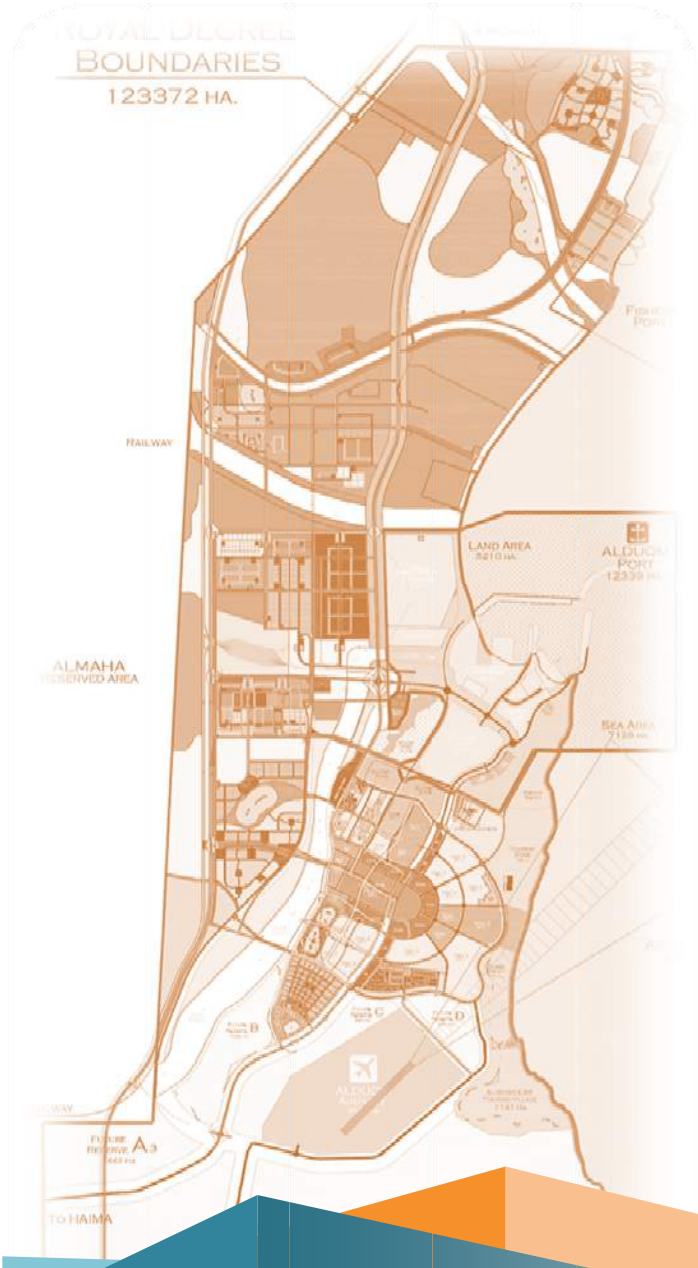

SULTANATE OF OMAN

الدقم
Duqm
هيئة المنطقة الاقتصادية الخاصة
Special Economic Zone Authority

TENDER NO. 1/2013

CONSULTANCY SERVICES FOR DESIGN AND SUPERVISION OF THE DUQM DEVELOPMENT DRAINAGE NETWORK AND PROTECTION SCHEMES – PHASE I
JURF DAM

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

RENARDET S.A. & PARTNERS
CONSULTING ENGINEERS L.L.C.

bonifica GROUP

JUNE 2015

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LIST OF ABBREVIATIONS

AE : Apparent endemic

BOQ : Bill of Quantities

BOD : Biological Oxygen Demand

CCEPP : Council for the Conservation of Environment and Prevention of Pollution

CO : Air Pollution by Carbon Monoxide Concentrations

COD : Chemical Oxygen Demand

DC : Diversion Channel

DDF : Dam Design Flood - Subject to Client approval and discussions

DE : Design Engineer

DGEA : Directorate General of Environmental Affairs

EIA : Environmental Impact Assessment

EIS : Environmental Impact Statement

EMP : Environmental Management Plan

EMC : Environmental Management Cell

EMS : Environmental Management System

ES : Environmental specifications

E&SU : Environmental and Social Unit

FR : Fragmented Population

FSL : (Full Supply Level): Subject to Client approval and discussions

SEL : Safety Evaluation Flood

SDF : Spillway Design Flood

PMF : flood - Subject to Client approval and discussions

GDP : Gross Domestic Product

HC : Air Pollution by Hydrocarbons Concentrations

H2S : Hydrogen Sulphide

IEE : Initial Environmental Evaluation

IDF : Intensity Duration Frequency

MDs : Ministerial Decisions

MECA : Ministry for Environment and Climate Affairs

MWL : Maximum water level in reservoir

mamsl : meters above mean sea level

MOCI : Ministry of Commerce and Industry

MOH : Ministry of Housing

MRM&WR: Ministry of Regional Municipalities and Water Resources

NAAQS : National Ambient Air Quality standards

NO_x : Air Pollution by Nitrogen Components Concentrations

NRs : Nature Reserves
PMF : Probable maximum flood
PM_{10} : Air Pollution Index
OR : Omani Rial
QA/QC : Quality Assurance and Quality Control Checks
RD : Royal Decree
RE : Resident Engineer
RGO : Regional Offices, Diwan's Offices
SEZAD : Duqm Authority
SC : Special Concern
SCTP : Supreme Committee for Town Planning
SOx : Air Pollution by Sulfur Components Concentrations
SRS : Standard Review Sheet
TA : Technical Assistant
TE : Trace Elements
TOR : Terms of Reference

1. INTRODUCTION

1.1 Background

The Special Economic Zone Authority for Duqm Project (SEZAD) appointed Renardet SA & Partners for the Consultancy services for feasibility and detailed design study of the Duqm Development Drainage Network and Protection Schemes for the free zone of Duqm located in Al Wusta Governorate of the Sultanate of Oman.

Duqm development undertakes the future construction of Modern Port & Dry Dock, International Airport, New Town complex, Industrial Areas, Fishing Harbor & Industry, Transport System, Power & Utilities and Tourism Zones (Hotels & Resorts).

The aim of the project is to provide a significant degree of flood protection to the free zone area under development. The construction of attenuation dams and flood conveyance channels is likely to form the principal components of such flood protection measures. The dam will be situated upstream of the target area and convey the remaining water safely through the development area. The following figure shows the approximate location of the project.

Within this Masterplan, preliminary calculations were done to obtain sizes of the dams and the channels. This initial dam designs performed in the previous study resulted in the positioning of 2 dams and 3 channels. This Environmental Impact Assessment concerns the Jurf dam, located in Wadi Jurf, in the city of Duqm in Al Wusta Governorate.

By RD 119/2011, SEZAD *enjoys juristic personality and shall be financially and administratively independent,* therefore is an autonomous authority and responsible for the approvals inside the designated area. Nevertheless, any project developed outside the SEZAD area must follow the MECAs' guidelines, therefore requiring an EIA study and approval from the Ministry of Environment and Climate Affairs before start up stage. Although the majority of the project lay down inside the SEZAD area, a small part of the Jurf Dam is located inside the Oryx Sanctuary Reserve and therefore an independent EIA study is presented bellow.

The study area is located within the Wadi Jurf in the Duqm city in Al Wusta Governorate.

Within the feasibility phase and hydrological assessment was carried out over the complete area and two dimensional models were established to show the effect of Jurf Dam implementation. Particular attention was paid to the land occupation within the SEZAD boundary. The hydrological model was adapted with right curve number in order to place our design on the safest side

The Consultant undertook a site investigation of the proposed dam site area as well as the surrounding environment to determine the impacts of the dam on the surrounding environment and foreseen future developments.

The general principle is to use the natural wadi channels as far as practically possible, bearing in mind the development plan. This minimise adverse environmental impacts in the first instance and reduce excavation quantities and associated costs.

Dam provided upstream of the development area reduces the flood peaks and volumes thereby reducing the need for wide channels. Optimisation of the entire project is required to ensure a balance exist between the cost of construction and the size of the respective dam.

The scope of works includes:

- Wadi Jurf Dam

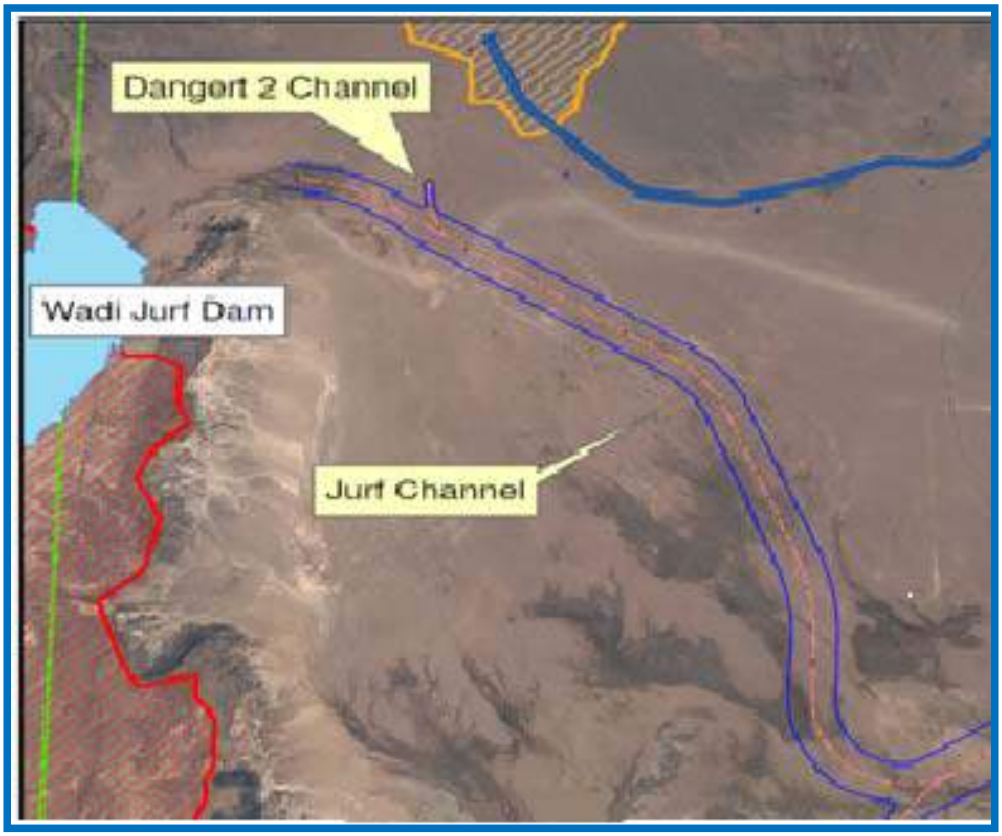


Figure 1-1: Flood Protection Scheme of the Project (including Jurf Dam)

Few livestock (camel, goats and sheep) are presently grazing the project area, since the wadi provides protection and food for some of these animals.

The natural habitats present in and around the project area are the below mentioned. These habitats will be preserved in the most possible way and mitigation measures are considered.

The habitats present in and around the Al Duqm town area can be broadly grouped into three main types:

- **Coastal habitats** and Sabkha (salt flats): these areas contain a mixture of wetlands (e.g. lagoons), very saline areas with little vegetation, and less saline areas with some vegetation. These habitats support internationally important species and, of the three main habitats, are the least common in the region

- **Wadis and gravel plains**: the water provided by wadis supports a diverse range of vegetation, typified locally by open acacia woodlands, low shrubs and ephemeral grasses. Wadis act as wildlife corridors, along which mammals and birds travel; and

- **Hills, slopes and escarpments**: these habitat types support the least vegetation and wildlife, although where water is retained in fissures and depressions, there is likely to be a higher density of vegetation.

These habitats shelter important protected species, such as the Arabian Oryx reserve, the bird area and the turtle nest area. Although, the project doesn't cross these areas, mitigation measures are contemplated, in order to no to disturb the natural habitat in the surrounding area of these important fauna nests.

