400	57.63908989710	Gravel and Sand Plains	*Salsola omanensis*
72	18	19.71752774490	57.62927328000	Gravel and Sand Plains	*Salsola omanensis*
73	19	19.65910546370	57.66181635570	Gravel and sand plains	*Salsola omanensis*
74	19	19.65606670990	57.67001016650	Gravel and sand plains	*Salsola omanensis*
75	19	19.65458062680	57.66939604400	Gravel and sand plains	*Salsola omanensis*
76	19	19.65761935130	57.66120229530	Gravel and sand plains	*Salsola omanensis*
77	20	19.65927649700	57.67012525350	Gravel and sand plains	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
78	20	19.65740565990	57.67073184530	Gravel and sand plains	*Salsola omanensis*
79	20	19.65721203540	57.67006644810	Gravel and sand plains	*Salsola omanensis*
80	20	19.65908287060	57.66945984920	Gravel and sand plains	*Salsola omanensis*
81	21	19.75178792890	57.60248602590	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
82	21	19.74625106480	57.60818744740	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
83	21	19.74431913920	57.60609452850	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
84	21	19.74985593790	57.60039309940	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
85	22	19.25790787900	57.65854592210	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
86	22	19.25019122790	57.65905634290	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
87	22	19.24990124290	57.65419711810	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
88	22	19.25761788740	57.65368646990	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
89	23	19.27496244130	57.62119935470	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
90	23	19.27947802890	57.62131424980	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
91	23	19.27939946810	57.62473682060	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
92	23	19.27488388520	57.62462183190	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
93	24	19.32117517930	57.60422485560	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
94	24	19.29918436390	57.60992538680	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
95	24	19.29809886470	57.60528000380	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
96	24	19.32008955340	57.59957888030	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
97	25	19.37626968410	57.59341549400	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
98	25	19.37371297850	57.59372660090	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
99	25	19.37364499090	57.59310625060	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
100	25	19.37620169570	57.59279513410	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
101	26	19.38997917800	57.59277045670	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
102	26	19.37666513020	57.59348751960	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
103	26	19.37643452680	57.58873438540	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
104	26	19.38974856630	57.58801693600	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
105	27	19.38985390930	57.59277821300	Wadis and other temporary watercourses	*Ochradenus harsusiticus*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
106	27	19.38461618360	57.59305919410	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
107	27	19.38453339150	57.59134556100	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
108	27	19.38977111620	57.59106452510	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
109	28	19.46870927790	57.58058705200	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
110	28	19.46318438040	57.58143792670	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
111	28	19.46253146770	57.57672592190	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
112	28	19.46805634750	57.57587488960	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
113	29	19.50496383260	57.56872412970	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
114	29	19.48954465840	57.57211997110	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
115	29	19.48859204410	57.56731044090	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
116	29	19.50401114060	57.56391415870	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
117	30	19.53788129730	57.56323411650	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
118	30	19.54035785970	57.56984614950	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
119	30	19.53802366090	57.57081880210	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
120	30	19.53554713140	57.56420685130	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
121	31	19.58809766450	57.56754117130	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
122	31	19.58787700710	57.57234404640	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
123	31	19.58686732530	57.57229239010	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
124	31	19.58708798060	57.56748954470	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
125	32	19.58396633550	57.56646355700	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
126	32	19.58477469950	57.57157048960	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
127	32	19.58334273770	57.57182278880	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
128	32	19.58253437970	57.56671590050	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
129	33	19.58257921890	57.56672328550	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
130	33	19.58295924190	57.56678587530	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
131	33	19.58295649190	57.56680446270	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
132	33	19.58257646890	57.56674187280	Wadis and other temporary watercourses	*Ochradenus harsusiticus*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
133	34	19.57747928700	57.56514940120	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
134	34	19.57996872760	57.57098937880	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
135	34	19.57873634020	57.57157412450	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
136	34	19.57624691730	57.56573418350	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
137	35	19.57904519050	57.57094211610	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
138	35	19.57967830230	57.57104640200	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
139	35	19.57967512140	57.57106789770	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
140	35	19.57904200970	57.57096361180	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
141	36	19.59349639090	57.57256159270	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
142	36	19.59534763250	57.57258050260	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
143	36	19.59534749990	57.57259495750	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
144	36	19.59349625830	57.57257604740	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
145	37	19.59167804850	57.56740583170	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
146	37	19.59786071900	57.57202151270	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
147	37	19.59617047950	57.57454216010	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
148	37	19.58998787370	57.56992643460	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
149	38	19.61682717890	57.56970423120	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
150	38	19.62339370000	57.57313917960	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
151	38	19.62138791030	57.57740946760	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
152	38	19.61482147250	57.57397439300	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
153	39	19.64049400480	57.57579581700	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
154	39	19.64496905340	57.58210657700	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
155	39	19.64181964550	57.58459441780	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
156	39	19.63734468120	57.57828371690	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
157	40	19.64618559510	57.57747104610	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
158	40	19.65091306690	57.57782588510	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
159	40	19.65059263410	57.58258117920	Wadis and other temporary watercourses	*Ochradenus harsusiticus*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
160	40	19.64586517500	57.58222620210	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
161	41	19.71830952020	57.62415802040	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
162	41	19.71576087430	57.62530844670	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
163	41	19.71501049610	57.62345478530	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
164	41	19.71755913100	57.62230433420	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
165	42	19.71764680290	57.60251285160	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
166	42	19.71759674070	57.61387608120	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
167	42	19.71308005060	57.61385373510	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
168	42	19.71313010290	57.60249082450	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
169	43	19.75367930650	57.60505890730	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
170	43	19.74801463830	57.60994813050	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
171	43	19.74696023930	57.60858533090	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
172	43	19.75262487140	57.60369608960	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
173	44	19.48486780670	57.57432009450	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
174	44	19.48438177520	57.57463105470	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
175	44	19.48417912720	57.57427889620	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
176	44	19.48466515820	57.57396793530	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
177	45	19.48419041420	57.57495032120	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
178	45	19.48342852330	57.57506234370	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
179	45	19.48334966550	57.57446605110	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
180	45	19.48411155610	57.57435402580	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
181	46	19.49474888700	57.57092401980	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
182	46	19.49033840940	57.57184563810	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
183	46	19.48996139770	57.56983952610	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
184	46	19.49437186650	57.56891785500	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
185	47	19.49234294570	57.57086884600	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
186	47	19.48526979830	57.57403118960	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis

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187	47	19.48340792550	57.56940103460	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
188	47	19.49048099770	57.56623852150	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
189	48	19.50000713690	57.56768739190	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
190	48	19.49241406740	57.57067523480	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
191	48	19.49104915460	57.56681824680	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
192	48	19.49864216550	57.56383024550	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
193	49	19.61055048200	57.56781560860	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
194	49	19.61241406410	57.56792206750	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
195	49	19.61238464630	57.56849551160	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
196	49	19.61052106460	57.56838904620	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
197	50	19.61837005210	57.57051127790	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
198	50	19.61764793830	57.57204869570	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
199	50	19.61630580410	57.57134663720	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
200	50	19.61702791170	57.56980922870	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
201	51	19.59760754120	57.56782469750	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
202	51	19.59969727270	57.56783202360	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
203	51	19.59969599810	57.56823664850	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
204	51	19.59760626680	57.56822931710	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
205	52	19.56901847340	57.56481077360	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
206	52	19.57376809480	57.56520024570	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
207	52	19.57361488920	57.56727960920	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
208	52	19.56886527370	57.56689007680	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
209	53	19.56681815330	57.56868349950	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
210	53	19.57039796920	57.56897708170	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
211	53	19.57034476710	57.56969908620	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
212	53	19.56676495280	57.56940548820	Mountains and rocky terrain	Egyptian Vulture, *Salsola omanensis*
213	54	19.72428741690	57.62654870170	Mountains and rocky terrain	*Salsola omanensis*

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214	54	19.71662653530	57.62994041150	Mountains and rocky terrain	*Salsola omanensis*
215	54	19.71595293580	57.62824380460	Mountains and rocky terrain	*Salsola omanensis*
216	54	19.72361378770	57.62485202620	Mountains and rocky terrain	*Salsola omanensis*
217	55	19.74358325900	57.61267273470	Mountains and rocky terrain	*Salsola omanensis*
218	55	19.74216269670	57.62259822760	Mountains and rocky terrain	*Salsola omanensis*
219	55	19.73947525740	57.62216911480	Mountains and rocky terrain	*Salsola omanensis*
220	55	19.74089579200	57.61224378270	Mountains and rocky terrain	*Salsola omanensis*
221	56	19.66143396780	57.58253107530	Mountains and rocky terrain	*Salsola omanensis*
222	56	19.64990144490	57.58279213910	Mountains and rocky terrain	*Salsola omanensis*
223	56	19.64980130220	57.57786659810	Mountains and rocky terrain	*Salsola omanensis*
224	56	19.66133382710	57.57760518200	Mountains and rocky terrain	*Salsola omanensis*
225	57	19.63255756970	57.57644802510	Mountains and rocky terrain	*Salsola omanensis*
226	57	19.64147615690	57.57711755770	Mountains and rocky terrain	*Salsola omanensis*
227	57	19.64115565850	57.58187231030	Mountains and rocky terrain	*Salsola omanensis*
228	57	19.63223709530	57.58120251750	Mountains and rocky terrain	*Salsola omanensis*
229	58	19.60858804970	57.57262918450	Mountains and rocky terrain	*Salsola omanensis*
230	58	19.60308610920	57.57260982260	Mountains and rocky terrain	*Salsola omanensis*
231	58	19.60309042180	57.57124339350	Mountains and rocky terrain	*Salsola omanensis*
232	58	19.60859236370	57.57126270900	Mountains and rocky terrain	*Salsola omanensis*
233	59	19.62649747540	57.57681786260	Mountains and rocky terrain	*Salsola omanensis*
234	59	19.63020034090	57.57825367910	Mountains and rocky terrain	*Salsola omanensis*
235	59	19.62929879510	57.58084329310	Mountains and rocky terrain	*Salsola omanensis*
236	59	19.62559595110	57.57940742630	Mountains and rocky terrain	*Salsola omanensis*
237	60	19.70757690440	57.64623710890	Mountains and rocky terrain	*Salsola omanensis*
238	60	19.71069300010	57.64625699970	Mountains and rocky terrain	*Salsola omanensis*
239	60	19.71068620990	57.64744230420	Mountains and rocky terrain	*Salsola omanensis*
240	60	19.70757011500	57.64742239050	Mountains and rocky terrain	*Salsola omanensis*
241	61	19.70810762150	57.64632506280	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
242	61	19.70706403050	57.64737301580	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
243	61	19.70706400520	57.64737298770	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
244	61	19.70810759620	57.64632503480	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
245	62	19.70814766360	57.64732457770	Mountains and rocky terrain	*Salsola omanensis*
246	62	19.69344916100	57.64798142390	Mountains and rocky terrain	*Salsola omanensis*
247	62	19.69336166570	57.64579903930	Mountains and rocky terrain	*Salsola omanensis*
248	62	19.70806016600	57.64514199370	Mountains and rocky terrain	*Salsola omanensis*
249	63	19.18292237090	57.74717338610	Mountains and rocky terrain	*Salsola omanensis*
250	63	19.16985442460	57.74862329920	Mountains and rocky terrain	*Salsola omanensis*
251	63	19.16907558020	57.74085019410	Mountains and rocky terrain	*Salsola omanensis*
252	63	19.18214348650	57.73939967020	Mountains and rocky terrain	*Salsola omanensis*
253	64	19.18153155210	57.73412434490	Mountains and rocky terrain	*Salsola omanensis*

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254	64	19.18626733340	57.73570444840	Mountains and rocky terrain	*Salsola omanensis*
255	64	19.18530052120	57.73891404640	Mountains and rocky terrain	*Salsola omanensis*
256	64	19.18056476970	57.73733386240	Mountains and rocky terrain	*Salsola omanensis*
257	65	19.19848957140	57.71946415020	Mountains and rocky terrain	*Salsola omanensis*
258	65	19.19525587810	57.72719649940	Mountains and rocky terrain	*Salsola omanensis*
259	65	19.19310884980	57.72620171720	Mountains and rocky terrain	*Salsola omanensis*
260	65	19.19634249920	57.71846944580	Mountains and rocky terrain	*Salsola omanensis*
261	66	19.40255544690	57.58903025890	Mountains and rocky terrain	*Salsola omanensis*
262	66	19.39849408200	57.58925036730	Mountains and rocky terrain	*Salsola omanensis*
263	66	19.39841119620	57.58755191760	Mountains and rocky terrain	*Salsola omanensis*
264	66	19.40247256020	57.58733176700	Mountains and rocky terrain	*Salsola omanensis*
265	67	19.41173818160	57.58850870860	Mountains and rocky terrain	*Salsola omanensis*
266	67	19.40310720020	57.59352901260	Mountains and rocky terrain	*Salsola omanensis*
267	67	19.40150010100	57.59046010960	Mountains and rocky terrain	*Salsola omanensis*
268	67	19.41013100200	57.58543968810	Mountains and rocky terrain	*Salsola omanensis*
269	68	19.40722697170	57.58725540760	Mountains and rocky terrain	*Salsola omanensis*
270	68	19.40074896210	57.59106182810	Mountains and rocky terrain	*Salsola omanensis*
271	68	19.39970172210	57.58908227890	Mountains and rocky terrain	*Salsola omanensis*
272	68	19.40617969240	57.58527580200	Mountains and rocky terrain	*Salsola omanensis*
273	69	19.41274765050	57.59155890160	Mountains and rocky terrain	*Salsola omanensis*
274	69	19.40726115360	57.59185416570	Mountains and rocky terrain	*Salsola omanensis*
275	69	19.40711840210	57.58890824360	Mountains and rocky terrain	*Salsola omanensis*
276	69	19.41260489680	57.58861288070	Mountains and rocky terrain	*Salsola omanensis*
277	70	19.44805212430	57.58272885860	Mountains and rocky terrain	*Salsola omanensis*
278	70	19.44368675060	57.58287377910	Mountains and rocky terrain	*Salsola omanensis*
279	70	19.44360908620	57.58027462990	Mountains and rocky terrain	*Salsola omanensis*
280	70	19.44797445970	57.58012963990	Mountains and rocky terrain	*Salsola omanensis*
281	71	19.45734937630	57.58241961950	Mountains and rocky terrain	*Salsola omanensis*
282	71	19.45092444270	57.58263339800	Mountains and rocky terrain	*Salsola omanensis*
283	71	19.45086032890	57.58049230720	Mountains and rocky terrain	*Salsola omanensis*
284	71	19.45728526210	57.58027844430	Mountains and rocky terrain	*Salsola omanensis*
285	72	19.46127525320	57.58173240600	Mountains and rocky terrain	*Salsola omanensis*
286	72	19.45829091090	57.58219295400	Mountains and rocky terrain	*Salsola omanensis*
287	72	19.45809635500	57.58079173020	Mountains and rocky terrain	*Salsola omanensis*
288	72	19.46108069440	57.58033115700	Mountains and rocky terrain	*Salsola omanensis*
289	73	19.45826978210	57.57827625280	Mountains and rocky terrain	*Salsola omanensis*
290	73	19.45561133430	57.57859448750	Mountains and rocky terrain	*Salsola omanensis*
291	73	19.45551678520	57.57771664930	Mountains and rocky terrain	*Salsola omanensis*
292	73	19.45817523180	57.57739840040	Mountains and rocky terrain	*Salsola omanensis*
293	74	19.46113343350	57.57880595160	Mountains and rocky terrain	*Salsola omanensis*
294	74	19.46149662590	57.57880724130	Mountains and rocky terrain	*Salsola omanensis*
295	74	19.46149545780	57.57917275240	Mountains and rocky terrain	*Salsola omanensis*

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296	74	19.46113226540	57.57917146180	Mountains and rocky terrain	*Salsola omanensis*
297	75	19.46489795190	57.57972228460	Mountains and rocky terrain	*Salsola omanensis*
298	75	19.46189002880	57.58014506670	Mountains and rocky terrain	*Salsola omanensis*
299	75	19.46170401150	57.57867407460	Mountains and rocky terrain	*Salsola omanensis*
300	75	19.46471193190	57.57825126570	Mountains and rocky terrain	*Salsola omanensis*
301	76	19.46830739170	57.57670072920	Mountains and rocky terrain	*Salsola omanensis*
302	76	19.46774797050	57.58108988430	Mountains and rocky terrain	*Salsola omanensis*
303	76	19.46653161770	57.58091753780	Mountains and rocky terrain	*Salsola omanensis*
304	76	19.46709103400	57.57652841470	Mountains and rocky terrain	*Salsola omanensis*
305	77	19.47315554260	57.57667480520	Mountains and rocky terrain	*Salsola omanensis*
306	77	19.47144261050	57.57832324390	Mountains and rocky terrain	*Salsola omanensis*
307	77	19.47086000040	57.57765024400	Mountains and rocky terrain	*Salsola omanensis*
308	77	19.47257292650	57.57600180380	Mountains and rocky terrain	*Salsola omanensis*
309	78	19.47121745640	57.57916438410	Mountains and rocky terrain	*Salsola omanensis*
310	78	19.47080944400	57.58041044880	Mountains and rocky terrain	*Salsola omanensis*
311	78	19.47039289180	57.58025882440	Mountains and rocky terrain	*Salsola omanensis*
312	78	19.47080090310	57.57901276250	Mountains and rocky terrain	*Salsola omanensis*
313	79	19.51895937150	57.56302448700	Mountains and rocky terrain	*Salsola omanensis*
314	79	19.51109665200	57.56433469000	Mountains and rocky terrain	*Salsola omanensis*
315	79	19.51036332850	57.55944040540	Mountains and rocky terrain	*Salsola omanensis*
316	79	19.51822601890	57.55812996970	Mountains and rocky terrain	*Salsola omanensis*
317	80	19.56545252630	57.56592048030	Mountains and rocky terrain	*Salsola omanensis*
318	80	19.56467588490	57.56937417910	Mountains and rocky terrain	*Salsola omanensis*
319	80	19.56302922180	57.56896205380	Mountains and rocky terrain	*Salsola omanensis*
320	80	19.56380585460	57.56550838770	Mountains and rocky terrain	*Salsola omanensis*
321	81	19.56564866120	57.56349571360	Mountains and rocky terrain	*Salsola omanensis*
322	81	19.56859401450	57.56558207750	Mountains and rocky terrain	*Salsola omanensis*
323	81	19.56766384670	57.56704353990	Mountains and rocky terrain	*Salsola omanensis*
324	81	19.56471851040	57.56495716230	Mountains and rocky terrain	*Salsola omanensis*
325	82	19.56773527540	57.56741153370	Mountains and rocky terrain	*Salsola omanensis*
326	82	19.56959612630	57.56882836690	Mountains and rocky terrain	*Salsola omanensis*
327	82	19.56918886740	57.56942369240	Mountains and rocky terrain	*Salsola omanensis*
328	82	19.56732802110	57.56800685620	Mountains and rocky terrain	*Salsola omanensis*
329	83	19.61496127960	57.57200776800	Mountains and rocky terrain	*Salsola omanensis*
330	83	19.61375132800	57.57212701600	Mountains and rocky terrain	*Salsola omanensis*
331	83	19.61365127750	57.57099653390	Mountains and rocky terrain	*Salsola omanensis*
332	83	19.61486122870	57.57087727750	Mountains and rocky terrain	*Salsola omanensis*
333	84	19.62230596330	57.57135175170	Mountains and rocky terrain	*Salsola omanensis*
334	84	19.62324186860	57.57459960600	Mountains and rocky terrain	*Salsola omanensis*
335	84	19.62179834910	57.57506287210	Mountains and rocky terrain	*Salsola omanensis*
336	84	19.62086245130	57.57181504460	Mountains and rocky terrain	*Salsola omanensis*
337	85	19.64676629350	57.57759692030	Mountains and rocky terrain	*Salsola omanensis*

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338	85	19.64714658950	57.58053088470	Mountains and rocky terrain	*Salsola omanensis*
339	85	19.64657168510	57.58061389960	Mountains and rocky terrain	*Salsola omanensis*
340	85	19.64619139020	57.57767994560	Mountains and rocky terrain	*Salsola omanensis*
341	86	19.64228237240	57.57633588700	Mountains and rocky terrain	*Salsola omanensis*
342	86	19.64750146920	57.58176663090	Mountains and rocky terrain	*Salsola omanensis*
343	86	19.64603994910	57.58333135930	Mountains and rocky terrain	*Salsola omanensis*
344	86	19.64082089870	57.57790061660	Mountains and rocky terrain	*Salsola omanensis*
345	87	19.65052764450	57.57779699110	Mountains and rocky terrain	*Salsola omanensis*
346	87	19.65020718060	57.58255221710	Mountains and rocky terrain	*Salsola omanensis*
347	87	19.64653365770	57.58227634670	Mountains and rocky terrain	*Salsola omanensis*
348	87	19.64685411170	57.57752122810	Mountains and rocky terrain	*Salsola omanensis*
349	88	19.66667616820	57.58114236110	Mountains and rocky terrain	*Salsola omanensis*
350	88	19.65880450990	57.58237779750	Mountains and rocky terrain	*Salsola omanensis*
351	88	19.65813874950	57.57765142240	Mountains and rocky terrain	*Salsola omanensis*
352	88	19.66601038170	57.57641575850	Mountains and rocky terrain	*Salsola omanensis*
353	89	19.66809572510	57.57601440770	Mountains and rocky terrain	*Salsola omanensis*
354	89	19.66860156660	57.57900905860	Mountains and rocky terrain	*Salsola omanensis*
355	89	19.66648993150	57.57940652440	Mountains and rocky terrain	*Salsola omanensis*
356	89	19.66598409550	57.57641191180	Mountains and rocky terrain	*Salsola omanensis*
357	90	19.66835925700	57.57619392840	Mountains and rocky terrain	*Salsola omanensis*
358	90	19.67018478450	57.57746697880	Mountains and rocky terrain	*Salsola omanensis*
359	90	19.66941722440	57.57869355420	Mountains and rocky terrain	*Salsola omanensis*
360	90	19.66759170570	57.57742049640	Mountains and rocky terrain	*Salsola omanensis*
361	91	19.67338777240	57.57836823010	Mountains and rocky terrain	*Salsola omanensis*
362	91	19.66903303020	57.57907546170	Mountains and rocky terrain	*Salsola omanensis*
363	91	19.66858272100	57.57598560070	Mountains and rocky terrain	*Salsola omanensis*
364	91	19.67293745330	57.57527828700	Mountains and rocky terrain	*Salsola omanensis*
365	92	19.67822170840	57.57786181420	Mountains and rocky terrain	*Salsola omanensis*
366	92	19.67260009210	57.57926920650	Mountains and rocky terrain	*Salsola omanensis*
367	92	19.67178646340	57.57564737580	Mountains and rocky terrain	*Salsola omanensis*
368	92	19.67740805490	57.57423986260	Mountains and rocky terrain	*Salsola omanensis*
369	93	19.67896895540	57.57429858450	Mountains and rocky terrain	*Salsola omanensis*
370	93	19.67929682690	57.57654832950	Mountains and rocky terrain	*Salsola omanensis*
371	93	19.67792331620	57.57677141890	Mountains and rocky terrain	*Salsola omanensis*
372	93	19.67759544710	57.57452169280	Mountains and rocky terrain	*Salsola omanensis*
373	94	19.67962533680	57.57464820510	Mountains and rocky terrain	*Salsola omanensis*
374	94	19.67906338970	57.57473948550	Mountains and rocky terrain	*Salsola omanensis*
375	94	19.67899843380	57.57429379600	Mountains and rocky terrain	*Salsola omanensis*
376	94	19.67956038070	57.57420251400	Mountains and rocky terrain	*Salsola omanensis*
377	95	19.68662020810	57.57605991260	Mountains and rocky terrain	*Salsola omanensis*
378	95	19.68001905580	57.57713211840	Mountains and rocky terrain	*Salsola omanensis*
379	95	19.67959137630	57.57419747940	Mountains and rocky terrain	*Salsola omanensis*

POINT ID	POLYGON ID	LATITUDE	LONGITUDE	DMU	SPECIES
380	95	19.68619251430	57.57312515520	Mountains and rocky terrain	*Salsola omanensis*
381	96	19.70743808260	57.57238122070	Mountains and rocky terrain	*Salsola omanensis*
382	96	19.70599774160	57.57485492620	Mountains and rocky terrain	*Salsola omanensis*
383	96	19.70467031130	57.57399317910	Mountains and rocky terrain	*Salsola omanensis*
384	96	19.70611064030	57.57151948560	Mountains and rocky terrain	*Salsola omanensis*
385	97	19.71038869890	57.57202856540	Mountains and rocky terrain	*Salsola omanensis*
386	97	19.71071273710	57.57438011570	Mountains and rocky terrain	*Salsola omanensis*
387	97	19.70897948120	57.57464640330	Mountains and rocky terrain	*Salsola omanensis*
388	97	19.70865544580	57.57229487790	Mountains and rocky terrain	*Salsola omanensis*
389	98	19.71688505810	57.64797668000	Mountains and rocky terrain	*Salsola omanensis*
390	98	19.71695058500	57.65962935120	Mountains and rocky terrain	*Salsola omanensis*
391	98	19.71506051670	57.65964113450	Mountains and rocky terrain	*Salsola omanensis*
392	98	19.71499498670	57.64798860030	Mountains and rocky terrain	*Salsola omanensis*
393	99	19.17120953270	57.74533551540	Mountains and rocky terrain	*Salsola omanensis*
394	99	19.17484806090	57.76207997590	Mountains and rocky terrain	*Salsola omanensis*
395	99	19.16715246380	57.76393157320	Mountains and rocky terrain	*Salsola omanensis*
396	99	19.16351407640	57.74718786210	Mountains and rocky terrain	*Salsola omanensis*
397	100	19.17425222650	57.76022509340	Mountains and rocky terrain	*Salsola omanensis*
398	100	19.17551113020	57.76213490680	Mountains and rocky terrain	*Salsola omanensis*
399	100	19.17447297100	57.76289283720	Mountains and rocky terrain	*Salsola omanensis*
400	100	19.17321407480	57.76098303050	Mountains and rocky terrain	*Salsola omanensis*
401	101	19.17497680570	57.76310801500	Mountains and rocky terrain	*Salsola omanensis*
402	101	19.17526663690	57.76354771420	Mountains and rocky terrain	*Salsola omanensis*
403	101	19.17502224690	57.76372613410	Mountains and rocky terrain	*Salsola omanensis*
404	101	19.17473241610	57.76328643520	Mountains and rocky terrain	*Salsola omanensis*
405	102	19.17590986160	57.76296899850	Mountains and rocky terrain	*Salsola omanensis*
406	102	19.17588383480	57.76372113390	Mountains and rocky terrain	*Salsola omanensis*
407	102	19.17544835790	57.76370444270	Mountains and rocky terrain	*Salsola omanensis*
408	102	19.17547438450	57.76295230920	Mountains and rocky terrain	*Salsola omanensis*
409	103	19.74792405050	57.60354852850	Gravel and sand plains and wadis and other temporary watercourses	*Salsola omanensis, Ochradenus harsusiticus*
410	103	19.74794580550	57.60356833310	Gravel and sand plains and wadis and other temporary watercourses	*Salsola omanensis, Ochradenus harsusiticus*
411	103	19.74792815710	57.60358995900	Gravel and sand plains and wadis and other temporary watercourses	*Salsola omanensis, Ochradenus harsusiticus*
412	103	19.74790640210	57.60357015440	Gravel and sand plains and wadis and other temporary watercourses	*Salsola omanensis, Ochradenus harsusiticus*
413	104	19.72400034990	57.63613917860	Gravel and sand plains	*Salsola omanensis*
414	104	19.72438455530	57.63831765850	Gravel and sand plains	*Salsola omanensis*
415	104	19.72348315130	57.63849493790	Gravel and sand plains	*Salsola omanensis*
416	104	19.72309894770	57.63631646990	Gravel and sand plains	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
417	105	19.69731465930	57.63076399420	Gravel and sand plains	*Salsola omanensis*
418	105	19.71300404670	57.63084310360	Gravel and sand plains	*Salsola omanensis*
419	105	19.71296831660	57.63870318370	Gravel and sand plains	*Salsola omanensis*
420	105	19.69727895390	57.63862330820	Gravel and sand plains	*Salsola omanensis*
421	106	19.70941119140	57.64628978010	Gravel and sand plains	*Salsola omanensis*
422	106	19.69601071310	57.64664296250	Gravel and sand plains	*Salsola omanensis*
423	106	19.69598091500	57.64538272800	Gravel and sand plains	*Salsola omanensis*
424	106	19.70938139390	57.64502944050	Gravel and sand plains	*Salsola omanensis*
425	107	19.71243677790	57.64621035430	Gravel and sand plains	*Salsola omanensis*
426	107	19.70911020840	57.64629774970	Gravel and sand plains	*Salsola omanensis*
427	107	19.70909238310	57.64554131200	Gravel and sand plains	*Salsola omanensis*
428	107	19.71241895270	57.64545390100	Gravel and sand plains	*Salsola omanensis*
429	108	19.71750934920	57.62900285970	Gravel and sand plains	*Salsola omanensis*
430	108	19.71803713550	57.64230239990	Gravel and sand plains	*Salsola omanensis*
431	108	19.71302850190	57.64252382980	Gravel and sand plains	*Salsola omanensis*
432	108	19.71250072030	57.62922470410	Gravel and sand plains	*Salsola omanensis*
433	109	19.72402220150	57.62930604170	Gravel and sand plains	*Salsola omanensis*
434	109	19.72397751770	57.63912305520	Gravel and sand plains	*Salsola omanensis*
435	109	19.71748307400	57.63908989710	Gravel and sand plains	*Salsola omanensis*
436	109	19.71752774490	57.62927328000	Gravel and sand plains	*Salsola omanensis*
437	110	19.68310552340	57.57362660340	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
438	110	19.68502862810	57.57368551520	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
439	110	19.68502862730	57.57368554460	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
440	110	19.68310552260	57.57362663280	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
441	111	19.55871740510	57.57264857280	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
442	111	19.53987471280	57.57352474550	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
443	111	19.53953632370	57.56543175590	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
444	111	19.55837900100	57.56455464330	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
445	112	19.55369902950	57.56566074570	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
446	112	19.55328779900	57.56721321960	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
447	112	19.55239995270	57.56695151280	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
448	112	19.55281118080	57.56539904660	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
449	113	19.70195206790	57.63363792330	Mountains and rocky terrain	*Salsola omanensis*
450	113	19.69850278290	57.63678212510	Mountains and rocky terrain	*Salsola omanensis*
451	113	19.69804208600	57.63621868270	Mountains and rocky terrain	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
452	113	19.70149136140	57.63307447720	Mountains and rocky terrain	*Salsola omanensis*
453	114	19.70195206790	57.63363792330	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
454	114	19.69850278290	57.63678212510	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
455	114	19.69804208600	57.63621868270	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
456	114	19.70149136140	57.63307447720	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
457	114	19.69619384590	57.64663814250	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
458	115	19.69516571750	57.64666520260	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
459	115	19.69514293900	57.64570052710	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
460	115	19.69617106740	57.64567346080	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
461	115	19.71644055920	57.62914239900	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
462	116	19.71754300030	57.62923629620	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
463	116	19.71751626340	57.62958633420	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
464	116	19.71641382250	57.62949243460	Mountains and rocky terrain and gravel and sand plains	*Salsola omanensis*
465	116	19.64150204020	57.57705749020	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
466	117	19.64425479230	57.58103403900	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
467	117	19.64368501920	57.58147343260	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
468	117	19.64093227650	57.57749689090	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
469	117	19.64235604160	57.57718358950	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
470	118	19.65109495660	57.57783727470	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
471	118	19.65088859130	57.58091044580	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
472	118	19.64214969140	57.58025659570	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
473	118	19.63770964260	57.57795819030	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
474	119	19.64143014530	57.57816111660	Mountains and rocky terrain and wadis and other	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
				temporary watercourses	
475	119	19.64124806010	57.58187925130	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
476	119	19.63752756380	57.58167623980	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
477	119	19.70794987260	57.64623948950	Mountains and rocky terrain	*Salsola omanensis*
478	120	19.71069300010	57.64625699970	Mountains and rocky terrain	*Salsola omanensis*
479	120	19.71068621020	57.64744226650	Mountains and rocky terrain	*Salsola omanensis*
480	120	19.70794308330	57.64742473610	Mountains and rocky terrain	*Salsola omanensis*
481	120	19.70814469900	57.64732843670	Mountains and rocky terrain	*Salsola omanensis*
482	121	19.69392274440	57.64791469920	Mountains and rocky terrain	*Salsola omanensis*
483	121	19.69387789580	57.64670192520	Mountains and rocky terrain	*Salsola omanensis*
484	121	19.70809984960	57.64611555550	Mountains and rocky terrain	*Salsola omanensis*
485	121	19.64074731010	57.57706283880	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
486	122	19.64075698110	57.57706356470	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
487	122	19.64075696130	57.57706385870	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
488	122	19.64074729030	57.57706313280	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
489	122	19.64819086980	57.58105815450	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
490	123	19.64949630250	57.58135315190	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
491	123	19.64926443300	57.58249630660	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
492	123	19.64795900240	57.58220130050	Mountains and rocky terrain and wadis and other temporary watercourses	*Salsola omanensis*
493	123	19.72400241330	57.63642229240	Gravel and Sand Plains	*Salsola omanensis*
494	124	19.72401149630	57.63766980300	Gravel and Sand Plains	*Salsola omanensis*
495	124	19.72399798110	57.63766991270	Gravel and Sand Plains	*Salsola omanensis*
496	124	19.72398889810	57.63642240220	Gravel and Sand Plains	*Salsola omanensis*
497	124	19.72400241330	57.63642229240	Gravel and Sand Plains	*Salsola omanensis*
498	125	19.72401149630	57.63766980300	Gravel and Sand Plains	*Salsola omanensis*
499	125	19.72399798110	57.63766991270	Gravel and Sand Plains	*Salsola omanensis*
500	125	19.72398889810	57.63642240220	Gravel and Sand Plains	*Salsola omanensis*
501	126	19.72400241330	57.63642229240	Gravel and sand plains	*Salsola omanensis*
502	126	19.72401149630	57.63766980300	Gravel and sand plains	*Salsola omanensis*