- An Arabian Oryx reserve lies approximately 5km west of the proposed town. The reserve contains a diverse range of habitat types and supports numerous internationally/regionally important and rare species, including the Arabian Oryx. The site was included on UNESCOs World Heritage List in 1994 but became the first site to be deleted from this list in 2007, due to Oman's decision to reduce the area of the protected site by

90% and because of a decline in Oryx numbers due to poaching and habitat degradation; and

- Duqm Important Bird Area, designated in 2001, comprises the coastal and sabkha habitat immediately north of the proposed town, which has been recognized as an internationally important site for migratory birds. Unfortunately, completion of Al Duqm port development will destroy this site.
- Turtle Area, nesting aggregations of the endangered green and loggerhead turtles in the world. Sea turtles are among the oldest and most important marine animals in Omani waters.


The project doesn't predict the need of occupation of private residential areas, since there are no houses to be relocated from the dam axis, reservoir or from the wadi bed.

Nevertheless, there are a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the project area before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.

During construction, some temporary areas will be affected to establish campsites, deposit areas and even borrow areas. The contractor will settle 1 area to establish the campsite where the construction material and logistic will take place. It is suggested this campsite to be upstream of the dam and close as possible as to the main road, in a flat area, avoiding the occupation of other areas with no access built and improving response in case of any emergency situation.

Also during construction phase, the excavation activities may generate surplus of soil that will have use for the construction of dam. This excavation material will be stockpiled on a temporary area near the project in a flat area (300 000 m^3), avoiding being run off from water or wind. This temporary stockpiled area is allocated to the stock material that SEZAD may to use for their future projects needs.

At this stage of the project it is not possible to assume the exact amount of material to stockpile or to borrow as the size of the dam is still under approval of SEZAD, but the predictable

quantities for deposit area are of 300 000 m^2 downstream the Jurf dam. Once approved the dimension of the dam, the volume and the exact location of these area can be confirmed for the borrow areas, quarries and the deposit, but the contractor will need permission/ approval from SEZAD.

Part of the Oryx Sanctuary Reserve will be permanently affected by the Jurf dam reservoir at its full supply level within an approximated area of 526 345 m^2, as it is need to construct the dam axis and that will partially inundate the reserve when FSL is reached.

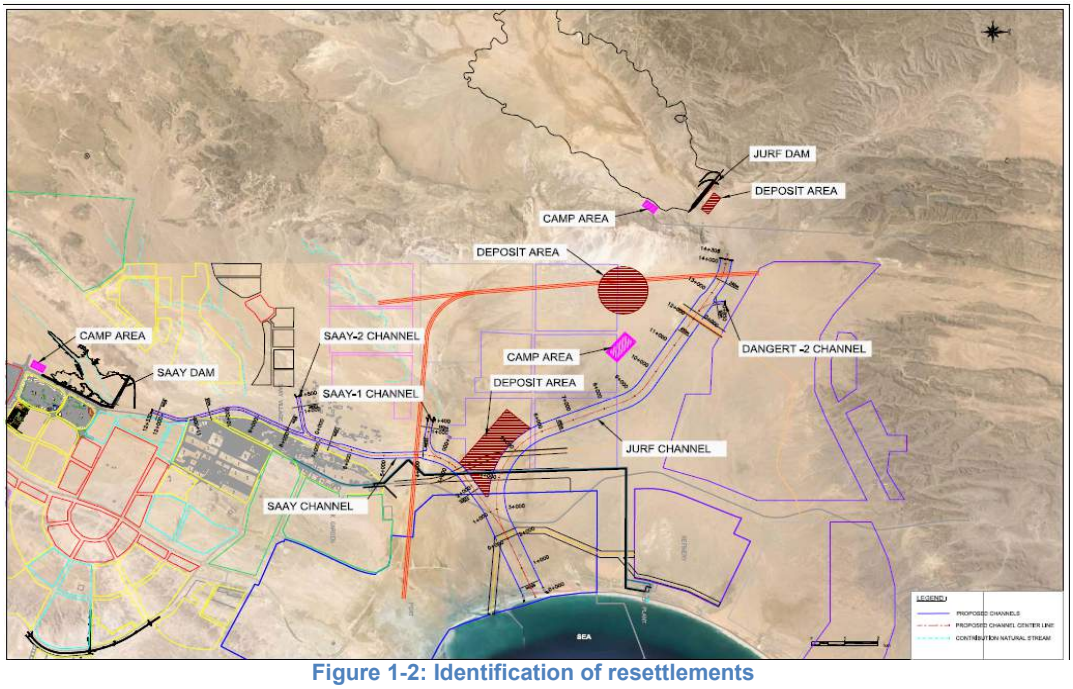


Figure 1-2: Identification of resettlements

There is no major air quality problem located in the project area as per the time being, since the study area is wide open, with natural habitats and absence of major air pollution sources, such as industry or big traffic roads.

The only concern is turned to the potential existence of H_2S at the Jurf dam axis area and this will be taken into consideration in the Environmental Management Plan and through the suggestion of preventive actions and mitigation measures. During geotechnical investigation H_2S was encountered in 2 boreholes. The realest of gas for the 1st borehole dissipated in hours and the 2nd in a few days indicating the gas reservoir are limited in size and not interconnected. A result of the geotechnical and geophysics investigation does not indicated any noticeable reservoir within the investigated area. In view of the above, we believe the H_2S within the foundation of the dam is limited in extend. Although we believe the H_2S is limited in extend, mitigation measure will be implemented during excavation to prevent hazardous to the life of humans, animal and flora in the site. In the meantime, water test are being performed in

laboratory to determine the presence of H_2S in its content and the results will be provided at the end of the stage.

Also, during construction, there would be temporary impact on the noise environment along the proposed dam due to excavation and material transport.

It is not anticipated that very toxic or hazardous materials will be used during this project. Fuel storage areas, if required, will be contained as required by law and solvents, paints and construction additives that may be toxic will be controlled in contained stores.

For the dam construction there are no borrow areas or quarries yet defined as the project studies don't allow at this stage to take any conclusion in this regard. Nevertheless, all the borrow areas to this project have to be requested and approved by SEZAD.

The current land use map shown below, indicates the developed within Duqm city. For the actual time, the area where the project of the proposed project is to be developed (Wadi Jurf) has no major occupation in terms of land use terminology. Some construction activities are in the on-going stage in the vicinity of the area and some small farms are visible along the project area on a small scale.

The bellow figure represents the adopted land use zoning for the entire Duqm Royal decree area as of September 2013.

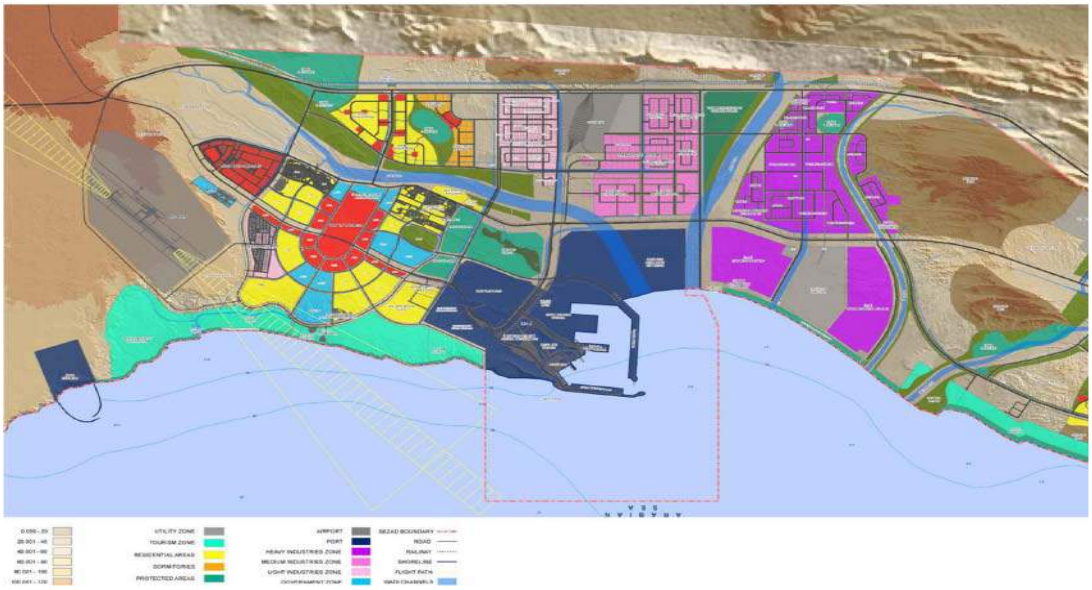


Figure 1-3: Land Use map approve by September 2013

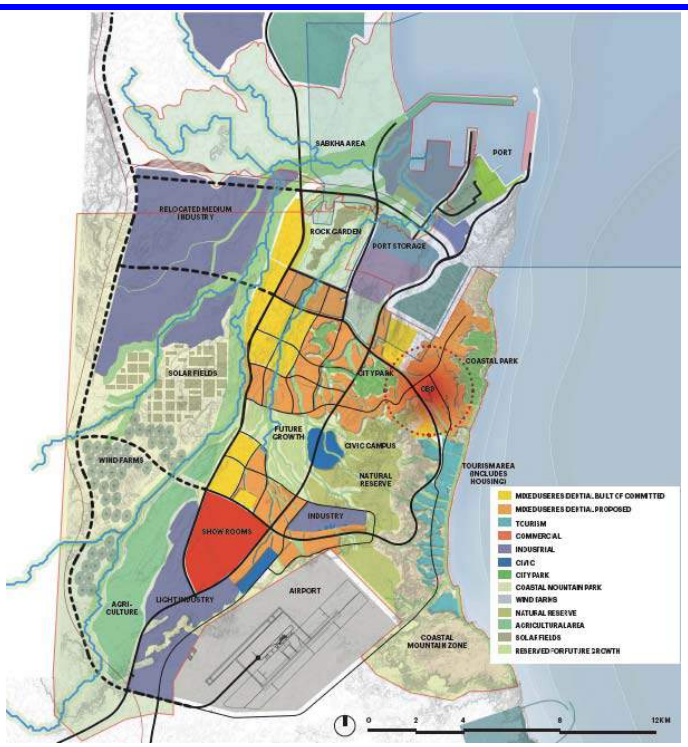


Figure 1-4: Land Use map approved by September 2013 – project developments

The project area, although is still untouched, will be subject to drastic changes within the future developments, highlighting the importance of building an dam capable of providing flood protection and natural drainage of the existing wadi.

In general, along the Jurf Dam there are no evidences of archeological or heritage traces. In these specific areas there is no presence of tombs, fossils or shells that normally are found in the region. Therefore, no archeological or heritage sites will disturbed by the project implementation.

Nevertheless, the project and the surrounding area of it seems to be a archeological and geological heritage key and there is a need to preserve as many of these sites from any potential damage, casual collection of fossil, rock and mineral specimens.

On approval of the final design report the Consultant will prepare Tender Documents for the construction of the Jurf dam. The Consultant will analyse the tenders, submit a tender report and based on the analysis recommend award of the tender. The appointment includes supervision of construction.

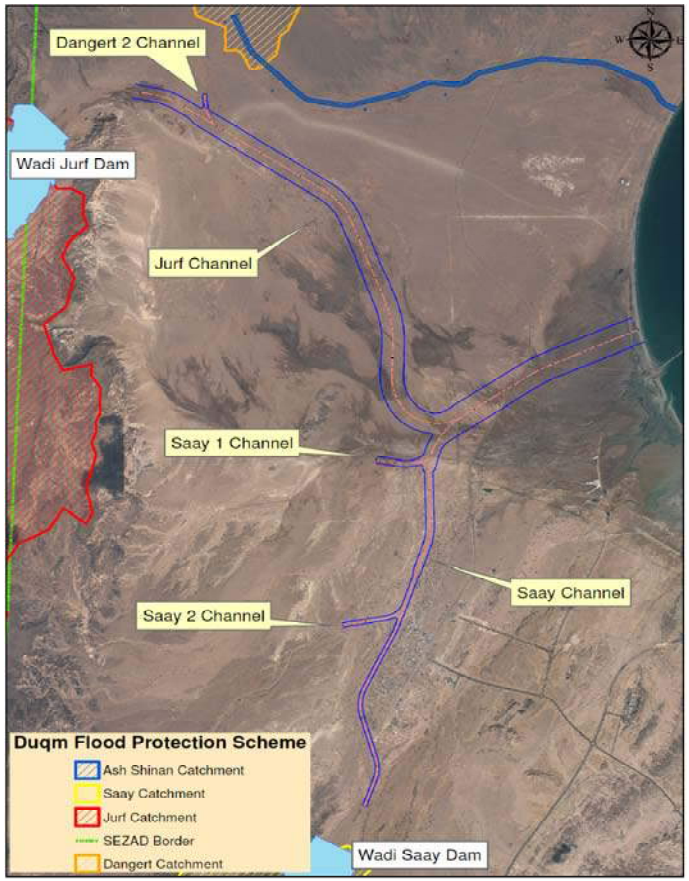
The overall assessment obtained from the investigation indicated that the project is environmentally feasible and substantial benefits are very likely to affect majority of the project environment in case of mitigation measures will be considered.

Adopted technology and design criteria ensure that no long-term negative impacts are to result from the development. Nevertheless, unavoidable minor negative impacts that are often associated with construction works should be expected and they are likely to result from excavation, transport and deposition of construction material. Such undesirable impacts are limited, and should be cleared upon the commissioning of the dam scheme.

The contractors will follow wide ranges of management and construction techniques and procedures to minimize and/or eliminate the pollution hazard; minimize visual intrusion and noise and air monitoring during construction by following the national recommendations; provide sanitation facilities and safeguard health of labourers and conduct environmental monitoring during and after construction for the concerned ecological element.

The satellite images below depict firstly the project area in relation to Duqm and secondly the general layout of the project works.

Figure 1-5: Project Area - Special Economic Zone at Duqm



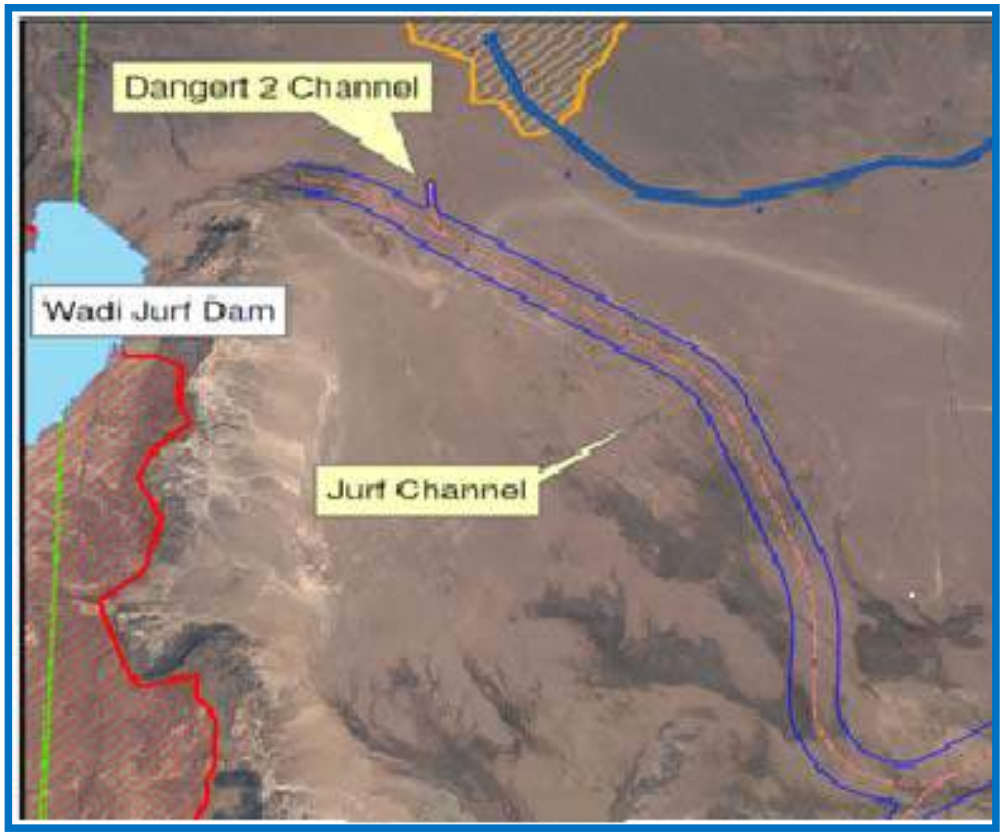


Figure 1-6: General Project Location

1.2 Environmental Impact Assessment Study Objective

The main objective of this environmental study is to furnish the appropriate information about the outcome and environmental impacts of this project so that decision-makers can take proper actions. Furthermore, the decision maker will want to know if the proposed project is likely to produce the stated results. A review of the natural process operating in the region is necessitated so that the project objectives are not in conflict with prevailing environmental scenario. The following objectives are to be considered:

1. Detailed statement of the significant both positive and negative environmental impacts during construction and operation of the proposed project that can affect the quality of life.
2. Suggestion of mitigation measures to enhance positive impacts and reduce negative impacts through compensation plans for the impacted areas, careful design, construction and operation of the project features.

1.3 Justification for Environmental Impact Assessment

EIA has become generally accepted worldwide as an essential procedure in initiating development projects and implementation of policies. The Environmental Impact Assessment (EIA) is an activity designed to identify and predict the impacts on the biogeochemical environment and on human health and well-being, of legislative proposals, policies, programs, projects, and operational procedures and to interpret and communicate information about impacts. An Environmental Impact Statement (EIS) is a public document written in a format specified by authorized national agencies (Ministry for Environment and Climate Affairs. In recognition of this, the Ministry for Environment and Climate Affairs (MECA) gives a list of all projects, which require EIA before they are implemented. Listed under flood protection and recharge dam project, the Interim Guideline on Environmental Impact Assessment draft version No.2 (6-6 -1999), are classified as Group 2 projects and require a detailed EIA study.

2 SCOPE OF METHODOLOGY AND ACTIVITIES

2.1 General Methodology

The study shall retain the basic premise of the TOR of the Duqm Development Drainage Network and Protection Schemes - Phase 1 and significantly expand the wide range of activities to be undertaken by the project technical team. The aim is to produce an Environmental Impact Assessment study incorporating environmental issues in conjunction with the project activities through three main elements as defined in the following Figure.

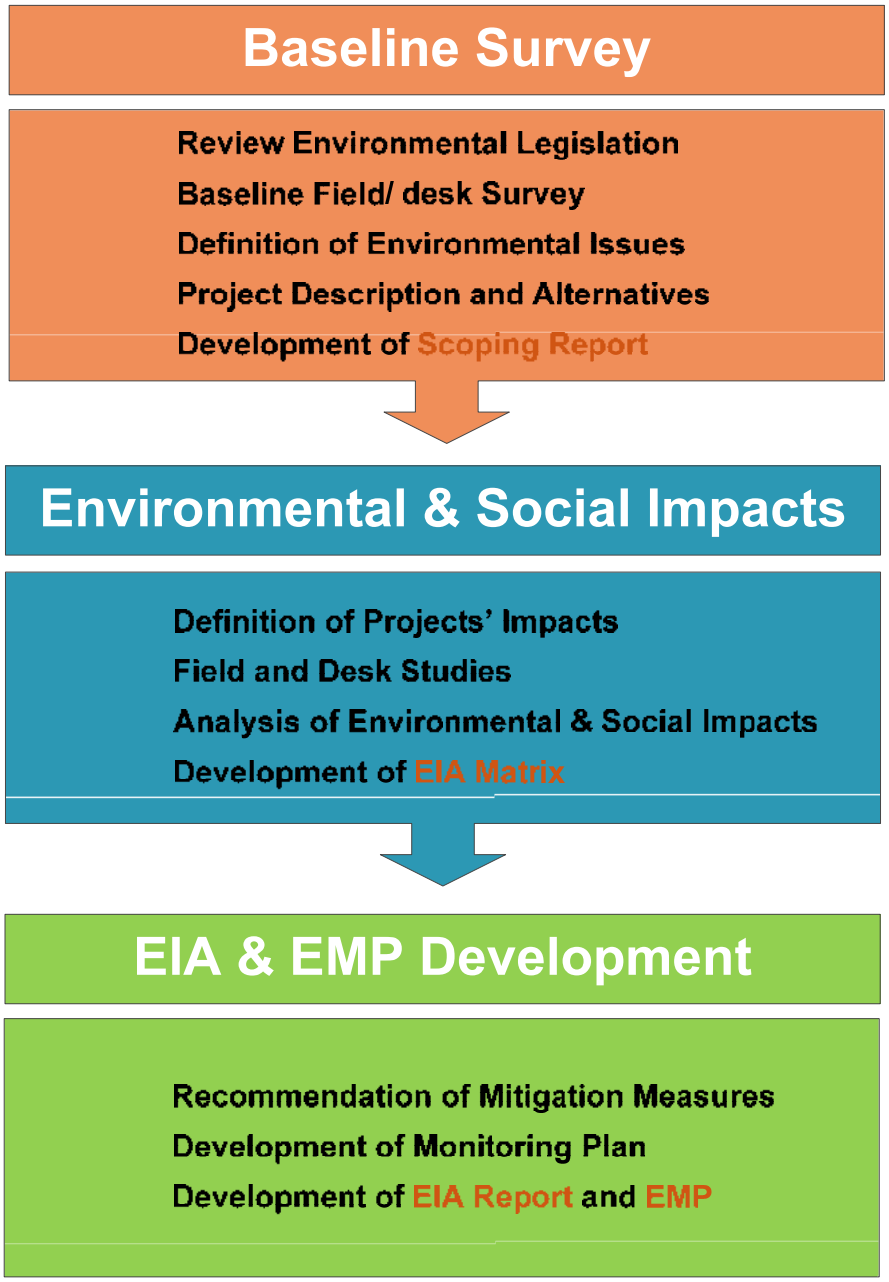


Figure 2-1: EIA main elements for the Project

The environmental study will aim to:

- Identify and predict in detail the positive and negative impacts of the development of the project on the environment;
- Make recommendations of appropriate solutions to minimize any undesirable effects resulting from the project to the developed schemes.
- Develop environmental monitoring and management schemes.

2.2 Scope of Achievements

Generally, a number of methods are applied either singly or in combination in order to adequately address all issues in the scope of this study. All steps (methodology) consistent with the Guidelines (Guidelines on Environmental Impact Assessment Planning and Approval, and Environmental Permit Application Review Process) have been followed and will be applied. In summary these methods (tasks) include:

2.2.1 Literature Review & Desk Studies

All available maps, aerial photos, reports, data, and notes taken during site visits utilized in this task to propose and study alternative routes.

2.2.2 Expert Consultations

Expert consultation through relevant persons conducted to solicit their views and comments on the projects' alternatives and the surrounding environment.

2.2.3 Field Visits

Several field visits were paid to the study area in 2013 and 2014 to have better understanding and knowledge, define the environmental issues of project area and conduct on-the-spot assessment.

2.2.4 Define the Environmental Issues

There are several environmental issues related to the dam project development and operation to be considered during the environmental studies. Examples of those issues are including but not limited to the followings:

- Socio – Economic
  - Developed schemes, land and infrastructure;
  - Future development schemes;
  - Resettlement and relocation works
- Hydrology and Wadis Flow Control
  - Flood protection
  - Water resources; Groundwater and Aflaj
- Sedimentation and Erosion

- Ecology
  - The historical and cultural heritage
  - The ecology and landscape
  - Fauna and flora
- Air Pollution and Noise generated during construction
- Risk Assessment
  - Hydraulic design
  - Reservoir flood
  - Dam safety factors
  - Dam break analysis

2.2.5 EIA Matrix Development

The environmental checklist shall comply with the level of details required to complete the EIA of the significant issues. This process enables the development of an EIA matrix to define the negative, positive and over all impacts of the environmental related issues. The EIA matrix for this project will be presented in Chapter **6**. The EIA matrix is developed according to project area physical, environmental consideration and national policy required.