Point ID	Polygon ID	Latitude	Longitude	DMU	Species
503	126	19.72399798110	57.63766991270	Gravel and sand plains	*Salsola omanensis*
504	126	19.72398889810	57.63642240220	Gravel and sand plains	*Salsola omanensis*
505	127	19.67245274330	57.57589912920	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
506	127	19.66870682370	57.57650754300	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
507	127	19.66862964240	57.57597797980	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
508	127	19.67237556060	57.57536955390	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
509	128	19.67245274330	57.57589912920	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
510	128	19.66870682370	57.57650754300	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
511	128	19.66862964240	57.57597797980	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
512	128	19.67237556060	57.57536955390	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
513	129	19.68696581320	57.57337085070	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
514	129	19.68315853940	57.57398933190	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
515	129	19.68310567520	57.57362660810	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
516	129	19.68691294800	57.57300811840	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
517	130	19.68696581320	57.57337085070	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
518	130	19.68315853940	57.57398933190	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
519	130	19.68310567520	57.57362660810	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
520	130	19.68691294800	57.57300811840	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
521	131	19.69110962950	57.57293498710	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
522	131	19.68915556130	57.57312670050	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
523	131	19.68911256020	57.57263814010	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
524	131	19.69106662800	57.57244642090	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
525	132	19.69110962950	57.57293498710	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
526	132	19.68915556130	57.57312670050	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
527	132	19.68911256020	57.57263814010	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
528	132	19.69106662800	57.57244642090	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
529	133	19.70712539820	57.57228949140	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
530	133	19.70649586840	57.57420715740	Mountains and rocky terrain	Egyptian Vulture,

POINT ID	POLYGON ID	LATITUDE	LONGITUDE	DMU	SPECIES
					Salsola omanensis
531	133	19.70526253900	57.57375574200	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
532	133	19.70589206370	57.57183808860	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
533	134	19.70712539820	57.57228949140	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
534	134	19.70649586840	57.57420715740	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
535	134	19.70526253900	57.57375574200	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
536	134	19.70589206370	57.57183808860	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
537	135	19.55350944520	57.56540056220	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
538	135	19.55405014240	57.56734868210	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
539	135	19.55254103660	57.56781476040	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
540	135	19.55200034400	57.56586665740	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
541	136	19.55351396460	57.56540296560	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
542	136	19.55336143710	57.56572212410	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
543	136	19.55322524410	57.56564969570	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
544	136	19.55337777150	57.56533053750	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
545	137	19.55408073580	57.56719642880	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
546	137	19.55266329830	57.56785504950	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
547	137	19.55228650490	57.56695269010	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
548	137	19.55370393920	57.56629406280	Mountains and rocky terrain	Egyptian Vulture, Salsola omanensis
549	138	19.64312960370	57.57724165380	Mountains and rocky terrain	*Salsola omanensis*
550	138	19.64525619990	57.57740128130	Mountains and rocky terrain	*Salsola omanensis*
551	138	19.64518544490	57.57845136030	Mountains and rocky terrain	*Salsola omanensis*
552	138	19.64305884990	57.57829171910	Mountains and rocky terrain	*Salsola omanensis*
553	139	19.64312960370	57.57724165380	Mountains and rocky terrain	*Salsola omanensis*
554	139	19.64525619990	57.57740128130	Mountains and rocky terrain	*Salsola omanensis*
555	139	19.64518544490	57.57845136030	Mountains and rocky terrain	*Salsola omanensis*
556	139	19.64305884990	57.57829171910	Mountains and rocky terrain	*Salsola omanensis*
557	140	19.64312960370	57.57724165380	Mountains and rocky terrain	*Salsola omanensis*
558	140	19.64525619990	57.57740128130	Mountains and rocky terrain	*Salsola omanensis*
559	140	19.64518544490	57.57845136030	Mountains and rocky terrain	*Salsola omanensis*
560	140	19.64305884990	57.57829171910	Mountains and rocky terrain	*Salsola omanensis*
561	141	19.64312960370	57.57724165380	Mountains and rocky terrain	*Salsola omanensis*

POINT ID	POLYGON ID	LATITUDE	LONGITUDE	DMU	SPECIES
562	141	19.64525619990	57.57740128130	Mountains and rocky terrain	*Salsola omanensis*
563	141	19.64518544490	57.57845136030	Mountains and rocky terrain	*Salsola omanensis*
564	141	19.64305884990	57.57829171910	Mountains and rocky terrain	*Salsola omanensis*
565	142	19.64620869550	57.57720380160	Mountains and rocky terrain	*Salsola omanensis*
566	142	19.64732875020	57.58039988940	Mountains and rocky terrain	*Salsola omanensis*
567	142	19.64571609470	57.58102949400	Mountains and rocky terrain	*Salsola omanensis*
568	142	19.64459605030	57.57783343440	Mountains and rocky terrain	*Salsola omanensis*
569	143	19.64620869550	57.57720380160	Mountains and rocky terrain	*Salsola omanensis*
570	143	19.64732875020	57.58039988940	Mountains and rocky terrain	*Salsola omanensis*
571	143	19.64571609470	57.58102949400	Mountains and rocky terrain	*Salsola omanensis*
572	143	19.64459605030	57.57783343440	Mountains and rocky terrain	*Salsola omanensis*
573	144	19.64620869550	57.57720380160	Mountains and rocky terrain	*Salsola omanensis*
574	144	19.64732875020	57.58039988940	Mountains and rocky terrain	*Salsola omanensis*
575	144	19.64571609470	57.58102949400	Mountains and rocky terrain	*Salsola omanensis*
576	144	19.64459605030	57.57783343440	Mountains and rocky terrain	*Salsola omanensis*
577	145	19.64620869550	57.57720380160	Mountains and rocky terrain	*Salsola omanensis*
578	145	19.64732875020	57.58039988940	Mountains and rocky terrain	*Salsola omanensis*
579	145	19.64571609470	57.58102949400	Mountains and rocky terrain	*Salsola omanensis*
580	145	19.64459605030	57.57783343440	Mountains and rocky terrain	*Salsola omanensis*
581	146	19.64209657580	57.57646003290	Mountains and rocky terrain	*Salsola omanensis*
582	146	19.64639357270	57.58042681620	Mountains and rocky terrain	*Salsola omanensis*
583	146	19.64515768450	57.58191824740	Mountains and rocky terrain	*Salsola omanensis*
584	146	19.64086072020	57.57795145670	Mountains and rocky terrain	*Salsola omanensis*
585	147	19.64209657580	57.57646003290	Mountains and rocky terrain	*Salsola omanensis*
586	147	19.64639357270	57.58042681620	Mountains and rocky terrain	*Salsola omanensis*
587	147	19.64515768450	57.58191824740	Mountains and rocky terrain	*Salsola omanensis*
588	147	19.64086072020	57.57795145670	Mountains and rocky terrain	*Salsola omanensis*
589	148	19.64209657580	57.57646003290	Mountains and rocky terrain	*Salsola omanensis*
590	148	19.64639357270	57.58042681620	Mountains and rocky terrain	*Salsola omanensis*
591	148	19.64515768450	57.58191824740	Mountains and rocky terrain	*Salsola omanensis*
592	148	19.64086072020	57.57795145670	Mountains and rocky terrain	*Salsola omanensis*
593	149	19.64685411170	57.57752122810	Mountains and rocky terrain	*Salsola omanensis*
594	149	19.65052764450	57.57779699110	Mountains and rocky terrain	*Salsola omanensis*
595	149	19.65028754790	57.58135985850	Mountains and rocky terrain	*Salsola omanensis*
596	149	19.64661402250	57.58108401510	Mountains and rocky terrain	*Salsola omanensis*
597	150	19.64685411170	57.57752122810	Mountains and rocky terrain	*Salsola omanensis*
598	150	19.65052764450	57.57779699110	Mountains and rocky terrain	*Salsola omanensis*
599	150	19.65028754790	57.58135985850	Mountains and rocky terrain	*Salsola omanensis*
600	150	19.64661402250	57.58108401510	Mountains and rocky terrain	*Salsola omanensis*
601	151	19.64685411170	57.57752122810	Mountains and rocky terrain	*Salsola omanensis*
602	151	19.65052764450	57.57779699110	Mountains and rocky terrain	*Salsola omanensis*
603	151	19.65028754790	57.58135985850	Mountains and rocky terrain	*Salsola omanensis*

POINT ID	POLYGON ID	LATITUDE	LONGITUDE	DMU	SPECIES
604	151	19.64661402250	57.58108401510	Mountains and rocky terrain	*Salsola omanensis*
605	152	19.65856940860	57.57791581690	Mountains and rocky terrain	*Salsola omanensis*
606	152	19.65755417560	57.58331883210	Mountains and rocky terrain	*Salsola omanensis*
607	152	19.65447246770	57.58267357970	Mountains and rocky terrain	*Salsola omanensis*
608	152	19.65548767910	57.57727066250	Mountains and rocky terrain	*Salsola omanensis*
609	153	19.65856940860	57.57791581690	Mountains and rocky terrain	*Salsola omanensis*
610	153	19.65755417560	57.58331883210	Mountains and rocky terrain	*Salsola omanensis*
611	153	19.65447246770	57.58267357970	Mountains and rocky terrain	*Salsola omanensis*
612	153	19.65548767910	57.57727066250	Mountains and rocky terrain	*Salsola omanensis*
613	154	19.65856940860	57.57791581690	Mountains and rocky terrain	*Salsola omanensis*
614	154	19.65755417560	57.58331883210	Mountains and rocky terrain	*Salsola omanensis*
615	154	19.65447246770	57.58267357970	Mountains and rocky terrain	*Salsola omanensis*
616	154	19.65548767910	57.57727066250	Mountains and rocky terrain	*Salsola omanensis*
617	155	19.63349841730	57.57696980810	Mountains and rocky terrain	*Salsola omanensis*
618	155	19.64144591060	57.57756651720	Mountains and rocky terrain	*Salsola omanensis*
619	155	19.64115564420	57.58187230950	Mountains and rocky terrain	*Salsola omanensis*
620	155	19.63320817040	57.58127539040	Mountains and rocky terrain	*Salsola omanensis*
621	156	19.63349841730	57.57696980810	Mountains and rocky terrain	*Salsola omanensis*
622	156	19.64144591060	57.57756651720	Mountains and rocky terrain	*Salsola omanensis*
623	156	19.64115564420	57.58187230950	Mountains and rocky terrain	*Salsola omanensis*
624	156	19.63320817040	57.58127539040	Mountains and rocky terrain	*Salsola omanensis*
625	157	19.63349841730	57.57696980810	Mountains and rocky terrain	*Salsola omanensis*
626	157	19.64144591060	57.57756651720	Mountains and rocky terrain	*Salsola omanensis*
627	157	19.64115564420	57.58187230950	Mountains and rocky terrain	*Salsola omanensis*
628	157	19.63320817040	57.58127539040	Mountains and rocky terrain	*Salsola omanensis*
629	158	19.55670991280	57.56894705560	Mountains and rocky terrain	*Salsola omanensis*
630	158	19.55643295000	57.56976511540	Mountains and rocky terrain	*Salsola omanensis*
631	158	19.55578056170	57.56951932100	Mountains and rocky terrain	*Salsola omanensis*
632	158	19.55605752330	57.56870126400	Mountains and rocky terrain	*Salsola omanensis*
633	159	19.55670991280	57.56894705560	Mountains and rocky terrain	*Salsola omanensis*
634	159	19.55643295000	57.56976511540	Mountains and rocky terrain	*Salsola omanensis*
635	159	19.55578056170	57.56951932100	Mountains and rocky terrain	*Salsola omanensis*
636	159	19.55605752330	57.56870126400	Mountains and rocky terrain	*Salsola omanensis*
637	160	19.68984283040	57.57284295880	Mountains and rocky terrain	*Salsola omanensis*
638	160	19.68994506450	57.57286492470	Mountains and rocky terrain	*Salsola omanensis*
639	160	19.68994216490	57.57287996840	Mountains and rocky terrain	*Salsola omanensis*
640	160	19.68983993070	57.57285800260	Mountains and rocky terrain	*Salsola omanensis*
641	161	19.68786495050	57.57032748910	Mountains and rocky terrain	*Salsola omanensis*
642	161	19.69163008680	57.57249932200	Mountains and rocky terrain	*Salsola omanensis*
643	161	19.69000697840	57.57563582310	Mountains and rocky terrain	*Salsola omanensis*
644	161	19.68624188070	57.57346394100	Mountains and rocky terrain	*Salsola omanensis*
645	162	19.70935799380	57.57706328780	Wadis and other temporary	*Ochradenus*

POINT ID	POLYGON ID	LATITUDE	LONGITUDE	DMU	SPECIES
				watercourses	*harsusiticus*
646	162	19.69226728590	57.57713299490	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
647	162	19.69224946460	57.57228146370	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
648	162	19.70934018360	57.57221124140	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
649	163	19.71423442200	57.57718124020	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
650	163	19.71323896550	57.57738768630	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
651	163	19.71318858510	57.57711681440	Wadis and other temporary watercourses	*Ochradenus harsusiticus*
652	163	19.71418404130	57.57691036670	Wadis and other temporary watercourses	*Ochradenus harsusiticus*

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APPENDIX D-4

APPENDIX 7.4: INVASIVE ALIEN SPECIES

TECHNICAL APPENDIX: INVASIVE ALIEN SPECIES STRATEGY

1. INTRODUCTION

Duqm Refinery and Petrochemical Industries Company LLC (DRPIC) is developing the Duqm Refinery Project (the “Project”) located within the Special Economic Zone at Duqm (Duqm SEZ). The Project comprises the Refinery and Offsite Facilities:

- 230,000 barrels per day (BPD) complex refinery and on-site utilities, infrastructure and storage (the ‘Refinery’);
- Product export terminal (‘Export Terminal’) at the Port of Duqm;
- Crude storage facility at the Ras Markaz crude oil terminal (the ‘DRPIC Ras Markaz Crude Storage Facility’); and
- 28” 80km Crude pipeline from Ras Markaz to the Refinery (‘DRPIC Crude Pipeline’ and together with the DRPIC Ras Markaz Crude Storage Facility and the Export Terminal, the ‘Offsite Facilities’).

As part of Project Financing, the Lenders’ Independent Environmental and Social Consultant identified the need to provide details of mitigation to be followed to address both marine and terrestrial invasive alien species (IAS).

2. INTERPRETATION OF LENDERS’ REQUIREMENTS – INVASIVE ALIEN SPECIES STRATEGY

The Project Lenders’ independent ESDD Report (Ramboll Environ, 2016) states the following in relation to IAS:

> *“There is generally little mention of invasive alien species in the assessments. Given the habitats present, few are believed likely to be present within the terrestrial areas. However construction activities have the potential to introduce them. The seawater intake EIA does identify a likely low significance impact of the introduction of marine exotic species as a result of ships’ hulls and ballast waters. No mitigation for the impact is described.” (Row 58, p.73)*

For the purpose of this report, an invasive species is defined as a plant, fungus, animal or microorganism that is not a native species to Oman (an alien or introduced species); it will have a tendency to reproduce and be distributed beyond its point of introduction to a degree believed to cause damage to the environment, human economy and/or human health. Not all alien species become invasive. A species could be an alien introduction to Oman but not regarded as damaging to the native environment. This document focusses solely on species which are IAS.

The Lender’s Report requests that an IAS strategy is prepared which provides:

> *“…details of mitigation measures to be followed to address the issue of both marine and terrestrial alien species.”*

The four Project ESIAs do not provide a comprehensive inventory of IAS which may occur in the Project Area. Also absent in the ESIAs is an assessment of the risk/potential for different IAS to be spread, or introduced by, activities associated with the Project. To address this information gap, this document provides a scoping review of different potential IAS in the Project Area and a risk rating of their likelihood that they could be introduced or exacerbated by Project construction or operation activities.

The final section of this document provides a series of recommendations to address potential IAS issues. Detailed management/mitigation actions to address IAS are provided in the Biodiversity Management Plan, rather than in this IAS strategy so that all biodiversity mitigation issues are integrated in a single place.

3. METHODOLOGY

A provisional list of IAS for Oman was obtained by searching a range of data sources including:

- Invasive Species Specialist Group Global Invasive Species Database (International Union for the Conservation of Nature, 2017);
- Sultanate of Oman - *5th National Report to the Convention on Biological Diversity* (Ministry of Environment and Climate Affairs, 2014); and
- Sultanate of Oman – National Biodiversity Strategy and Action Plan (Ministry of Regional Municipalities, Environment and Water Resources, 2001)
- Al-Yamani, F., Skryabin, V., Durvasula, S.R.V., (2015). Suspected ballast water introductions in the Arabian Gulf. Aquatic Ecosystem Health & Management 18, 282–289.
- Hamza, (2006). Observations on transported exotic plankton species to UAE coastal waters by gas tankers ballast water, in: Living Marine Ecosystem Diversity in the Arabian Gulf: Threats and Conservation. A. Tubielewicz (Ed.).

For each potential IAS, the following information was evaluated to provide a Red/Amber/Green (RAG) risk rating:

- Species name/group – scientific name and taxon group (e.g. mammal, plant);
- Pathway source – identification of the most likely source of infestation associated with Project activities (e.g. ballast water, ship hull colonist, natural colonist); and
- Project element – identification of the Project element applicable to the species in question (e.g. certain species are purely terrestrial).

The RAG rating is defined as follows. RAG ratings incorporate advice provided by the International Petroleum Industry Environmental Conservation Association (IPIECA; 2010)[1].

The term Project Area is the physical footprint of the Refinery, the Off-site Facilities or the AFs in both the terrestrial and marine environment; and a broad zone in the Gulf of Masirah, defined by a worst case oil spill model, which has been used as a proxy to indicate the likely area over which shipping movements associated with the Project may occur. This definition accords with the definition of Area of Influence (AoI) provided in Section 2.3 of the biodiversity assessment.

Table D-1: RAG Risk Rating Definitions

RAG Risk Rating	Description
Green	IAS colonisation likely to be beyond the sphere of influence of the Project for a number of reasons

[1] IPIECA is the global oil and gas industry association for environmental and social issues.

RAG Risk Rating	Description
	including a the specie in question is widespread IAS which is present everywhere in the region from unrelated sources of colonisation/regional ecosystem change (e.g. climate change); Or The IAS is not sensitive/unlikely to respond (e.g. population growth; range expansion) to any environmental changes that may be caused by the Project; Or Habitat for the IAS unlikely to be present in the Duqm region or to be affected by the Project.
Amber	The IAS is relatively easily controlled by implementation of basic precautionary or hygiene measures which may be implemented during Project construction or operation.
Red	The IAS may be present in the Project area and, based on available knowledge of its ecology, it is likely to be highly invasive, could be specifically introduced or exacerbated by Project activities and could significantly damage native biodiversity. Or An IAS that is relatively hard to control if introduced and would significantly damage native Omani biodiversity. Even if IAS introduction is not a high probability as a result of Project construction or operational activities.

4. LIMITATIONS

The provisional list of IAS is unlikely to be comprehensive as data is not collated at a national or regional scale in Oman. IAS data is largely opportunistic and incidental where it occurs.

Due to lack of coverage in the Project EIAs the potential distribution of IAS is unknown for the Project Area. However, the site verification survey undertaken to inform the Project (Technical Appendix A: Survey Record) recorded incidental occurrences of some IAS present in the project site. Whilst the verification surveys did not find any significant IAS infestations they only covered a small portion of the Project area and did not include the marine environment.

Knowledge of terrestrial and avian IAS ecology is limited to that which can be obtained from incidental observations and the referenced sources outlined in this document. For certain IAS, their ecology and behaviour in their native range may not be reflective of their response to introduction to a non-native environment. For both these reasons terrestrial IAS responses in relation to the Project cannot always be confidently predicted. A precautionary approach has therefore been adopted where uncertainty exists. A less clear picture exists for marine IAS, where survey methods are more complicated, taxonomy is more difficult with fewer taxonomists available to carry out the necessary identification work, and there is a poorly developed inventory of marine species in Oman, particularly for invertebrates and planktonic species i.e. the groups most likely to be introduced in ballast water.

Table D-2: IAS RAG Risk Rating

Species Name	Group	Vector Source	Project Element	Assessment / RAG Rating
Terrestrial Species				
Indian mynah (*Acridotheres tristis)*	Bird	Natural colonisation, international shipping	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native species of bird for food and resources. Colonisation likely to be beyond the sphere of influence of the Project – this bird is already present across Oman.
Agave (*Agave americana*)	Plant	Potential for importation with soil	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline	This species may be introduced through importation of soil for construction which contain its seeds. Once introduced it may compete with native species of plant for resources (e.g. water, light, space). Introduction risk can be controlled through management and checking of soil sources to ensure they are not contaminated and monitoring locations where soil is imported for evidence of infestation. Spot treatment may then be applied.
Mesquite (*Prosopis juliflora*)	Plant	Natural colonisation from source population previously recorded in the Duqm Area	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native tree species' water resources, and forms thickets that out compete native species and reduce value of forage for livestock and wildlife. Particularly problematic if it gets into wadi courses as it has already done near Duqm. Existing knowledge suggests that colonisation may be exacerbated by soil disturbance brought about by Project construction which may create niches for this species to colonise the Project Area. Introduction of this species may be controlled by adopting a range of measures including: i) monitoring and decontamination of vehicles that may have come into contact with areas where it is known to grow; ii) detailed mapping of the intended construction footprint to identify any infestations – then applying spot-treatment (herbicide); iii) implementation of an integrated management programme that may involve mechanical removal of plants and regular check-ups to clear new saplings that may emerge from seeds; iv) discourage workers from cultivating the species around Labour Camps and other facilities (Insall, 2006); v) ensuring construction vehicles designated access routes and do not venture across desert habitats.
***Ghuwayf*/Speed Tree**	Plant	Potential for importation	Refinery	This species may be introduced through importation of soil for construction

Species Name	**Group**	**Vector Source**	**Project Element**	**Assessment / RAG Rating**
(*Leucaena leucocephala*)		with landscaping soil or on vehicles that have come into contact with the species	DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	which contain its seeds. Once introduced it may compete with native species of plant for resources (e.g. water, light, space). This species is not through to have yet invaded to the extent of *Prosopis juliflora* but it grows and spreads rapidly through seeds falling on the ground. Control of this species may be achieved by following the protocol outlined in this table for *Prosopis juliflora.*
Indian house-crow (*Corvus splendens*)	Bird	Natural colonisation, international shipping	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native bird species for food and resources. Predation of native bird chicks. Colonisation likely to be beyond the sphere of influence of the Project – this bird is already present across Oman.
Speargrass/cogon grass (*Imperata cylindrical*)	Plant	Potential for importation with soil	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline	Competition with native species of plant for resources (e.g. water, light, space). . Introduction risk can be controlled through management and checking of soil sources to ensure they are not contaminated and monitoring locations where soil is imported for evidence of infestation. Spot treatment may then be applied.
Bitter lettuce (*Launaea intybacea*)	Plant	Potential for importation with soil	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline	Competition with native species of plant for resources. Introduction risk can be controlled through management and checking of soil sources to ensure they are not contaminated and monitoring locations where soil is imported for evidence of infestation. Spot treatment may then be applied.
Longhorn crazy ant (*Paratrechina longicornis*)	Insect	Natural colonisation, international shipping, movement of human migrants	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native species of mammal for food and resources. Human migrant population (labour camp) may import this species accidentally. Control via screening and monitoring.

SPECIES NAME	GROUP	VECTOR SOURCE	PROJECT ELEMENT	ASSESSMENT / RAG RATING
Rose-ringed parakeet (*Psittacula krameri*)	Bird	Natural colonisation, international shipping	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native species of bird for food and resources, and potential vector for spread of *Prosopis juliflora*. Colonisation likely to be beyond the sphere of influence of the Project - bird is already present across Oman.
The flowerpot snake (*Ramphotyphlops braminus*)	Reptile	International shipping; importation of plant stock for landscaping puposes	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	This species is reputed to be a common introduction to the U.S., South Africa and other countries which are outside of its non-native range owing to its very small size (less than 20 cm) and ability to conceal itself in horticultural products. It is also highlighted by the IUCN as a possible introduction risk for Oman. Available evidence suggests that this species is unlikely to causes significant effects on native biodiversity in the Duqm region as its habitat requirements do not appear to include highly arid ecosystems. In addition, there is no evidence to suggest that where introduced (e.g. in the US and South Africa), it competes with native reptile populations or significantly depredates native invertebrate communities.
Asian hornet shrew/brown musk shrew (*Suncus murinus*)	Mammal	International shipping, movement of human migrants	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native species of mammal for food and resources. Tends to associated with human habitation and activity. Human migrant population (labour camp) may import this species accidentally. Control via screening and monitoring.
Tramp ant (*Tapinoma melanocephalum*)	Insect	International shipping, movement of human migrants	Refinery DRPIC Ras Markaz Crude Storage Facility DRPIC Crude Pipeline Labour Camps	Competition with native species of mammal for food and resources. Human migrant population (labour camp) may import this species accidentally. Control via screening and monitoring.
Red palm mite (*Raoiella indica*)	Arachnid	Pest of the fruit trade. Importation of infected	Labour Camps	Blight of food crops. Damage and death of date palms (*Phoenix dactylifera*)

Species Name	**Group**	**Vector Source**	**Project Element**	**Assessment / RAG Rating**
		produce.		Colonisation likely to be beyond the sphere of influence of the Project as date palms will not be used in landscaping planting as they are relatively water intensive crops.
Red Palm Weevil (*Rhynchophorus ferrugineus)*	Beetle	Transfer of date palms for landscaping	Landscaped areas	Blight of food crops. Damage and death of date palms (*Phoenix dactylifera*) Colonisation likely to be beyond the sphere of influence of the Project as date palms will not be used in landscaping planting as they are relatively water intensive crops.
Marine Species				
***Cochlodinium polikrikoides* (a primitive species of Eukaryotic/cellular organism)**	Dinoflagellate	Ballast water	Ras Markaz Crude Storage Facility Export Terminal	This species may be introduced by contaminated ballast water associated with oil import and export. This species may causes an extensive algal bloom, such as occurred in Oman Aug 2008 – June 2009 (Al Azri et al., 2014). When in bloom this species has been linked to mass fish kill incidents, damage to coral reefs, and interference with desalinization plants.
List of 14 marine species given in Al Yamani *et al* (2015) ranging from microalgae to fish	Various	Ballast water	Ras Markaz Crude Storage Facility Export Terminal	A range of effects leading to ecosystem disruption from fouling, toxins and predation pressure on native biodiversity. The Port of Duqm has a draft set of Port Rules & Regulations (Port of Duqm, 2016) that includes a section (2.10.6) on water. It specifies that the discharge of ballast water shall only be conducted through Ballast Water Management in terms of a range of stated provisions, for example, vessels from overseas port of call conducting ballast water exchange at least 200 nautical miles (nm) from the nearest land and in water at least 200m depth, or if this is not possible at least 50 nm in the same depth.

5. RECOMMENDATIONS FOR INCORPORATION IN BIODIVERSITY MANAGEMENT PLAN

The following recommendations have been divided into two categories:

- Project related recommendations – factors that DRPIC has direct influence or control over.
- Strategic recommendations – factors and conservation issues which the Project may effect in a cumulative way but relating more to regional planning and Government policy.

In the first category, DRPIC will seek to mitigation for these issues through implementation of the Project ESMP. In the second category, DRPIC will seek to influence and address these issues through consultation and advocacy with SEZAD and potentially through Coporate Social Responsbilty (CSR) initiatives.

Project Related Recommendations

1. **Soil biosecurity and hygiene** – the review of terrestrial IAS has signposted a possible vector source for the introduction of invasive plant species as contaminated soil. When any topsoil (including plants imported with top soil) is imported into the Project environment for landscaping or structural engineering purposes, the EPC Contractor must seek appropriate assurance (and evidence) from the soil source provider (or provide a guarantee if winning the soil itself) to ensure it is free from IAS contamination. Regular monitoring by a suitable qualified ecologist of areas of soil importation should be undertaken during the construction phase and for an appropriate period thereafter (approximately 3 – 5 years). Monitoring should aim to identify any non-native plant infestations. These may then be targeted for appropriate spot-treatment (e.g. herbicide application).
2. **Vehicles** – construction vehicles should be subjected to regular inspections to ensure that they are not acting as vectors of invasive plant species, particularly in cases where they may come into contact with established IAS such as *Prosopis juliflora.* Vehicles most likely to act as vectors are those regularly parked under *P. juliflora* trees (e.g. in Muscat). Vehicles should be appropriately cleaned prior to importation into the DSEZ. Construction vehicles should be restricted to designated construction access routes to minimise the possibile spread of IAS.
3. **Disturbance** – the review of terrestrial IAS highlights the potential for soil disturbance caused by construction activities to create the conditions favourable to ruderal plant species and non-native shrubs such as *Prosopis juliflora*. Soil disturbance is an inherent part of construction, therefore, regular monitoring should be undertaken to assess colonisation by mesquite or other ruderal plants during the construction phase and for a period until native vegetation has recolonized the construction footprint (approximately three to five years).
4. **IAS treatment strategy** – the appointed EPC contractor should have a strategy for treating infestations of non-native plant and animal species. The strategy should identify necessary treatment approaches and methods should an infestation be detected. The strategy should also detail the necessary equipment, products and specialised personnel required. Appropriate integrated control measures may include treatment with an appropriate herbicide or physical uprooting and removal (for localised instances) and safe disposal where no danger of recolonization can emanate. Regular monitoring of infestation sites needs to be conducted in order to ensure that new saplings germinating from the seedbank are removed before the infestation is re-established. This process may take several years.
5. **Labour Camps** – The Labour camps will be a key source of foreign migrants who may inadvertently import non-native plants and animals into the Project Area. Foreign

labourers may also deliberately import foreign plant species to cultivate around their living quarters. Large aggregations of workers are likely to generate refuse, which although unlikely to cause the introduction of any IAS, may create habitat conditions suitable for scavenging IAS (e.g. birds) or IAS that benefit from soil/ground disturbance. Monitoring effort should be directed at these locations; effective waste removal and storage; and potential screening of any imported food produce.

6. **Records** – should be kept (by the EPC Contractor) of all terrestrial IAS sightings (plants, birds, mammals etc.) for collation and submission to DRPIC and for the regional planning authority (SEZAD). Data can be used to inform cumulative assessment of other development schemes in the Duqm area and for IAS surveillance purposes.
7. **Assurance of ballast water procedures** – DRPIC should carry out assurance across its shipping supply chain to ensure import and export vessels are fully compliant with Port of Duqm ballast water treatment and use requirements and International Maritime Organisation requirements.
8. **Ballast water risk assessment** - Request confirmation from Port of Duqm that they have undertaken a ballast water risk assessment for all shipping under ballast arriving at Duqm using the Globallast system or equivalent. Vessels will include unladen or partially laden oil tankers arriving at the loading terminal and at Ras Markaz, as well as vessels requiring dry docking at ODC.
9. **Ballast water management protocols -** Request confirmation from Port of Duqm that ballast water management protocols for ships arriving at Port of Duqm are aligned with i) ROPME ballast water management protocols, ii) International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), which will come into force on 8 September 2017. Put in place necessary administrative and management structures to implement and ensure compliance with the applicable ballast water management protocols.

<u>Strategic Recommendations</u>

10. **Marine IAS monitoring** – DRPIC should lobby the Port of Duqm and regional authorities (e.g. SEZAD) to establish a marine IAS monitoring programme to species level of key groups of IAS most likely to be transported in ballast water. The monitoring programme should be established in the vicinity of Duqm Port (e.g. breakwaters, surrounding seabed) as well as at Ras Markaz (hard and soft subtidal habitats).

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APPENDIX D-5

APPENDIX 7.5: BIODIVERSITY OFFSET FRAMEWORK

TECHNICAL APPENDIX: BIODIVERSITY OFFSETTING FRAMEWORK

1. BACKGROUND

Duqm Refinery and Petrochemical Industries Company LLC (DRPIC) is developing the Duqm Refinery Project (the "Project") which comprises the Refinery and Offsite Facilities:

- 230,000 barrels per day (BPD) complex refinery and on-site utilities, infrastructure and storage (the 'Refinery');
- Product export terminal ('Export Terminal') at the Port of Duqm;
- Crude storage facility at the Ras Markaz crude oil terminal (the 'DRPIC Ras Markaz Crude Storage Facility'); and
- 28" 80km Crude pipeline from Ras Markaz to the Refinery ('DRPIC Crude Pipeline' and together with the DRPIC Ras Markaz Crude Storage Facility and the Export Terminal, the 'Offsite Facilities').

As part of Project Financing, the Lenders' Independent Environmental and Social Consultant identified a number of areas in the Project ESIA Reports and Project documentation that require supplementing and/or enhancing to bring them up to Lender standards. This included the need to provide a consolidated biodiversity assessment incorporating a biodiversity no net loss strategy to enable compliance the International Financial Corporation's Performance Standard 6 (IFC PS6).

2. INTERPRETATION OF LENDERS' REQUIREMENTS – BIODIVERSITY OFFSETTING FRAMEWORK

The independent ESDD Report (Ramboll Environ, 2016) identified the need to consider how no net loss of natural habitat (see definition of natural habitat in Table 1) would be achieved for the Project in order to comply with the IFC's PS6:

> *"Assessments should be updated to address the concept of natural habitat as set out in International IFC PS6 Paragraph 13, particularly to outline how no net loss of those habitats would be achieved. Measures included in the EIAs at present fall short of no net loss, they are mitigation to minimise the loss of vegetation or avoid direct mortality of fauna"*. (Row 55, p.92).

The Project will directly affect the following natural habitats (as defined by IFC PS6). See Table E.4 in this document for habitat areas present in the Project Footprint and 0.25 km survey area. See Technical Appendix B: Harmonisted Habitat Mapping for habitat defintions. Note that these areas present in Table E.4 are not necessarily reflective of permanent habitat loss associated with Project construction as some habitat will be restored post-Project construction (e.g. restoration of habitat including plating of native trees above the buried DRPIC Crude Oil pipeline which will be buried benath the ground surface):

- Gravel & sand plains with dwarf shrub cover (accounts for approximately 65% of the Project Footprint);
- Gravel & sand plains with trees;
- Rocky mountain & escarpment;
- Rocky outcrops & gravel hills;

- Vegetated dune;
- Vegetated sabkha;
- Wadis in close association with mountains; and
- Wadis in open terrain.

The review of the Project Lenders' requirements has highlighted that other elements of the broader topic area of biodiversity offsetting may also apply to the Project in order to comply with IFC PS6. Specifically, IFC PS6 requires the adoption of a biodiversity offsetting approach to address potential impacts on species for which critical habitat exists in the Project area (see definition of critical habitat in Table 1). In relation to potential impacts on critical habitat, IFC PS6 states that developers may need to demonstrate a net gain (i.e. beyond no net loss) in biodiversity (see definition of net gain in Table 1). A critical habitat assessment (CHA) is provided in Technical Appendix C.