3 LEGISLATIVE AND REGULATORY FRAMEWORK

3.1 ENVIRONMENTAL LEGISLATION IN OMAN

3.1.1 Overview

The Omani law on environmental protection, control and management is covered under the basic law viz., the 'Law for the Conservation of the Environment and Prevention of Pollution' first promulgated in 1982 as RD 10/82 and superseded in November 2001 as RD 114/2001. The responsibility for the implementation of the environmental laws and regulations rests with MECA, which issues regulations, standards and guidelines through MDs. Within MECA, the Directorate General for Environmental Affairs (DGEA) is the authority responsible for environmental permitting, inspection and control in the Sultanate of Oman. Recently, MECA has established DGCA (Directorate General for Climate Affairs), which is the authority to assess the potential aspects of the project with regard to climate change. The Omani environmental laws and regulations with regard to air emissions, noise, wastewater, solid and hazardous wastes, hazardous materials and chemicals etc., potentially applicable for the present project are listed in Table 3-1.

Table 3-1 Applicable Omani Environmental Laws and Regulations

Law / Regulation	Description
General	
RD 90/2007	Establishing the Ministry of Environment and Climate Affairs
RD 114/2001	Law on Conservation of the Environment and Prevention of Pollution
Permit / License	
MD 16/210	Regulations on environmental requirements for industrial and service activities
RD 187/2001	Regulations for the issuance of Environmental Approvals and the Final Environmental Permit
MD 68/2004	Amendment of RD 187/2011

Law / Regulation	Description
MD 199/2001	Issuance of municipal license for establishment, companies and factories
MD 209/95	Obligating industrial and commercial organizations and others to apply environmental regulations as stated in environmental permits
Water and Wastewater	
MD 3/2009	Regulations on wells and springs
MD 159/2005 MD 39/2004	Discharge of Liquid Waste in the Marine Environment Marine environmental management permits
RD 115/2001	Law on Protection of Sources of Potable Water from Pollution
MD 192/2000	Determination of the Dhahira Region Water Supply Wellfield Protection Zones
RD 29/2000	Promulgating the Water Wealth Conservation Law
MD 241/98	Regulations for septic tanks, soak-away pits and holding tanks
MD 342/1997 MD 263/2000	Regulations for organizing the use of water desalination units in wells

Law / Regulation	Description
MD 145/93	Wastewater discharge and re-use
MD 55/2002	Amendment of MD 145/93
RD 90/91	Protocol Protection of Marine Environment from Pollution from Land-based Sources
MD 8/84	Standards for the disposal of trade effluents
RD 26/81	Approving the accession of Oman to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter
MD 2/90	Regulations for registration of existing wells and new well permits
RD 76/77	Issuing the Water Resources Development Law
RD 34/74	Law on Marine Pollution Control
Air Emissions	
MD 243/2005	Regulations for the Control and Management of Ozone Depleting Sub stances
MD 118/2004	Regulations for Air Pollution Control from Stationary Sources

Law / Regulation	Description
Environmental Noise	
MD 79/94	Noise Pollution Control in the Public Environment
Waste	
RD 88/2002	Sanctioning Resolution 3/1 Adopted by the COP to Basel Convention on the Control of the Transboundary Movement of Hazardous Wastes and their Disposal
MD 17/93	Regulations for the Management of Solid Non-Hazardous Waste
MD 57/2002	Amendment MD 17/93
MD 18/93	Regulations for the Management of Hazardous Waste
MD 56/2002	Amendment of MD 18/93
Chemicals and Radioactive Materials	
MD 317/2001	Regulations for Packaging and Labeling of Hazardous Chemicals
MD 326/2001	Regulation regarding barring of circulation and usage of some hazardous chemical substances including PCBs, brown asbestos and blue asbestos
MD 281/2003 MD 249/97	Regulation for the control and management of radioactive materials
RD 46/95	Law on Handling and Use of Chemicals

Law / Regulation	Description
RD 81/99	Accession of the Sultanate of Oman to the Rotterdam Convention Related to Application of Prior informed Consent to Certain Hazardous Chemicals and Pesticides in International Trade
MD 248/97	Registration of Chemicals Substances and the Relevant Permits
MD 68/2000	Amendment MD 248/97
Cultural Heritage	
RD 6/1980	Protection of National Heritage
Land and Resource Use	
MD 81/2004	Gathering and transportation of wood
MD 200/2000	Crushers, quarries and the transport of sand from coasts, beaches and wadis
RD 5/96	Relating to the international Convention to Combat Desertification
MD 20/90	Rules Regulating and Specifying Coastal Setbacks
RD 8/2003	Law of Grazing Lands and Animal Resources
MD 4/87	Issuance of Quarries and Mines Licenses
Ecology and Nature Reserves	
MD 110/2007	Regulations of the Law on Nature Reserves and Wildlife Conservation

Law / Regulation	Description
RD 6/2003	Law on Nature Reserves and Wildlife Conservation
MD 4/2001	Providing Rules for the Jebel Samhan Nature Reserve
MD 3/2002	Providing Rules for the Coves Reserves (Khawrs) on the Salalah Coast
RD 67/2002	Conservation of Wildlife and Their Habitats
MD 101/2002	Killing, Hunting and Catching of Wild Animals and Birds
MD 113/2000	Regulating the Management of the Turtles Nature Reserve
MD 55/2006	Amendment MD 113/2000
MD 112/2000	Regulating the Management of the Dimaniyat Island Reserve
MD 56/2006	Amendment MD 112/2000
MD 111/2000	Regulating the Management of the Arabian Oryx Reserve
MD 56/2006	Amendment MD 112/2000

Law / Regulation	Description
RD 50/97	Establishing the Al Saleel National Park in the Kaamil Wo Wafi Wilaya
RD 48/97	Establishing Reserves in Some Coves (Khwars) on the Salalah Coast
RD 25/96	Establishing the Jabal Samhan Reserve
RD 23/96	Establishing the Dimaniyat Islands Nature Reserve
RD 11/2007	Concerning the Arabian Oryx Sanctuary
Social and Health and Safety	
RD 35/2003	Labour Law
RD 74/2006 RD 112/2006 RD 113/2011	Amendments RD 35/2003
MD 286/2008	Regulation of Occupational Safety and Health for Establishment Governed by Labour Law
MD 80/94	Noise Pollution Control in the Working Environment
MD 19/82	Occupational Health & Industrial Safety Precautions

Law / Regulation	Description
RD 119/94	Sanctioning the Accession of the Sultanate of Oman to Basel Convention on the Control of the Transboundary Movement of Hazardous Wastes and their Disposal, the United Nations Framework Convention on Climate Change and Convention on Biological Diversity
Climate Change	
Climate Change	Guidelines on information to be provided towards evaluation of Climate Change Impacts of the Project

3.1.2 Environmental Protection and Prevention of Pollution

RD 114/2001 provides the framework for environmental protection and prevention of pollution in Oman. Applicable requirements of the above RD are listed below:

- Article 7 imposes a general prohibition on disposal of pollutants to the environment unless permitted by a regulation or MD;
- Article 9 requires all establishments to possess requisite permits prior to commencing work;
- Article 10 requires the use of best available technology to prevent pollution and protect natural resources;
- Article 11 requires all establishments to comply with emissions/discharge limits specified in relevant MDs;
- Article 19 and 22 restrict dumping /disposal of hazardous and non hazardous wastes into the environment without any permit; and
- Article 41 states that in the event of any violation, the violator must undertake the removal of pollution at his own expense in addition to payment of the specified compensation.

3.1.3 Protection of potable Water sources from Pollution

RD 115/2001 provides the framework for protection of potable water sources from pollution. Listed below are applicable Articles from this RD:

- Article 8 states that non-household effluents shall not be discharged in sewage networks unless they are treated to specifications stated in Appendix No. 3 of the RD;
- Article 9 requires that solid non-hazardous waste shall only be disposed off in sanitary landfills (sites licensed by the Ministry for disposal of non-hazardous solid wastes) licensed by the Ministry. Solid non-hazardous waste shall not be mixed with any category of hazardous waste at any stage;
- Article 13 requires any person causing pollution to water to remove the pollution at his own expense in addition to payment of the specified compensation;
- Article 16 prohibits discharge of hazardous wastes or substances into aflaj and their channels, surface watercourses, wadis or places of groundwater recharge; and
- The RD further specifies conditions for treatment, discharge, and re-use of wastewater

3.1.4 Wastewater Reuse and Discharge

The Omani standards for wastewater discharge and re-use on land are issued under MD 145/93 and RD 115/2001. There are two types of standards, based on the crops grown on the land where the wastewater is applied, as described in Table 3-2.

Table 3-2 Wastewater Discharge and Reuse Standards - Categories

Specification	Standard A-1	Standard A-2
Crops	Vegetables and fruits likely to be eaten within 2 weeks of irrigation	▪ Vegetables to be cooked or processed ▪ Fruits if no irrigated within 2weeks of cropping ▪ Fodder, cereal and seed crops
Grass and ornamental areas	▪ Public parks, hotel lawns, recreational areas	Pastures and areas with no public access

Specification	Standard A-1	Standard A-2
	▪ Areas and lakes accessed by public	
Aquifer recharge	All aquifer recharge controlled and monitored by the Ministry	
Methods of irrigation	Spray on any other method of aerial irrigation is not permitted in areas with public access unless with timing control	
Any other reuse applications	Subject to the approval of the Ministry	

The maximum permissible concentrations of various pollutants in the treated wastewater are as presented in Table 3-3.

Table 3-3 Wastewater Discharge and Reuse Standards

Parameter	Units	Standard A-1	Standard A-2
Aluminum (Al)	mg/l	5	5
Arsenic (As)	mg/l	0.10	0.10
Barium (Ba)	mg/l	1	2
Beryllium (Be)	mg/l	0.10	0.30
Biochemical oxygen demand (BOD) – days @ 20°C	mg/l	15	20
Boron (B0	mg/l	0.50	1.00
Cadmium (Ca)	mg/l	0.01	0.01
Chemical oxygen demand	mg/l	150	200
Chloride (Cl)	mg/l	650	650
Chromium (Cr)	mg/l	0.05	0.05
Cobalt (Co)	mg/l	0.05	0.05
Copper (Cu)	mg/l	0.50	1.00
Cyanic (CN)	mg/l	0.05	0.10
Electrical conductivity (EC)	mg/l	2000	2700
Faccal coliform bacteria	Number per 100 mL	200	1000
Flouride (F)	mg/l	1	2
Iron (Fe)	mg/l	1	5

Parameter	Units	Standard A-1	Standard A-2
Lead (Pb)	mg/l	0.10	0.20
Lithium (Li)	mg/l	0.07	0.07
Magnesium (Mn)	mg/l	150	150
Manganese (Mg)	mg/l	0.10	0.05
Mercury (Hg)	mg/l	0.001	0.001
Molybdenum (Mo)	mg/l	0.01	0.05
Nickel (Ni)	mg/l	0.10	0.10
Nitrogen: Ammoniacal (N) Nitrate (NO_3) Organic (Kjeldahl as N)	mg/l	 5 50 5	 10 50 10
Oil and grease (total extractable)	mg/l	0.50	0.50
pH	mg/l	6 – 9	6 – 9
Phenols (Total)	mg/l	0.001	0.002
Phosphorus (P)	mg/l	30	30
Selenium (Se)	mg/l	0.02	0.02
Silver (Ag)	mg/l	0.01	0.01
Sodium (Na)	mg/l	200	300
Sodium absorption ratio (SAR)	--	10	10
Sulfate (SO_4)	mg/l	400	400
Sulfide (S)	mg/l	0.10	0.10
Suspended solids (SS)	mg/l	15	30
Total dissolved solids (TDS)	mg/l	1500	2000
Vanadium (V)	mg/l	0.10	0.10
Viable nematode ova	Number per L	<1	<1
Zinc (Zn)	mg/l	5	5

The following are Omani standards for reuse and disposal of sludge resulting from wastewater

treatment. The sludge generated from the wastewater treatment may be applied on land for agricultural use (after obtaining permit from MECA) for the same), subject to the conditions given in Table 3-4.

Table 3-4 Wastewater Treatment Sludge Reuse Standards

Metal	Maximum Concentration (mg/kg of dry solid)	Maximum Applicable Rate (kg/ha)*	Maximum permitted concentration in soil (mg/kg of dry solids)
Cadmium	20	0.15	3
Chromium	1000	10.00	400
Copper	1000	10.00	150
Lead	1000	15.00	150
Mercury	10	0.10	1
Molybdenum	20	0.10	3
Nickel	300	3.00	75
Selenium	50	0.15	5
Zinc	3000	15.00	300

Note: * Based on a ten-year average and a soil pH>7.0

After the spreading of the sludge, there must be at least three weeks period before grazing or harvesting of forage crops. Sludge use is prohibited in the following cases:

- On soils whilst fruits or vegetable crops, other than fruit trees, are growing or being harvested;
- For six months preceding the harvesting of fruit or vegetables, which grow in contact with the soil and which are normally eaten raw; and
- On soils with a pH < 7.0.

3.1.5 Air Emission from Stationary Sources

Omani standards for air emissions from stationary sources are specified under MD 118/2004. Applicable limits for emissions from stationary point sources in the present project are provided in Table 3-5. The key provisions of this regulation applicable for the project are presented below:

- Article (2) – Emission controls have to be provided to emission sources from

the facility in order to prevent noxious or offensive emissions;

- Articles (3) – The emission standards specified by this regulation are to be complied with. Further, the monitoring of emissions from sources within the facility is to be conducted and reported to the Ministry. The Ministry has the right to request to improve the monitoring method and equipment used in such monitoring;

- Article (4) – Necessary action shall be taken by the operator of the facility to eliminate any harmful effects to public health, nuisance or emission of noxious odours arising from the work area;

- Article (5) – Dark smoke shall not be emitted from chimneys unless specially permitted by the Ministry for specific reasons and periods. The smoke shall not be as dark as or darker than shade one on the Ringelmann scale (20% opacity);

- Article (6) – The facility shall submit an application for an environmental permit and shall not commission or operate the plant unless the height of the chimney serving the plant has been approved by the Ministry that it is sufficient enough to prevent the smoke, grit, dust and toxic gases from becoming prejudicial to health or nuisance. The minimum stack heights for power plants, from ground level shall be as follows:

Power plants (Natural gas fired) - 26 m

Power plants (Diesel fired) - 35 m

Boiler plants (Natural gas fired) - 15 m

Boiler plants (Diesel fired) - 20 m

In other cases, the chimney height shall be calculated as “2.5 times multiplied by the height of the highest building (in meters) in the concerned establishment complex”.

- Article (7) – The permit to operate shall be issued for a period of three years, renewable for a same period within one month from the date of expiry;

- Article (8) – Concerned inspectors from the Ministry may enter the facility to inspect any processes causing emission of any noxious or offensive substances, to ensure efficiency of emission controls and to ascertain the quantity and quality of emissions and suggest requirements for further controls

or measurements;

- Article (9) – The facility shall provide access and assistance to the concerned environmental inspectors from the Ministry to perform their duties for inspection and monitoring of the sources at the facility;

- Article (10) – Any change of ownership or production process of the facility shall be communicated to DGEA; and

Article (11) – Failure to comply with any provisions of this regulation will result in penalties and the Ministry may close down the establishment if there is prejudice harm to the public health or environmental damage.

Table 3-5 Emission Standards as per MD 118/2004

Pollutants	Maximum permissible limits
General	
Grit dust Dark some products of combustion shall not emit smoke as dark as or darker than shade one on the Ringelmann scale (20% opacity)	0.050 g/m^3
Power Plants – Natural Gas Fired	
Nitrogen dioxide	0.150 g/m^3
Particulates	0.050 g/m^3
Unburnt hydrocarbons	0.010 g/m^3
Carbon dioxide	5 g/m^3
Power Plants – Diesel Oil-Fired (less than 0.5% Sulfur)	
Sulfur dioxide	0.035 g/m^3
Carbon monoxide	0.050 g/m^3
Nitrogen dioxide	0.150 g/m^3
Particulates	0.100 g/m^3

Pollutants	Maximum permissible limits
Unburnt hydrocarbons	0.010 g/m^3
Combustion Sources – Diesel Oil-Fired*	
Sulfur dioxide	0.035 g/m^3
Carbon monoxide	0.050 g/m^3
Nitrogen dioxide	0.150 g/m^3
Particulates	0.100 g/m^3
Unburnt hydrocarbons	0.010 g/m^3
Combustion Sources – Natural Gas-Fired	
Carbon dioxide	5 g/m^3
Nitrogen dioxide	0.150 g/m^3
Particulates	0.050 g/m^3
Unburnt hydrocarbons	0.010 g/m^3

*Note: * industrial boilers, furnaces, industrial ovens*

3.1.6 Noise

The regulations for noise control are applicable to workplace noise levels and ambient noise levels. The ambient noise standards are issued under MD 79/94 and the limits for ambient noise levels from industrial sources are summarized in Table 3-6.

MD 80/94 specifies the regulations for noise pollution control in working environment. These regulations state that no employee shall be exposed to noise levels exceeding 85 dB(A). If the workplace noise level exceeds 85 dB(A), suitable ear protection devices shall be provided. The attenuation of such protection devices shall reduce the noise level to 80 dB(A) or lower.

Table 3-6 Ambient Noise Standards

Type of District	Day Time (7 AM – 6 PM) workdays	Evening Time (6 PM – 11 PM) workdays	Night Time (11 PM – 7 AM) workdays and all times on holidays
Rural residential and recreational	45	40	35
Sub-urban residential	50	45	40
Urban residential	55	50	45
Urban residential with some workshops or business city hub	60	55	50
Industrial and commercial	70	70	70

3.1.7 Hazardous Waste

MD 18/93 specifies the Omani regulations on hazardous waste management. Hazardous waste is defined as "any liquid or solid waste, which because of its quantity, physical, chemical or infectious characteristics can result in hazards to human health or the environment when improperly handled, stored, transported, treated or disposed off". The relevant articles in the regulation are listed below:

- Article (4) – No hazardous waste shall be mixed with any other category of waste nor shall it be discharged to a common or other internal or external sewerage or other drainage system without a licence from the Ministry;
- Article (5) – Every hazardous waste generator shall complete a Consignment Note for each category of hazardous waste before the hazardous waste leaves his land or premises;
- Article (6) – All hazardous waste shall be labelled and packed according to the Ministerial Decision issued in this respect;
- Article (7) – A hazardous waste or any components of a hazardous waste may be recycled at the point of generation or elsewhere only within the conditions of these Regulations. In case recycling is limited only to the point of generation, hazardous waste generator shall not be committed to complete a consignment

note;

- Article (8) – Every hazardous waste generator shall store hazardous waste in approved storage facilities on his land or at his premises until its removal in accordance with the terms of the licence issued by the Ministry;

- Article (9) – Hazardous waste shall be transported by transporters licensed by the Ministry to collect, handle, store and dispose hazardous waste outside the waste generator's premises. This licence will be issued with conditions after the approval of Royal Oman Police (ROP);

- Article (10) – Every owner of any site where hazardous waste is to be stored, shall apply for a licence from the Ministry and shall operate the site only in accordance with the terms of the issued licence which shall include a requirement that all hazardous waste received at the site shall be accompanied by appropriate Consignment Note(s) in accordance with Article (5); and

- Article (11) – Every owner of a storage facility shall only release hazardous waste from that facility if it is accompanied by a Consignment Note in accordance with Article (5).

3.1.8 Solid Non Hazardous Waste

MD 17/93 specifies the Omani regulations for non-hazardous solid waste management (the relevant articles of RD 115/2001 are also to be referred to). The relevant articles in the regulation are listed below:

- Article (2) – Occupants of the premises (including industries which generate any solid or semi solid non-hazardous waste) shall store and dispose of solid non-hazardous waste in accordance with the provisions of these regulations and decision of the concerned authorities to this effect, such that there is no nuisance or hazard to the public health;

- Article (5) – The occupants of the premises shall collect these wastes and transport it in a safe manner to a site designated by the concerned authority; and

Article (13) – No solid non-hazardous waste should be mixed with any category of hazardous waste at any time.

3.1.9 Establishment of Septic Tanks, Holding Tanks and Soak Away Pits

MD 421/98 specifies requirements for designing, locations, and constructing septic tanks, soak away pits, and holding tanks. Important Articles of this MD are listed below:

- Article 3 of the MD allows the use of septic tanks in institutions where the population equivalent is not greater than 150;

- Article 4 and 11 states requirement of consent of local municipality prior to establishment of septic and holding tanks; and

- Article 10 and 13 present the minimum setback distances for construction of septic tanks, soak away pits, and holding tanks.

3.1.10 Ambient Air Quality

Presently, there are no Omani standards for ambient air quality. Therefore, MECA recommends the use of U.S. EPA's National Ambient Air Quality (NAAQ) standards. The NAAQ standards are presented in Table 3-7.

Table 3-7 Ambient Air Quality Standards

Pollutant	Averaging Period	Maximum Permissible Limit
Particulate (PM_{10})	24-hour average	150 µg/m^3
Particulates (PM_{25})	24-hour average	35 µg/m^3
	Annual arithmetic mean	15 µg/m^3
Sulfur dioxide (SO_2)	3-hour average	0.5 ppm (1300 µg/m^3)
	24-hour average	0.14 ppm
	Annual arithmetic mean	0.0 3
Nitrogen dioxide (NO_2)	Annual arithmetic mean	0.053 ppm (100 µg/m^3)
	1-hour average	0.100 ppm
Carbon monoxide (CO)	1-hour average	35 ppm (40 mg/m^3)
	8-hour average	9 ppm (10 mg/m^3)
Ozone (O_3)	1-hour average	0.12 ppm
	8-hour average	0.075 ppm
Lead (Pb)	Rolling 3-month average	0.15 µg/m^3
	Quarterly average	1.5 µg/m^3

MECA however is currently in the process of developing Omani Ambient Air Quality (AAQ) Standards. Although the standards have not yet been promulgated, the provisional standards are provided as presented in Table 3-8.

Table 3-8 Omani AAQ Standards (Provisional)

Parameters	Averaging Period	Standard Limits (µg/m^3)
NO_2	24-hour average	112
SO_2	24-hour average	125
CO	8-hour average	6000
H_2S	24-hour average	40
O_3	8-hour average	120
HCNM	3-hour average	160
PM_{10}	24-hour average	125

There are no Omani standards for work place air quality as of this writing. Therefore, United States Occupational Safety and Health Administration (OSHA) 8-hour Time Weighted Average (TWA) can be used. The maximum permissible limit specified by OSHA[1] for respirable particulate matter (PM_{10}) within the workplace is 5,000 µg/m^3.

3.1.11 National Heritage Protection

RD 6/80 states the requirement for the protection of areas of cultural importance. These include the following:

- All types of monuments and antiquities; and
- Chattels of cultural properties including archaeological fossils and fragments of monuments / ancient ruins or sites and ancient building blocks.

3.1.12 Protected Areas in Oman

Fourteen protection areas designated as the nature conservation by Royal Decree are shown in the next table. These areas are highly regulated and controlled by Ministry for Environment and Climate Affairs (MECA). On the marine environment, the Regulation for Conservation of Marine

[1] OSHA Regulations Standards – 29 CFR

an Coastal Environment as MD20/90 and Decision no: 19/90 of the Supreme Committee for Town Planning (SCTP), which was instituted in 1990, is established control zone of development being within 50 to 300 meters from natural coastal line.