Although biodiversity offsets may have been delivered in relation to a number of different development projects in Oman, at present there is no formal Government policy or best practice for biodiversity offsetting in Oman. This situation is the same for Duqm Special Economic Zone (Duqm SEZ) where no specific biodiversity compensation or offsetting policy exists. The use of constructed wetland technologies to treat wastewater has been trialled as a system for the beneficial use of wastewater associated with oil refining at the Nimr oilfield south of Ras Madrakah(Breuer, 2011). Reedbed habitat has been created in the Nimr oilfield where previously, this habitat could not survive due to the arid conditions. Although reedbed creation is a potential opportunity in relation to the Project, no loss of reedbed vegetation will be associated with the Project and thus this would be a potential biodiversity enhancement opportunity, or an 'out of kind' offset (see definitions herein) rather than an offset to compensate for Project impacts. Deploying artificial reefs to create new reef habitat has been utilised in other states in the region including Abu Dhabi and Bharain (The National, 2017) and other areas in Oman, again these measures would constitute an 'out of kind' offset if implemented in relation to the Project, as no reef loss is envisaged. Table E.4 lists the habitats in the Project Footprint and 0.25 km survey area. The Project will not result in an direct loss of marine habitat as the Export Terminal and Ras Markaz Single Point Mooring facility are both AFs.

Related to the lack of a formal policy/procedure for biodiversity offsetting in Oman, a number of other factors must be considered before biodiversity offsets can be delivered. These include:

- The complexity of the land tenure in the Duqm area and plans for development expansion (i.e. the strategic relationship between the Project and other developments within the SEZAD area). There would be little point in DRPIC delivering an offset on land which is later developed, subject to potential impact from third party development, or over which it doesn't have some measure of control;
- There are gaps in the ecological data coverage of key species and habitats in the region as a whole – in order to best target habitat creation or conservation management the distribution and habitat use of key species needs to be better understood;
- There is a need to fully engage with Governmental, non-Government organisations and local community stakeholders to ensure potential offsets are delivered with consent and buy-in from those potentially affected by them (both benefiting from them or potential suffering a loss arising from the creation of a biodiversity offset);
- When considering the multiple species which may trigger critical habitat in the Project Area and particularly the area in which Associated Facilities are proposed or operational, there is a requirement to adopt a coordinated approach which is beyond the scope of the Project – this needs to be agreed at a strategic level with Government authorities before offsetting solutions can be delivered; and

- In compiling a biodiversity offsetting strategy, the need for the project proponent and the lender to agree in principle on the focus of the initiative (e.g. habitat, species), the principles, goals, targets and indicators to be adopted and commitment to gain support and buy-in from interested parties.

In summary, the Lenders' report asks for consideration of no net loss of biodiversity only in connection with natural habitat affected by the Project. However, by virtue of the fact that the Lenders' report asks for compliance with PS6 in general; and because the CHA (Technical Appendix C: CHA) identifies the presence of critical habitat for a number of species in the Project Area - a broader application of biodiversity offsetting may need to be applied, full delivery of which sits partly outside DRPICs sphere of influence and involves those constructing and operating Associated Facilities, other SEZ development and DRPICs wider supply chain include shipping operations. Furthermore, there are several political, stakeholder related and technical issues that need to be further researched before biodiversity offsetting can be adopted for the Project.

For the above reasons a biodiversity offsetting framework for the Project has been produced which is a first step in deriving a detailed biodiversity offsetting strategy in the future.

3. PURPOSE OF THIS BIODIVERSITY OFFSETTING FRAMEWORK

This biodiversity offsetting framework identifies issues and actions that should be adopted to apply a biodiversity offsetting approach to deal with potential significant, residual ecological impacts on natural habitat and critical habitat which are identified in the main biodiversity assessment. It does this by:

1. Defining key terms and concepts;
2. Identifying principal sources of guidance and best practice;
3. Setting-out a framework of recommendations which DRPIC can pursue to take forward biodiversity offsetting ideas and initiatives, including the requirement to engage with Government, NGOs and the developers of Associated Facilities which may also cause an ecological impact;
4. Identifying key stakeholders required to develop and implement biodiversity offsetting; and
5. Producing a preliminary inventory of natural habitat features and species triggering critical habitat relating to the Project for consideration in developing a detailed strategy for biodiversity offsetting.

The Biodiversity Management Plan (BMP) for the Project will also make reference to the set of reports comprising the Biodiversity work collated for the Consolidated ESIA, of which this Appendix is one. The BMP is a practical DRPIC document used by the EPC Contractors during construction and commissioning to ensure activities are in line with Project requirements and commitments. It is therefore important that the EPC Contractors are aware of the issues and aspects relating to the topic of biodiversity offsetting, as addressed in this Appendix.

4. DEFINITION OF KEY TERMS AND CONCEPTS

The following terms and concepts relating to biodiversity offsetting will be used throughout this document.

Table E-1: Biodiversity Offsetting Terms and Concepts

TERM	DEFINITION AND/OR DESCRIPTION
The mitigation hierarchy	The ecological mitigation hierarchy is a core principle of biodiversity offsetting. It has been defined variously by different bodies (e.g. the International Finance Corporation (IFC) and the Business and Biodiversity Offsets Programme, BBOP). It states that new developments should adopt the following step-by-step process in

TERM	DEFINITION AND/OR DESCRIPTION
	relation to potential ecological impacts. **1.** Avoid through project design; **2.** Minimise by adopting measures to reduce or abate potential ecological impacts (sometime referred to as mitigation); **3.** Rehabilitate/restore natural habitats once development has occurred **4.** Compensate/offset for ecological impacts by creating new habitats or increasing the quality/condition of existing habitats. Measures to ensure avoidance and minimisation of ecological impacts are contained in the Project BMP.
Biodiversity offsetting	Biodiversity offsetting is the process of design and delivery of biodiversity offsets. BBOP define biodiversity offsets as: *"Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity."* (BBOP, 2012: pg. 1). Within the mitigation hierarchy, offsets are seen as: *"a specific kind of compensation designed to achieve no net loss or a net gain of biodiversity, while compensation may not achieve no net loss"* (BBOP, 2012: pg. 2). A key aspect of biodiversity offsetting is the need to measure conservation losses and balance these with gains using a quantifiable metric. Biodiversity offsets may be physical actions involving the acquisition and management of land. They may equally be procedural or organisational interventions (such as contributing to strategic/regional nature conservation projects) aimed at increasing the conservation status of species or habitats.
Biodiversity No Net Loss/Biodiversity Net Gain	Biodiversity no net loss is a biodiversity offsetting objective which aims to secure no net change of biodiversity: *"on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity"*. Biodiversity net gain is an offsetting objective which aims to secure a net increase in biodiversity (e.g. structure, function, species composition). No net loss and net gain are typically quantified using a biodiversity metric as a surrogate for 'biodiversity'.
IFC Performance Standard 6 (PS6)	The IFC has produced a Sustainability Framework which articulates the IFC's strategic commitment to sustainable development. PS 6 of the IFC's framework recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. Among other requirements, PS6 notes the following in relation to biodiversity offsetting: *"In areas of natural habitat, mitigation measures will be designed to achieve no net loss of biodiversity where feasible"* (IFC, 2012: pg. 3).

TERM	DEFINITION AND/OR DESCRIPTION
	"[In areas of Critical Habitat] *…the project's mitigation strategy will be described in a Biodiversity Action Plan and will be designed to achieve net gains of those biodiversity values for which the critical habitat was designated"* (IFC, 2012: pg. 3). PS6 define no net loss as: *"the point at which project-related impacts on biodiversity are balanced by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale (e.g., local, landscape-level, national, regional)"* (IFC, 2012: pg. 3). PS6 defines net gain as: *"Net gains are additional conservation outcomes that can be achieved for the biodiversity values for which the critical habitat was designated. Net gains may be achieved through the development of a biodiversity offset and/or, in instances where the client could meet the requirements of paragraph 17 of this Performance Standard without a biodiversity offset, the client should achieve net gains through the implementation of programs that could be implemented in situ (on-the-ground) to enhance habitat, and protect and conserve biodiversity"* (IFC, 2012: pg. 4).
Natural Habitat	PS6 defines natural habitat as: *"areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."*
Modified Habitat	PS6 defines modified habitat as: *"areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands."* (IFC, 2012: pg. *3*).
Critical Habitat	PS6 defines critical habitat as: *"areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered11 species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes. All conservation status listing relate to the International Union for the Conservation of Nature (IUCN) categories."* (IFC, 2012: pg. 4).
Biodiversity metric	A metric is a mathematical tool that allows biodiversity losses and compensation to be measured.
In kind offset	Provision of compensatory habitat or conservation actions which are like-for-like in directly addressing the ecological feature or function which is subject to an impact (e.g. loss of wadi vegetation to be compensated by fostering the growth of new wadi vegetation).
Out of kind offset	Provision of compensatory habitat or conservation actions which are not like-for-like in that they are spatially removed or of a different type or function from the feature subject to an ecological impact.

5. PRINCIPAL SOURCES OF GUIDANCE AND BEST PRACTICE

The key source of information and standards about biodiversity offsetting is presented by BBOP. BBOP has produced a comprehensive guidance library covering all aspects of offsetting practice and implementation. A directory to the various guidance documentation is provided on the BBOP website (BBOP, 2017).

The IFC has provided guidance on implementation of PS6 which includes detail on how the concepts of net gain and no net loss should be interpreted (IFC, 2012b).

The UK model which is focussed on delivering offsets for impacts on habitats is explained in a series of publications issued by the UK Department of Agriculture Food and Rural Affairs (DEFRA 2011, DEFRA, 2012). The UK model does not incorporate offsetting for species at present but is relatively simple to add to any context where land take on natural habitats is occurring. It employs a simple metric to determine the area of offset that must be delivered to compensate for habitat damaged or removed by a development. The metric is based on a scoring system derived from multiplying the area of habitat lost by its condition and by its uniqueness or replaceability in terms nature conservation. Similar habitat based metric approaches have been extensively used in Australia and in the United States of America (these are reviewed by BBOP).

The review of principal sources of guidance and best practice has not revealed any specific biodiversity offsetting best practice that has emerged for Arabia or any particular approaches which are most suitable for arid ecosystems or applicable to marine species (e.g. cetaceans) such as those identified in the CHA (Technical Appendix C). As part of the development of a biodiversity offsetting strategy for the Project a thorough review of regional case studies would assist adoption of the most appropriate model for the Duqm region.

6. BIODIVERSITY OFFSETTING FRAMEWORK

The following framework has been derived on the basis of experience in delivering offsetting projects in a UK and in an international context utilizing BBOP and IFC guidance. The various elements in the framework are entitled ‘steps’ but should not be seen a linear stages that need to be progressed in strict sequence. Progress towards delivery of a detailed biodiversity offsetting strategy may be achieved by addressing different elements as opportunities arise and to best fit with the Project and planning programme.

Table E-2: Project Offsetting Road Map

STAGE	RECOMMENDED ACTIONS	STAKEHOLDERS WITH GREATEST INFLUENCE ON THIS STAGE	INFORMATION REQUIREMENTS
Step 1: Define off-setting principles			
BBOP (among other bodies) has set out a clear set of principles to be adopted by those seeking to use offsetting as part of their wider approach to delivery of ecological mitigation. The BBOP principles are founded on protection of those the most critical ecological resources, strict adherence to the ecological mitigation hierarchy; and adopting an open, transparent and auditable approach to offset selection and delivery. There is a certain amount of negative press surrounding the practice of biodiversity offsetting. Among other criticisms, this is part founded on a perception that offsetting offers developers a 'licence to trash' natural ecosystems. If uncontrolled, the negative association with offsetting may have significant public relations connotations for a developer advocating an offsetting approach. A negative association with offsetting may be equally damaging for attracting future inward investment – particularly where compliance with IFC PS6 is a requirement. Equally poorly designed and delivered offsets could alienate a local community in which a development is based or result in negative perceptions should the offset not "deliver" on the predicted offset benefits. It is recommended that DRPIC set out and agree guiding principles for offsetting as part of their Corporate Social Responsibility policy to address these potential risks. BBOP has established 10 guiding principles which should form a starting point for consideration relating to the Project: 1. Adherence to the mitigation hierarchy - avoidance and mitigation first and offsetting as a	DRPIC to agree offsetting principles with SEZAD, MECA (if applicable) and relevant stakeholder groups.	DRPIC/SEZAD/MECA	Technical note on suitable offsetting principles for consideration by DRPIC and to secure agreement/acceptance from SEZAD and MECA (if applicable). Guidance from SEZAD / MECA on approach.

Stage	Recommended Actions	Stakeholders with greatest influence on this Stage	Information Requirements
last resort. 2. Limits to what can be offset – exclude certain, irreplaceable habitats and species features (those which cannot be recreated) from offsetting. 3. Landscape context - A biodiversity offset should take into account available information on the full range of biological, social and cultural values of biodiversity and the local ecosystem. 4. No net loss/net gain – the aim should be to achieve no net loss or preferably net gain of biodiversity as measured by a biodiversity metric. **5.** Additional conservation outcomes **-** A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. 6. Stakeholder participation – Be democratic. Fully include relevant location community and conservation groups. 7. Equity: Biodiversity offsets should be designed and implemented in an equitable manner which respecting legal and customary arrangements and considers recognised rights of indigenous peoples and local communities. 8. Long-term outcomes – biodiversity offsets should incorporate monitoring and adaptive management to ensure they provide biodiversity benefits into the long-term; preferably in perpetuity. 9. Transparency - The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner. 10. Science and traditional knowledge – offset design and implementation should be respectful of scientific and traditional sources of knowledge.			
Step 2: Engaging with stakeholders			

STAGE	RECOMMENDED ACTIONS	STAKEHOLDERS WITH GREATEST INFLUENCE ON THIS STAGE	INFORMATION REQUIREMENTS
Engagement with stakeholders should be undertaken to: a) Define and agree offsetting principles; b) Agree local nature conservation priorities; c) Identify potential offset sites and providers.	Produce an inventory of potential stakeholders. Consult with stakeholder groups. SEZAD to provide list of tenants and potential stakeholders (including other developers).	DRPIC, SEZAD	• Land owners, tenants and developers; • Inventory of potential conservation organisations with an interest in management, delivery or monitoring of offset sites.
Step 3: Quantify loss of natural habitat and critical habitat associated with the Project and define offset requirement			
A hallmark of a biodiversity offsetting approach is that changes in biodiversity must be quantified. In order to achieve this, a metric must be selected which is appropriate to the local ecosystem; and reflects the offsetting principles agreed for the project. A number of metrics have been developed for different applications – a detailed review has been undertaken by BBOP (2009). Many metrics convert ecological data into 'biodiversity units' as a surrogate measure for biodiversity. Units present before and after development can be an effective guide to the size and type of offset required. Many biodiversity metrics rely on basic habitat information. Habitat area and condition are two basic criteria that can be used as a surrogate for quantification of biodiversity change. For example, this approach has been adopted in a UK context by DEFRA.	Develop a biodiversity metric in consultation with stakeholder organisations (different approaches may be required for the terrestrial and marine environments). Produce a detailed baseline habitat map for the terrestrial and marine elements of the Project. Agree a habitat typology to be used for the Project Area with stakeholders (e.g. Brown and Boer, 2004). Undertake a baseline biodiversity unit calculation for the Project.	DRPIC, SEZAD	• BBOP information and guidance on biodiversity metrics including criteria to assign habitat scores to support the prioritisation process; • Habitat mapping for the Project area (see Technical Appendix B: Harmonised Habitat Mapping). • In order to utilise a habitat based metric to quantify 'biodiversity' information is typically required for both habitat type and its condition (e.g. good, degraded, recofering etc.) However, this requirement will be influenced by what metric is selected/designed for the Duqm area.
Step 4: Informing environmental mitigation design			
Application of the offsetting principles agreed at the outset; knowledge of the quantity of biodiversity units likely to be impacted (the baseline biodiversity calculation); and identification of suitable offsetting locations with stakeholders will enable design of a robust ecological mitigation strategy.	SEZAD to publish strategic biodiversity network/green infrastructure plan for the region. Produce an integrated ecological mitigation plan specifying new areas of habitat which are to be created or managed differently. Consult on proposed mitigation strategy.	SEZARD, , stakeholder groups	Biodiversity opportunity and critical habitat mapping study across SEZAD region including both terrestrial and marine areas. Habitat mapping of mitigation land or marine zone area to indicate habitat creation aims and objectives. Consultation inputs from stakeholder groups.
Step 5: Calculating the potential biodiversity units of Project and offset sites			

Stage	Recommended Actions	Stakeholders with greatest influence on this Stage	Information Requirements
When a mitigation strategy has been finalised, the biodiversity metric which was developed as part of the Step 3 works should be re-run to demonstrate the number of biodiversity units generated by selected mitigation actions. An assessment can be made at this stage, whether no net loss or a net gain (of biodiversity units) has been achieved. Mitigation plan can be updated to reflect to meet no net loss or net gain targets.	Undertake an operational Project biodiversity unit calculation for the Project. In the case that the offset proposal is defined as a contribution to a strategic conservation initiative which is not within DRPIC ownership or control (e.g. a programme to reinstate native vegetation in an area that has been overgrazed conducted by a third party conservation organisation) – the metric developed as part of Stage 3 could be used to quantify the increase in biodiversity value of a third party organisation's land to ascertain if no net loss or net gain has been acheived.	DRPIC, stakeholder groups	Habitat mapping of mitigation land to indicate habitat creation aims and objectives.
Step 6: Selection of offset providers and setting up legal/delivery agreements			
Consultation with stakeholders and land owners should be undertaken to agree and implement legal delivery mechanisms, management agreements and to arrange offset financing.	Consultation and negotiation with offset providers.	SEZAD, DRPIC	N/A
Step 7: Monitoring, review and evaluation			
A monitoring strategy should be developed to monitor the success of the biodiversity offset and to ensure that management is effective at preserving its biodiversity importance. Clear goals should be defined for DRPIC, stakeholder organisations and regulatory bodies to monitor its success. Adaptive management should be undertaken subject to the outcome of ecological monitoring studies.	Produce and implement monitoring strategy.	DRPIC, stakeholder groups	N/A

7. IDENTIFICATION OF POTENTIAL OFFSETTING STAKEHOLDERS

Table E-3 sets out stakeholders who will require engagement and consultation in order to develop a biodiversity offsetting strategy for the Project Area.

Table E-3: Potential Biodiversity Offsetting Stakeholders: Potential Stakeholders in Biodiversity Offsetting Stakeholder/Stakeholder Group

STAKEHOLDER GROUP	AREA OF INFLUENCE	ROLE
Ministry of Environment and Climate Affairs	Government policy, management of protected areas and onshore/offshore (outside Duqm SEZ) environmental authority.	Government policy, direction and funding. Offsetting scheme regulator (outside SEZ). Strategic allocation of offset land within Duqm SEZ.
Office for Conservation of the Environment, Diwan of Royal Court	Government policy, protected areas and wildlife management and research (e.g. Al Wusta Wildlife Reserve)	Biodiversity conservation including protected areas management and wildlife research. Government policy.
Special Economic Zone in Duqm Authority (SEZAD)	Duqm SEZ authority and strategic planner, environmental regulator for Duqm SEZ.	Offsetting scheme regulator. Strategic allocation of offset land within Duqm SEZ. Critical habitat assessment of strategic development plans and identification of likely mitigation and compensation objectives. Strategic broker for offsetting finances.
DRPIC	Project area	Funding and management of potential offsets to address impacts specifically associated with the Project.
Other developers/oil and gas industries/residential and business commercial industries	Various locations in the Duqm SEZ area.	Funding and management of potential offsets areas to address impacts specifically associated with existing and future developments.
Tourism industry (to include Ministry of Tourism, Omran, developers, operators)	Development of business streams around natural habitats/funding of offsets	Beneficiaries of biodiversity offsets (tourist attractions). Potential funders of biodiversity offsets (e.g. ecotourism).
Fisherman, farmers and pastoralists	These land/sea users could contribute to delivery of offsets by adapting their management of marine or terrestrial recources possibly by accepting payment from those requiring an offset.	Responsible for delivery of habitat management or adapting land management to enable ecological gain (e.g. modifying grazing regimes). Potential beneficiaries of biodiversity offsets.
Nature Conservation Non-Governmental Organisations	Delivery of offset projects by adapting land/sea nature conservation projects /land management. Technical knowledge of nature conservation initiatives.	Provision of third party verification of offset success. Potential offset management agencies. Provision of scientific expertise and advice.
Consultants, biodiversity offsetting brokers	Contract/project specific.	Quantification and definition of offsets. Technical advice. Stakeholder consultation.

8. REVIEW OF ECOLOGICAL FEATURES POTENTIALLY TRIGGERING AN OFFSETTING REQUIREMENT IN THE PROJECT AREAS

The following list of habitats and species has been extracted from the main Biodiversity Chapter and accompanying Technical Appendix series (particularly the Harmonised Habitat Mapping in Technical Appendix B and the Critical Habitat Assessment in Technical Appendix C).

A list of natural habitats as defined by PS6, triggering the requirement to achieve no net loss is as follows. Note – the Study Area in this context is the area within the Project footprint and a 0.25 km zone around this. This is not the area of habitat loss.

Approaches to deliver offset potential residual impacts on natural habitats could be delivered by adopting a habitat based metric similar to the US, UK and Australian models (adapted to the local context). However, a first step would be to provide an accurate habitat loss estimate for the Project taking into consideration permanent loss and habitats which are restored post-construction to define an accurate offset requirement.

Table E-4: Habitats and Species in Duqm Area

Habitat type	Area in km^2 in the Study Area	Percentage of Overall Study Area	Distribution within the project footprint
Gravel & sand plains with dwarf shrub cover	31.28	65.41	Along the length of the pipeline, dominant habitat at both constructions camps and along part of service corridor close to oil refinery. Co-dominant habitat at Ras Markaz crude oil park
Gravel & sand plains with trees	2.23	4.66	Scattered locations along the pipeline
Rocky mountain & escarpment	0.96	2.01	A few locations along pipeline north of Haima road junction
Rocky outcrops & gravel hills	5.97	12.48	Scattered locations including services corridor, construction camp 2, Ras Markaz crude oil park and along the length of the pipeline
Vegetated dune	0.05	0.10	Ras Markaz crude oil park
Vegetated sabkha	1.73	3.62	Co-dominant habitat along the services corridor. Also present where pipeline turns east and heads towards construction camp 1
Wadis in close association with mountains	0.3	0.63	Just north of Haima road junction
Wadis in open terrain	5.3	11.08	Scattered along length of the pipeline. Also in NE corner of construction camp 2

A list of species which may trigger the requirement as per IFC PS6 to achieve net gain of critical habitat is stated in table E5 (terrestrial) and E6 (marine). As noted in the biodiversity chapter and the CHA (Technical Appendix C). The several endemic plant species which are listed have relatively well defined habitat requirements although recent distribution data is lacking (see Technical Appendix C). Approaches to deliver offset potential residual impacts on these could be delivered by adopting a habitat based metric similar to the US, UK and Australian models (adapted to the local context).

However, the majority of these species listed in table E5 are extremely wide-ranging (e.g. predatory mammals) or make use of the entire Gulf of Masirah (e.g. cetacean species, turtle species). Arriving at suitable conservation approaches for these species, and potential offsetting projects is a cumulative issue relating to all users and potential developers within the Duqm SEZ and the marine environment. When considering the multiple species which may trigger critical habitat in the Project Area and particularly the area in which Associated Facilities are proposed or operational, there is a requirement to adopt a coordinated approach which is beyond the scope of the Project – this needs to be agreed at a strategic level with Government authorities before offsetting solutions can be effectively delivered.

Table E-5: Inventory of Terrestrial Species Triggering Critical Habitat which may be affected by the Project and Associated Facilities

Species/Feature	Feature type	Endemism (Oman or regional)	Oman status	Regional status	Global status
Salsola omanensis	Plant	Endemic	NE	NE	VU
Ochradenus harsusiticus	Plant	Endemic	NE	NE	VU
Pycnocycla sp. nov.	Plant	Endemic	Dd	NE	NE
Campylanthus sedoides	Plant	Endemic	NE	NE	NT
Convolvulus oppositifolius	Plant	Endemic	NE	NE	NT
Pulicaria pulvinata	Plant	Endemic	NE	NE	NT
Striped hyaena (*Hyaena hyaena*)	Mammal	N/A	CR[1]	EN[2]	NT
Arabian wolf (*Canis lupus arabs*)	Mammal	N/A	EN[1]	EN[2]	LC
Rüppell's sand fox (*Vulpes rueppellii*)	Mammal	N/A	EN[1]	LC[2]	LC
Caracal (*Caracal caracal*)	Mammal	N/A	EN[1]	LC[2]	LC
Ibex (*Capra ibex)*	Mammal	N/A	EN[1]	NE	VU
Wetland bird assemblage using Duqm IBA	Bird	N/A	N/A	N/A	N/A

Table E-6: Inventory of Marine Species Potentially Triggering Critical Habitat which may be affected by the Project and Associated Facilities

Species	*Feature Type*	*Oman Status*	Regional Status	Global Status
Arabian long-beaked common dolphin *Delphinus capensis tropicalis*	Cetacean	NE	NE	DD
Blue Whale *Balaenoptera musculus*	Cetacean	NE	NE	EN
Bryde's Whale *Balaenoptera edeni*	Cetacean	NE	NE	DD
Cuvier's beaked whale *Ziphius cavirostris*	Cetacean	NE	NE	LC

Species	Feature Type	Oman Status	Regional Status	Global Status
Dwarf sperm whale *Kogia sima*	Cetacean	NE	NE	DD
False killer whale *Pseudorca crassidens*	Cetacean	NE	NE	DD
Humpback whale *Megaptera novaeangliae*	Cetacean	NE	EN	LC
Indian Ocean humpback dolphin *Sousa plumbea*	Cetacean	NE	NE	EN*
Indo-pacific bottlenose dolphin *Tursiops aduncus*	Cetacean	NE	NE	DD
Orca *Orcinus orca*	Cetacean	NE	NE	DD
Pygmy killer whale *Feresa attenuata*	Cetacean	NE	NE	DD
Risso's Dolphin *Grampus griseus*	Cetacean	NE	NE	LC
Rough toothed dolphin *Steno bredanensis*	Cetacean	NE	NE	LC
Sperm Whale *Physeter macrocephalus*	Cetacean	NE	NE	VU
Spinner Dolphin *Stenella longirostris*	Cetacean	NE	NE	DD
Pantropical Spotted Dolphin *Stenella attenuata*	Cetacean	NE	NE	LC
Hawksbill turtle *Eretmochelys imbricata*	Turtle	NE	NE	CR
Green turtle *Chelonia mydas*	Turtle	NE	NE	EN
Leatherback turtle *Dermochelys coriacea*	Turtle	NE	CR	VU
Loggerhead turtle *Caretta caretta*	Turtle	NE	CR	VU
Olive Ridley turtle *Lepidochelys olivacea*	Turtle	NE	NE	VU

Species	Feature Type	Oman Status	Regional Status	Global Status
Oman Butterflyfish *Chaetodon dialeucos*	Fish	NE	NE	LC
Yellow-bellied sea snake *Pelamis platura*	Snake	NE	NE	LC
A coral species *Dipsastraea favus*	Hard coral	NE	NE	NE
A coral species *Favites pentagona*	Hard coral	NE	NE	LC
Cabage Coral *Montipora foliosa*	Hard coral	NE	NE	NT
A coral species *Platygyra daedalea*	Hard coral	NE	NE	LC
A coral species *Plesiastrea versipora*	Hard coral	NE	NE	LC
A coral species *Porites lobata*	Hard coral	NE	NE	NT
A coral species *Stylophora pistillata*	Hard coral	NE	NE	NT
A coral species *Turbinaria mesenterena*	Hard coral	NE	NE	VU
A coral species *Turbinaria peltata*	Hard coral	NE	NE	VU
Cabbage leather coral *Sinularia brassica*	Soft Coral	NE	NE	NE
Arabian cushion star *Culcita coriacea*	Marine Fauna	NE	NE	NE
Spiny cushion star *Culcita schmideliana*	Marine Fauna	NE	NE	NE
Indian Sea Star *Fromia indica*	Marine Fauna	NE	NE	NE
A starfish *Linckia multifora*	Marine Fauna	NE	NE	NE
Lollyfish *Holothuria atra*	Marine Fauna	NE	NE	LC
Tiger-tail sea cucumber *Holothuria hilla*	Marine Fauna	NE	NE	LC
White thread fish *Holothuria leucospilota*	Marine Fauna	NE	NE	LC
Macroalgae *Nizamuddinia*	Macroalga	NE	NE	NE

SPECIES	FEATURE TYPE	OMAN STATUS	REGIONAL STATUS	GLOBAL STATUS
zanardinii				

9. RECOMMENDATIONS

In order to take forward the delivery of no net loss/net gain of biodiversity using a biodiversity offsetting approach the following key actions need to take place:

- Consultation with SEZAD on this framework to identify the potential contribution of DRPIC to strategic efforts and/or to outline scope, extent and design principles of a potential offsetting strategy; consultation should be extended to MECA and OCE if the strategy includes remote offsetting in areas outside SEZAD area
- Engagement of key internal and external stakeholders to gather information on this biodiversity offsetting framework;
- Work with SEZAD to identify strategic opportunities for offsetting;
- Work to define a metric to measure biodiversity loss/gain for the Project so the extent of offsetting required can be determined;
- With reference to natural habitats and habitats potentially supporting critical habitat plant species – produce an accurate permanent habitat loss estimate for the scheme (considering first land that will be restored post-construction) and develop a simple habitat based metric suitable for the arid zone to quantify the requirement for compensatory habitat creation or management.
- With reference to wide-ranging critical habitat species – collaborate with industry groups and wider users of the Gulf of Masirah and Duqm SEZ to define an effective conservation strategy and offsetting approach to which DRPIC can contribute.
- Further detail on steps that could be taken to address marine critical habitat issues based on a Strategic Initiative Approach are provided in Technical Appendix C: Critical Habitat Assessment.

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APPENDIX D-6

APPENDIX 7.6: ECOSYSTEM SERVICES ASSESSMENT

TECHNICAL APPENDIX: ECOSYSTEM SERVICES ASSESSMENT

1. INTRODUCTION

Duqm Refinery and Petrochemical Industries Company LLC (DRPIC) is developing the Duqm Refinery Project (the 'Project') located within the Special Economic Zone at Duqm (Duqm SEZ). The Project comprises the Refinery and Offsite Facilities:

- 230,000 barrels per day (BPD) complex refinery and on-site utilities, infrastructure and storage (the 'Refinery');
- Product export terminal ('Export Terminal') at the Port of Duqm;
- Crude storage facility at the Ras Markaz crude oil terminal (the 'DRPIC Ras Markaz Crude Storage Facility'); and
- 28" 80km Crude pipeline from Ras Markaz to the Refinery ('DRPIC Crude Pipeline' and together with the DRPIC Ras Markaz Crude Storage Facility and the Export Terminal, the 'Offsite Facilities').

As part of Project financing, the Lenders' ESDD Report (Ramboll Environ, 2016) identified the need to provide details of potential impacts on ecosystem services arising from the Project.

2. INTERPRETATION OF LENDERS' REQUIREMENTS – ECOSYSTEM SERVICE ASSESSMENT

The Project Lenders' independent Environment and Social Due Diligence report (Ramboll Environ, Dec. 2016) states the following in relation to ecosystem services:

> *"There is little or no mention of the concept of ecosystem services throughout the various assessments. Natural resources are discussed but often these sections describe the hydrocarbons to be processed by the proposed project rather than the resources of the sites or area." (Row 59, p.73)*

The Lender's report requires DRPIC to:

> *"Complete an ecosystem services assessment which includes consultation to ascertain levels of livelihood dependence."*

For the purpose of this assessment, ecosystem services are defined following the definition used in the International Financial Corporation Performance Standard 6 (IFC PS6):

> *"Ecosystem services are the benefits that people, including businesses, derive from ecosystems. Ecosystem services are organized into four types: (i) provisioning services, which are the products people obtain from ecosystems; (ii) regulating services, which are the benefits people obtain from the regulation of ecosystem processes; (iii) cultural services, which are the nonmaterial benefits people obtain from ecosystems; and (iv) supporting services, which are the natural processes that maintain the other services"* (IFC PS6, 2012: pg. 1).

3. METHODOLOGY

DATA SOURCES

The following desktop sources of information were used to inform this assessment:

- Aerial imagery;
- 5th National Report to the Convention on Biological Diversity (MECA, 2014); and
- Ministry of Tourism, Sultanate of Oman website (Ministry of Tourism, 2017).

Desktop sources of information were supplemented by the following primary survey information collated and prepared as part of the Consolidated ESIA:

- Biodiversity Assessment – Technical Appendix A contains a survey record. Alongside biodiversity ground truthing surveys, incidental observations were gathered of settlements, grazing, fishing and other 'ecosystem benefits' being utilised or derived by the location population in the project area.;
- Socio-economic and health baseline, including ecosystem services – a series of structured and informal interview and questionnaire surveys were carried out targeting local residents in the principle settlements surrounding the refinery (Al Tayari, Nafun and Duqm) and surveying members of the fishing community based at Nafun;
- Enhanced Cultural Heritage baseline – historic desk-top studies and field survey along 80 km linear transect (DRPIC Crude Oil Pipeline ROW) inspected for, inter alia, National Archaeological and Environmental Heritage Sites. The heritage assessment was compiled using historic desk top studies carried out within the vicinity of the site and a field survey of a proposed pipeline corridor completed by Dr. Yamandú Hilbert in April 2017.
- Landscape and Visual Intrusion baseline and impact appraisal – desktop study supported by teams visiting Duqm to establish Landscape Character Areas (LCA) and potential receptors. Visual amenity effects on a small number of visual receptors and landscape effects due to the change in character of the natural coastal areas were documented.
- Greenhouse gas Emissions Report. (DRPIC Ref. 03-CL-Tech/GHG)

4. ECOSYSTEM SERVICE CATEGORISATION AND PRIORITISATION

A provisional inventory of ecosystem services was compiled by reviewing the above listed data sources. The list was expanded by including other ecosystem services likely to be relevant to arid ecosystems such as those found in Oman using available ecosystem typologies in the Millennium Ecosystem Assessment series of publications and in the guidance document prepared to accompany IFC PS6 (IFC, 2012b). The provisional ecosystem service inventory is presented in Table F-1.

Following IFC guidance (IFC, 2012b), ecosystem services were then categorized as follows:

- **Type I**: Provisioning, regulating, cultural and supporting ecosystem services, over which DRPIC has direct management control or significant influence, and where impacts on such services may adversely affect communities.
- **Type II**: Provisioning, regulating, cultural and supporting ecosystem services, over which the DRPIC has direct management control or significant influence, and on which the project directly depends for its operations.
- **N/A:** Ecosystem services outside the sphere of control of the Project.

Each ecosystem service was then prioritised as follows (IFC, 2012b):

- Type 1 ecosystem services will be considered a priority if:
  - Project operations are likely to result in a significant impact on the ecosystem service;
  - The impact will result in a direct adverse impact on affected communities' livelihood, health, safety and/or cultural heritage; and
  - The project has direct management control or significant influence over the service.
- Type II ecosystem services will be considered priority if:
  - The project directly depends on the service for its primary operations; and
  - The project has direct management control or significant influence over the service.

Prioritisation of an ecosystem service is a technique for screening or 'flagging' potential ecosystem services which may be significantly impacted by a project and highlighting where mitigation efforts should best be directed to preserve ecosystem service function.

The prioritisation exercise clearly distinguishes between potential impacts on ecosystem services which are attributable to the Project and those that are likely to be attributable to Associated Facilities (AF). The four Project elements are defined in Table 1.1 of the main biodiversity assessment:

- Duqm Refinery;
- Crude oil storage tanks (at the Ras Markaz Crude Oil Storage Terminal, an AF);
- DRPIC Crude Pipeline; and
- Product Export Terminal.

AFs are listed and defined in Table 1.1 of the main biodiversity assessment.

When assessing potential operational impacts on ecosystem services 'normal Project activities' are assessed. Risks associated with accidental/catastrophic oil spill into the marine environment are not considered in this assessment. However, it is acknowledged that low likelihood/high magnitude oil spill event may significantly disrupt provision of an ecosystem service and this is considered in Section 5.

Table F-1: Ecosystem Service Assessment

Project Element >	Ecosystem Service type	Potential Ecosystem Service Beneficiary	Refinery	Export Terminal	Crude oil storage tanks (at the Ras Markaz Crude Oil Storage Terminal	DRPIC Crude Pipeline	Priority Ecosystem Service relevant to the Project
SUPPORTING SERVICES							
Soil formation	Type 1	Human population, native biodiversity	Localised modification of the soil profile caused by Project construction may reduce future agricultural or alternative land use in the affected area by altering soil nutrient and structural characteristics. This impact on ecosystem service provision will apply only to the Project footprint which represents a small proportion of the overall soil resource in the Duqm region. The arid environment in the Duqm area does not support intensive agricultural land uses – there are no beneficiary groups which will be markedly impacted, especially in light that as a Special Economic Zone any activity is controlled by SEZAD. Project construction is unlikely to significantly affect ecosystem service provision to potential beneficiary groups.				Non-priority.
Nutrient cycling	N/A	Human population, native biodiversity	Soils in arid areas tend to be nutrient poor with low nutrient flux, and no specific soil nutrient cycling systems have been identified at any of the project sites, other than the wetlands at the Duqm Important Bird Ares (IBA). In contrast to local soils, coastal seawater in the project area tends to be well supplied with nutrients with inputs from upwelling at Ras Madrakah and then recycled locally. Nutrient cycling onshore and off are unlikely to be affected by project construction or normal operational activities.				Non-priority.
Primary production	N/A	Human population, native biodiversity	Primary productivity on land is limited by dry conditions and low soil nutrient concentrations. Vegetation across all project sites is sparse, particularly at Ras Markaz. Primary productivity may be affected in the immediate vicinity of the project areas during the construction phase by dust emissions which could smother plants, preventing their growth. In addition , lichen communities potentially presence in the limestone hills of the Jiddat al Hariziz are potentially sensitive to air emissions from Project activities. Marine primary productivity is high in coastal waters but is unlikely to be affected by Project construction or normal operational activities. Marine nutrient cycling could be significantly impacted by accidental oil spill because of its effect on light penetration into ocean surface waters.				Non-priority.
Hydrological cycles	Type 1	Native Biodiversity (birds at the Duqm IBA) Natural habitat – intertidal habitat and wetlands Biodiversity associated with wadi systems.	A diversion channel, Dangert Channel, has been construction in the SEZAD Industrial Area to divert wadi flows around the industrial area to points of discharge to the marine environment, following the original wadi flow pathways. This will change the flood water discharge characteristics to the shoreline (including the formation of temporary brackish ponds after rain and the supply of sediments to the beach). It is possible that these hydrological changes may alter the distribution and abundance of bird foraging habitats. Fluvial engineering of flood water around the entire industrial zone was implemented by SEZAD prior to allocation of land to the Project for Refinery construction. As such this environmental change is not within the control of Project activities. Diversion of wadi flows around the Refinery is not considered an Associated Facility in relation to assessment of ecosystem service effects according to IFC PS6. It is not considered further in this assessment. Diversion of the flows within Wadi Saay around the northern breakwater of the port will alter the flow of flood water into the creeks and mudflats of the Duqm IBA. In addition, creation of coatal flood protection for the Export |Terminal will reduce the exchange of sea water between lagoons in the high-tidal lagoons in the Dum IBA. The primary loss of ecosystem services is the infilling of a portion of the Duqm IBA, with the redirection flows around the northern breakwater and creation of coastal flood defences therefore being secondary (although holding potential for the supply of flood water to a new portion of coast which may eventually develop increased value as bird habitat). The creation of the Export terminal (along with flood protection and hydrological diversion) is under the direct control of SEZAD and the PDA. The Project will adopt a tenancy for the use of the		No significant wadi systems exist within the Ras Markaz storage facility project footprint. No significant alteration of ecosystem service provision is likely.	The crude pipeline intersects numerous wadi systems along its length.	**PRIORITY –** Alteration of the hydrology of the inter-tidal area around the Port of Duqm is outside the scope of Project influence as it is an AF. However, as a key user of the newly created Export terminal (by tenancy to the PDA) DRPIC should seek assurances from SEZAD and the PDA that measures are being adopted to mitigate for the loss of bird habitat in Duqm IBA (strategically or at the local scale). This may include a strategy for replacement of damaged or degraded wetland bird habitats.

Project Element >	Ecosystem Service type	Potential Ecosystem Service Beneficiary	Refinery	Export Terminal	Crude oil storage tanks (at the Ras Markaz Crude Oil Storage Terminal	DRPIC Crude Pipeline	Priority Ecosystem Service relevant to the Project
			shipping berth and export facilities. However, hydrological impacts associated with construction relate to the activities of SEZAD and PDA.				
PROVISIONING SERVICES							
Food production	Type 1	Human population	The Project is unlikely to have any significant effect on food production as no prime agricultural land will be degraded.				Non-priority.
Fresh water	Type 1	Freshwater biodiversity, human population	Numerous small drainage channels and wadi systems bisected the refinery plot. These have now been diverted into the larger wadi system via a major channel which will provide reduced area for grazing after rain. The socio-economic survey did not record extensive use of this area by local communities for grazing. Alternate, post rainfall, grazing resources associated with ephemeral wadis are relatively frequent in the Duqm region.		No significant wadi systems exist within the Ras Markaz storage facility project footprint. No significant alteration of ecosystem service provision is likely.	The crude pipeline will be buried below ground for the majority of its approximate 60 km span. Where the pipeline crosses wadi systems there is scope for significant disruption of local hydrological flows and sedimentation/erosion patterns which could propagate up and down stream. This may affect freshwater biodiversity depending on seasonal flooding wadi systems and local settlements/herders who rely on floodwaters to stimulate seasonal grazing opportunities for their livestock.	**PRIORITY** – the DRPIC crude oil pipeline is likely to be buried below ground for the majority of its length. However, during the construction phase there will be excavations through wadi systems. In certain places the DRPIC crude oil pipeline may need to be supported across a wadi system or elevated above ground surface (depending on the topography). Construction techniques and design measures should be adopted to avoid disruption of hydrological and sedimentaty flows.
Fuelwood production	Type 1	Rural settlements and other residents	The Project only requires localised removal of woody vegetation (particularly in wadi crossings) and then only in the construction phase. There is little scope for Project construction to alter provision of this ecosystem service. The Project will comply with national legislation to protected trees.				Non-priority.
Grazing land	Type 1	Rural settlements and other residents	Refinery construction has removed several square kilometres of informal livestock grazing land. However, this resource remains extensive elsewhere in the Project area. It should be noted that while the SEZAD area has been designated for industrial and urban development, in practice grazing is permitted and occurs on as yet undeveloped land.	Export terminal construction will remove < 1 square kilometre of informal livestock grazing land. However, this resource remains extensive elsewhere in the Project area.	Crude storage facility construction will remove a small area of informal livestock grazing land. However, this resource remains extensive elsewhere in the Project area.	Construction and operation has the potential to act as a barrier for animal movements once constructed, which would reduce access to grazing areas for livestock and wildlife. If buried the pipeline will have little impact. If above ground its barrier effect should be mitigated by regular, effectively designed animal (and vehicle) crossing points.	Non-priority. Unlikely to significantly affect provision of this ecosystem service. A measure of reduced access to grazing areas, and a reduced standing stock may improve quality of grazing overall.
Livestock rearing (camels and goats)	Type 1	Rural settlements and other residents	Social surveys of residents of Al Tayari, Nafun and Duqm/Saay area (WSP, 2017b) reveal informal livestock raising (camel and goat rearing) to be a widespread ecosystem service provided in the area, and it is assumed to be valued by the population of all settlements in the Project Area. The desert environment will remain extensive even after Project construction and thus depletion of grazing/animal rearing resources is unlikely to be an economically significant impact associated with the Project. However, consideration should be given to impacts such as loss of traditional agricultural activity and knowledge (i.e. cultural impact), severance or reduction of access to grazing areas by project infrastructure; and potential road traffic incidents between Project vehicles and livestock. The socio-economic and health assessment concluded that a third of respondents claimed some income from grazing. Although grazing was not cited as a primary source of income, the social surveys found that grazing may provide a key source of income (e.g. selling/buying camels, meat and other products) at certain times of year when other seasonal income sources are scare. Livestock rearing was thus considered an important source of household income. In addition, graziers may suffer an opportunity cost of having to import animal feed where natural grazing is not available.				**PRIORITY** – It is recommended that communal area for grazing is provided for local community use (see recommendations in the socio-economic and health assessment).
Fish production	Type 1 (SEZAD – Associated Facility)	Fishing industry, local settlements	Fish production is unlikely to be impacted by construction or normal project activities, however, there is potential for	Associated Facility (Marine), Project (Topsides) and Non-Project (Port): This Project element is located within the	Associated Facility: Construction and normal operation of this facility is unlikely to affect fish	The majority of this Project element is not in close proximity to the marine environment. No significant effect on fisheries ecosystem	**PRIORITY** – further assessment of fishery impacts linked DIPWP Associated Facility and future dredging

Project Element >	Ecosystem Service type	Potential Ecosystem Service Beneficiary	Refinery	Export Terminal	Crude oil storage tanks (at the Ras Markaz Crude Oil Storage Terminal	DRPIC Crude Pipeline	Priority Ecosystem Service relevant to the Project
			the cooling water system, an Associated Facility, to reduce fish production because of entrainment. The fishing community near the refinery will be displaced. This will have positive and negative consequences: it is hoped that the expat (largely Bengali) community will be re-housed in permanent and better designed facilities which will remove significant waste issues associated with the ad hoc/unplanned compound that exists today and affect the coast and marine environment. However, the new location will be away from the beach and landing site, so will affect operational efficiency to some extent.	port boundaries in which fishing is prohibited. Dredging, disposal of dredged material and marine fill material borrow areas will impact the marine environment, including fish habitats. Similar habitat exists in the vicinity so the impact is unlikely to be significant other than in the immediate footprint of these area extending out to the zone of impact of the sediment plume. No permanent effect on fisheries ecosystem service provision predicted, and recovery after initial disturbance is likely unless further use of disposal and borrow area occurs. However, the port has been used as a sheltered anchorage for the dhow fishing fleet during bad weather. During construction and operation this service will no longer be available except in emergency/extreme scenarios (e.g. cyclone). Until the dedicated fishery harbour is built, in the short-term, the dhow fleet may be at risk during inclement weather.	productivity in the area and the exclusion area around the SPMs will effectively close the area to fishing (i.e. serve as a fisheries reserve). However, the project introduces the risk of oil pollution (small volume, chronic operational spills and large volume acute accidental spills) which have the potential to negatively and significantly impact fish production, as well as affecting the fishery. The facility is located at the southern end of a 6 km long beach, the northern end of which is a major landing site for inshore skiffs. No change is expected for this northern landing site by the Project or Associated Facilities.	service provision predicted.	activities is required to design mitigation measures and compensate any residual impact. Further assessment is likely to fall within the remit of SEZAD or the Port of Duqm Authority (PDA) who control and plan these activities and not the Project. The Project will operate only the topsides of the Export Terminal under a Sub-Usufruct Agreement with Port of Duqm. In addition, DIPWP will be operated as an Associated Facility. However, DRPIC should seek assurance that marine ecosystem issues are being assessed, controlled and appropriately mitigated (if necessary). This may involve encouraging AF operators to carry out appropriate monitoring activities and the need to audit data collected by AF operators as part of Project environmental due diligence.. Control of use of the port by fishermen is under the control of the PDA and is not within the sphere of influence of the Project.
REGULATING SERVICES							
Climate regulation	Type 1	Human population	Project activities will increase the supply chain of fossil fuels to energy markets, and while the end consumer is ultimately responsible for consumption of fossil fuels and the GHG emissions that arise, the Project is responsible for the GHG emissions arising from the construction and operation of the Project facilities across the 30 year design life. The Project will form part of the global production and supply system for the fossil fuels upon which society currently depends, however, the Project recognises, and has estimated, its relative contribution towards global warming and Oman's own designated climate change targets. Direct GHG emissions from the Project are relatively small in global terms but will have a tangible impact on Oman's contributions. Heat island effect arising from project facilities is negligible in the context of development in the SEZAD area.				PRIORITY – Strategic issue subject to national Government management/policy.
Water regulation	N/A						Non-priority.
Water purification	Type 1	Freshwater biodiversity, human population	Infiltration of run off through wadi bed sediments provides a purification service for groundwater. Groundwater in the Duqm area is only used for agricultural applications, with most wells (and associated camel and goat rearing pens) being found in Wadi Saay. An alternative (albeit commercial) resource is produced by desalinating seawater and distributed through the mains water supply network, which provides high quality and secure water for human and, if essential, agricultural use. Water purification service will not be affected during normal operations, but the oil pipeline introduces the risk of spills and potential contamination of groundwater.				**PRIORITY** – Design of the pipeline must minimise the risk of loss of containment, particularly at wadi crossings and areas where pipeline rupture could result in flow of

PROJECT ELEMENT >	ECOSYSTEM SERVICE TYPE	POTENTIAL ECOSYSTEM SERVICE BENEFICIARY	REFINERY	EXPORT TERMINAL	CRUDE OIL STORAGE TANKS (AT THE RAS MARKAZ CRUDE OIL STORAGE TERMINAL	DRPIC CRUDE PIPELINE	PRIORITY ECOSYSTEM SERVICE RELEVANT TO THE PROJECT
							spilt product into drainage channels and wadi network.
CULTURAL SERVICES							
Recreation and ecotourism	Type 1	Tourist industry, local tourist industries (Potential)	Scenic effect on coastal bay/beach scenery in the Duqm area. Industrial backdrop to the Rock Garden heritage feature. Noise affecting location tranquillity. Although little use by tourists is evident at this location. No tourist facilities are present. In addition, significant urban and industrial development is already being progressed by SEZAD in this zone with the Project not the most immediate backdrop.	Scenic effect on coastal bay/beach scenery in the Duqm area in general, and loss of significant area of the Duqm IBA, which has diminished potential as an eco-tourism attractor. Although little use by tourists is evident at this location. No tourist facilities are present.	Scenic effect on coastal bay/beach scenery of the Ras Markaz headland. Although little use by tourists is evident at this location. No tourist facilities are present.	Generally – the pipeline passes through largely uninhabited desert. Low potential for tourist recreation use. The pipeline will be buried and thus the visual impact will only last for the construction phase.	**PRIORITY** – SEZAD allocated the Project to development plots which were sited in proximity to potential tourist and recreational resources. It is evident that macro-Project siting is not something that can be influenced by the Project. Where possible, project green infrastructure should be used to provide screening or to soften the backdrop of hard, above ground infrastructure on heritage and recreation assets (e.g. Al Wusta Wildlife Reserve, coastal scenery, eco-tourism opportunities, recreational fishing etc.). .
Sense of place	Type 1	Rural settlements and other residents	Refinery construction will be out-of-scale with low-lying character of area. Light from the flare stack may be visible at night, particularly at sea. However, the flare is only for use in emergency upset conditions and is not likely to be a marked source of light pollution at night.	Construction confined to existing Port area.	Associated Facility: Construction will radically alter the coastal landscape of the Ras Markaz headland and bay area – although as noted in the landscape and visual assessment the DRPIC tanks themselves are set back approximately 2 km from the sea..	When operational the majority of the crude pipeline will be buried below ground and is unlikely to degrade the tranquillity and 'naturalness' of the desert environment.	**PRIORITY –** Spatial planning is the responsibility of SEZAD and thus much of the landscape and visual impact is outside of the sphere of influence of the Project as it relates to the allocation of development plots to different industrial uses. DRPIC should implement measures to 'soften' the landscape impact of the refinery to mitigate the degradation of the sense- of-place ecosystem service through use of green infrastructure. DRPIC should seek assurances from OTTCO that similar measures are in place for the wider tank storage facility.
Reputation as a pristine fishing area	Type 1	Current and future fisheries	Associated Facility activities introduce the risk of pollution to an area previously remote from industrial activity including the oil industry. Pollution includes both toxic contaminants such as fuel oils and chemicals and non-toxic contaminants such as sediment arising from maintenance dredging activities and potential changes in the thermal properties of the sea linked to cooling water discharge. Introduction of non-native invasive biological contaminants associated with ballast water are also a risk to the pristine fishing environment. .				**PRIORITY** – The general issue of marine pollution is one of wider commercial use of the marine zone and sites outside direct Project influence however the

PROJECT ELEMENT >	ECOSYSTEM SERVICE TYPE	POTENTIAL ECOSYSTEM SERVICE BENEFICIARY	REFINERY	EXPORT TERMINAL	CRUDE OIL STORAGE TANKS (AT THE RAS MARKAZ CRUDE OIL STORAGE TERMINAL	DRPIC CRUDE PIPELINE	PRIORITY ECOSYSTEM SERVICE RELEVANT TO THE PROJECT
			The Project but moreover the Associated Facilities may introduce the risk and perception of contamination in the area which may affect the market value of fisheries products landed in Duqm. This issue will intensify and consolidate significantly in case of any significant pollution event.				Project will ensure that it's discharges meet Project Standards which is the more stringent between Omani and IFC guidelines. The DIPWP will be operated as an Associated Facility and is not directly within Project control. DRPIC should seek assurance that marine ecosystem issues are being assessed, controlled and appropriately mitigated (if necessary). An appropriate response may need to be coordinated by SEZAD and Government agencies responsible for management of the marine environment. Suitable actions may include a marine monitoring scheme to regulate industrial use of the marine zone and development of emergency response plans to address oil spill.

5. RECOMMENDATIONS

The following recommendations arise from the ecosystem service prioritisation exercise and are divided into two categories:

- Project related recommendations – factors that DRPIC has influence or direct control over; and
- Strategic recommendations – factors which the Project may affect in a cumulative way (with AFs and other developments in the DSEZ) but which relate mainly to regional planning and Government policy.

In the first category, DRPIC will seek to mitigation for these issues through implementation of the Project ESMP. In the second category, DRPIC will seek to influence (where possible) and address these issues through consultation and advocacy with SEZAD and potentially through Corporate Social Responsibly (CSR) initiatives.

Further recommendations are provided for how DRPIC might use CSR and environmental initiatives to contribute to safeguarding ecosystem service provision and in relation to DRPICs potential responsibility for addressing accidental oil spill risk and its potential impact on marine ecosystem service provision at Associated Facilities.

PROJECT-RELATED

1. The Community Health and Safety Management Plan in the ESMP contains measures to ensure any barrier effect that may impede movement of livestock during the construction phase of the DRPIC crude import pipeline is minimised.
2. The DRPIC Crude Oil Pipeline is primarily buried below ground for the majority of its length. However, during the construction phase there will be excavations through wadi systems. In certain places the DRPIC crude oil pipeline may need to be supported across a wadi system or elevated above ground surface (depending on the topography). DRPIC should ensure methods adopted by the EPC contractor are designed to avoid disruption of hydrological cycle ecosystem service provision.
3. To mitigate adverse impacts on the livestock rearing ecosystem service, it is recommended that the Project encourages SEZAD to provide a communal area for grazing for local community use (see recommendations in the socio-economic and health assessment).
4. Project green infrastructure should be used to provide screening or to soften the backdrop of hard, above ground infrastructure on heritage and recreation assets (e.g. Al Wusta Wildlife Reserve, coastal scenery, eco-tourism opportunities, recreational fishing etc.).

STRATEGIC

5. Alteration of the hydrology of the intertidal area around the Port of Duqm is outside the scope of Project influence. However, as a key user of the newly created Export terminal (by tenancy to the PDA) DRPIC should seek assurances from SEZAD and the PDA that measures are being adopted to mitigate for the loss of bird habitat in Duqm IBA (strategically or at the local scale). This may include a strategy for replacement of damaged or degraded wetland bird habitats and implementation of a management plan for the un-impacted portion of the Duqm IBA.
6. Further assessment is required of fishery impacts linked to the DIPWP (Associated Facility); future dredging activities which may be undertaken by the PDA; and possible toxic inputs or introductions of invasive species to the marine environment by import and export vessels. Assessment findings should be used to design mitigation measures and compensate any deleterious impacts on fishery ecosystem service provision. Further assessment falls within

the remit of SEZAD and the PDA who control and plan these activities and not the Project. DRPIC should seek assurance that potential marine ecosystem pollution impacts are being assessed, controlled and appropriately mitigated (if necessary). This may involve encouraging AF operators to carry out appropriate impact assessment and monitoring activities and the need to audit data collected by AF operators as part of Project environmental due diligence.

7. DRPIC should seek assurances from OTTCO that appropriate landscaping and/or design measures are in place for the wider tank storage facility to partially mitigate the impact on sense of place ecosystem service provision.

ACCIDENTAL OIL SPILL

8. Accidental oil spill is likely to be the single biggest factor which could degrade ecosystem service provision in the marine environment across a broad range of ecosystem service types. The responsibility to address oil spill risk rests with the strategic regulators of the marine environment including SEZAD and the PDA (and MECA outside of the SEZ). DPRIC should embed auditing of its oil supply chain in its environmental due diligence protocols to ensure appropriate oil spill avoidance and emergency response measures are in place. Along with SEZAD, the PDA and OTTCO, DRPIC should contribute to oil spill emergency response requirements.

OTHER MEASURES

9. DRPIC should explore the potential for CSR activities around developing provision of an artificial reef program to benefit local fisheries.
10. As a CSR activity in coordination with SEZAD, DRPIC may seek to engage with emerging Omani eco-tourism operators working in the Duqm area to develop business skills, facilities and attractions in the vicinity of the project activities under SME initiatives. Attractions in the area which may be developed or enhanced include the Duqm IBA, recreational fishing and marine wildlife watching, Al Wusta Wildlife Reserve, Duqm Rock Garden.

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Appendix E

APPENDICES FOR SECTION 8 – SOCIO-ECONOMICS AND HEALTH

APPENDIX E-1

APPENDIX 8.1: SOCIO-ECONOMIC AND HEALTH BASELINE REPORT

REPORT N^{O} 70029220-05-C-BASE/SOC

SOCIO-ECONOMIC AND HEALTH BASELINE

DUQM REFINERY PROJECT, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

CONFIDENTIAL

JULY 2017

SOCIO-ECONOMIC AND HEALTH BASELINE

DUQM REFINERY PROJECT, OMAN

Duqm Refinery & Petrochemical Industries Company

Confidential

Project no: 70029220
Date: July 2017

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QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2
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1 INTRODUCTION

1.1 BACKGROUND

Duqm Refinery and Petrochemical Industries Company LLC (DRPIC) is developing the Duqm Refinery Project (the “Project”) located within the Special Economic Zone at Duqm (Duqm SEZ). The Project is a joint venture between Oman Oil Company (OOC) and Kuwait Petroleum (Europe) B.V. (KPE) to develop, build, own and operate an export refinery complex, with each shareholder holding 50% interest. A minority of the Project Company may be owned by one or more strategic or financial investors in the future.

The Project comprises the Refinery and Offsite Facilities:

- 230,000 BPD complex refinery and on-site utilities, infrastructure and storage (the “Refinery”);
- Product export terminal (“Export Terminal”) at the Port of Duqm;
- Crude storage facility at the Ras Markaz crude oil terminal (the “DRPIC Ras Markaz Crude Storage Facility”); and
- 28” 80km Crude pipeline from Ras Markaz to the Refinery (“DRPIC Crude Pipeline” and together with the DRPIC Ras Markaz Crude Storage Facility and the Export Terminal, the “Offsite Facilities”).

The Duqm Refinery Project, one of several industrial projects in land allocated within the Duqm Industrial Zone, is a key project in the Special Economic Zone that will serve as the economic springboard for Duqm’s transformation into one of the largest industrial and commercial hubs in the region.

In March 2017, WSP UK Ltd. (WSP) was commissioned by DRPIC to carry out the development of a supplementary package of information comprising environmental, social and health assessment documentation in order to provide a holistic summary of the Project while consolidating the aspects, impacts and mitigation from historical reports and new data. This is to be supplemented with technical reports where required, including this report.

This report presents the methodology and results of an investigation into socio-economic and health aspects to inform a consolidated social baseline around the geographic area of the Project components comprising the proposed Refinery at Duqm, Oman.

1.2 PROJECT DESCRIPTION

A more detailed description of the Duqm Refinery Project – comprising the Refinery itself and its Off-site Facilities (i.e. the “Funded Project”) – provides more context for socio-economic information. The involvement of lenders has also identified the need for the Consolidated ESIA to take into account “Associated Facilities” (AF) – developments being progressed by third parties that will contribute services and/or functions to the Duqm Refinery Project. The components of both the Project and its AFs are described in Table 1.1.

Table 1.1: Duqm Refinery Project and AFs

PROJECT COMPONENT	DESCRIPTION
Duqm Refinery	A 230,000 BDP complex refinery on a plot of 9km^2 area to the north of the main industrial area within the Special Economic Zone at Duqm (Duqm SEZ). This includes: • Site clearance and levelling (completed in late 2016) • Product pipelines and service lines to the Export Terminal • Construction accommodation/workers' camps • Laydown areas.
Off-site Facilities	i. Crude storage facility at the Ras Markaz (RM) Crude Oil Terminal: eight tanks located within, and part of the wider Tank Farm, approx. 80km from the Refinery. The large-scale Tank Farm (Oman Oil Tank Terminal Company, OTTCO) in its entirety is not part of the Project. ii. 'DRPIC Crude Pipeline': 28-inch diameter 80km crude oil import pipeline to transport crude oil from RM to Duqm Refinery. iii. Product 'Export Terminal': on the lee breakwater of Port of Duqm, immediately to the south-east of the Refinery plot. Topside works only, i.e., to establish storage for products and export handling facilities.
Associated Facilities	i. Natural gas spur line/metering station used to supply gas feedstock to DR from the national gas network (Oman Gas Company, OGC) ii. Export pipeline corridor – Construction of the corridor and infrastructure, i.e., pipe supports, bridges, fencing drainage, etc., including pipeline and services themselves under the Refinery. (Under SEZAD/Marafiq responsibility). Note: SEZAD has overall responsibility for the Pipeline Corridor, excluding the DR pipelines and cables, extending from the Refinery Boundary Marker fence-line to the Port fence-line. iii. The marine scope including dredging and reclamation and jetty and quay wall construction of the Duqm Export Terminal. (SEZAD). iv. Haul road or dedicated lane (on Existing Road) for solid product from DR to the Duqm Export Terminal. (SEZAD). v. Duqm Integrated Power and Water Plant (DIPWP) supplying electricity and desalinated water to DR (and in the future other consumers in the DSEZ. (Marafiq, also known as Central Utilities Company, CUC). Note that this now includes items vi and vii below. vi. Seawater supply network (to DIPWP). (Marafiq). vii. Common wastewater outfall for industrial zone users. (SEZAD). viii. Offshore oil import facilities (including offshore single point mooring (SPM) and crude oil pipeline to shore at RM. (OTTCO).

1.3 PREVIOUS BASELINE WORK

Some high level socio-economic details are included in local EIAs prepared earlier for various project components, however certain key local EIAs (i.e. EIA Study for Duqm Refinery, 2015 and EIA Study for Duqm Industrial Free Zone Masterplan, 2011) do not include sufficient socio-economic baseline or heath data. In addition, national social statistics are being regularly updated and as a consequence the earlier high level socio-economic details can be considered outdated. This report supplements the existing high level socio-economic data and provides more granulation on the socio-economic profile of local communities in the project area.

1.4 SCOPE OF REPORT

The Lenders' Independent Environmental and Social Due Diligence review, undertaken by Ramboll Environ in 2016 identified a number of data gaps relating to socio-economic aspects of the Project. The review stated:

> "*The social baseline report does not provide detail on the socio-economic characteristics of the Project affected settlements and therefore does not provide an adequate baseline for the purposes of monitoring of Project impacts. This is of significance in two areas:* ***community health profiling*** *(which is likely to be affected by the Duqm Refinery Project); and understanding levels of* ***livelihood dependencies on ecosystem services*** *(which are likely to be affected by Associated Facilities*)".

This report on the socio-economic baseline in and around Duqm provides a description of the socio-economic profile of the local communities, briefly describes the survey methodology and focuses on the survey results which form the socio-economic and health baseline in the Project area (see Figure 1).

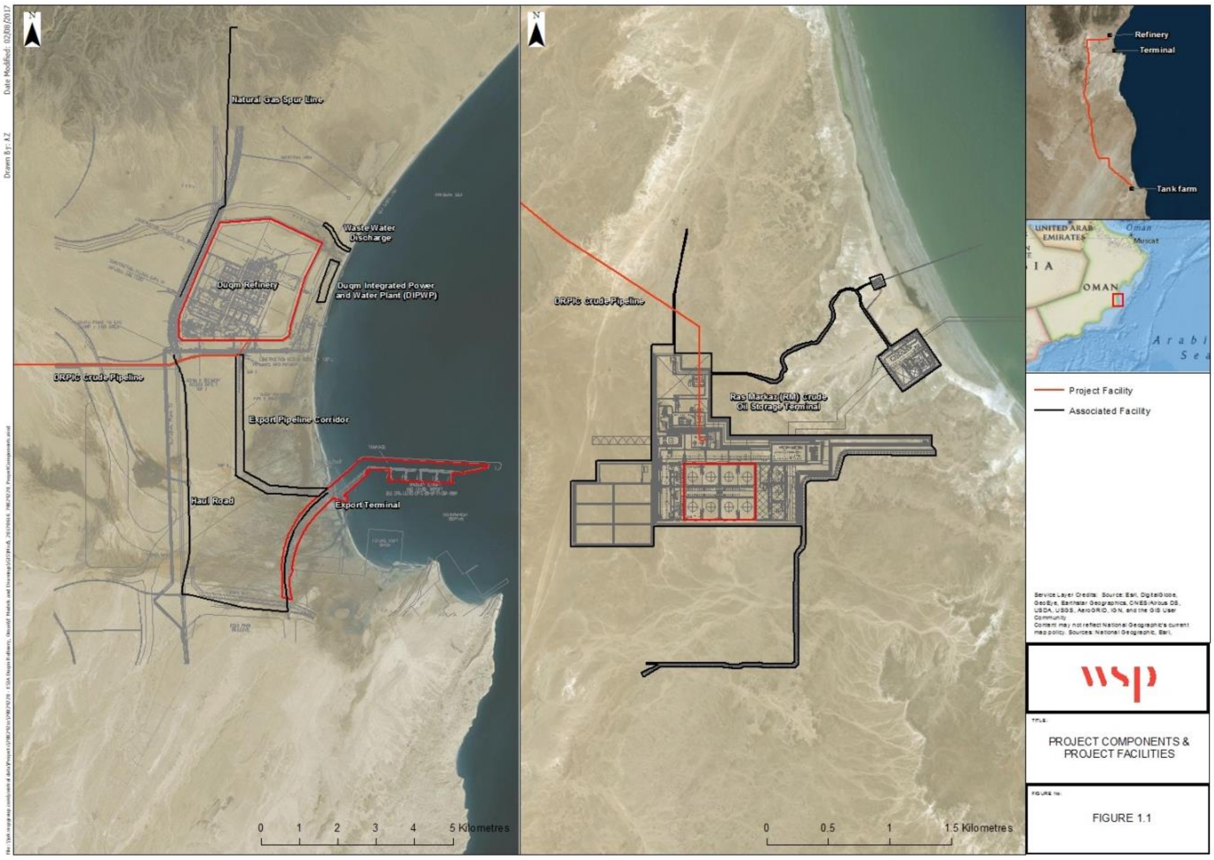

Figure 1.1: Schematic Plan of the funded project components

The limitations of the survey are discussed in Section 2.3 of this Report.

The funded components of the project include the following elements:

- The Refinery (including land clearance, product pipelines and service lines from refinery to Duqm Export Terminal and construction accommodation camps including laydown areas)
- Ras Markaz Crude Oil Storage Terminal (dedicated eight tank area and essential infrastructure only)
- Crude Import Pipeline (Ras Markaz to Duqm Refinery)
- Duqm Export Terminal (topside only, comprising Products Storage & Export Facilities).

2 SURVEY IMPLEMENTATION

2.1 APPROACH AND SCOPE TO SOCIO-ECONOMIC SURVEY (HOUSEHOLD AND FISHERMEN SURVEYS)

The purpose of the socio-economic survey was to facilitate closing gaps and uncertainties in the existing social baseline in order to subsequently provide a robust socio-economic assessment that will meet international standards, guidance and best practices requirements.

The socio-economic surveys were carried out by experienced Omani surveyors, including a female from 5OES in conjunction with the lead social specialist from WSP. The local surveyors took part in a pre-survey briefing workshop in Muscat and Duqm and mobilize for survey work locally in Duqm together.

The surveyors carried out the survey work via face-to-face visits with two approved questionnaires (one for households and another for fishermen - see Appendix A), where both questionnaires included questions on elements of ecosystem services and their use by local residents.

Both questionnaires are based on tried and tested socio-economic questionnaires that have been used previously in Oman but also include modifications suggested by DRPIC and SEZAD to enhance the tailor-made approach for this survey effort. The English language questionnaires were translated into Arabic for delivery in the targeted areas and the outputs translated back into English for analysis.

In planning the socio-economic and health surveys, consideration was given to both Duqm and the wider Duqm area by considering the range of settlements within the wider area. This included reviewing the information on receptors in previous EIA Reports. Following this review, the team carrying out the local surveys targeted the following four key areas:

- Nafun village;
- Al Tayari;
- Representatives of smaller settlements, individual residences in the wider Duqm area); and
- The fishermen group at Antoot.