Table 3-9: Protection areas in Oman

Name of area	*Location (Region)*	*Reserve resources (Biological, others)*
The Arabian Oryx Sanctuary	**Al Wusta**	***Arabian oryx, Nubian ibex, etc., conserving biodiversity***
As Saleel natural Park	Ash Sharqiyah	***Simr, Arabian gazelle, Gordon's wild cat, protecting wildlife***
Ra's al Hadd Turtle Reserve	Ash Sharqiyah	***Turtles, Coral reefs, mangroves, Prosopis cineraria wildlife***
Jebel Samhan Nature Reserve	Dhofar Governorate	***Leopard, Ibex, Arabian wolf, Gazelle, Blandford's fox, protecting wildlife***
Dimaniyan Islands nature Reserve	North of Muscat	***Coral reefs, fish, birds and turtles, conserving wildlife***
The Khawrs Reserve of Dhofar Coast	Dhofar Governorate	***Khawrs, springs, and archaeological sites, Mangroves, sustainable use of the resources***
Wadi Al Sarin	**South of Muscat**	***Arabian tahr and mountain goat***

3.2 Environmental Impact Assessment Interim Guidelines

The Interim Guideline on Environmental Impact Assessment was issued in 2001. The legislative authority of the guideline is based on the Royal Decree 114/2001 and its amendments "Amending some provisions of the law on Conservation of The Environment and Prevention of Pollution (Royal Decree 10/82)". However, this Interim Guideline on Environmental Impact Assessment has been replaced with EIA Guideline called "Guidelines for Obtaining Environmental Permits for year 2001". The Interim Guideline lists the projects, which are subject to a detailed EIA study. At the initial of the project stage, the Ministry for Environment and Climate Affairs conducts an environmental screening to ensure the proposed project is subject to an appropriate environmental assessment. Based on the screening results, the projects are classified into projects that in the proposed location have negligible environmental impacts, and projects that likely to have significant environmental impacts. The Guideline lists the key features of EIA, such as scoping, developing EIA, and data and information to be included (kindly consider below Figure).

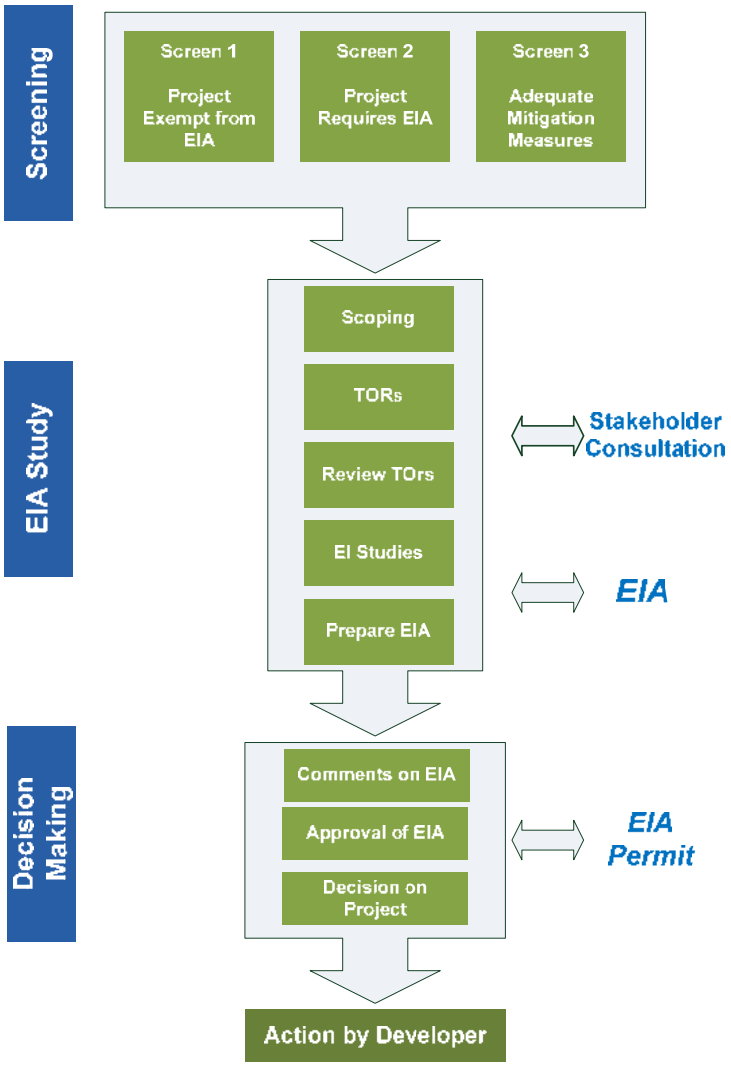


Figure 3-1: EIA Procedures in Oman

3.2.1 Overview

The Regulation for the issuance of the Environmental Approvals and the Final Environmental Permit (Ministerial Decision No. 187/2001, 16 June 2001) is composed of six (6) articles and two (2) annexes. The following are highlights of the regulation applicable to the proposed Project:

- Article 1: The establishments subject to this Regulation are classified into categories according to the materials used in production, production capacity and the degree of their impact on the environment as indicated in Annex 1.
- Article 2: The owner of an establishment shall present an application to the Ministry and enclose an EIA, if required by the Ministry.
- Article 3: The owner of the establishment shall abide by all environmental requirements and conditions before obtaining the Environmental Approval or Final Environmental Permit
- Article 4: The establishments shall abide by carrying out an Environmental Audit by a specialized company approved by the Ministry.
- Article 5: Dividing the Establishment into categories.
- Annex I: Desalination stations are included in category two and water supply networks as category three.
- Annex II: Fees for the Environmental Approvals and for the Final Environmental Permit.
- Ministerial Decision 68/2004 amends the Ministerial Decision No. 187/2001, referring that the Ministry (MECA) can add any new project or any projects resembling the projects stated in the annex of Division of Establishments into Categories after the approval of the Ministry of Finance (MoF) and modify the categories stated in the annex of MD 187/2001.

3.2.2 Preliminary Consultation

Before submitting the application for permit, the proponent (or its appointed consultant) should contact MECA to discuss details of the required documentation. The proponent is encouraged to discuss the proposed projects informally with staff of the Ministry at an early stage before detailed studies or plans are drawn up. A feasibility study, complete with its environmental chapter, maybe utilized during the preliminary consultation.

3.2.3 Application Review Process

The procedure for processing of an application for an Environmental Permit from MECA can be divided into three (3) stages:

Stage 1: Application Submission Stage

This stage begins the application review process and consists of submitting a completed Environmental Permit Application Form, to MECA supporting technical documents, and permits from other Ministries (if necessary).

Stage 2: Technical Stage Appraisal (Screening and Scoping)

At this stage, technical staff of the Ministry conducts a screening followed by a detailed review of the application to determine the type of environmental analysis that is required for the project.

There is no fixed list of specific industries, developments or their sizes, which would trigger a detailed EIA. Instead the Ministry's procedure relies on screening, identifying significant impacts on sensitive areas, and discussion between MECA and the applicant to identify any critical issues and to establish the scope of the EIA. However, certain types of projects or their elements fall into categories of projects usually requiring a detailed EIA, including desalination plants. The final decision rests with MECA.

A formal EIA should include but not limited to the following:

- Project description
- Baseline data
- Comparison of alternatives and their impacts (negative or positive) on all aspects of the environment
- Proposed mitigation measures
- Risk assessment
- Evaluation of the net effects of the development
- Proposed monitoring and follow-up activities
- Inter-agency coordination
- Consultation with affected communities
- Clear and complete Environmental Impact Statement document

Stage 3: Decision and Permit Stage

Once completed, MECA will review the EIA and, if satisfied, will issue a Preliminary Environmental Approval, approving the commencement of the construction process and including environmental conditions to be fulfilled prior starting operation.

A Final Environmental Permit will be issued after fulfillment of the conditions stated in the Preliminary Environmental Approval.

The development must also be in conformity with the various Regulations / Ministerial Decisions, some of which require sub-permits / licenses to the Environmental Permit and these must also be obtained by the proponent/applicant.

3.2.4 Follow up

If the nature of the activities, as evaluated by MECA, shall be bound to conduct an Environmental Audit, every two years from the date of receiving the Final Environmental Permit.

3.2.5 Required Permits for the Proposed Project

The proposed project will potentially require the following permits, as applicable for the construction or operation phases:

- Preliminary Environmental Permit (PEP) from MECA – Issued upon submission of EIA Report along with application for the Environmental Permit;
- Permit for disposal of treated wastewater (if any) during construction phase;
- Permit for storage, handling, transportation and disposal of hazardous wastes during construction and operation;
- Permit for storage, handling and transportation of chemicals and fuel used at site during construction and operation;
- Permit for operating stationary emission sources (stacks);
- Permit for import, transportation, usage and storage of radioactive material, if required (mainly during construction phase);
- Consent for setting up construction camps from local municipality; and
- Approvals from the Ministry of Heritage and Culture (MHC) and Ministry of Awqaf and Religious Affairs (MARA), as required.

In addition to the above, the contractors transporting / handling chemicals, fuels, other hazardous materials and hazardous wastes will require approvals / permits.

3.3 Legal Framework for Social Issues

In addition to the environmental regulations discussed in the preceding sections, the project will be governed by relevant regulations for addressing the social issues. The social laws in Sultanate of Oman address aspects such as community involvement, local employment, protection of cultural / heritage / archaeological sites etc. These are stipulated through RDs as presented in Table 3-10.

Table 3-10 Omani Laws for Social Aspects

Ref. No.	Description	Applicability to Project
RD 6/80	Law on national heritage protection	▪ Any development work to protect and conserve archaeological sites. ▪ Any development activity to be initiated only after obtaining clearance from the MHC and MARA.
Oman Labour Policy	Law for involving local citizens in project	Provision for employing local citizens
Supreme Committee for Town Planning (SCTP) standards	Guidelines for development of new areas	Physical planning norms to be adopted for infrastructure development
Ministry of Agriculture RD 8/2003	Protection of grazing areas	Areas in and around the site, used for grazing
RD 34/74	Management of fishery and supporting its habitats	It prohibits interference with movement of marine species or harm to their eggs and young ones

3.4 Conventions and Protocols

Several RDs concerning conventions and protocols to which Oman has acceded have been issued so that these are taken into account during development of new projects in the country. RDs which potentially apply to the proposed sanitary landfill project are listed below:

- Sanctioning the Accession of the Sultanate of Oman to the Marine Environment Protection Protocol (RD 90/91);
- Sanctioning the Accession of the Sultanate of Oman to two Protocols on Environment Protection (RD 57/94);
- Sanctioning the Accession of the Sultanate of Oman to Basel Convention on the Control of the Transboundary Movement of Hazardous Wastes and their disposal, the United Nations Framework Convention on Climate Change and Convention on Biological Diversity (RD 119/94);
- Sanctioning the Accession of the Sultanate of Oman to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer (RD 73/98);
- Sanctioning the Protocol on the Transboundary Movement of Hazardous Wastes and Other Wastes and their Disposal (RD 24/2002);
- Sanctioning Montreal and Beijing Amendments to Montreal Protocol on Substances that deplete the Ozone Layer (RD 106/2004);
- Sanctioning Kyoto Protocol to the United Nations Framework Convention on Climate Change (RD 107/2004); and
- Sanctioning Stockholm Convention on Persistent Organic Pollutants (POPs) (RD117/2004).

3.5 International and Regional Treaties

Other international guidelines used in assessment methods, mitigation measures, climate change issues, cumulative impacts, etc., specifically for solid waste management facilities are the following:

- World Bank Annex 4C.4 – Definition of the scope of work for the EIA and feasibility study for regional SWM facilities;
- World Bank Operational Policy / Bank Procedures / Good Practices (OP/BP/GP/4.01) and

associated documents;

- UN Convention on Climate Change and Biological Diversity;
- U.S. EPA 40 CFR Part 98 – Greenhouse Gas Reporting Program (GHGRP);
- European Commission (EC) Directive 2011/92/EU – Environmental Impact Assessment – EIA directive;
- EC Directive 85/337 and 97/11/EC;
- EC Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013).