In being physically present in the area during the survey period, the surveyors were able to gather information and opinions of representatives of smaller settlements from the wider Duqm area, by engaging with, for example, women attending the Women’s Event, local teachers and school assistance, policemen from Royal Omani Police and hotel guests.

The previous EIA work (see References) and ESDD (Ramboll Environ, 2016) confirmed that there are no Indigenous People in Duqm and the wider Duqm area, and thus, these have been scoped out. The situation is the same for traditional nomadic bedu who are not present in the study area. There are seasonal and transient visitors, travelling to Duqm for reasons such as family connections, taking a break from a city or for fishing; these are not traditional bedu.

The local surveyors checked with potential interviewees whether the timing was convenient to answer the questionnaire and if asked to come later, an alternative visit was scheduled. Care was taken to approach fishermen to try to increase the response rate among fishermen, for instance where they might not be fully registered.

For the household survey, and as is typical for similar projects aligning with international standards, the planned coverage is 5-10% of the population in densely populated (often urban) areas and the survey team was aiming for up to 15% coverage. For the fishermen's survey, the surveyors were aiming to collect approximately eight questionnaires in the Antoot area.

Figure 2-11 shows the approximate locations where the survey team conducted the socio-economic surveys. Household surveys were undertaken at Nafun, Al Tayari and in the wider Duqm Area. The survey of fishermen was undertaken in the fishermen's area near the beach at Antoot.

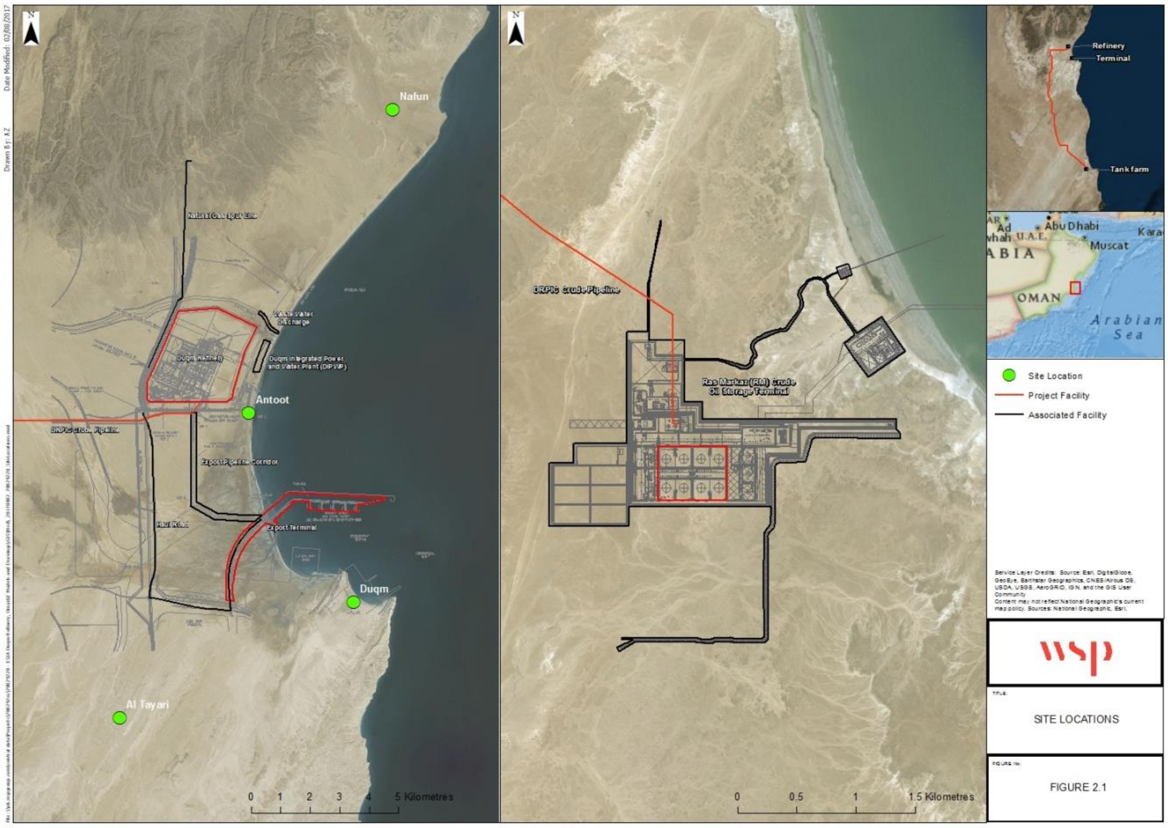

Figure 2-1 Nafun, Antoot and Al Tayari locations in the Project area

The survey included a series of structured interviews with local residents and informal discussions with local families in the Project area to obtain an understanding of their socio-economic settings and assess their needs, values, livelihood strategies, and expectations about the Project.

The household questionnaire used in Al Tayari, Nafun and Duqm was designed to be coded for efficient analysis of the collected data, and included questions on:

- Demographic profile (e.g. age, gender, family structure);
- Occupational profile, employment and income sources and expenditure;
- Education (all levels);
- Asset ownership (including cars, household technology, etc);
- Health data, and
- Project Awareness, concerns and expectations.

The questionnaire for fishermen used in Antoot was designed to collect general information about fishing activities, average earning amounts, equipment used, information on catch and expectations from the project.

2.2 GOVERNMENT-LED RESETTLEMENT IN THE AREA

In Al-Tayari, the resettlement process affects about 100 families and the Government identified all owners and their potentially affected assets through an asset survey and satellite imagery. The survey team learned that by spring 2017 all the affected households have already received their compensation. Over 800 compensation claims by Al Tayari residents were processed for all types of affected assets including improvements on land (e.g. irrigation schemes), various structures/sheds, animal enclosures and trees/plants. In addition, the Government commissioned a new development of modern houses, located approximately 15km from the Duqm airport. The development has been known as '150 Villas' but also referred to as 150 Housing Units.

Each affected family will receive a new replacement house (villa) each containing six bedrooms some with ensuite bathrooms. The 150 Housing Units settlement is nearly complete and soon will start to receive the Al-Tayari and Nafun families.

In Nafun, around 40 families are affected by the process. To identify all affected owners and their assets, and to define the compensation amounts, a new Compensation and Evaluation Committee was formed at the end of 2016. In summer 2017, it will proceed with the collection of satellite imagery in the Nafun area. The Committee will include the Wali office, Minister of Regional Municipality and Water Resources, MoH, Oman Royal Police and SEZAD. In addition to compensation, each affected Nafun family will also be offered a replacement house in the 150 Housing Units area. The authorities hope that the resettlement process in the Al Tayari and Nafun areas will be finished by the end of 2017.

More details on the resettlement process can be found in the Resettlement Statement (DRPIC Report Ref 10-CL-Tech/Res).

2.3 IMPLEMENTATION OF THE SURVEYS AND INTERVIEWS

Since the start of the resettlement process, households in the Al Tayari and Nafun areas have already been surveyed a number of times by SEZAD and other Government Ministries involved in the process. Additionally, all the previous ESIAs that have been undertaken in the Duqm area also could have contributed to survey fatigue.

As a result, a comparatively high percentage of households declined to participate in the surveys (approximately 42% of households approached) for the Consolidated ESIA. General survey-fatigue among the surveyed households was a consequence of these circumstances.

85 individuals were approached by surveyors and 36 of them declined to take part in the surveys. Overall, 49 completed household questionnaires were obtained by the team which resulted in a response rate of 58%. As a separate task, eight fishermen were approached through fishermen survey but only five fishermen agreed to be interviewed.

As a result, the achieved sample represents 8% of the targeted households which, as mentioned, is believed to be due to survey fatigue, over the long-term, amongst the surveyed households.

The “raw” data obtained during the household survey and fishermen survey, were first checked for quality and then uploaded into an Excel spreadsheet which was later analysed.

The targeted communities in Al Tayari and Nafun were interviewed during working hours and also in the evenings, to ensure that various groups of respondents are available for the survey.

Schools and governmental offices, as well as mosques were all visited in Duqm during the survey. To ensure wider gender participation and to capture the views of both men and women, the survey team also visited a number of households separately in Al Tayari and Nafun. A local women’s group was also visited in Duqm to ensure participation of women from all educational backgrounds. Literacy levels did not present an issue during the survey, as all questions were explained during the survey interviews and surveyors wrote down the respondents’ answers.

To address some respondents’ sensitivity about answering personal questions (e.g. on income sources, salaries, land ownership), a short introduction about the purpose of the survey was given to all groups at the beginning of the interview. The survey team included both men and women to ensure a gender-balanced approach to the survey.

During the survey of fishermen, the surveyors visited the Antoot area early in the morning and also later in the evening to ensure that fishermen were available for interviews before leaving for the sea, and also upon their return.

3 GENERAL POPULATION PROFILE

3.1 DEMOGRAPHICS AND GENDER DATA

Oman’s total population has been recorded as 3,992,893, where 57% of the population are Omanis and 43% represent overseas workers (NCSI Oman, 2015). The national gender statistics show that the total population is distributed as 35% women and 65% men. The higher proportion of men in Oman is explained by the sizeable population of foreign workers who often tend to be men within the 20-40 years age bracket.

The Al Wusta Governorate is spread over 79,700 km^2 and consists of four Wilayats: Hayma, Muhut, Ad Duqm and Al Jazir, with the total population in the Governorate of 40,936 people (or 1% of the total population) and a population density of only 0.5 ppl/km^2.

The total population in the Al Wusta Governorate is split: 54% Omanis and 46% foreign workers or expats. This illustrates a slightly higher presence of foreign workers in the Governorate compared with the average national level NCSI, 2015). The population of the Ad Duqm area shows the same trend, where the total population of 8,559 people (or 0.2% of the total population) is split: 52% Omani and 48% foreign citizens.

At the national level, in 2015 over 28% of the total population in Oman was represented by the youth demographic and children who, under the national statistics, fall into the 1-19 years’ old age range. Importantly, over 57% of the total population are 20-44 year olds, where there are two foreign workers/expats for every Omani in the same age category. In Oman, only 2.4% of the total population falls within the above 65 years of age category.

Comparatively, in Al Wusta, 24% of the Governorate population are 1-19 year olds (lower than the national average), over 63% are 20-44 year olds (higher than the national average), over 10% of the Governorate population are 45-64 year olds and 3.3% of people are over 65 (higher than the national average).

At the national level, out of a total number of individuals claiming welfare benefits in Oman, 39% claim on the basis of mental disability (dementia and other related diseases), 31.2% of social welfare payments in the country are claimed on the basis of other types of disabilities and 15% of the social welfare payments are claimed by divorcees (mainly women).

In contrast, the top three social welfare payment claims in the Al Wusta Governorate are: 40.5% for mental disability (this much higher rate can be explained by Al Wusta's slightly longer than average national life expectancy), 27% for other types of disabilities (lower than national) and 21% for divorced (much higher than the average national rate).

3.2 EDUCATION

Based on World Bank Data from 2015, the basic literacy level in Oman is recorded as close to 89%, an increase from the 2010 level of 87%. The National Census data from 2010 shows that approximately 79% of the total population finished school and approximately 10% of the total population holds a Bachelor degree or higher.

At the national level, the educational status varies according to the place of residence. Based on the national data (NCSI, 2016), around 30.5% of the households residing in rural areas has at least one family member who is illiterate, while the same is true only for 13.6% households in urban areas.

No government-collected data could be found on the literacy levels in Al Wusta.

Desktop research on literacy levels in the region showed that although Al-Wusta has 23 basic education schools in the region (NCSI, 2015), the level of literacy is generally quite poor, when compared to the national figures. This situation was reflected in the research results carried out in 2013 in the region and published in the Asian Fisheries Society publication, "Gender in Aquaculture and Fisheries: Navigating Change", 2014. The results of the survey which covered only women in Al Wusta, showed that with 40% of local women engaged in providing services for the fishing sector, are illiterate and a further 40% only attained preparatory, or lower level schooling. As a rule, literacy rates in coastal areas in developing nations are commonly considered to be low (Akpaniteaku et al., 2005; FAO, 2006; and Maddox, 2007).

3.3 UNEMPLOYMENT

Data from 2015 provided by the National Centre of Statistic Information of Oman showed that unemployment at national levels stood at 11.75%, a decrease from a rate of 14.4% in 2003. The ratio of Omani workers varies within the public and the private sectors. Omanis constitute 85% of the workforce in the public sector, but only 11% in the private sector.

Unemployment among nationals is an issue of concern to the Government. Unemployment especially affects young males entering the labour market who have secondary level education or less according to a study by the Gulf Investment Corporation (2014). The youth (19-25) national unemployment rate was 23% in 2013. Population growth, increase in female participation rates and contraction of the traditional sectors are factors contributing to changes in the unemployment for male nationals.

It must be noted that the National Centre for Statistics and Information (NCSI) does not regularly collect the data on unemployment in the country and as a result it is rather challenging to find reliable and recent national statistics on unemployment in Oman.

Instead, the NCSI regularly collects information on job seekers who are defined mainly as graduates or those who graduated recently and are in the process of seeking their first job.

According to the data released by NCSI, the governorate–wise number of job-seekers was as follows by the end of 2016 (Time of Oman, 2017): North Al Batinah (9,544), Muscat (5,359), South

Al Batinah (5,132), Al Dakhiliyah (5,025), Dhofar (4,521), Al Dhahirah (3,750), North Al Sharqiyah (2,994), Al Buraimi (1,684), Musandam (794) and Al Wusta (346).

3.4 ASSET OWNERSHIP

Based on the data obtained from the Final Findings of the Household Expenditure and Income Survey (2012), households in Al Wusta have the highest house ownership comparing with the rest of the country.

National data indicated that 97.3% of households in the Sultanate have mobile phones and 96.5% have televisions. A majority of households (more than 80%) own at least one computer (e.g. desktop, laptop or tablet), with no noticeable difference between urban and rural areas.

The Internet is mainly accessed through mobile phones (48%), followed by fixed wireless broadband (35%) and narrow band analogue modem (17%).

Based on national 2015 statistics, around 60% of households do not have Internet connections, out of which 42% do not have Internet access due to lack of coverage, 32% due to high price of services, 25% due to lack of knowledge and skills, and lack of need and high cost of the equipment.

Fixed telephone lines were present in 73.5% of homes across Oman at the end of 2016. At the national level, home ownership among Omani households stood at 82.2%.

3.5 INCOME

Based on 2012 national statistics (NCSI, 2013), the average monthly salary of employed individuals in the Sultanate of Oman was reported to be the following (in 2012 values):

- For an Omani citizen with primary/preparatory level of education – average monthly salary of Omani Riyals (OMR) 466;
- With College/Diploma level of education – average monthly salary of OMR 787; and
- Bachelor and above, average monthly salary of around OMR 1,050.

The same report states that in 2012, 40% of Omani households had a monthly income of OMR 1,100 or more compared to only 16.3% of expatriate households

The highest household monthly income was registered in the Muscat Governorate, while the Al Wusta Governorate had the lowest average household income in the country (2012), OMR 856, with an average expenditure level of OMR 513 in rural areas.

Adjusting these figures for compound inflation in the country (2012-2017), the average household income in Al Wusta estimated by the National Statistics Centre stands at approximately OMR 1,005/month with an average expenditure level of OMR 602/month.

Based on the obtained data, around 30% of the expenditure at the national level is typically spent on food, 16% on housing/rent (this percentage is lower in Al Wusta due to higher house ownership), and around 13% on transportation.

3.6 HEALTH

Based on Oman's country profile with the World Health Organisation (WHO, 2014), non-communicable diseases (NCDs) cause 68% of total deaths in the country and 18% of these deaths occur amongst people between the ages of 30 and 70 years' old. This means that nearly one of every five Omani adults dies from NCDs.

In April 2016 the United Nations Interagency Task Force on the Prevention and Control of Non-communicable Diseases (NCDs) carried out a joint mission to Oman to support the Government of Oman in their efforts to tackle NCDs. The Joint Mission learned that despite recent progress in addressing NCDs and their risk factors, the large majority of Omani adults have insufficient intake of fruits and vegetables, that 40% are physically inactive and one in seven Omani men use tobacco. More than 40% of adult Omanis have hypertension and 12% have been diagnosed with diabetes.

The 2014 national NCD data published by WHO is presented below.

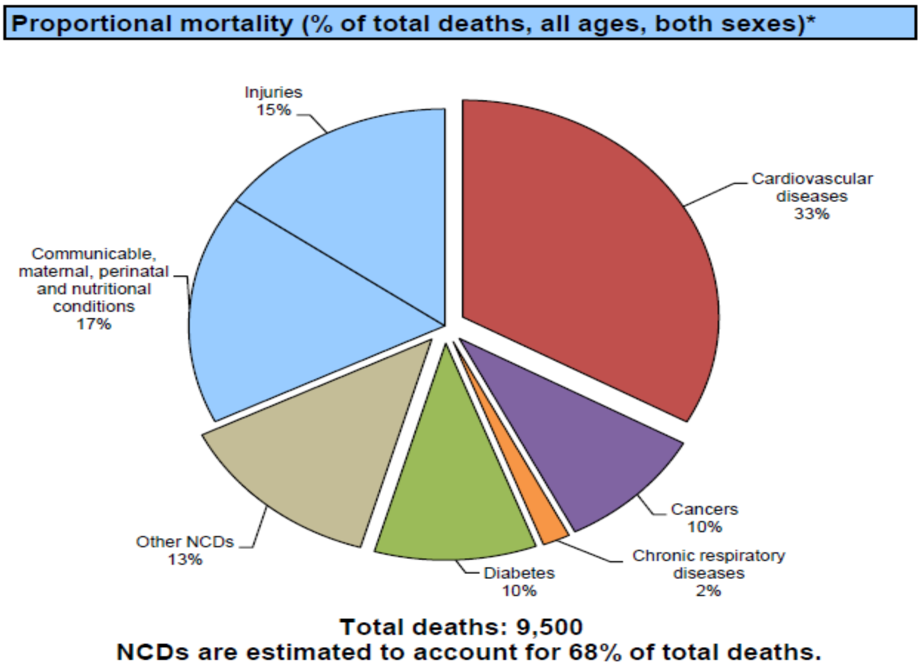

Figure 3.1: National mortality rates from Non-communicable diseases (WHO, 2014)

Based on the national health research results published by the Sultan Qaboos University (2014) regarding the amount of exercise and physical activity in the country, two particular diseases – Type II diabetes and cardiovascular disease were noted as presenting major public health challenges. The health assessment results demonstrate that among adults, 33% of men and 41% of women do not regularly engage in physical exercise. The lack of physical activities is even higher among young people of college age: 43% of young men and 57.8% of young women in the Sultanate of Oman do not exercise.

The national statistics data shows that there are currently three hospitals in Al Wusta which accommodate 68 beds for patients, while there is only one hospital in Duqm with eight beds. Based on the number of deaths recorded in the national hospitals (i.e. those that do not operate privately), there was only one recorded death in the Al-Wusta region in 2014, which resulted from a disease of the circulatory system. There are four private pharmacies but no dental clinics in Al Wusta.

Based on the latest UNICEF Report on the health data of children and women in Oman (May 2017), Oman has seen a gradual decline in diarrhoeal diseases. The downward trends in diarrhoeal diseases indicate a better and cleaner environment for young children. The change also reflects better knowledge amongst caregivers and health service workers, all of which may be attributed to the overall socio-economic progress of the country. All these improvements have contributed to the decline in infant and under-five mortality rates. Nonetheless, the diarrhoea incidence rates in 2012-2014 were still relatively high (254 per thousand children under the age of five years). The diarrhoea rates are much higher in North Ash Sharqiyah, Al Wusta, Musandam and South Ash Sharqiyah (350-450 cases per thousand children under the age of five).

Based on the same UNICEF report, Oman aims to have 90% of its population connected to the water network by 2035. Oman has been experiencing in the last few years a rapid and continuous growth of water demand: an average of 15 % increase per year, as a result of its robust growth. For household use, the piped network currently reaches 57 % of occupied housing units (dwelling places or dwellings). If access to public water points is also counted, then 77 % of dwellings are served by pipes in homes or by public water points. The coverage by the piped network is lower than the national average in Al Wusta, Ash Sharqiyah, Adh Dhahirah, Ad Dakhliyah and Al Batinah; however, Al Wusta has a high proportion of households served by public water points.

The Oman governorates most affected by obesity and overweight are also those most affected by stunting. For example, Al Wusta and Musandam have much higher proportions of overweight and obese children than the other governorates: 8 and 9 % respectively, compared to below 2 % for South Ash Sharqiyah, Dakhliyah, Adh Dhahirahb and South Batinah. Thus, Musandam and Al Wusta are the top two provinces in overweight and obesity amongst children as well as being amongst the three governorates with highest levels of stunting.

Oman has higher rates of obesity than many OECD countries. 30 % of Omanis above age 18 are overweight and 24 % are obese, whilst amongst adults above 40 years, over one-third is overweight and another third (34 %) is obese. This is higher than the OECD average, where obese adults (not just overweight) constitute 23 % of the adult population. These obesity rates are documented in the Annual Health Reports of the Ministry of Health as well as in the World Health Survey (2012).

Based on the 2014 data published by the Communicable Disease Surveillance and Control Department (MoH), the Al Wusta Governorate had the second highest rate of viral hepatitis A cases among the local population (104 cases in 2014), with the highest number of cases registered in Muhut and Duqm (CDSC Oman, 2012). On the positive side, the Al Wusta Governorate had the second lowest national level of protein energy malnutrition and anaemia among children under five years of age.

The Governorate also has the second lowest national rate of divorces and crimes (Statistical Year Book, 2015).

4 HOUSEHOLD SURVEY RESULTS AND ANALYSIS

4.1 GENERAL

Despite Duqm's distance from other strongholds of national economy, the region has seen significant recent growth; the population of the Al Wusta region increased from 25,499 in 2006 to 40,936 in 2014 (National Statistics, 2015), an increase of 60.5% compared to the population increase of Oman which was 54.9%.

In addition, the development of the Duqm Port required moving fishermen from port area to the beach area known as Antoot. From there, they are to be moved to the New Fishing Harbour south of Port Duqm. This will affect fishermen who regularly fish and store their boats and equipment on the beach close to Antoot. Based on the site observations in March 2017, it is estimated that around 20 individual fishermen (but not households) will be affected by the move to the Fishing Harbour.

Al Tayari, Nafun and Antoot settlements are located within the area being considered for study, and all three settlements as well the wider Duqm area were surveyed in April 2017 to obtain the necessary socio-economic baseline data.

4.1.1 SEZAD

The Special Economic Zone Authority at Duqm (SEZAD) was established in 2011 by the Royal Decree 119/2011 and as a financially and administratively independent entity, is responsible for development activities in Duqm. It has, for the purpose of achieving its objectives, the right to own various assets, the right to manage and dispose of such assets, to carry out business and to undertake all necessary acts to achieve its objectives, and to commence necessary activities to achieve such objectives.

As a result, SEZAD has legal powers and rights to initiate the land acquisition and expropriation process in the special economic area. It is currently implementing the resettlement process on Al Tayari and Nafun (also known as Nufoon) on behalf of the Government.

4.1.2 ADMINISTRATIVE SETTING

Al Wusta is one of the governorates of Oman, with Haima being its capital

The main wilayats (or Provinces) of the Governorate include:

- Haima – the centre of the Al Wusta Governorate and a commercial centre. It is located on the highway connecting Muscat with Salalah.
- Al Duqm (also known as Wadi Say) – the Second regional centre of the Governorate and is the coastal centre of the Governorate.
- Mahut – the second most populous wilayat in the Governorate; and
- Al Jazur – the smallest of the four wilayats in the Governorate.

Figure 4.1: Location of four wilayats in the Al Wusta region

The Al Wusta communities are slowly adjusting to the changes in the region as a result of the on-going development of SEZAD and the corresponding changes from a traditional to faster-paced contemporary way of life associated with industrial and infrastructure development.

4.2 DEMOGRAPHIC PROFILE OF RESPONDENTS

Both women and men were encouraged to participate in the household survey which resulted in 69.4% of men and 22.4 % of women answering the questionnaire, whilst 8.2% of respondents chose not to disclose their gender.

Of the respondents, over 41% were living in the Duqm area, just over 32% in Nafun to the north and 26% in Al Tayari to the south.

Of the respondents, 43% were 21-35 years of age, 20% were 36-45 year olds, 20.2% were 46-55 year olds and 10.2% were 56-75. Under 7% chose not to disclose their age. Around three quarters of all respondents were noted as being in their mid-20s to mid-50s (see Figure 3 below).
6% of respondents reported that a woman or widow was the head of the household.

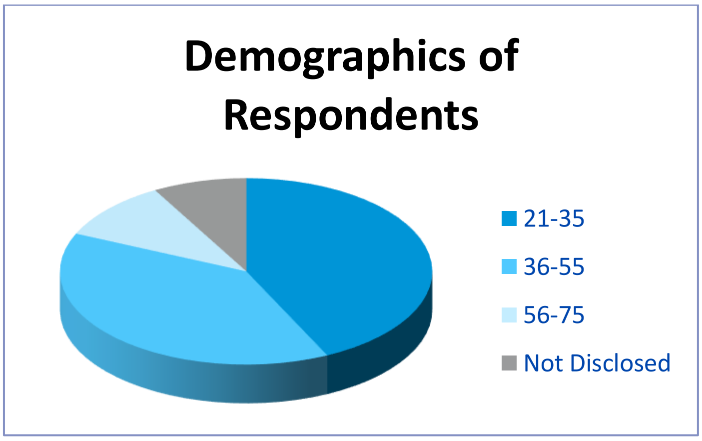

Figure 4.2: Demographic profile of respondents (years of age)

4.3 EDUCATION

The educational profile of the respondents revealed that 18.4% had not finished their basic schooling or had no education which is higher than the national average of 11%. Further survey results showed that 32.7% reported to have up to high school level education and 20.4% as having a diploma as their highest education level; there were no respondents reporting having a Bachelor's degree, which contrast to the 10% of the national population reported to have such a qualification.

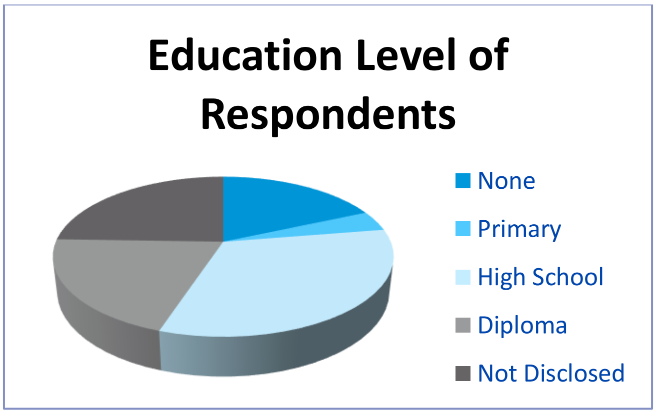

Figure 4.3: Reported educational level among respondents

The majority of respondents within the 56-75 age group reported having had no form of education (80%). However, those in the 21-35 year age bracket had either a high school education (52.4%) or diploma (19%), with nearly a quarter of 21-35 year old respondents choosing not to provide a response (23.8%). Such relatively high number of young people declining to reveal their education attainment is relatively unusual and created a feeling among the survey team that the real level of illiteracy or low levels of educational attainment could be even higher than the one reported by respondents.

4.4 EMPLOYMENT

Of those surveyed, 53.1% declared their employment status and of these 11.5% were unemployed; a rate which reflects the national level of unemployment. Of those who were currently employed, the average salary was 1,061.30 OMR with the highest salary being 6,000 OMR and the lowest being 250 OMR/month.

In addition to formal employment/occupation, the interviewees reported the following top five methods to supplement their income:

- Camels and goats (selling and racing of);
- Renting property;
- Fishing related activities;
- Social security benefits, and
- Financial help from family.

4.5 ASSET OWNERSHIP

The recent increase in population and the push for economic development in the Region may have increased the opportunities for investment in residential developments and commercial properties, as opposed to buying agricultural land. All of the surveyed respondents are currently living in the houses that belong to them (owner-occupiers), whilst 50% owned camels and 89% owned goats, which demonstrates how important animal husbandry is for supplementary income in the survey area.

Over 76% of respondents have no access to the internet in their homes and over 91% of respondents confirmed that they have no landline telephone in their homes. This is a comparatively higher rate of homes not connected to a fixed landline in contrast to the national average rate. However, over 95% of respondents confirmed that they owned a mobile phone, whilst 93.5% had a television and almost 64% had a satellite dish which allows them to watch a much wider number of channels, both national ones and also those from the Gulf Cooperation Council (GCC) countries.

Car ownership amongst the surveyed households stood at 87%, which is slightly lower than the national car ownership level amongst Omani households (89.6%) but nearly twice the registered car ownership among expat households in Oman (44.1%).

The survey asked respondents to list any areas of cultural heritage within the area. Exactly half the respondents stated that there were areas of cultural significance located nearby, whilst half stated that there were not. Areas of cultural heritage reported included the well-known Rock Garden and old houses built of clay; the distance of these areas from the surveyed households ranged from 3km to 20km. Respondents were also asked the distance to the nearest cemetery from their home, this ranged from 1km to 13km, with an average of 3.1km.

4.6 HOUSEHOLD INCOME AND EXPENDITURES

In this section of the survey only 34 people chose to respond to questions relating to their household income and expenses (69% response rate); this is typically a difficult question which people often find challenging to discuss and therefore may choose to opt out of answering.

Of the respondents who agreed to provide details of their income, 23.5% declared that their salaries is the only type of regular income, over 44% of respondents reported to supplement their regular salaries with alternative income-generating activities, whilst 32.4% regularly receive their income solely from ‘alternative’ activities. It is highly unlikely that nearly a third of respondents who agreed to discuss their income with the survey team, actively chose to forgo employment as their main source of income. Instead, the general feeling among the survey team was that this group of people might find it difficult to find permanent employment due to a lack of education/skills or job opportunities in the area.

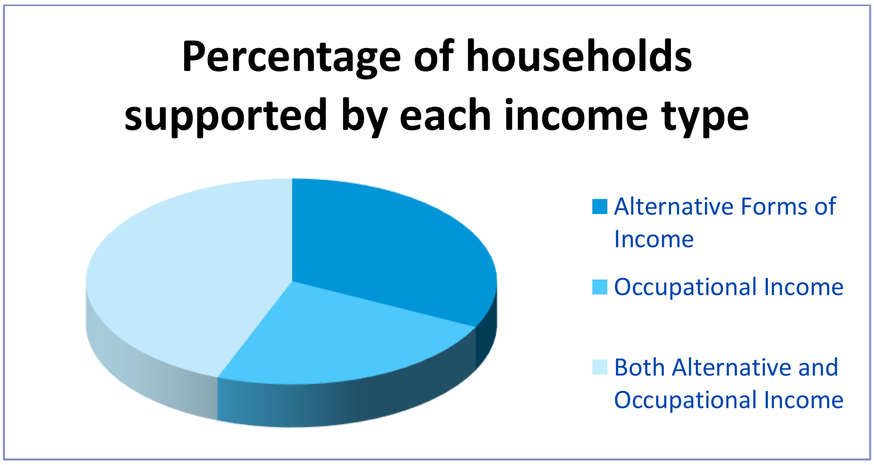

Figure 4.4: Details on income types

The following alternative forms of income (separate from occupational/salaried employment) were reported by the respondents who regularly source their income from one or more of these activities, as detailed in Table 4.1 below.

Table 4.1: Details on Alternative Sources of Income

Alternative Source of Income	Households receiving income from these activities
Agriculture/Collecting Medicinal Plants/Herbs	0
Camels & Goats	29.4%
Renting assets/property	38.2%
Fishing	8.8%
Social Security Benefits[1]	32.4%
Financial support from family	2.9%
Inheritance/scholarships	5.9%

NB: please note that some households derive income from more than one "alternative" activity

From the obtained information, the top three most popular income supplementing activities (or in cases, alternative ways to earn a living) in the study area are: (a) renting assets/property, (b) social security benefits and (c) selling racing camels and raising goats. With only over 10% of respondents being in the 56-75 age group eligible to receive state pension, and one of the lowest birth rate in the country[2], this data could indicate that a third of respondents who receive social benefits would fall under the definition of "vulnerable" group", which typically include widows/widowers, elderly, disabled, orphans, etc.

For those who agreed to discuss their income with the surveyors, the average revealed household income obtained from all types of income-generating activities totalled 1,967 OMR/month, which is much higher than the average estimated 1,005 OMR/month income in Al Wusta as per the official National Household Income data.

This higher than average (total) household income among the interviewees does not seem to match the lower than average national education level among the same group of people. The WSP team has the following explanations for this disparity. Based on the information received from the respondents during the survey (and verified by the number of observed animal enclosures located close to the surveyed properties), the team learned that raising camels and renting property is a lucrative business among local communities, where for example, a well raised and groomed camel can be sold for a very high price. In this situation, the proceeds of the sale can often provide ten to 12 months' income for an average local household. This type of business activity does not require any educational attainment and yet can provide significant and relatively regular annual income.

Approximately 80% of respondents were willing to answer questions relating to their expenditure. Of these respondents approximately 72% confirmed that food was the item they primarily spent most of their money on, which was expected to be the most popular answer. The respondents were asked to state how much they spend on their main expenditure; the average amount across the respondents was just over 644 OMR.
The next most important expenditures for the respondents appeared to be 'other', an answer given by over 23% of respondents, 'services' which was given by 5% of respondents and 'health' which was noted by just one respondent.

[1] Social welfare system in Oman provides benefits to orphans, the disabled, widows/widowers, divorced women, unmarried girls, the elderly/pensioners and prisoner's families.
[2] Al Wusta Governorate: 1.8% of total births in the country for the last 12 months, Times of Oman, 2016

4.7 HEALTH SITUATION

It was reported that just over 20% of the households support a family member who had a disability or illness, whilst over 60% reported having no illness or disability and 16% chose not to answer. The respondents listed the following top three diseases to have affected members of their household in the past three years: diabetes, hepatitis and asthma.

The survey asked questions regarding recent deaths in families and their causes. Over 64% of the respondents stated that there had been no deaths in the past year whilst almost 35% reported that there had been one death in the household; these were reported to be mainly due to illness and old age.

4.8 PROJECT EXPECTATIONS

All respondents were aware about the Project, of which most of them have primarily learnt about through newspaper articles, but around a third had learned about the Refinery through friends and family (or their connection with the Omani Woman Association supported by DRPIC's Corporate Social Responsibility (CSR) activities), as well as colleagues or classmates and the television.

Around 80% of the respondents had a positive attitude towards the Project and just over 14% had a neutral opinion of it. The positive opinions were largely reported to be due to expectations related to an increase in the number of available jobs for young Omanis as well as the Project to contribute to the development of a kindergarten or a school, or a new hospital in the Duqm area.

Only 6% of respondents reported expecting some negative impacts from the Project; these included worries about air quality, concerns over traffic accidents and an increase in the number of foreign manual labourers to the area. It is interesting to note that none of the respondents expressed concerns related to fishing-related or other income-generating activities potentially being interrupted by the Project.

5 FISHERMEN SURVEY RESULTS AND ANALYSIS

5.1 GENERAL

In addition to the household survey in Nafun, Al Tayari and Duqm, five fishermen from the area were surveyed regarding their use and ownership of boats, the cost of fishing activities, information relating to catches and their opinion of the impact that the Project may have on their trade. The fishermen interviewed were from the following local settlements: Antoot, Antoot-Saai, and Al Shuayr.

The fisheries sector still accounts for only a small share of GDP. Government revenues from the fishery sector are minimal and reported to be US$2.4 million per annum. In contrast, current government expenditures on fisheries for infrastructure, monitoring and other services are estimated to be on the order of 50% of gross ex-vessel revenues (World Bank Group, 2015).

The volume of fish exports has also been steadily increasing over the past ten years—ranging from 62 million (M) tonnes (t) in 2002 to 132Mt in 2014. In 2011, half of exports were to the United Arab Emirates, where there is strong demand for seafood. The current growth of fish exports is mainly from artisanal fishing, a sub-sector that has remained important, post-development of the Port/Dry Dock.

Based on the World Bank assessment, despite a plethora of new ports, fishermen still prefer to land their catch on beaches in proximity to where they live and make their own arrangements for the sale of fish which limits opportunity for quality improvement and value addition and often results in over-fishing. Based on discussions with stakeholders and fishermen in 2014, the World Bank specialists concluded that fishermen in Oman tend to perceive the new fishing facilities tend to be more suitable for commercial boats, and often lack a cluster of services that would attract the artisanal sector.

The same stakeholder consultations session for the World Bank study revealed that the pool of Omanis living in coastal areas and who traditionally provided the core of the small-scale inshore fishing sector, has shrunk dramatically in recent years, and this decline is expected to continue.

Although detailed employment data is lacking, one clear fact is that fewer young Omanis wish to enter the traditional skiff sector as full-time fishermen. This is not surprising when remuneration for boat crew can be as low as 200 to 300 OMR per month (based on the WB 2015 data). While some may be prepared to engage in part-time fishing, perhaps supporting family traditions, many Omanis living in the coastal area are pursuing alternative employment opportunities and have aspirations for a lifestyle with greater economic reward.

5.2 FISHERMEN SURVEY AND APPROACH

Of surveyed fishermen, three boats were owned, with one fisherman owning a dhow (a traditional Arabic sailing vessel) in addition to his boats and one managing several other boats as well as owning his own. Most of the surveyed fishermen reported sharing ownership of their boats with other fishermen while just over a third stated that they or their family owned the boats. In terms of funding their boat purchases most of them took out a loan, one fisherman used family savings and another one used personal savings. All interviewed fishermen send their boats into the sea with predominantly expatriate labour.

All the boats owned were reported to be made of fibreglass and the fishermen all reported using fishing nets, with some also using long lines and hand lines in addition to the nets. Each of the respondents stated that they tend to fish or go onto the sea every day, with a few noting that this would always be subject to weather conditions.

The costs to run the boats varied significantly between fishermen with fuel costs per boat, ranging from 25 OMR to 100 OMR/day. The cost of ice used to preserve the fish once caught was reported to range from 13 to 400 OMR, with an average of 143 OMR. The fishermen were asked several questions regarding the maintenance of the boats which showed that the cost of spare parts and repairs could reach up to 500 OMR, the cost of ropes and nets ranges from 50 OMR/month to 500 OMR/season whilst additional costs can include expat visas for workers/seasonal fishermen hired to help during high fishing season (140 OMR each) or may be paid for by the boat owner instead. All of the respondents confirmed that they are not a member of a local Fishermen Association or Cooperative. The fishing season for lobster for example lasts two months (March and April), and also two months for shrimp fishing (September and October).

The second section of the survey questioned fishermen on their catches. When asked how far they travelled to fish, 100% of the respondents confirmed that this very much depended on the weather and the sea conditions. Those who fish in boats noted that they would generally go out to sea between 05.00 and 08.00 hours and return between 17.00 and 18.00 hours; the respondent who also reported using a dhow, stated that when using this vessel he would take it out at 17.00 hours and return the next morning around 08.00.

The fishermen were asked which species of fish they catch; the most common include: Spotted grunt, Sardines, Hilsa, Lobster, Shrimps, Mackerel, Catfish and Cuttlefish. All of the fishermen reported sardines as being one of their most frequent catches with the weight of sardine catches ranging from 2,000kg to 10,000kg /month with a reported value of 5 OMR/kg. The average catch weighs 3,083kg and catches ranged from 20kg to 20,000kg depending on the catch and species.

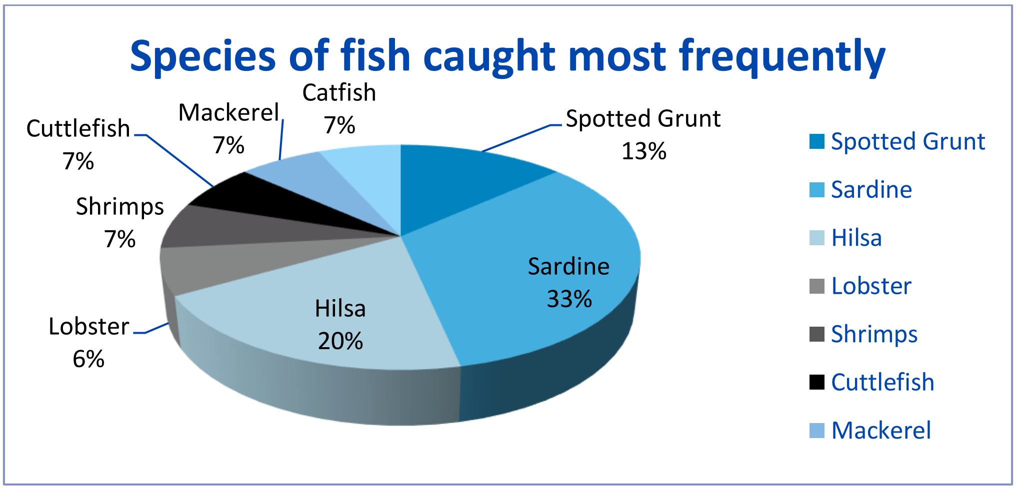

Figure 4.5: Main catch of fishermen by species details

All of the fishermen confirmed that their catches are not consumed solely by their families, but instead they also provide a form of income. The amount of gross income from fishing activities alone ranged from 200 to 700 OMR per month, with an average gross monthly income among interviewed fishermen of 380 OMR/month. The survey showed that most of the surveyed fishermen had no other means of income in addition to fishing, whilst two of them also earn a salary as well as their fishing income. All of the fishermen reported that they have an agreement with a local fish trader registered in Duqm.

The fishermen were asked their opinion about the state of fishing resources over the past five years. They unanimously agreed that the productivity of fish in the area had decreased and that the amount they were catching per trip had also decreased. In terms of fish resource diversity the opinions were split, with the majority believing they had decreased and two of them stating that they were stable. Similarly, based on their observations of general pollution in the sea, most were of the opinion that pollution of the sea had increased.

The final section of the fishermen survey asked about attitudes to the Project. All of the fishermen reported to be aware of the Project and all had heard about the Project through friends, although some had also heard about it through their offices and the media. All interviewed fishermen had a negative opinion of the Project, although a couple of them noted the likelihood of job opportunities resulting from the general development in Duqm. The main concerns across the fishermen stemmed from a lack of areas to fish in and to land their boats at, particularly as the new Fishery Harbour is not ready.

6 CONCLUSIONS

It is clear that the ongoing surveys in the area, particularly in Nafun and Al Tayari, may be affecting the local people's willingness to engage fully in the survey and resulted in a lower than expected response for the household survey .

Two thirds of those who agreed to be interviewed were men and one third of respondents were women. A significant proportion of the respondents were aged in their twenties to early fifties, highlighting that the area has a proportionally high number of people at working age. This may explain why there is a largely positive attitude (85%) towards the Project among the surveyed households, with high project expectations for increased numbers of jobs, improved infrastructure and a new hospital.

It is interesting to note that nearly 20% of all respondents had no or unfinished education. However, because 24% of respondents refused to provide their education details, the real number of local people with no or low level of attainment could be much higher than stated. Over 80% of respondents over 56 years old admitted that they had no education.

This current low level of education among interviewees does not necessarily translate into low levels of income for each of the surveyed households. This is largely because the traditional income generating activities (fishing and cattle raising and selling) allow local families to generate income without requiring any form of formal education. High levels of cattle ownership and renting property for supplementing income (including renting houses and fishing boats) among interviewees indeed support this conclusion.

A variety of illnesses were reported amongst the households, with high levels of hepatitis A and also diabetes and asthma noted to have impacted members of the surveyed households in the last three years. The birth rates are quite low in the project area however there is relatively high reliance on social welfare payments among the households covered by the survey. This corresponds with the fact that every fifth respondents reported to have at least one member of their family with a serious health condition/disease. Of the surveyed households, 6% are led by widows or divorced women.

Attitudes towards the Project amongst the fishermen were largely negative as they believe it will directly affect their fishing and therefore their income, although the possibility of new jobs from the Project was also noted in the fishermen surveys. Overall, the average monthly income reported by the surveyed fishermen is in line with the average national monthly income. It is interesting to note that most of the surveyed fishermen confirmed that the fishing productivity and catch sizes are decreasing. As such, both the local fishermen's livelihood and food supply might not be sustainable.

Across both the main survey and the fishermen surveys the overwhelming majority of the respondents were aware of the Project, highlighting that there has been good coverage and resulting awareness of the proposed Project in the area so far.

Camel and goat rearing is an essential livelihood activity which can have a large influence over local households' incomes, and the lack of animal enclosures at the 150 Housing Units settlement could delay the Nafun and Al Tayari families moving into their new homes.

Importantly, the survey provided a valuable insight into socio-economic profile of local residents and also their project-related concerns and expectations. As mentioned in Section 4.8, the minority of the surveyed households (6%) are concerned about air emissions and pollution that will be generated by the project, as well as workers influx. At the same time 80% of respondents have positive attitude towards the project and expect it to generate new jobs,and contribute to the development of a kindergarten or a school, or a new hospital in the Duqm area.

These four main social “themes” will be incorporated into the Social Management Plan, to be monitored by DRPIC throughout the project life-cycle and reported to the Lenders.

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Appendix A

SOCIO-ECONOMIC SURVEY QUESTIONNAIRES

APPENDIX A-1
SOCIO-ECONOMIC HOUSEHOLD QUESTIONNAIRE

Date: ___________________; Time:____________________; Name(s) of surveyor:__________________________

SECTION 1: General Details

1. **Address of the surveyed Household (HH)/Settlement**: ____

2. Full name of the head of the HH: ___________________________

3. HH Composition: questions below_

	1 (Head of HH)	2nd member	3rd member	4th member	5th member
Relationship to HH Head - See codes below	N/A				
Age					
Gender (M/F)					
Primary occupation See codes below					
Educational level See codes below					
How long have you been living here					

Relationship to Household Head:	1: Spouse	2: Son or Daughter	3: Father or Mother	4: Brother or Sister	5:Other
Primary Occupation: 1. Farmer	2. Pensioner	3. Unemployed	4. Civil Servant	5. Business/Trade)	6. Other
Educational Level: 1. Primary	2. Secondary	3. Technical Diploma	4. Higher (univ./institute)	5. None (primary not completed)	

4. **Does your HH own one or several of the following items** (Yes=1, No=0)

Colour TV	Satellite Dish	Telephone	Mobile phone	Internet	Radio
Personal computer	Washing machine	Refrigerator	Goat	Car	Camel

5. What is your most important item of expenditures? ______________________________________

1. Food 2. Housing 3. Schooling or university expenses 4. Utilities 5. Health 6. Business Expenditures 7.Other

6. How much on average do you spend monthly on these items (in Omani Rial/OR)?

____

7. What is the main source of fresh water for your HH?

1. Water from the lorry that regularly brings water, 2. Freshwater lense nearby, 3. Water well, 4.Other

____

8. How much do you pay monthly for water and wastewater?____

SECTION 2: House Ownership

9. Houses or Structures

Location (Village)	Construction type: Permanent /immovable structure (P) Not Permanent) (NP)		Ownership Status: (Owner/ Co-Owner/Tenant)			Condition
	P	NP	O	CO	T/COT	
	P	NP	O	CO	T/COT	

SECTION 3: Income Sources

10. Income details, estimates

Item Description	In Omani Rial, 2017 (could be an estimate, also put 0 if the answer is No to certain categories)
Income from Household Activities	
Agriculture/ Farming (if applicable) or collecting any ecosystem services goods (e.g. honey, herbs)	
Income from raising and selling cattle (eg Camels or Goats, if applicable – also includes camel racing)	

Date: ___________________; Time:____________________; Name(s) of surveyor:__________________________

Item Description	In Omani Rial, 2017 (could be an estimate, also put 0 if the answer is No to certain categories)
Income from fishing – if a member of this HH is engaged in small-scale (non-licensed) fishing	
Property Income	
Rent received from rented property (land, housing)	
Benefits	
Social security benefits/benefits received by the family from the State	
Remittances and assistance received from other family members	
Other (inheritance, alimony, scholarships, etc)	
Employment	
Formal employment income (indicate type of work)	
TOTAL	

SECTION 4: Health

11. **Are there disabled or chronically ill people in the household? YES NO**

12. If **YES**: - **Type of disability/illness**: ____

13. Number of births & deaths over the last 12 months in the household:

- Births: _________________
- Deaths:_________________ Cause: ____

14. What are the most common diseases that affect the family (last 3 years)?

- ____
- ____

15. Is this a household where a woman is a head of the Household (widow, etc?) YES NO

SECTION 5: Expectations and Concerns about the Project

16. Attitude towards the Project:

16.1 Are you aware of the proposed Duqm Refinery Project? Yes -1, No -0
16.2 If Yes, Source of information, how did you find out about it__________________________________
16.3 What is your opinion about the project? Positive -0, Negative – 1, Neutral-2
16.4 If positive, what positive impacts do you expect from it? ___________________________________
16.5 If negative, what negative impacts do you expect from it? ___________________________________

SECTION 6: Cultural Heritage

17. Are you aware about the following:

17.1 Any cultural heritage or archaeological places of significance within your area? Yes -1, No -0
17.2 If Yes, please name them ____
17.3 (if Yes in 16.1), Estimated distance to this place (in km) or name the settlement where they are located____
17.4 Where is the nearest cemetery from here (estimated distance in km)_____________________________

APPENDIX A-2
QUESTIONNAIRE USED FOR SURVEY OF FISHERMEN

Date: ____________________; Time:_____________________; Name(s) of surveyor:________________________

Fishermen Survey for the Duqm Refinery Project, Oman

SECTION 1: General Data and Fishing Equipment Information

1. **Settlement /Location of the interview**: ____

2. **Full name of the interviewed fisherman** (could be anonymous)___________________________

3. **How many boats do you personally own?**____

4. **For the boat that you use, what is the type of this main boat**:__________________________
(1.wooden, 2.fiberglass, 3. other)

5. **Do you own this boat yourself or do you share it with others:**__________________________
(1.share it with others, 2.it belongs to me/my family only, 3.owned by someone else)

6. **If you paid for the boat yourself, what was the source of funds to pay for the boat:**_________
(1. family savings, 2. loan, 3. personal savings, etc)

7. **Types of fishing gear you most often use to catch fish:**_______________________________
(1.net, 2.fishing rods, 3.both, 4.other gear)

8. **Number of people/crew on the boat that you use**:___________________________________

9. **How often do you fish/go onto the sea?**____
(1.daily, 2.every second day, 3.every 2 days, 4.weekly)

10. **Fuel/Oil for the main boat (if used), cost**:____

11. **Food, cost:** ____

12. **Ice for fish (if used), cost:**____

13. **Boat repair and maintenance details (if it is you who pays for it):**
a. Spare parts/Repairs, cost:____

b. Net and ropes, cost:____

c. Other consumables, cost: ____

14. **Do you belong to any local Fishermen Association/Cooperative**:____________(1. YES, 2. NO)

SECTION 2: Catch Information

15. **Fishing Territory, how far do you go in your main boat to fish in the sea:** ________________
(estimate: 1.minimum 2 km, 2.over 5 km, 3.it depends on the season and sea)

16. **Time to go into the sea:**______________________**Time to return:** _____________________

17. **MONTHLY. Main types of fish that you catch most often:**______________________________

a. Fish/species:_______________ Wt/kg: ________ Value/OR:_____________

b. Fish/species:_________________ Wt/kg: ________ Value/OR:_____________

Date: ___________________; Time:____________________; Name(s) of surveyor:_______________________

c. Fish/species:_________________ Wt/kg: ________ Value/OR:_____________

d. Fish/species:_______________ Wt/kg: ________ Value/OR:____________

18. Typically, all of my catch is eaten by my family/myself: __________________(1. Yes, 2. No)

19. Estimated monthly average Income (resulting from fishing activities only):______________

20. I have other sources of income when I do not fish, estimate:___________________________

21. Do you have any agreement or a contract with a local fish trader:____________(1. Yes, 2. No)

22. What is your opinion about fish resources <u>during the last five years</u>:

a) Productivity of fish:	1.Increase	2.Decrease	3.Stable	4.No idea
b) Amount of catch per effort/boat trip:	1.Increase	2.Decrease	3.Stable	4.No idea
c) Diversity of fish resources:	1.Increase	2.Decrease	3.Stable	4.No idea
d) Lagoon and sea water pollution:	1.Increase	2.Decrease	3.Stable	4.No idea

SECTION 3: Expectations and Concerns about the Project

23. Attitude towards the Project:

a. Are you aware of the proposed Duqm Refinery Project?______________________1. Yes, 2. No

b. If Yes, Source of information, how did you find out about it____________________________
(1. Friends, 2. Consultations with Duqm Refinery, 3. Someone mentioned it)

c. What is your opinion about the project? (1. Positive, 2. Negative, 3. Neutral)

d. If positive, what positive impacts do you expect from it? ____________________________

e. If negative, what negative impacts do you expect from it? ___________________________

Appendix F

APPENDICES FOR SECTION 9 – CULTURAL HERITAGE

APPENDIX F-1

APPENDIX 9.1: CULTURAL HERITAGE BASELINE AND SURVEY REPORT

REPORT N^{O} 70029220-102-BS01

ENVIRONMENTAL BASELINE: CULTURAL HERITAGE

DUQM REFINERY PROJECT, OMAN

CONSOLIDATED ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

CONFIDENTIAL

JULY 2017

ENVIRONMENTAL BASELINE: CULTURAL HERITAGE

DUQM REFINERY PROJECT, OMAN

Duqm Refinery & Petrochemical Industries Company

Draft
Confidential

Project no: 70029220
Date: July 2017

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QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	DRAFT	FINAL		
Date	21/06/17	30/06/17		
Project number	70029220	70029220		
File reference	Project drive	Project drive		

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1 INTRODUCTION

1.1 BACKGROUND

This report presents the methodology and results of an environmental baseline cultural heritage survey carried out around the geographic area of the Duqm Refinery Project, specifically along the pipeline right of way and DRPIC Ras Markaz site as these areas were previously unsurveyed. .

1.2 PREVIOUS BASELINE WORK

The initial archaeological assessment of southern Huqf was conducted by the Central Oman Palaeolithic Survey (COPS) project, directed by Dr. Reto Jagher (University of Basel). COPS overlaps, in part, with the Duqm Industrial Development Zone (IDZ), where Jagher mapped sixteen archaeological findspots in the southern part of the zone. To assess the rest of the IDZ, Five Oceans Environmental Services was commissioned to undertake a comprehensive survey of the area, carried out by David Insall from May 17th-21st, 2010, with a second visit July 28th-30th, 2010 (5OES #3046). The survey identified 182 heritage sites within the IDZ (Figure 2-2). These included cemeteries, enclosures, lithic scatters, graves, shell middens, temporary mosques, potsherds, structures, triliths, and isolated graves (Table 1). In addition, field survey was undertaken conducted by Dr. Yamandú Hilbert from 23/04/2017 to 27/04/2017 along the underground pipeline route and is referenced in this report. The results of this survey have been compiled into the Duqm Gazetteer.

1.3 SCOPE OF REPORT

The following report summarises all of the archaeological findings from field surveys undertaken for or reported in EIA documents pertaining to the IDZ. These surveys were conducted to evaluate the impact on Oman's archaeological heritage and locations of geological significance by infrastructure components to be developed as part of the Duqm Refinery Project in the Wilayat of Ad Duqm, within the Central Oman region (Section 1.4 and Section 7).

1.4 PROJECT OVERVIEW

The Duqm Refinery Project comprises the Refinery itself and its Off-site Facilities (i.e. the “Funded Project”). The components of the Project are described in Table 1-1 below.

Table 1-1: Duqm Refinery Project

PROJECT COMPONENT	DESCRIPTION
Duqm Refinery	A 230,000 BDP complex refinery on a plot of 9km^2 area to the north of the main industrial area within the Duqm Special Economic Zone. Includes: • Site clearance and levelling (completed in late 2016) • Product pipelines and service lines to the Duqm Export Terminal • Construction accommodation/workers’ camps • Laydown areas
Off-site Facilities	i. **Crude storage facility at the Ras Markaz (RM) Crude Oil Terminal**: eight tanks located within, and part of the wider Tank Farm, approx. 80km from the Refinery. The large-scale Tank Farm (Oman Oil Tank Terminal Company, OTTCO) in its entirety is not part of the Project. ii. **‘DRPIC Crude Pipeline’:** 28-inch diameter 80km crude oil import pipeline to transport crude oil from RM to Duqm Refinery.

PROJECT COMPONENT	DESCRIPTION
	iii. **Product 'Export Terminal'**: on the lee breakwater of Port of Duqm, immediately to the south-east of the Refinery plot. Topside works only, i.e., to establish storage for products and export handling facilities. For marine works, see Associated Facilities below.
Associated Facilities	i. Natural gas spur line/metering station used to supply gas feedstock to DR from the national gas network (Oman gas Company, OGC) ii. Export pipeline corridor – Construction of the corridor and infrastructure (pipe supports, bridges, fencing drainage, etc, including pipeline and services themselves under the refinery) (SEZAD / Marafiq). Note: SEZAD SEZAD have overall responsibility for the Pipeline Corridor, excluding the DR pipelines and cables, extending from the Refinery Boundary Marker fenceline to the Port fenceline. iii. The marine scope including dredging and reclamation and jetty and quay wall construction of the Duqm Export Terminal. (SEZAD). iv. Haul road or dedicated lane (on Existing Road) for solid product from DR to Duqm Export Terminal. (SEZAD). v. Duqm Integrated Power and Water Plant (DIPWP) supplying electricity and desalinated water to DR (and in the future other consumers in DSEZ). (Marafiq, also known as Central Utilities Company, CUC). vi. Seawater supply network (to DIPWP). (Marafiq). vii. Common wastewater outfall for industrial zone users. (SEZAD). viii. Offshore oil import facilities (including offshore single point mooring (SPM) and crude oil pipeline to shore at RM (OTTCO).

The transition from crude oil import (via a Single Point Mooring, (SPM) at Raz Markaz to the export of refined products through the Project facilities follows these key stages:

1. Offload of crude oil from offshore vessel delivery. Crude oil is stored within the crude import and storage facility at Ras Markaz Tank Farm of which only eight crude oil tanks are part of the Project.
2. The oil is transferred to the Duqm Refinery through the 80.7km Crude Import Pipeline. The Duqm Refinery will have a design capacity of 230,000 barrels per day and will produce the following products:
   a. Naphtha;
   b. Liquid Petroleum Gas (LPG);
   c. Jet A-1;
   d. Diesel;
   e. Heavy Sulphur Fuel Oil (intermittently);
   f. Petroleum Coke (Solid); and
   g. Sulphur (Solid).
3. Once the crude oil is refined to the final products then these are marine exported via the Duqm Export Terminal. The liquid products are conveyed to the terminal via a pipeline and the solid products via ground transport.

2 STUDY BACKGROUND

2.1 PREVIOUS ARCHAEOLOGICAL RESEARCH IN THE HUQF

In 1984, a team of Italian researchers investigating bitumen sources in the northern Huqf near Gunaim (formerly Saiwan), discovered the first Palaeolithic site in Oman (Figure 2.1). The findspot is an extensive, dense scatter of stone tools and chipping debris made on locally outcropping chert nodules. Most of the lithic assemblage is comprised of debitage, predominantly flakes and elongated “blade-like” flakes struck from the core using hard hammer percussion. The cores consist of discoids and single-platform, unidirectional blade cores. The blade cores typically have plain striking platforms and primarily show parallel scar patterns on a single working surface. Among the tools, there were most notably sidescrapers and a series of well-made bifaces with flaking scars that suggest a mix of both soft and hard hammer reduction. Although precise dating is impossible because the material was only found on the surface, Biagi (1994) initially attributed the site of Saiwan to the “Upper Acheulean” (late Lower Palaeolithic) time period around 200,000 bp, based on the assemblage’s particular technological and typological characteristics.

Subsequent expeditions to Huqf have mapped several hundred sites throughout this area (Whalen, 2003; Rose, 2006, 2007, 2012, 2014a, 2014b, 2014c, 2015; Jagher, 2009; Jagher and Pümpin 2010). These sprawling archaeological landscapes, in some cases dense carpets of chipping debris composed of tens of thousands of artifacts, are linked to chert outcrops occurring within the Khuff and Minjur geological formations. Most known prehistoric sites in this region are stone tool manufacturing zones accumulated by the successive exploitation of this local, abundant high quality raw material.

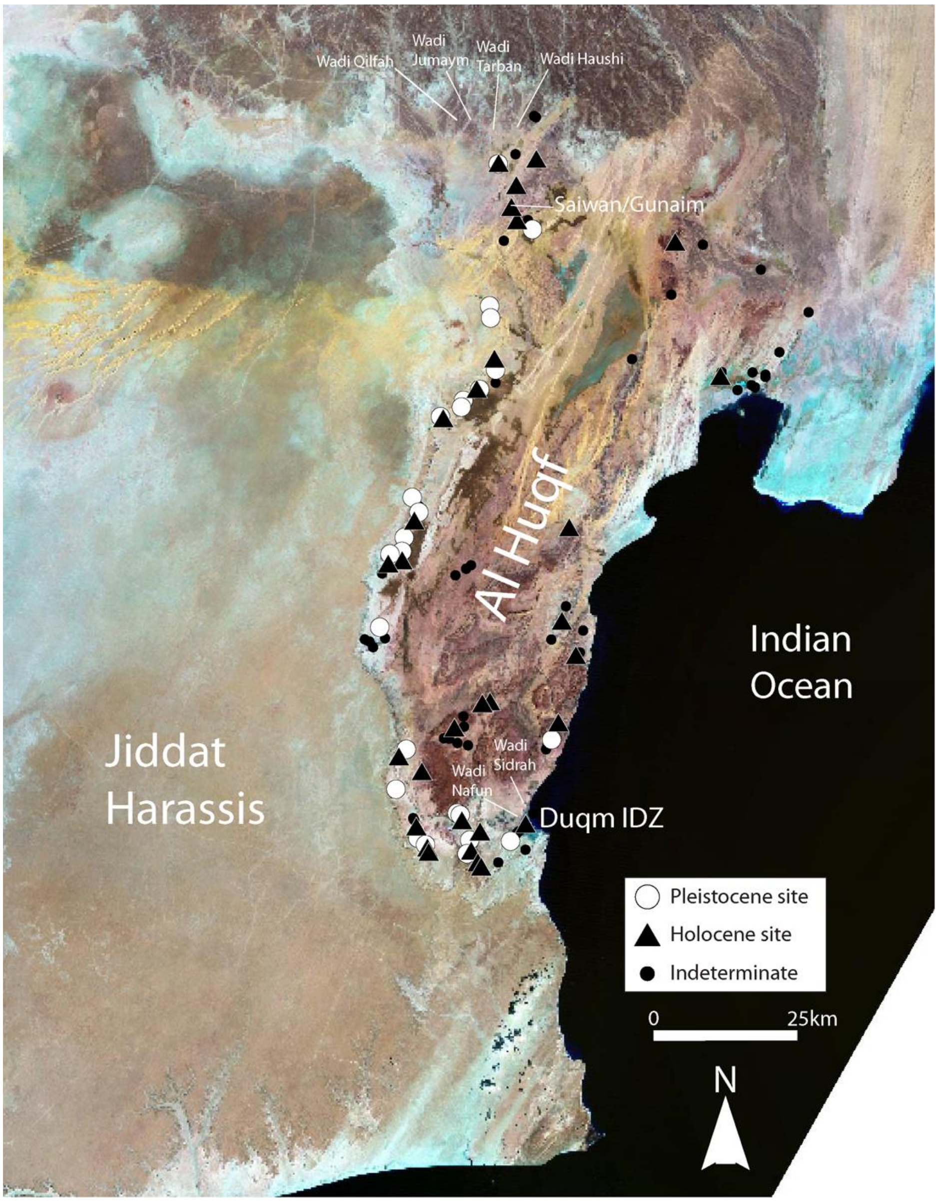

Figure 2-1: Map illustration of concerned area including Al Huqf and Gunaim

Scholars have observed widespread and homogenous technological and typological features of the Palaeolithic in Huqf. Rose (2006, 2007, 2014b) describes a series of lithic surface scatters located at the confluence of Wadi Qilfah, Wadi Jumaym and Wadi Tarban approximately 20km northwest of Saiwan, which all exhibit the same technological and typological characteristics as those recorded at the nearby site of Saiwan. Tools such as sidescrapers and cordiform bifacial handaxes, as well as large blades and large, single platform blade cores occur frequently within the assemblages. As there are no absolute dates from these sites, there is disagreement among scholars regarding their age. Earlier publications (e.g. Biagi, 1994; Rose, 2006; Jagher, 2009) tentatively placed this industry between the late Lower Palaeolithic and the Middle Palaeolithic, between roughly 400,000 and 40,000 bp. More recent research analysing the chronology of Palaeolithic industries in Oman, however, suggests they may be much younger, dating to the Late Palaeolithic period from 13,000 to 8,000 bp (Rose et al., nd).

In two field seasons between 2007 and 2008, the Central Oman Palaeolithic Survey (COPS) mapped over nearly 300 700 archaeological sites throughout the entire Huqf depression (Jagher, 2009; Jagher and Pümpin 2010). These included Palaeolithic sites with technological affinities to the Saiwan-type, as well as Neolithic stone tool scatters and historic-period features such as stone cairns, stone circles, and triliths (described below). Neolithic sites in the Huqf are as numerous as those from the preceding Palaeolithic phases (Jagher, 2009; Jagher and Pümpin 2010). These primarily occur as manufacturing workshops on the same Khuff and Minjur chert outcrops. The stone tools at such sites are similar to their Palaeolithic antecedents, primarily differentiated by their smaller proportions and more minor degree of surface weathering. As in the Palaeolithic period, the predominant core reduction strategy is the production of simple blades struck from single platform cores along the narrow, elongated face of tabular chert slabs and nodules. Tools include heavy duty bifacial axes, knives, foliates, and, rarely, pressure-flaked spear points. As was recently demonstrated in the southern Levant (Yerkes and Barkai 2013), the intensive manufacture of flint axes may indicate a more forested environment, where heavy duty bifacial axes were used for cutting trees and shaping wood. Late Palaeolithic and Neolithic sites in the Huqf are presumed to coincide with the Holocene Climatic Optimum that lasted from roughly 10,000 to 6,000 bp, at which time southern Arabia enjoyed increased precipitation, grasslands, lakes, rivers, and greater forest cover (Preston et al., 2015).

Jagher and Pümpin (2010) report that a third of all mapped archaeological sites in central Oman belong to the historic periods. These include all extant architectural features such as stone structures, stone circles, and pre-Islamic stone burial cairns. These later sites tend to be concentrated in the southern portion of the Huqf. One of the most unique archaeological features of this period are “triliths” - enigmatic stone constructions found across a large swath of southern Arabia, from the Hadramawt Valley in Yemen to Al Huqf in Oman. Each trilith comprises a well-constructed stone platform with large blocks ringing the outside and rubble used to fill the interior space. Atop the platforms are clusters of three stone slabs resting against each other like a tripod, with a fourth slab capping the top. Trilith clusters are always arranged in a straight line, typically occur in odd numbers, are found in lengths between ~3 and 30 metres, and have varying axes of orientation. The furthest north they have been mapped is the Wadi Haushi area in northern Huqf.

2.2 EXISTING BASELINE INFORMATION

As outlined in Section 1.2, there have been two prior archaeological surveys (not including the new survey results presented in this report) of the Duqm area: a general scientific study of the region carried out by the COPS research project in 2008 and 2009, and a targeted assessment of heritage assets within the Duqm Industrial Development Zone (IDZ) in 2010. The COPS project mapped sixteen archaeological findspots in the southern part of their survey area that overlaps with the IDZ (Figure 2-2 and Figure 2-3). Five Oceans was subsequently commissioned to assess the rest of the IDZ, identifying 182 heritage sites in and around Duqm (Figure 2-2). These included cemeteries, enclosures, lithic scatters, graves, shell middens, temporary mosques, potsherds, structures, triliths, and isolated graves (Table 2-1). The measure of significance in Table 2-1 reflects the surveyor's impressions of scientific and cultural value, with 1 being minimal.