The Gulf Cooperating Council (GCC), on the other hand, has an Environmental Coordination Committee and the GCC Secretariat General, a sector of Human and Environment Affairs. In this regard, this study, also considered the General Policies and Principles for Environment Protection, together with the following:

- Unified Regulation for Protection and Development of Wildlife;
- GCC Environmental Impact Regulation (1995);
- General Regulations of the Environment (1997);
- Unified Regulation for Handling Radioactive Materials;
- Unified Regulation for Waste Recycling;
- Procedures of Transferring Hazardous through GCC borders; and
- Unified Guiding Regulation for the Control of Substances that Deplete the Ozone Layer in the GCC Countries (2007).

4. DESCRIPTION OF THE PROPOSED PROJECT

4.1 Project Description

The project encompasses a very large area at the north of Duqm in the Al Wusta Governorate. A royal decree defined the boundaries of the foreseen development. This area is situated in a bay where several wadis draining the higher plateaus, located inland, enters the sea.

Previous studies were performed over this area in order to establish a Master plan for the development. The area will be developed in accordance with this Masterplan with industrial, commercial and residential areas demarcated and joined with arterial roads. The previous Masterplan foresaw at least two dams and three channels over the studied area to provide safe conveyance of stormwater.

Within this Masterplan, preliminary calculations were done to obtain sizes of the dams and the channels. This initial dam designs performed in the previous study resulted in the positioning of 2 dams and 3 channels. This Environmental Impact Assessment concerns the Jurf dam, located in Wadi Jurf, in the city of Duqm in Al Wusta Governorate.

By RD 119/2011, SEZAD *enjoys juristic personality and shall be financially and administratively independent,* therefore is an autonomous authority and responsible for the approvals inside the designated area. Nevertheless, any project developed outside the SEZAD area must follow the MECAs' guidelines, therefore requiring an EIA study and approval from the Ministry of Environment and Climate Affairs before start up stage. Although the majority of the project lay down inside the SEZAD area, a small part of the Jurf Dam is located inside the Oryx Sanctuary Reserve and therefore an independent EIA study is presented bellow.

For the Inception phase, some initial information were gathered and made available. The documents received relates largely to the Master plan carried by Sering Consultancy. In addition, several reports relating to the geological aspects of the development area and geotechnical interpretation reports were made available to us.

The aim of the project is to provide a significant degree of flood protection to the free zone area under development. The construction of attenuation dams and flood conveyance channels is likely to form the principal components of such flood protection measures. The dam will be situated upstream of the target area and convey the remaining water safely through the development area. The following figure shows the approximate location of the project.

The following figure shows the location of the Special Economic Zone at Duqm where this project will be implemented.

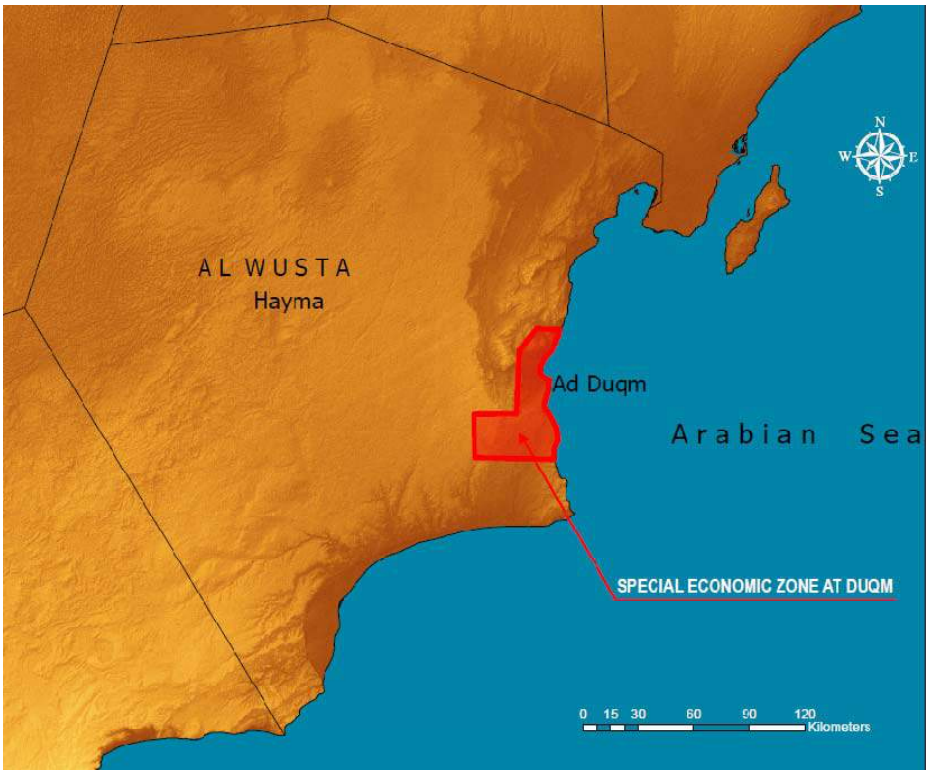
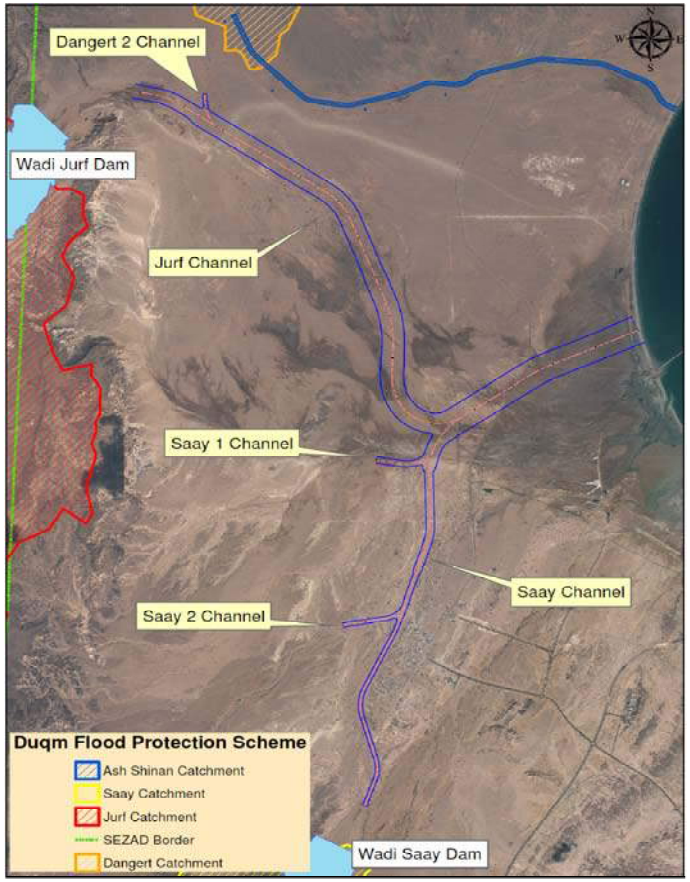


Figure 4-1: Project Location in Duqm (SEZAD area)

4.2 Scope of Project Services

The scope of works includes:

- Wadi Jurf Dam.



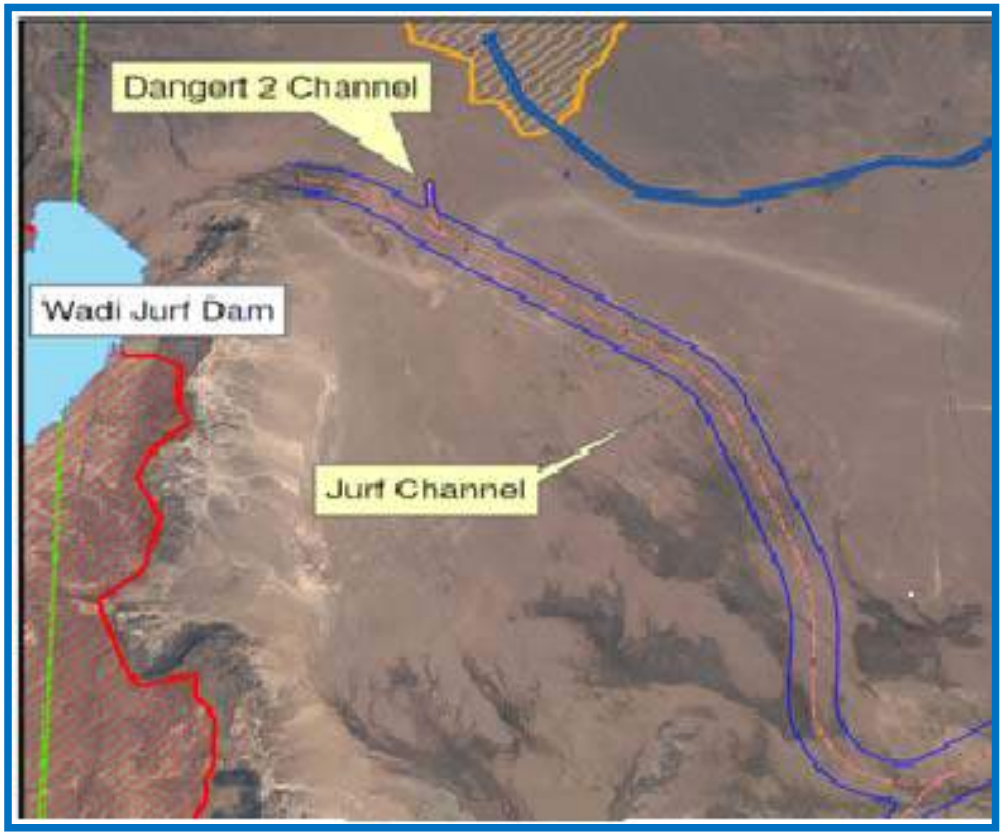


Figure 4-2: Flood Protection Scheme of the Project

Copies of the design drawings are included as Annexure A.

4.3 Description of Proposed Project

4.3.1 Topographic survey

Topographical survey was carried out over the conceptual design alignment of the channels of Jurf. This was initiated during the month of June 2014 and terminated at the beginning of September 2014.

After submission some discrepancies were revealed and an house check was made in order to ensure about the accuracy of the received data.

It appears that the ZAWAWI 3D results are accurate and present differences in elevation according to the satellite data received at the early stage of the project.

4.3.2 General Design Criteria

International, American and European standards shall be used as well as the Oman Highway Design Manual and Sultanate of Oman General Specification for Roads.

As far as civil and building works are concerned, the American Codes, Standards and Recommendations shall be used for the design of the structures, except as otherwise mentioned. An inconsistent mixing of various standards on the same structures must be avoided because of the different safety factors in the critical load combinations for stability analysis and dimensioning. Nevertheless, where American Codes do not provide pertinent information, other codes could be followed as reference.

Main applicable organizations, codes, standards and recommendations are listed in the subsequent sections.

Embankment dams

a. US Army Corps of Engineer (USACE)

Earth and Rock Fill Dams – General Design and Construction consideration- Engineering and Design – Seepage analysis and Control for Dams-	EM 1110-2-2300 EM 1110-2-1901

b. Recommendations of International Committee on Large Dams (ICOLD)

Embankment dams – Granular filters and drains	Bulletin 95

c. Recommendations of United States Bureau of Reclamation (USBR)

Embankment dams	Design Guide No. 13
Design of small dams	

Hydraulic calculations for spillways and associated structures
The hydraulic design of the spillways will be undertaken, using the following references:

General design criteria:	USCE engineering manual EM 1110-2-1603 Hydraulic design of spillways
Ogee crest:	USCE engineering manual EM 1110-2-1603
Chute flow depth convergence if adopted:	USBR Design of small dams
Stepped chute if adopted:	Hydraulic Structure Design Manual – 1995 The Hydraulics of stepped chute and spillways – Chanson – 2001 Flow Characteristics of skimming flows in stepped channels _ Ohtsu / Yasuda /Takahashi _ 2004
Stilling basin:	USBR EM 25 Design of stilling basins
Outlet works	USBR design of small dams US department of transport publication FHWA – NHI-01-020 – Hydraulic design of culverts USCE engineering manual EM 1110-2 -1602 Hydraulic design of reservoir outlet works USCE engineering manual EM 1110-2 -2400 Structural design of outlet works USCE engineering manual EM 1110-2 -2902 Conduits, culverts and pipes

4.3.3 Principal Design Criterion

The upstream dams are to be designed to ensure the attenuation of the peak discharge from the 1'000yrs natural discharge to a reduced value corresponding to the 100yrs natural peak discharge.