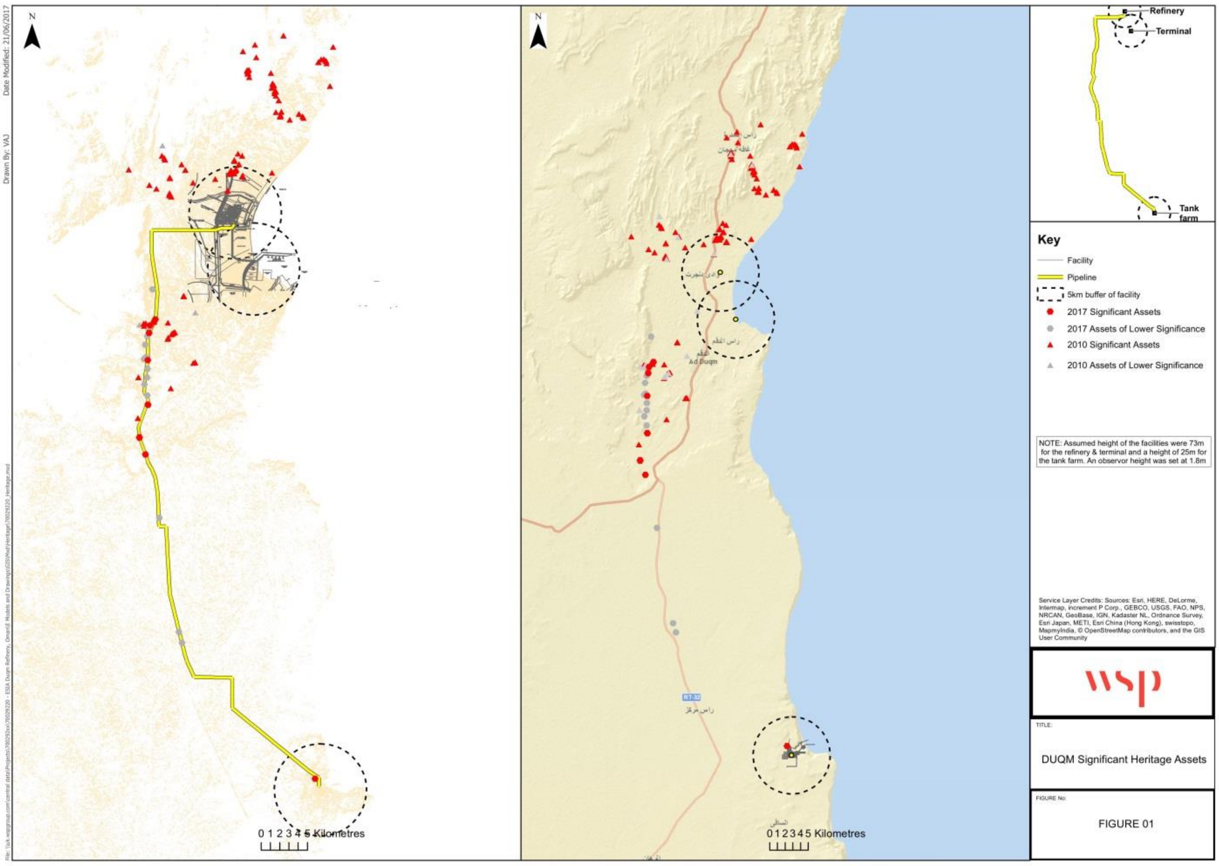

Figure 2-22: Duqm Significant Heritage Assets

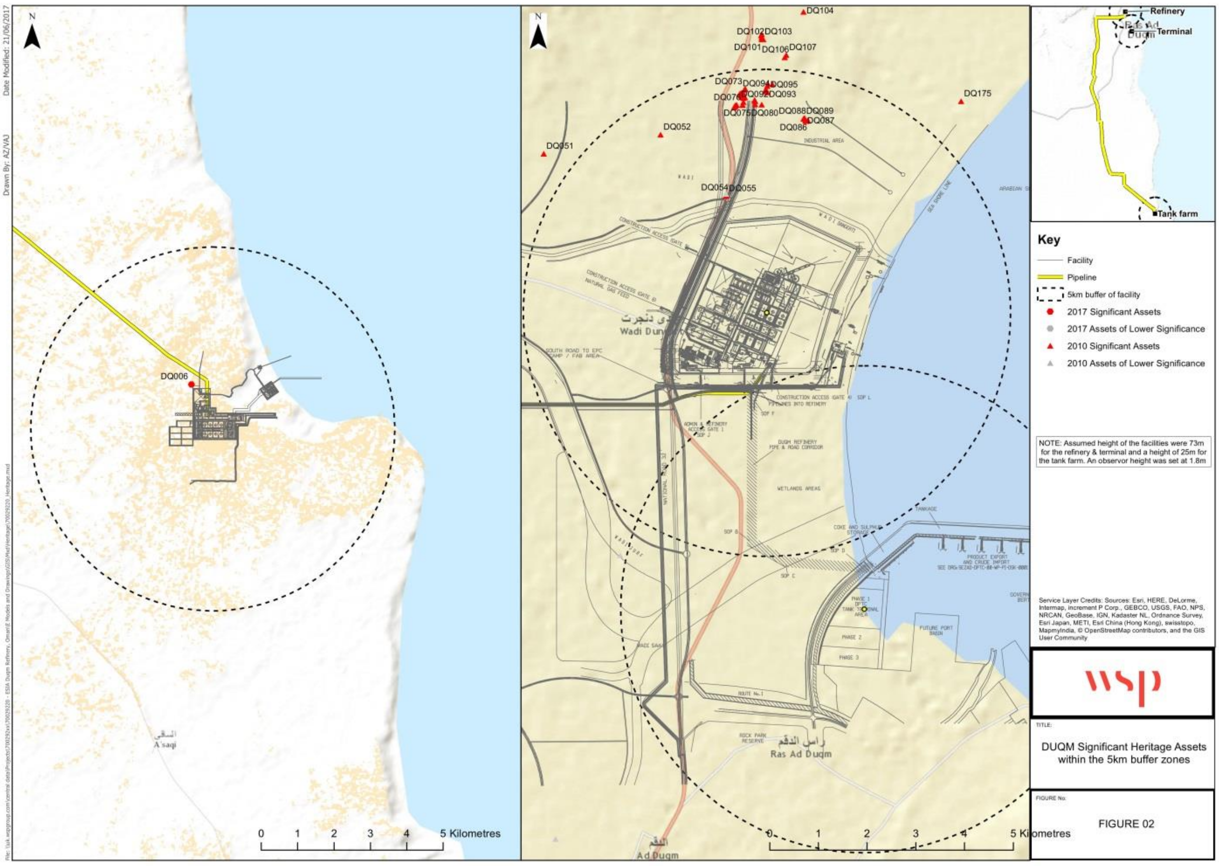

Figure 2-33: Duqm Significant Heritage Assets within 5 km Buffer Zones

Table 2-1: Archaeological sites mapped by the COPS project (2008-2009)

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
1	40 Q 564902 2165712	Trilith	4
2	40 Q 564926 2165778	Pre-Islamic Graves	3
3	40 Q 564723 2165696	Trilith	5
4	40 Q 562294 2162942	Trilith	5
5	40 Q 558721 2159706	Pre-Islamic Graves	3
6	40 Q 558770 2164143	Enclosure	3
7	40 Q 558770 2164143	Lithics	1
8	40 Q 558648 2165255	Enclosure	3
9	40 Q 561951 2168291	Lithics, Pre-Islamic Graves	3
10	40 Q 562015 2168452	Pre-Islamic Graves	3
11	40 Q 562015 2168452	Lithics	1
12	40 Q 562316 2168731	Pre-Islamic Graves	1
13	40 Q 562368 2168815	Lithics	4
14	40 Q 562368 2168815	Enclosure	3
15	40 Q 562479 2168889	Pre-Islamic Graves	3
16	40 Q 562532 2168931	Pre-Islamic Graves	3

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
17	40 Q 562559 2168966	Pre-Islamic Graves	3
18	40 Q 562559 2168966	Temporary Mosque	1
19	40 Q 562641 2169003	Pre-Islamic Graves	3
20	40 Q 562735 2169016	Pre-Islamic Graves	3
21	40 Q 561985 2170068	Lithics	4
22	40 Q 560488 2170139	Triliths, Pre-Islamic Graves	4
23	40 Q 560488 2170139	Lithics	3
24	40 Q 559569 2170001	Pre-Islamic Graves	3
25	40 Q 559600 2169946	Enclosure	2
26	40 Q 559600 2169946	Lithics	2
27	40 Q 559600 2169946	Pre-Islamic Graves	3
28	40 Q 559545 2170007	Pre-Islamic Graves	2
29	40 Q 559343 2169988	Pre-Islamic Graves	3
30	40 Q 558890 2169848	Lithics	2
31	40 Q 559394 2169717	Structure (indeterminate)	2
32	40 Q 559394 2169717	Lithics	3
33	40 Q 563694 2172917	Pre-Islamic Graves	3
34	40 Q 563698 2172952	Pre-Islamic Graves	3
35	40 Q 563691 2172962	Pre-Islamic Graves	3
36	40 Q 563688 2172966	Pre-Islamic Graves	3
37	40 Q 563687 2172979	Pre-Islamic Graves	3
38	40 Q 563676 2172979	Pre-Islamic Graves	3
39	40 Q 564943 2171180	Temporary Mosque	1
40	40 Q 566275 2177005	Pre-Islamic Graves	1
41	40 Q 562342 2183748	Pre-Islamic Graves	3
42	40 Q 562294 2183709	Structure (indeterminate)	1
43	40 Q 562219 2183867	Islamic Graves	3
44	40 Q 562111 2183889	Islamic Graves	3
45	40 Q 562137 2184095	Islamic Graves	3
46	40 Q 560736 2184609	Pre-Islamic Graves	3
47	40 Q 561654 2187744	Trilith	4
48	40 Q 561641 2187755	Islamic Graves	3
49	40 Q 561594 2187944	Islamic Graves	3
50	40 Q 561382 2189295	Pre-Islamic Graves	2
51	40 Q 563449 2187253	Islamic Graves	3
52	40 Q 563883 2186648	Pre-Islamic Graves	3
53	40 Q 563798 2186574	Pre-Islamic Graves	1
54	40 Q 564699 2185252	Pre-Islamic Graves	3
55	40 Q 567098 2185643	Pre-Islamic Graves	3
56	40 Q 573156 2197159	Traditional Ritual Site	5
57	40 Q 568450 2184399	Pre-Islamic Graves	3

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
58	40 Q 568441 2184422	Enclosure	2
59	40 Q 568441 2184380	Pre-Islamic Graves	3
60	40 Q 568608 2186200	Pre-Islamic Graves	3
61	40 Q 568616 2186221	Pre-Islamic Graves	3
62	40 Q 568627 2186219	Pre-Islamic Graves	3
63	40 Q 568638 2186243	Pre-Islamic Graves	3
64	40 Q 568640 2186249	Pre-Islamic Graves	3
65	40 Q 568659 2186253	Pre-Islamic Graves	3
66	40 Q 568831 2186408	Pre-Islamic Graves	3
67	40 Q 568801 2186398	Pre-Islamic Graves	3
68	40 Q 568797 2186392	Pre-Islamic Graves	3
69	40 Q 568769 2186416	Pre-Islamic Graves	3
70	40 Q 568743 2186443	Pre-Islamic Graves	3
71	40 Q 568722 2186477	Pre-Islamic Graves	3
72	40 Q 568724 2186480	Pre-Islamic Graves	3
73	40 Q 568739 2186482	Pre-Islamic Graves	3
74	40 Q 568762 2186500	Pre-Islamic Graves	3
75	40 Q 568792 2186503	Pre-Islamic Graves	3
76	40 Q 568821 2186570	Pre-Islamic Graves	3
77	40 Q 568843 2186577	Pre-Islamic Graves	3
78	40 Q 568797 2186313	Pre-Islamic Graves	3
79	40 Q 568784 2186255	Pre-Islamic Graves	3
80	40 Q 568781 2186249	Pre-Islamic Graves	3
81	40 Q 569041 2186265	Pre-Islamic Graves	3
82	40 Q 569040 2186329	Pre-Islamic Graves	3
83	40 Q 569032 2186353	Pre-Islamic Graves	3
84	40 Q 569172 2186257	Pre-Islamic Graves	3
85	40 Q 570125 2185934	Pre-Islamic Graves	3
86	40 Q 570125 2185934	Pre-Islamic Graves	3
87	40 Q 570115 2185925	Pre-Islamic Graves	3
88	40 Q 570082 2185920	Pre-Islamic Graves	3
89	40 Q 570075 2185934	Pre-Islamic Graves	3
90	40 Q 570063 2185957	Pre-Islamic Graves	3
91	40 Q 570052 2185984	Pre-Islamic Graves	3
92	40 Q 570032 2185970	Pre-Islamic Graves	3
93	40 Q 570032 2185970	Pre-Islamic Graves	3
94	40 Q 569395 2186678	Pre-Islamic Graves	3
95	40 Q 569302 2186677	Pre-Islamic Graves	3
96	40 Q 569289 2186642	Pre-Islamic Graves	3
97	40 Q 569261 2186578	Pre-Islamic Graves	3
98	40 Q 569252 2186531	Pre-Islamic Graves	3

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
99	40 Q 569292 2186513	Pre-Islamic Graves	3
100	40 Q 569173 2187709	Pre-Islamic Graves	3
101	40 Q 569166 2187678	Pre-Islamic Graves	3
102	40 Q 569166 2187678	Pre-Islamic Graves	3
103	40 Q 569173 2187639	Pre-Islamic Graves	3
104	40 Q 569189 2187613	Pre-Islamic Graves	3
105	40 Q 569200 2187608	Pre-Islamic Graves	3
106	40 Q 569206 2187601	Pre-Islamic Graves	3
107	40 Q 569175 2187602	Pre-Islamic Graves	3
108	40 Q 570036 2188166	Pre-Islamic Graves	3
109	40 Q 569582 2188404	Pre-Islamic Graves	3
110	40 Q 569649 2187230	Pre-Islamic Graves	3
111	40 Q 569682 2187278	Pre-Islamic Graves	3
112	40 Q 573390 2195905	Trilith	4
113	40 Q 573384 2195933	Trilith	1
114	40 Q 573382 2195949	Pottery	4
115	40 Q 573495 2195827	Trilith	4
116	40 Q 573392 2195730	Islamic Graves	5
117	40 Q 573542 2195179	Trilith	4
118	40 Q 573561 2195169	Trilith	4
119	40 Q 573534 2194960	Pre-Islamic Graves	4
120	40 Q 573670 2194687	Pre-Islamic Graves	3
121	40 Q 573678 2195114	Trilith	4
122	40 Q 573685 2195180	Trilith	4
123	40 Q 573322 2196034	Trilith	4
124	40 Q 574005 2194178	Trilith	4
125	40 Q 574274 2192932	Trilith	4
126	40 Q 574271 2192942	Trilith	4
127	40 Q 574266 2192963	Trilith	4
128	40 Q 5736722 2192897	Pre-Islamic Graves	3
129	40 Q 574168 2192421	Trilith	4
130	40 Q 574171 2192438	Trilith	4
131	40 Q 574179 2192461	Trilith	4
132	40 Q 574137 2192510	Trilith	3
133	40 Q 574178 2192547	Trilith	4
134	40 Q 574184 2192584	Pre-Islamic Graves	3
135	40 Q 570626 2197081	Pre-Islamic Graves	3
136	40 Q 570670 2197081	Pre-Islamic Graves	3
137	40 Q 570658 2197194	Pre-Islamic Graves	3
138	40 Q 570638 2197312	Pre-Islamic Graves	3
139	40 Q 570610 2197400	Pre-Islamic Graves	3

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
140	40 Q 570599 2197427	Pre-Islamic Graves	3
141	40 Q 570567 2197475	Pre-Islamic Graves	3
142	40 Q 570637 2197358	Temporary Mosque	1
143	40 Q 570754 2197514	Trilith	4
144	40 Q 570106 2199511	Enclosure	3
145	40 Q 571562 2198874	Pre-Islamic Graves	3
146	40 Q 574508 2201213	Trilith	4
147	40 Q 579884 2199993	Pre-Islamic Graves	3
148	40 Q 579118 2198481	Pre-Islamic Graves	3
149	40 Q 579124 2198453	Shell Midden, Pre-Islamic Graves	3
150	40 Q 579122 2198423	Pre-Islamic Graves	3
151	40 Q 578933 2198614	Islamic Graves	4
152	40 Q 578840 2198629	Islamic Graves	4
153	40 Q 578586 2198636	Islamic Graves	4
154	40 Q 578578 2198635	Shell Midden	3
155	40 Q 578306 2198323	Pre-Islamic Graves	3
156	40 Q 578306 2198323	Pre-Islamic Graves	3
157	40 Q 578300 2198324	Pre-Islamic Graves	3
158	40 Q 578310 2198323	Pre-Islamic Graves	3
159	40 Q 578296 2198357	Pre-Islamic Graves	3
160	40 Q 578296 2198357	Pre-Islamic Graves	3
161	40 Q 578302 2198336	Pre-Islamic Graves	3
162	40 Q 579191 2198201	Islamic Graves	5
163	40 Q 579539 2195751	Pre-Islamic Graves	3
164	40 Q 576678 2192289	Islamic Graves	3
165	40 Q 576568 2192444	Islamic Graves	3
166	40 Q 576568 2192444	Pre-Islamic Graves	3
167	40 Q 576180 2192723	Enclosure	3
168	40 Q 576195 2192719	Enclosure	3
169	40 Q 559960 2184996	Pre-Islamic Graves	3
170	40 Q 557728 2186687	Trilith	4
171	40 Q 562160 2184127	Islamic Graves	3
172	40 Q 570785 2196712	Trilith	3
173	40 Q 571416 2200211	Pre-Islamic Graves	3
174	40 Q 575186 2192094	Rock Art	3
175	40 Q 573228 2195555	Traditional Ritual Site, Islamic Graves	5
176	40 Q 562213 2185747	Pre-Islamic Graves	3
177	40 Q 562184 2185817	Pre-Islamic Graves	3
178		Pre-Islamic Graves	2
179		Trilith	3
180	40 Q 561319 2188182	Islamic Graves	4

SITE #	UTM GRID REFERENCE	SITE FEATURE(S)	SIGNIFICANCE (1-5)
181	40 Q 561319 2188182	Islamic Graves	4
182	40 Q 573268 2186326	Lithics	3

These sites were found to cluster in three general areas within the IDZ. In the northern sector, findspots were located within the Wadis Sidrah and Nafun. These were predominantly Islamic and Pre-Islamic graves, triliths, and a rock art site depicting a human figure holding a large male Nubian ibex (*Capra nubiana*) on a tether. In the central area, the surveyor identified numerous Islamic and pre-Islamic graves at the edge of the foothills. The highest density of sites was mapped in the southern zone, which included burial mounds, triliths, and flint scatters (Figure 2-2). The report recommends a 40m buffer zone around significant archaeological sites.

The 2014 HMR EIAs assessing the Duqm Refinery and Refinery Construction Camp did not identify any sites that required mitigation. These reports, however, only use the 2008-2009 COPS survey as the basis for their archaeological impact assessments. They do not include results of the 2010 Insall survey, which identified archaeological sites in vicinity of the Refinery Camps, nor was any targeted archaeological survey carried out specifically for this EIA.

The 2015 WorleyParsons EIA report of the Duqm Terminal Liquid Bulk Storage facility found that the development had low archaeological impact, as it is built on reclaimed land.

The 2016 WorleyParsons assessment of the Ras Markaz Pipeline did not examine heritage sites along the pipeline development corridor, although Five Ocean's 2010 survey in the area did cover a portion of the right of way. The survey of the entire pipeline right of way was completed by Dr. Yamandú Hilbert from 23/04/2017 to 27/04/2017. The predominant sites within the pipeline development corridor were found to be stone tool manufacturing workshops associated with local outcrops of chert or other siliceous materials. Other archaeological site types included small architectural features such as triliths, stone cairns, hearths, Islamic and pre-Islamic graves, and stone foundation walls.

2.3 GENERAL SIGNIFICANCE

The coast and hinterlands of central Oman are dominated by landscapes of low, eroded hills encompassing a variety of geological exposures and ecosystems. In the northern portion of this area is Al Huqf, an elongated depression generally oriented along a north-south axis, extending some 200km through the eastern portions of Ad Dakhliyiah and Al Wusta regions. It is bounded to the west by a steep limestone escarpment that rises onto the barren Jiddat Al Harrasis plain and to the east by the Indian Ocean littoral. Al Huqf is characterized by a series of low-lying hills, sabkha flats, and an intricate network of widian that debouch southward and ultimately terminate around Duqm.

The setting of the central Oman hill country would have been attractive to nomadic hunter-gatherer and pastoral populations throughout human history, as it encompasses a mosaic of terrestrial ecosystems, as well as being in proximity to a rich diversity of coastal resources (Jagher, 2009). Duqm, situated at the outlet of the only major drainage system in central Oman, was likely to have played a particularly important role due to the presence of freshwater in antiquity. While the region is presently governed by a hyperarid climatic regime, there have been multiple phases of increased rainfall over the course of the Pleistocene and Holocene geological ages. Terrestrial archives from lake sediments and cave speleothems show heightened precipitation during the following timeframes: 130,000 – 120,000 years before present (bp), 110,000 to 100,000 bp, 90,000 – 80,000 bp, 60,000 – 55,000 bp, and 8,000 – 5,000 bp (Parker et al., 2006; Parker and Rose, 2008; Fleitmann and Matter, 2009; Preusser, 2009; Rosenberg et al., 2011; Parton et al., 2013; Preston et al., 2015). It is likely that the Huqf was occupied most intensively during these periodic wet periods, called pluvials. A large palaeolake was identified in northern Huqf, dating to the most pronounced pluvial in human history: the Last Interglacial between 130,000 and 100,000 bp (Rosenberg et al., 2012). During this period, the first anatomically modern humans expanded from Africa into southern Arabia, facilitated by the favourable conditions that transformed the landscapes into lush grasslands. As such, Duqm and the entire Huqf region are of high scientific value in elucidating the history of our species.

3 METHODOLOGY

3.1 GUIDANCE

3.1.1 International Finance Corporation

The work conducted as part of this study conforms with Performance Standard 8 Cultural Heritage, International Finance Corporation, 2012.

3.2 PROCEDURE

The report has been provided to the Ministry of Heritage and Culture and SEZAD were consulted as part of the overall survey plan. The pipeline survey was conducted along an approximately 80 km linear transect following the development corridor of the planned pipeline. The survey transect extended from the storage facility at Ras Markaz to the refinery (see Figure 2-2 and Figure 2-3). An area of roughly 200m on either side of the survey transect was inspected for locations of archaeological and geological significance. Specific landscape features such as terraces and hilltops were also targeted due to their pre-established archaeological sensitivity. There is presently little vegetation and soil cover on the heavily eroded and deflated limestone bedrock of the study area, allowing for high archaeological visibility and a relatively straight driving path along the development corridor. Although most architectural features are in a poor state of repair, typically not preserved more than 20-50cm in height, the high visibility enabled surveyors to spot architectural features and chipped stone debris scatters from a distance of up to 200m away.

Findspots were photographed and recorded on site survey forms (Appendix B); no artefacts were collected. The survey followed the trajectory of the pipeline and examined from the location of the Tank Farm at Ras Markaz to the Duqm Refinery (see also in Figure 2-2). To navigate in the field, surveyors used a digital satellite map overlain with the development corridor. A total of 24 archaeological sites and four sites of geological interest were documented. Archaeological sites included lithic workshops, Islamic and pre-Islamic graves, stone walls, and a trilith site. Sites ranged from within 50m of the corridor of impact to more than 400m away. The distance of each site to the development corridor is presented in Table 2-1. The archaeological phase(s) attributed to each lithic scatter site is based on observations of specific technical features on the waste material as well as classification of tool types. This techno-typological approach examines patterns in both the chipped stone debris and completed tool types to assess the period of lithic production.

A tiered ranking system is applied to these archaeological sites, with which to guide future infrastructure development activities. The site rank corresponds with mitigation strategy and is not an indicator of significance.

- **Rank #1** sites are those with extant architectural features (e.g. triliths, walls, graves, cairns). If working in this area, all standing structures should be delineated with survey flags and there should be no access by light vehicles, heavy vehicles, nor bulldozing within 100m.
- **Rank #2** sites are high density stone tool scatters in pristine condition that are conscripted and clearly demarcated across the landscape. These findspots should be delineated with survey flags and there should be no access by heavy vehicle nor bulldozing. Light vehicle access is permissible and no buffer zone is required.

- **Rank #3** sites are low density and/or sprawling lithic scatters whose limits cannot be easily defined. These landscapes should not be bulldozed, although light and heavy vehicle access is permissible.
- **Rank #4** sites are isolated or very low density surface lithic scatters that are of minimal scientific value and will not be impacted by construction activities. Table 4-1 lists all of the archaeological sites discovered during the survey, their distance to the impact zone, and mitigation rank. The map of sites presented in Figure 1 depicts the location of findspots along the survey transect.

4 NEW ARCHAEOLOGICAL SITES

4.1 SURVEY RESULTS

The cultural heritage assets identified during survey are shown in Table 4-1.

Table 4-1: Archaeological sites, location, description, and mitigation rank

SITE #	SITE FEATURES	LAT (N)	LONG (E)	SIZE (SQ M)	DENSITY (ARTIFACTS/SQ M)	TIME PERIOD(S)	MITIGATION RANK	DISTANCE TO IMPACT ZONE (M)
DQM01	lithics	19.59091	57.56823	100	4-10	Late Pal., Neolithic	3	170
DQM02	lithics	19.58927	57.56620	60	0-3	non-diag. Holocene	4	360
DQM03	lithics	19.57980	57.56984	n/a	isolated	Lower Pal.	4	>400
DQM04	lithics	19.56423	57.56656	?	0-3	non-diag. Holocene	4	>400
DQM05	lithics	19.55364	57.56948	?	4-10	non-diag. Holocene	3	50
DQM06	lithics	19.57122	57.56927	n/a	isolated	non-diag. Holocene	4	>400
DQM07	lithics, structures	19.54445	57.57032	?	0-3	Neolithic, Bronze/Iron Age	1	130
DQM08	lithics, hearth, shells	19.54457	57.57009	25	11-50	Neolithic, Bronze/Iron Age	1	130
DQM09	stone cairn(s)	19.51266	57.56126	n/a	n/a	Bronze/Iron Age	1	<50
DQM10	stone cairn(s)	19.51205	57.56125	n/a	n/a	Bronze/Iron Age	1	<50

Site #	Site Features	Lat (N)	Long (E)	Size (sq m)	Density (artifacts/sq m)	Time Period(s)	Mitigation Rank	Distance to Impact Zone (m)
DQM11	stone cairn(s)	19.49571	57.56743	n/a	n/a	Bronze/Iron Age	1	<50
DQM12	lithics, hearth	19.43329	57.58154	10	0-3	Late Pal.	4	>400
DQM13	lithics	19.32171	57.60125	n/a	isolated	Middle Pal.	4	>400
DQM14	lithics	19.31081	57.60460	n/a	isolated	non-diag. Holocene	4	>400
DQM15	lithics, structures, shells	19.17716	57.74119	?	4-10	non-diag. Holocene	1	<50
DQM16	lithics	19.65763	57.57535	n/a	isolated	non-diag. Holocene	4	>400
DQM17	lithics	19.62802	57.57809	30	11-50	Late Pal., Neolithic	2	<50
DQM18	lithics, Trilith	19.62568	57.57666	40	11-50	Middle Pal., Neo., Iron Age	1	<50
DQM19	lithics	19.62214	57.57257	200	11-50	Late Pal.	2	>400
DQM20	lithics	19.61743	57.57114	20	4-10	Late Pal.	3	>400
DQM21	lithics, structures, grave	19.61471	57.57154	30	4-10	Middle Pal., Neolithic	1	<50
DQM22	lithics	19.61173	57.56966	?	0-3	Lower Pal., non-diag. Holocene	4	>400
DQM23	lithics	19.60331	57.56762	30	4-10	Lower Pal., non-diag. Holocene	3	250
DQM24	lithics, structures, hearths	19.58807	57.57014	30	11-50	non-diag. Holocene	1	<50

A total of 24 archaeological sites were identified, labelled DQM01 to DQM24. The locations of these sites are shown in maps Figure 2-2 and Appendix A. Table 4-1 provides the coordinates, description, mitigation rank, and mitigation strategy for each site. Appendix B includes the survey forms upon which individual site data were recorded in the field. Figures 15 to 83 are photographs of the site landscapes and associated artifacts.

Nine of the sites (DQM05, DQM09-11, DQM15, DQM17-DQM18, DQM21, and DQM24) are situated within 100m of the development corridor and require specific action described in Section 6 below. The landscapes around the Port, the worker's camps, and the Refinery have already been so heavily altered by construction activities that traces of potential archaeology have been erased. No mitigation strategy is required within these zones (Figure 2.2). Although the coordinates are undocumented, archaeological surveyors observed some areas along the northern section of the transect where bulldozers already excavated the landscape and removed potential archaeological sites prior to survey (Figure 84 and 85).

Most archaeological sites mapped during the survey were found in association with naturally occurring conchoidal stone outcrops of chert, flint, quartz, and quartzite (e.g. Figures 11 - 14). These lithic (stone tool) raw material sources were visited repeatedly throughout multiple phases of prehistory and can be easily identified by the abundant vestiges of chipped stone debris littering the landscape surfaces around the outcrops. The majority of lithic sites were found in the northwestern part of the survey area, where the pipeline cuts across an undulating Quaternary alluvial plain that is dissected by a series of seaward streaming wadis. Along this actively eroding landscape, a variety of raw materials are present and were utilized for tool production by early humans and other hominid groups since the Lower Palaeolithic.

Three sites (DQM03, DQM22, DQM23) bear evidence for Lower Palaeolithic archaeological remains, including artefacts belonging to a weathered Kombewa flake technology at DQM03 and DQM22, and a weathered handaxe collected at DQM 23 (Figure 81). There are fleeting examples of Middle Palaeolithic cores (DQM13, DQM18, DQM21), however, they have no consistent presence at any one site. Most lithic scatters are attributed to the Late Palaeolithic (13,000 - 8,000 bp) and Neolithic (8,000 - 6,000 bp) periods, which are often difficult to distinguish from one another in this region. It is noteworthy that the majority of the archaeological sites around Duqm seem to coincide with a period of improved environmental conditions during the Holocene, which reached peak rainfall between approximately 10,000 and 6,000 bp (e.g., Fleitmann & Matter, 2009; Preston et al., 2015; Engel et al., 2016).

Architectural structures were mapped at sites DQM07-11, DQM15, DQM18, DQM21, and DQM24, including circular stone cairns, stone fireplaces, circular stone houses, large anchor stones (perhaps for tent poles or livestock enclosures), and a trilith feature. With the exception of DQM07 and DQM08, all of these standing structures are located within 100m of the development corridor and require mitigation suggested below in Section 6. While most of these structural features are non-diagnostic of a specific time period, we can surmise that they post-date the Palaeolithic periods and are the remains of human occupation after 8,000 years ago. The stone cairns likely fall between the Bronze and Iron Ages (5,000 - 2,500 bp). The trilith found at DQM18 (Figures 60 - 62) can be dated to the late Iron Age between approximately 2,500 and 1,500 years ago (Bin 'Aqil & McCorriston 2009).

5 GEOLOGICAL SITES

Table 5-1: Locations of geological interest

SITE REFERENCE	LAT	LONG	ELEVATION	DESCRIPTION	MITIGATION RANK
	(n)	(e)	(masl)		
DQM-Spring 1	19.67704	57.57364	56	Active artesian spring system	3
DQM-Spring 2	19.65836	57.57570	45	Active artesian spring system	3
DQM-GEO-1	19.59066	57.60314	47	Fossil-rich limestone beds	3
DQM-Salt Spring	19.69313	57.64155	30	Hyperalkaline spring heads	3

There are four locations considered to be of potential geological interest (Appendix A): the fossil outcrops, active hyperalkaline spring heads north of Duqm, and artesian springs on the edge of the escarpment (Table 5-1). These loci are unique geological features on the landscapes around Duqm. The limestone fossil beds (Figures 2 to 5) are located east of the pipeline and stretch for approximately five square kilometres around GPS waypoint DQM-GEO 1. The salt domes in the northeast of the survey area (Figure 6 to 9) are active spring heads where mineral rich, saline waters emerge from the underlying sediments. The area around the springs has already been heavily disturbed by various construction projects. On the western side of the survey area, at the foot of the limestone plateau, a series of artesian spring systems were observed (Figure 10). While only one findspot (DQM16) has associated artefacts, the available freshwater from springs along the escarpment makes this a zone of archaeological interest for future research.

6 MITIGATION STRATEGIES

Sites designated as **Mitigation Rank #4** (9) are either isolated surface finds or are of minimal scientific value; therefore, these do not require any special action at this time (DQM02-04, DQM06, DQM12-14, DQM16, DQM22).

Mitigation Rank #3 sites (4), including DQM01, DQM19, DQM20, and DQM23 are lithic findspots more than 100m away from the impact zone. Bulldozing directly on these location should be avoided, but no other action is required.

Mitigation Rank #2 sites (2) include DQM05 and DQM17. These are lithic artefact scatters found in situ, which have scientific value for further study. Bulldozing and driving over these sites should be avoided. Both are located within 50m of the development corridor; therefore, it is recommended that a systematic collection of lithic artefacts should first be taken from these findspot to mitigate the loss of archaeological data. This should be done in conjunction with the Ministry of Culture and Heritage and SEZAD.

Mitigation Rank #1 sites (9) include all of those with stone structures and other standing architectural features: DQM07-DQM11, DQM15, DQM18, DQM21, and DQM24. These features are an indelible part of Oman's heritage landscapes and should be preserved wherever possible. In addition to the trilith architectural feature at DQM 18, there is a clearly delimited lithic scatter associated with it. This diagnostic Iron Age site has considerable value to Oman's heritage. In this case, it is recommended to assess the site further in coordiation with SEZAD and the Ministry of Heritage and Culture along wih a heritage specialist. With the exception of DQM07 and DQM08, all other findspots with structures are within 100m of the development corridor and should be entered into Project mapping and delineated with survey stakes to restrict all access.

Overall, the Duqm pipeline archaeological survey has documented areas of potential geological interest, lithic surface scatters, and architectural features indicating that this area was intermittently occupied during the Lower Palaeolithic (1.5 million - 300,000 bp), Middle Palaeolithic (300,000 - 40,000 bp), Late Palaeolithic (13,000 - 8,000 bp), Neolithic (8,000 - 6,000 bp), Bronze (5,000 - 3,500 bp), and Iron Ages (2,500 - 1,500 bp). Some of these sites have value in the development of heritage tourism and for scientific study. Within the Duqm area, SEZAD is the authority on environmental matters. SEZAD have adopted MECA Guidelines for Environmental Impact Assessment, which includes geological assets (including fossils) within the range of resources that are to be assessed. The springs in question are hyper-saline and are therefore not exploitable as water resources and are of less concern or interest to the Directorate of Water Resources in the Ministry of Regional Municipalities and Water Resources. However, around these springs evidence of offerings (clothing, food items) which therefore increase their sensitivity. Sites DQM02-04, DQM06, DQM12-14, DQM16, DQM22 have minimal scientific or heritage value and no action is required. Sites DQM01, DQM19, DQM20, and DQM23 are lithic scatters outside the development area, where bulldozing should be avoided. Sites DQM07-11, DQM15, DQM18, DQM21, and DQM24 have standing architectural features. With the exception of DQM07 and DQM08, which are more than 100m away from the impact zone, these architectural features should be cordoned off with survey flags to avoid disturbance. Sites DQM05 and DQM17 are lithic scatters located within the impact zone. It is recommended that a systematic collection of artefacts be sampled from these sites prior to landscape development. Site DQM18 has both a significant late Iron Age architectural feature and a scientifically important lithic scatter associated with it; it is suggested to assess the site further in coordination with SEZAD and the Ministry of Heritage and Culture along with a heritage specialist.

Table 6-1, below, provides a list of each site along with rank and proposed mitigation strategy.

Table 6-1: Site ID, including rank and proposed mitigation strategy

Site #	Site Features	Lat (n)	Long (e)	Elevation (masl)	Size (sq m)	Density (artifacts / sq m)	Time Period(s)	Mitigation Rank	Distance to Development Corridor (m)	Mitigation Strategy
DQM01	lithics	19.59091	57.56823	82	100	4-10	Late Pal., Neolithic	3	170	avoid bulldozing
DQM02	lithics	19.58927	57.56620	74	60	0-3	non-diag. Holocene	4	360	no action required
DQM03	lithics	19.57980	57.56984	70	n/a	isolated	Lower Pal.	4	>400	no action required
DQM04	lithics	19.56423	57.56656	78	?	0-3	non-diag. Holocene	4	>400	no action required
DQM05	lithics	19.55364	57.56948	93	?	4-10	non-diag. Holocene	3	50	systematic artefact collection
DQM06	lithics	19.57122	57.56927	78	n/a	isolated	non-diag. Holocene	4	>400	no action required
DQM07	lithics, structures	19.54445	57.57032	87	?	0-3	Neolithic, Bronze/Iron Age	1	130	structures cordoned off
DQM08	lithics, hearth, shells	19.54457	57.57009	86	25	11-50	Neolithic, Bronze/Iron Age	1	130	structures cordoned off
DQM09	stone cairn(s)	19.51266	57.56126	93	n/a	n/a	Bronze/Iron Age	1	<50	structures cordoned off
DQM10	stone cairn(s)	19.51205	57.56125	87	n/a	n/a	Bronze/Iron Age	1	<50	structures cordoned off
DQM11	stone cairn(s)	19.49571	57.56743	107	n/a	n/a	Bronze/Iron Age	1	<50	structures cordoned off
DQM12	lithics, hearth	19.43329	57.58154	103	10	0-3	Late Pal.	4	>400	no action required
DQM13	lithics	19.32171	57.60125	99	n/a	isolated	Middle Pal.	4	>400	no action required
DQM14	lithics	19.31081	57.60460	88	n/a	isolated	non-diag. Holocene	4	>400	no action required
DQM15	lithics, structures, shells	19.17716	57.74119	96	?	4-10	non-diag. Holocene	1	<50	structures cordoned off
DQM16	lithics	19.65763	57.57535	34	n/a	isolated	non-diag. Holocene	4	>400	no action required
DQM17	lithics	19.62802	57.57809	59	30	11-50	Late Pal., Neolithic	2	<50	systematic artefact collection
DQM18	lithics, Trilith	19.62568	57.57666	57	40	11-50	Middle Pal., Neo., Iron Age	1	<50	assess further with design details
DQM19	lithics	19.62214	57.57257	62	200	11-50	Late Pal.	2	>400	systematic artefact collection
DQM20	lithics	19.61743	57.57114	66	20	4-10	Late Pal.	3	>400	avoid bulldozing
DQM21	lithics, structures, grave	19.61471	57.57154	65	30	4-10	Middle Pal., Neolithic	1	<50	structures cordoned off
DQM22	lithics	19.61173	57.56966	64	?	0-3	Lower Pal., non-diag. Holocene	4	>400	No action required
DQM23	lithics	19.60331	57.56762	70	30	4-10	Lower Pal., non-diag. Holocene	3	250	avoid bulldozing
DQM24	lithics, structures, hearths	19.58807	57.57014	68	30	11-50	non-diag. Holocene	1	<50	structures cordoned off

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Appendix A

ARCHAEOLOGICAL AND GEOLOGICAL FINDSPOTS DOCUMENTED DURING SURVEY

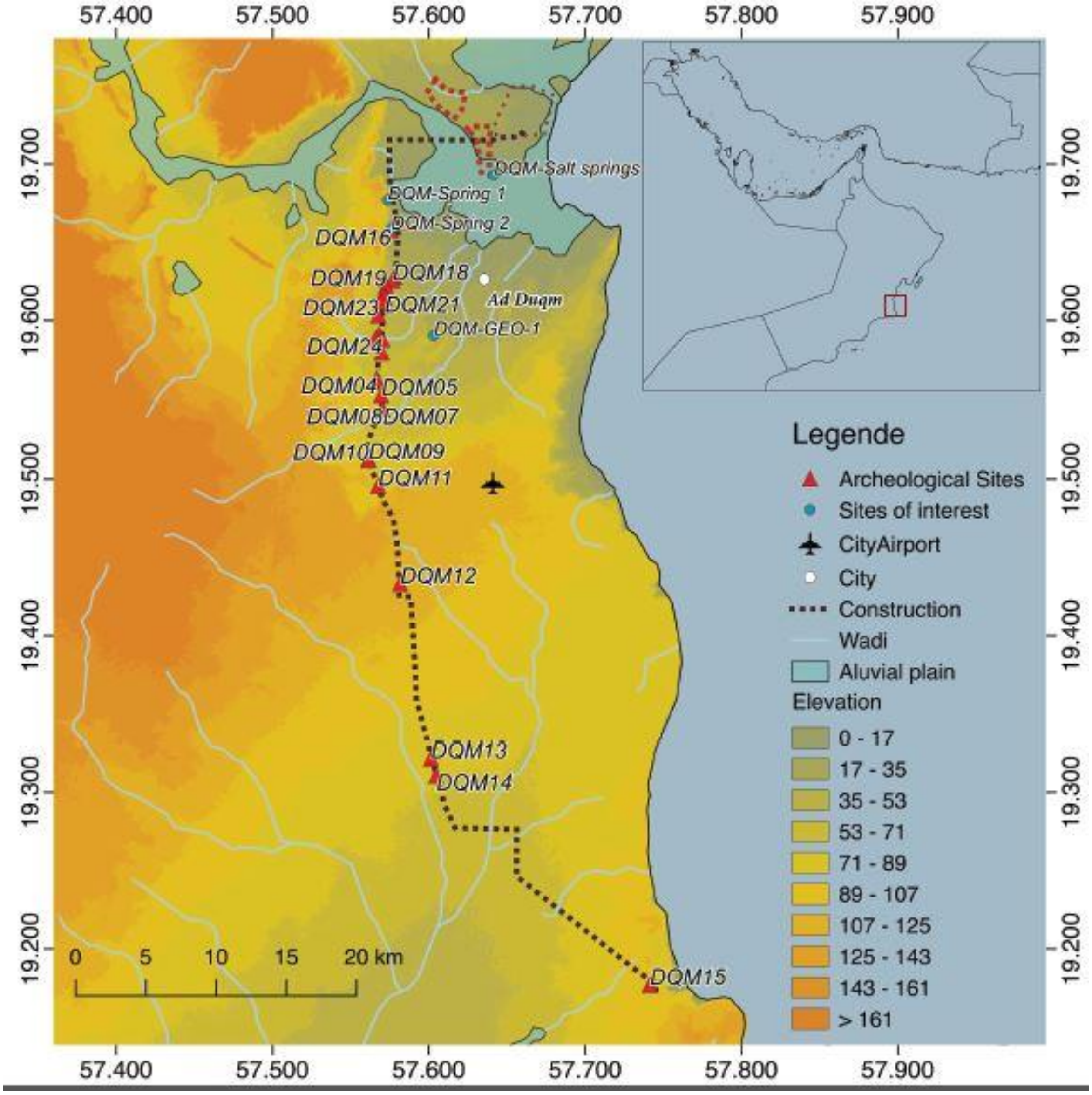

Figure 1 - Map showing location of archaeological and geological findspots documented during survey

Appendix B

ARCHAEOLOGICAL SITE CATALOGUE

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017
time point was taken 16:47

DQM **01**

feature: JEBEL TOP

site ◉ lithic ○ other

LOCALISATION

GPS N 19,590911 GPS E 57,568225

Altitude 82 m.

Topography: The site is located on a plaine disected by gullys and covered by sparse vegetation

General aspect: low density site at raw material outcrop, possibly multiple occupations

Structure ● lithic ○ other

Type str.

Proximity

SITE

State of preservation of site: eroded

Industry position: surface

Density: low

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☒ 4-10 ☐ 51-100 ☐ isolated find

Surface of site: 20 x50

Explored surface:

Potentiality of site: intermediate

PERIOD(S)
☐ Lower Pal.
☐ Middle Pal.
☒ Late Pal.
☐ Neolithic
☐ Mid Holocene
☐ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☒ weathered ☒ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☒ interm. ☐ big

Types of artifacts

☒ flakes	☐ levallois recurent cores	☒ bifaces
☒ blades	☐ levallois preferential cores	☐ thin bifacial pieces
☐ bladelets	☐ nubian levallois cores	☐ pressure made bifacial
☐ levallois flakes	☐ bidirectional cores (flake)	☐ arrowheads
☐ levallois points	☐ bidirectional core (blade)	
☒ single plat. unid. cores (flake)	☐ discoidal cores	
☐ single plat. unid. cores (blade)	☒ tools	
☐ single plat (narrow)	☒ retouched flakes	
☒ multi plat. cores	☐ hand axes	

Preliminary observations on material: Material found on slope and on top of low limestone remnant close to wadi tools include notches and scrapers. Biface with thin crosssectionaand bipointed shape was also found.

MITIGATION STRATEGY: ***DQM01 is a 170 meters west of the pipeline. stay clear of site.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017 | time point was taken 17:10

DQM 02 | feature: JEBEL TOP | site: ◉ lithic ○ other

LOCALISATION

Altitude 74 m. | GPS N 19,589270 | GPS E 57,566203

Topography: On a 3 meter high and eroded limestone inselberg

General aspect: stone tools artifacts around the elevetaion and on tow of the elevation

Structure: ○ lithic ○ other

Type str.:

Proximity:

SITE

State of preservation of site: eroded

Industry position: surface

Density: low

Quantity by m²: ☒ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find

Surface of site: 60 sqm

Explored surface:

Potentiality of site: bad

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☒ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☒ interm. ☐ big

Types of artifacts:

☒ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☐ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☒ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☒ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: Multiple platform cores and some indicsation of bifacial production. retouched tools include ad-hoc tools made on flakes.

MITIGATION STRATEGY: ***DQM02 is a 360 meters west of the pipeline. stay clear of site.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017 | time point was taken 17:27

DQM 03 | feature: EROSIONAL TERRACE | site: ◉ lithic ○ other

LOCALISATION

Altitude 70 m. | GPS N 19,579801 | GPS E 57,569840

Topography: large wadi crossing. deeply incised 4 to 6 meter high erosional terace

General aspect: isolated artifacts on teh edges of the terrace

Structure: ○ lithic ○ other

Type str.:

Proximity:

SITE

State of preservation of site: eroded

Industry position: surface

Density: low

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☒ isolated find

Surface of site:

Explored surface:

Potentiality of site: none

PERIOD(S): ☒ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☐ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☒ close to site ☐ far from site ☐ no RM on site

State of raw material: ☒ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☒ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:

☒ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☐ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☐ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: some very weathered flakes with large pain points of percusion. Undiagnostic but concideing the weathering is likely to be very old, maybe Lower Paleolithic

MITIGATION STRATEGY: ***The site is not in primary condition and has litle potential for further studie. the trajectoy of the pipeline does not need to be altered.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017
time point was taken 17:57

DQM 04

feature JEBEL TOP

site ◉ lithic ○ other

LOCALISATION

GPS N 19,564225 GPS E 57,566557

Altitude 78 m.

Topography: low limestone hill chaine on the edges of teh limetone plateau

General aspect: the area around teh site is covered by sediments.

Structure ○ lithic ○ other
Type str.
Proximity

SITE

State of preservation of site: eroded
Industry position: surface
Density: low
Quantity by m²: ☒ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find

Surface of site:
Explored surface:
Potentiality of site: intermediate

PERIOD(S)
☐ Lower Pal.
☐ Middle Pal.
☐ Late Pal.
☐ Neolithic
☐ Mid Holocene
☒ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site
State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☐ fresh
Type raw material: ☐ chert ☐ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☒ other ☐ chert (red) ☒ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts
☒ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☒ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☒ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: likely a middle Holocene (6000 to 4000 years BP) stone workshop site. Different raw materials at the site, may indicated trade routs and long distance transport of stone tools.

MITIGATION STRATEGY: ***The low density of the site makes it hard to classify chronologically. further work at this location may help but the information potention of this particula surface scater is small. No action is suggested***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017
time point was taken 18:10

DQM 05

feature JEBEL TOP

site ◉ lithic ○ other

LOCALISATION

GPS N 19,553644 GPS E 57,569482

Altitude 93 m.

Topography: eroded dolomite rock desert with limestone hills and alluvial plains filled with sediment

General aspect: flat hiltop with differently weathered artifacts

Structure ○ lithic ○ other
Type str.
Proximity

SITE

State of preservation of site: eroded
Industry position: surface
Density: medium
Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☒ 4-10 ☐ 51-100 ☐ isolated find

Surface of site:
Explored surface:
Potentiality of site: bad

PERIOD(S)
☐ Lower Pal.
☐ Middle Pal.
☐ Late Pal.
☐ Neolithic
☐ Mid Holocene
☒ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site
State of raw material: ☐ higly weathered ☒ weathered ☒ lightly weathered ☐ fresh
Type raw material: ☐ chert ☒ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☒ interm. ☐ big

Types of artifacts
☒ flakes
☒ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☒ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☒ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☒ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: artifacts and geofacts mixed together on a large suface, knaping zones are not detectable and stone tool production waste is evenly distributed across the sites surface.

MITIGATION STRATEGY: ***The pipeline pases by aproximatly 50 meters close to the site. it is sugested to stay clear of the site if possible.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 24.04.2017

time point was taken 17:41

DQM 06

feature: EROSIONAL TERRACE

site: ◉ lithic ○ other

LOCALISATION

GPS N 19.571223 GPS E 57.569271

Altitude 78 m.

Topography aluvial terrace at the foot of a low hill chaine

General aspect

Structure ○ lithic ○ other

Type str.

Proximity

SITE

State of preservation of site: eroded

Industry position: surface

Density

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☒ isolated find

Surface of site:

Explored surface:

Potentiality of site: bad

PERIOD(S)

- ☐ Lower Pal.
- ☐ Middle Pal.
- ☐ Late Pal.
- ☐ Neolithic
- ☐ Mid Holocene
- ☒ Unknown

RAW MATERIAL

Present at site: ☐ on site ☒ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☒ fresh

Type raw material: ☒ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts

- ☒ flakes
- ☐ blades
- ☐ bladelets
- ☐ levallois flakes
- ☐ levallois points
- ☐ single plat. unid. cores (flake)
- ☐ single plat. unid. cores (blade)
- ☐ single plat (narrow)
- ☒ multi plat. cores
- ☐ levallois recurent cores
- ☐ levallois preferential cores
- ☐ nubian levallois cores
- ☐ bidirectional cores (flake)
- ☐ bidirectional core (blade)
- ☐ discoidal cores
- ☐ tools
- ☐ retouched flakes
- ☐ hand axes
- ☐ bifaces
- ☐ thin bifacial pieces
- ☐ pressure made bifacial
- ☐ arrowheads

Preliminary observations on material: undiagnostic flakes and stone tool production debries. early stage.

MITIGATION STRATEGY: ***The pipeline bypasses the site. No danger for the archaeology here.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 25.04.2017
time point was taken 9:06

DQM 07 — feature: JEBEL TOP — site: ◉ lithic ○ other

LOCALISATION

GPS N 19.544445 — GPS E 57.570318

Altitude 87 m.

Topography: limestone boulders on top of the plain overlooking a drainage system

General aspect: wide circular bee hive graves and dispersed lithic material

Structure: ● lithic ○ other
Type str.: 4 circular structurs
Proximity: close

SITE

State of preservation of site: eroded
Industry position: surface
Density: low
Quantity by m²: ☒ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site:
Explored surface:
Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☒ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☒ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☒ fresh

Type raw material: ☒ chert ☒ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:

☒ flakes ☒ blades ☐ bladelets ☐ levallois flakes ☐ levallois points ☐ single plat. unid. cores (flake) ☐ single plat. unid. cores (blade) ☐ single plat (narrow) ☒ multi plat. cores

☐ levallois recurent cores ☐ levallois preferential cores ☐ nubian levallois cores ☐ bidirectional cores (flake) ☐ bidirectional core (blade) ☐ discoidal cores ☐ tools ☐ retouched flakes ☐ hand axes

☒ bifaces ☐ thin bifacial pieces ☐ pressure made bifacial ☐ arrowheads

Preliminary observations on material: some bifacial technology using soft hammer percusion, a lot of production waste was found.

MITIGATION STRATEGY: ***the site is located 130 meters to the east of the pipeline. If no incursions from the construction of the pipeline ocure the site will remain safe.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 25.04.2017
time point was taken 9:17

DQM 08 — feature: JEBEL FOOT — site: ◉ lithic ○ other

LOCALISATION

GPS N 19.544573 — GPS E 57.570089

Altitude 86 m.

Topography: depresion between hill

General aspect: structures are found hugging the side walls of the canyon for wind cover

Structure: ● lithic ○ other
Type str.: round stone buildings 3 m
Proximity: close

SITE

State of preservation of site: moderately preserved
Industry position: surface
Density: high
Quantity by m²: ☐ 0-3 ☒ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site: 5 x 5
Explored surface: total
Potentiality of site: good

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☒ Neolithic ☐ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☒ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☒ chert (grey) ☐ quartzite ☒ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:

☒ flakes ☐ blades ☐ bladelets ☐ levallois flakes ☐ levallois points ☐ single plat. unid. cores (flake) ☐ single plat. unid. cores (blade) ☐ single plat (narrow) ☐ multi plat. cores

☐ levallois recurent cores ☐ levallois preferential cores ☐ nubian levallois cores ☐ bidirectional cores (flake) ☐ bidirectional core (blade) ☐ discoidal cores ☐ tools ☐ retouched flakes ☐ hand axes

☐ bifaces ☒ thin bifacial pieces ☒ pressure made bifacial ☒ arrowheads

Preliminary observations on material: Well made presure flakes thin arrowheads, aproximatly 6000 to 5000 years old. Signs of fire indicated the area was used as a camp site. Sea shells have also been found.

MITIGATION STRATEGY: ***site with good potential for further work. same as DQM07***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 25.04.2017
time point was taken: 10:03

DQM 09 — feature: JEBEL TOP — site: ○ lithic ◉ other

LOCALISATION

GPS N: 19.512662 — GPS E: 57.561263

Altitude: 93 m.

Topography: low bio clastic limestone terrace amidsplain

General aspect: just the grave

Structure: ◉ lithic ○ other
Type str.: smal 150 cm circular grave
Proximity: close

SITE

State of preservation of site: well preserved
Industry position Density: surface

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find

Surface of site:
Explored surface:
Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☐ Mid Holocene ☒ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☒ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☐ interm. ☐ big

Types of artifacts:
☐ flakes ☐ blades ☐ bladelets ☐ levallois flakes ☐ levallois points ☐ single plat. unid. cores (flake) ☐ single plat. unid. cores (blade) ☐ single plat (narrow) ☐ multi plat. cores
☐ levallois recurent cores ☐ levallois preferential cores ☐ nubian levallois cores ☐ bidirectional cores (flake) ☐ bidirectional core (blade) ☐ discoidal cores ☐ tools ☐ retouched flakes ☐ hand axes
☐ bifaces ☐ thin bifacial pieces ☐ pressure made bifacial ☐ arrowheads

Preliminary observations on material: just grave no othr archaeological material

MITIGATION STRATEGY: ***One of teh graves remains undisturbed. Try stayng clear of this erosive landscape and move the pipelien further west, across a fluvial plain, which is softer to dig that limestone.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 25.04.2017
time point was taken: 10:11

DQM 10 — feature: JEBEL TOP — site: ○ lithic ◉ other

LOCALISATION

GPS N: 19.512052 — GPS E: 57.561247

Altitude: 87 m.

Topography: same as dqm09

General aspect: preserved grave no lithics on terrace amids alluvial plain

Structure: ◉ lithic ○ other
Type str.: grave
Proximity:

SITE

State of preservation of site: well preserved
Industry position Density: surface

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find

Surface of site:
Explored surface:
Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☐ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☐ interm. ☐ big

Types of artifacts:
☐ flakes ☐ blades ☐ bladelets ☐ levallois flakes ☐ levallois points ☐ single plat. unid. cores (flake) ☐ single plat. unid. cores (blade) ☐ single plat (narrow) ☐ multi plat. cores
☐ levallois recurent cores ☐ levallois preferential cores ☐ nubian levallois cores ☐ bidirectional cores (flake) ☐ bidirectional core (blade) ☐ discoidal cores ☐ tools ☐ retouched flakes ☐ hand axes
☐ bifaces ☐ thin bifacial pieces ☐ pressure made bifacial ☐ arrowheads

Preliminary observations on material: A two meter wide circular structure, possibly a mid Holocene grave.

MITIGATION STRATEGY: ***same as DQM09***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 25.04.2017
time point was taken: 10:27

DQM 11 — feature: JEBEL TOP — site: ○ lithic ◉ other

LOCALISATION

GPS N: 19.495709 — GPS E: 57.567428

Altitude: 107 m.

Topography: terrace chaine Dwight of pipe line

General aspect: three graves on top and one on the foot of the terrace

Structure: ◉ lithic ○ other
Type str.: circular graves
Proximity:

SITE

State of preservation of site: well preserved
Industry position: other
Density:
Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site:
Explored surface:
Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☒ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☒ no RM on site
State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh
Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☐ interm. ☐ big

Types of artifacts:
☐ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☐ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☐ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: just graves no lithics

MITIGATION STRATEGY: ***same as DQM09***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 25.04.2017
time point was taken: 11:45

DQM 12 — feature: EROSIONAL TERRACE — site: ◉ lithic ○ other

LOCALISATION

GPS N: 19.433292 — GPS E: 57.581544

Altitude: 103 m.

Topography: low limestone terrace, 1 meter above plain dissected be small wadis

General aspect: the area around teh site is covered by sediments and vegetation

Structure: ◉ lithic ○ other
Type str.: placed rocks for tent
Proximity:

SITE

State of preservation of site: eroded
Industry position: surface
Density: low
Quantity by m²: ☒ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site: 10 meter
Explored surface:
Potentiality of site: bad

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☒ Late Pal. ☐ Neolithic ☐ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☒ no RM on site
State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☒ fresh
Type raw material: ☐ chert ☒ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:
☒ flakes
☒ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☒ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☒ single plat (narrow)
☐ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: one flat bidirectional lateral core very fresh patina a stone set firaplace and some rocks for stabilazing he tent poles

MITIGATION STRATEGY: ***Site has little potential. No action is suggested***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 25.04.2017
time point was taken 12:46

DQM 13

feature: EROSIONAL TERRACE

site: ◉ lithic ○ other

LOCALISATION

Altitude 99 m.

GPS N 19.321708 GPS E 57.601246

Topography: Edge of erosional stone terrace on a wide aluvial plain

General aspect: Old expodes rocky surface

Structure: ○ lithic ○ other
Type str.:
Proximity:

SITE

State of preservation of site: eroded
Industry position Density: surface

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☒ isolated find

Surface of site:
Explored surface:
Potentiality of site: bad

PERIOD(S)
☐ Lower Pal.
☒ Middle Pal.
☐ Late Pal.
☐ Neolithic
☐ Mid Holocene
☐ Unknown

RAW MATERIAL

Present at site: ☐ on site ☒ close to site ☐ far from site ☐ no RM on site

State of raw material: ☒ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh

Type raw material: ☐ chert ☒ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts

☐ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☐ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☐ multi plat. cores
☒ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: Very eroded flat radial core. raw material is very small and eroded one possible small flake as well.

MITIGATION STRATEGY: ***The site is too erodet. No action is suggested***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 25.04.2017
time point was taken 14:46

DQM 14

feature: JEBEL TOP

site: ◉ lithic ○ other

LOCALISATION

Altitude 88 m.

GPS N 19.310807 GPS E 57.604602

Topography: agregational of limestone rocks on the surface probably eroding bedrock.

General aspect: Surrounding characterized by plain filled with sediments and covered by sparse vegetation.

Structure: ○ lithic ○ other
Type str.:
Proximity:

SITE

State of preservation of site: eroded
Industry position Density: surface

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☒ isolated find

Surface of site: 20 sq
Explored surface:
Potentiality of site:

PERIOD(S)
☐ Lower Pal.
☐ Middle Pal.
☐ Late Pal.
☐ Neolithic
☐ Mid Holocene
☒ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☐ lightly weathered ☐ fresh

Type raw material: ☐ chert ☒ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☒ interm. ☐ big

Types of artifacts

☒ flakes
☐ blades
☐ bladelets
☐ levallois flakes
☐ levallois points
☐ single plat. unid. cores (flake)
☐ single plat. unid. cores (blade)
☐ single plat (narrow)
☐ multi plat. cores
☐ levallois recurent cores
☐ levallois preferential cores
☐ nubian levallois cores
☐ bidirectional cores (flake)
☐ bidirectional core (blade)
☐ discoidal cores
☐ tools
☐ retouched flakes
☐ hand axes
☐ bifaces
☐ thin bifacial pieces
☐ pressure made bifacial
☐ arrowheads

Preliminary observations on material: some isolated flakes, lightly weathered undiagnostic

MITIGATION STRATEGY: ***No action suggested.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 25.04.2017
time point was taken 16:32

DQM 15

feature: JEBEL FOOT

site ◉ lithic ○ other

LOCALISATION

GPS N **19.177162** GPS E **57.741193**

Altitude 96 m.

Topography: side and front of hill approximately 5 structures ranging in size

General aspect:

Structure ◉ lithic ○ other

Type str. circular structures

Proximity:

SITE

State of preservation of site: moderately preserved

Industry position: surface

Density: medium

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☒ 4-10 ☐ 51-100 ☐ isolated find

Surface of site:

Explored surface:

Potentiality of site: bad

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☐ Mid Holocene ☒ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☒ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☒ chert (grey) ☐ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:
- ☒ flakes
- ☐ blades
- ☐ bladelets
- ☐ levallois flakes
- ☐ levallois points
- ☐ single plat. unid. cores (flake)
- ☐ single plat. unid. cores (blade)
- ☐ single plat (narrow)
- ☒ multi plat. cores
- ☐ levallois recurent cores
- ☐ levallois preferential cores
- ☐ nubian levallois cores
- ☐ bidirectional cores (flake)
- ☐ bidirectional core (blade)
- ☐ discoidal cores
- ☐ tools
- ☐ retouched flakes
- ☐ hand axes
- ☐ bifaces
- ☐ thin bifacial pieces
- ☐ pressure made bifacial
- ☐ arrowheads

Preliminary observations on material: Some Shells and lithics found in small quantities within and suroundinhg teh circular structures on the edges of the limestone hill.

MITIGATION STRATEGY: ***the site is at teh edge of the crude oil storage facilities. stay clear of area.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey 26.04.2017
time point was taken 11:38

DQM 16

feature: WADI TERRACE

site ◉ lithic ○ other

LOCALISATION

GPS N **19.657632** GPS E **57.575345**

Altitude 34 m.

Topography: box canyon with active spring below.

General aspect: heavily eroded area with signs of recurrent spring activation

Structure ○ lithic ○ other

Type str.

Proximity:

SITE

State of preservation of site: eroded

Industry position: surface

Density:

Quantity by m²: ☐ 0-3 ☐ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☒ isolated find

Surface of site:

Explored surface:

Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☐ Late Pal. ☐ Neolithic ☐ Mid Holocene ☒ Unknown

RAW MATERIAL

Present at site: ☐ on site ☐ close to site ☐ far from site ☒ no RM on site

State of raw material: ☐ higly weathered ☐ weathered ☒ lightly weathered ☐ fresh

Type raw material: ☐ chert ☐ chert (orange) ☐ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☒ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☐ interm. ☐ big

Types of artifacts:
- ☐ flakes
- ☐ blades
- ☐ bladelets
- ☐ levallois flakes
- ☐ levallois points
- ☐ single plat. unid. cores (flake)
- ☐ single plat. unid. cores (blade)
- ☐ single plat (narrow)
- ☐ multi plat. cores
- ☐ levallois recurent cores
- ☐ levallois preferential cores
- ☐ nubian levallois cores
- ☐ bidirectional cores (flake)
- ☐ bidirectional core (blade)
- ☐ discoidal cores
- ☒ tools
- ☐ retouched flakes
- ☐ hand axes
- ☐ bifaces
- ☐ thin bifacial pieces
- ☐ pressure made bifacial
- ☐ arrowheads

Preliminary observations on material: unifacialy knaped piece, could be core. thin cutting edge with thick cortical back. most likely knife.

MITIGATION STRATEGY: ***No action required. site outside of range***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 26.04.2017
time point was taken: 12:30

DQM 17

feature: EROSIONAL TERRACE

site: ◉ lithic ○ other

LOCALISATION

Altitude: 59 m. GPS N: 19.628016 GPS E: 57.578093

Topography: on top and slope of erosional terrace containing different raw materials.

General aspect: Surface is covered by desert carpet that looks very stable and old.

Structure: ○ lithic ○ other
Type str.:
Proximity:

SITE

State of preservation of site: moderately preserved
Industry position: surface
Density: moderate
Quantity by m²: ☐ 0-3 ☒ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site: 30 sqm
Explored surface:
Potentiality of site:

PERIOD(S): ☐ Lower Pal. ☐ Middle Pal. ☒ Late Pal. ☐ Neolithic ☐ Mid Holocene ☐ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☒ weathered ☒ lightly weathered ☒ fresh

Type raw material: ☐ chert ☒ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☒ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☐ small ☐ interm. ☐ big

Types of artifacts:

☒ flakes	☐ levallois recurent cores	☒ bifaces
☒ blades	☐ levallois preferential cores	☐ thin bifacial pieces
☐ bladelets	☐ nubian levallois cores	☐ pressure made bifacial
☐ levallois flakes	☐ bidirectional cores (flake)	☐ arrowheads
☐ levallois points	☐ bidirectional core (blade)	
☒ single plat. unid. cores (flake)	☐ discoidal cores	
☒ single plat. unid. cores (blade)	☐ tools	
☒ single plat (narrow)	☐ retouched flakes	
☒ multi plat. cores	☐ hand axes	

Preliminary observations on material: tools include various scrapers, think bifaces, and a plane. Different artifacts some more weathered than others. Hard hammer percussion no faceted striking platforms on debitage.

MITIGATION STRATEGY: ***The pipe line cuts right across the site, which is very extensive and rich. moving the pipeline tragectory only 500 meters to the west would save DQM17 and the following site DQM18.***

Archaeological Site Catalogue for Ad Duqm - Dr. Y. Hilbert

date of survey: 26.04.2017
time point was taken: 14:20

DQM 18

feature: WADI TERRACE

site: ◉ lithic ○ other

LOCALISATION

Altitude: 57 m. GPS N: 19.625679 GPS E: 57.576663

Topography: 1 km east of the limestone clifs of the plateau on a wadi that cuts through aluvial sediments

General aspect: elevation above wadi terrace, triliths set amids stone workshop site

Structure: ◉ lithic ○ other
Type str.: triliths
Proximity: close

SITE

State of preservation of site: moderately preserved
Industry position: surface
Density: high
Quantity by m²: ☐ 0-3 ☒ 11-50 ☐ > 100 ☐ 4-10 ☐ 51-100 ☐ isolated find
Surface of site: 40 sqm
Explored surface:
Potentiality of site: good

PERIOD(S): ☐ Lower Pal. ☒ Middle Pal. ☐ Late Pal. ☐ Neolithic ☒ Mid Holocene ☒ Unknown

RAW MATERIAL

Present at site: ☒ on site ☐ close to site ☐ far from site ☐ no RM on site

State of raw material: ☐ higly weathered ☒ weathered ☐ lightly weathered ☒ fresh

Type raw material: ☒ chert ☒ chert (orange) ☒ chert (brown) ☐ quartzite (grey) ☐ other ☐ chert (red) ☐ chert (grey) ☒ quartzite ☐ quartzite (dark)

TECHNO-TYPOLOGY

General dimension of pieces: ☒ small ☒ interm. ☒ big

Types of artifacts:

☒ flakes	☒ levallois recurent cores	☐ bifaces
☒ blades	☐ levallois preferential cores	☒ thin bifacial pieces
☐ bladelets	☐ nubian levallois cores	☐ pressure made bifacial
☐ levallois flakes	☐ bidirectional cores (flake)	☐ arrowheads
☐ levallois points	☐ bidirectional core (blade)	
☐ single plat. unid. cores (flake)	☐ discoidal cores	
☐ single plat. unid. cores (blade)	☒ tools	
☐ single plat (narrow)	☐ retouched flakes	
☒ multi plat. cores	☐ hand axes	

Preliminary observations on material: Soft hammer percussion production of thin bipointed bifaces. Most pieces found on site were Brocken or at a early state of production. Three rows of thriliths, monuments of navigation during the caravane trades times. One possible Midde Paleolithic core.

MITIGATION STRATEGY: ***see DQM17. The site is worth protecting and should by avoided by the pipeline.***

Appendix C

SITE SURVEY FIGURES


Figure 2 - Fossil-rich beds at DQM-GEO1


Figure 4 - DQM-GEO1 siliceous spheroid limestone erosional features


Figure 9 – Hyper-alkaline water filling small excavation hole at the top of DQM-Salt Spring


Figure 13 - Natural chert nodule eroding from sediments around DQM-Spring 1


Figure 10 - Active spring head DQM-Spring 1 at the edge of the limestone plateau

Figure 14 - Alluvial sediments around DQM-Spring 1 containing chert and quartzite nodules in secondary position

Figure 15 - View of archaeological site DQM01

Figure 17 - Sample of lithic artefacts from DQM01 including bifacial tools, multiple platform cores, and waste flakes

Figure 18 - Bifacial tool from DQM01

Figure 20 - View of archaeological site DQM02

Figure 21 - Sample of lithic artefacts from DQM02 including retouched flakes, debitage, and cores

Figure 23 - Isolated lithic artefact from DQM03 is an old and very weathered flake, possible Lower Palaeolithic

Figure 24 - View of archaeological site DQM04

Figure 28 - View of DQM05 on surface of hill, overlooking alluvial plain

Figure 30 - Sample of lithics from DQM05; artefacts found on surface have different patina than those embedded within remnant, suggesting multiple phases of occupation or variable taphonomic processes

Figure 32 - Stone cairn from DQM07

Figure 37 - Circular structure 1 from DQM08