Consequently, both channels are designed to withstand the 100yrs natural flood which is equivalent to the 1'000yrs event with the upstream dam implemented.

4.3.4 Retained Flood Protection Scheme

The global scheme is graphically presented bellow, corresponding to the preliminary design layout of each flood protection scheme component.

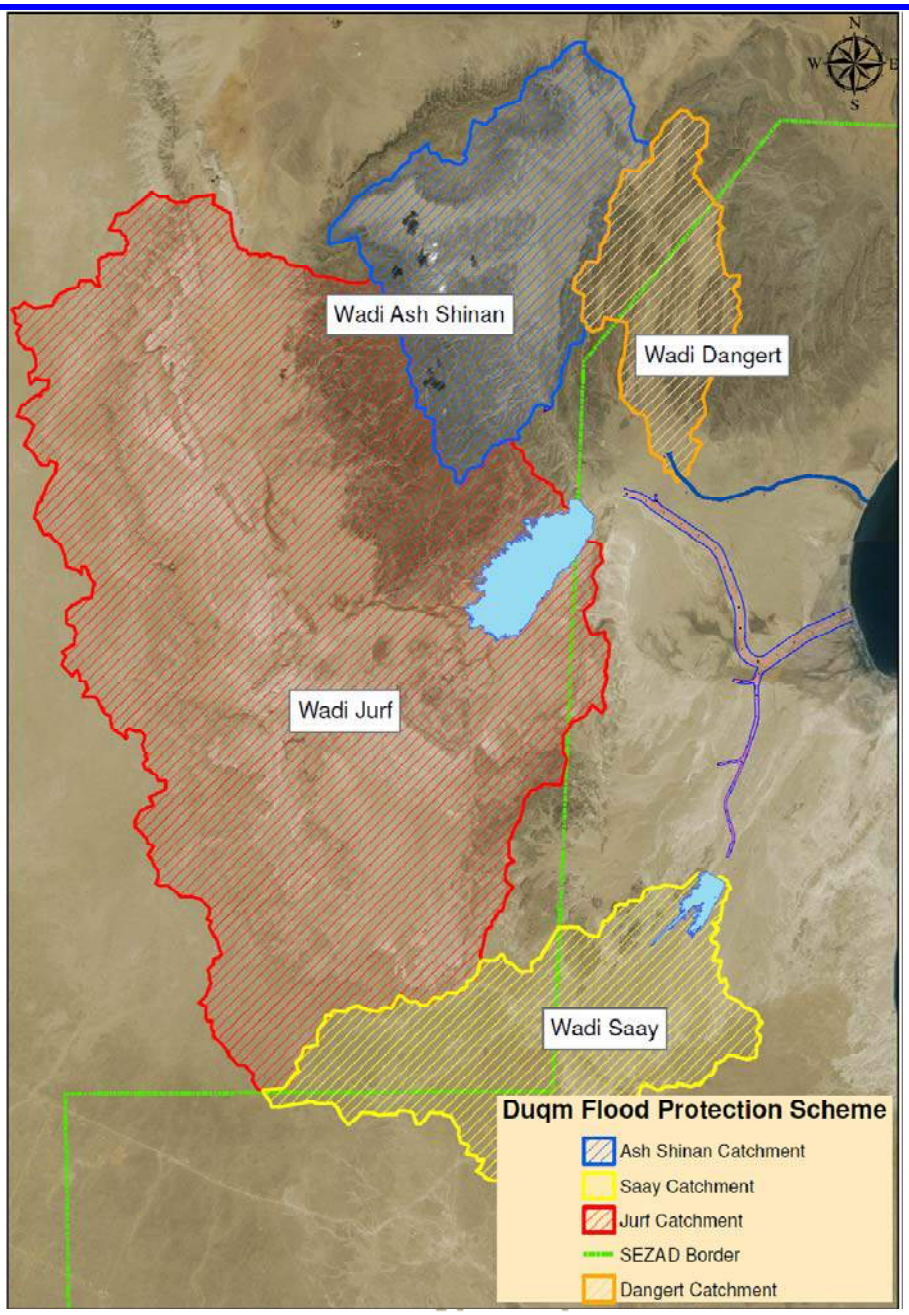


Figure 4-3: Retained Flood Defence Global Concept (Wadi Jurf included)

4.4 Hydrological & Hydraulic

4.4.1 Assessment

Within the feasibility phase and hydrological assessment was carried out over the complete area and two dimensional models were established to show the effect of dam and channel implementation. Particular attention was paid to the land occupation within the SEZAD boundary. The hydrological

model was adapted with right curve number in order to place our design on the safest side. Hec-Ras was used in order to size the dykes and the slopes along the two main channels.

A small sensitivity analysis was carried out over the lower part of the catchment where development area will be present and where change in curve number can be allocated. This shows only very small effects on the resulted flow at the combined outlet for extreme event beyond our design criteria value. This was observed within any other part of the channels network.

The hydrological results obtained at the preliminary design were considered satisfactory and were conserved for the detailed design stage.

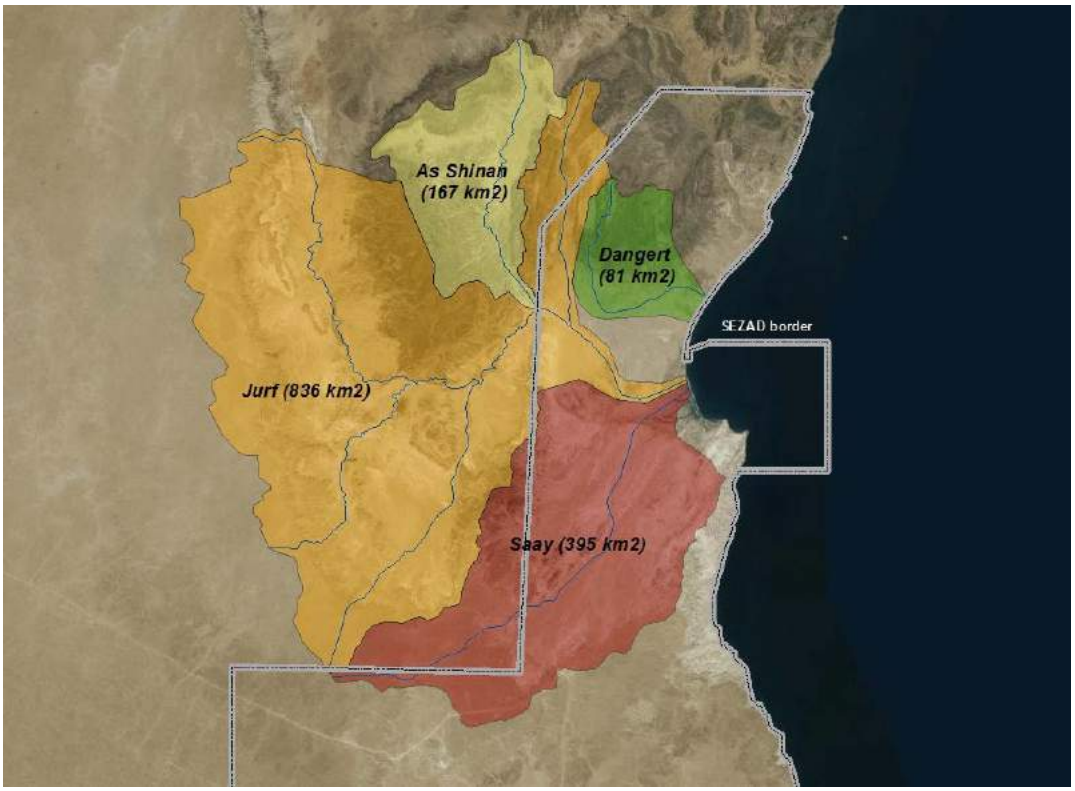


Figure 4-4: Wadi Catchment in Duqm (including Jurf)

After submission of the preliminary design report related to the channels, the Consultant exposed its concerns toward a very important aspect of the project. The alignments were revised during the last phase of the preliminary design to take into account various constraints emanated from the Client. This resulted in a combined outlet with an extreme hydraulic turn which might endanger the complete area downstream.

4.4.2 Inflows Hydrographs

The inflows peak discharges used under this detailed design remained unchanged and are as follows:

Table 4-1 - Peak Discharges at Jurf Dam

Return Period	100	500	1000	10000	PMF
Inflow volume (m^3)	57391530	96410118	112858872	168963360	353806176
Inflow peak discharge (m^3/s)	**2323**	**3924**	**4599**	**6890**	**14966**

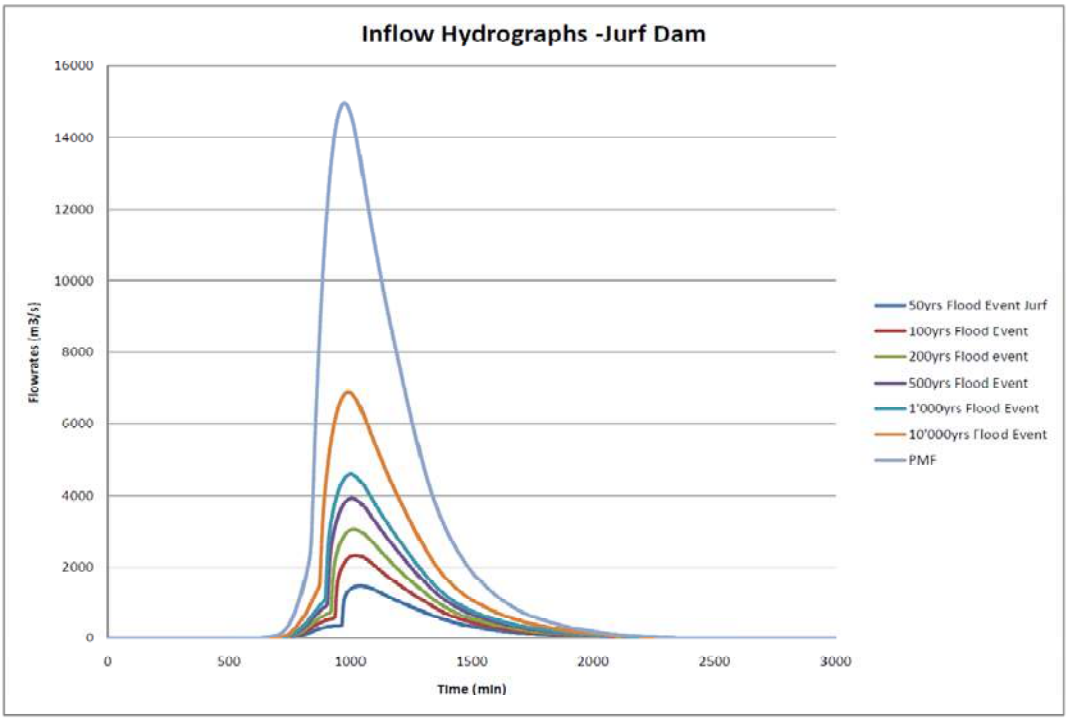


Figure 4-5 – Inflows Hydrograph Jurf Dam

According to the retained design criteria the 1'000 peak discharge of about 4'600m3/s must be reduced to a more reasonable value of 2'300m3/s corresponding to the 100yrs peak disharge

4.4.3 Storage Curve

The dam site is able to store significant volume of the order of the hundreds of Millions of cubic meters. The reservoir possesses a very shallow slope which has for effect to create a wide reservoir.

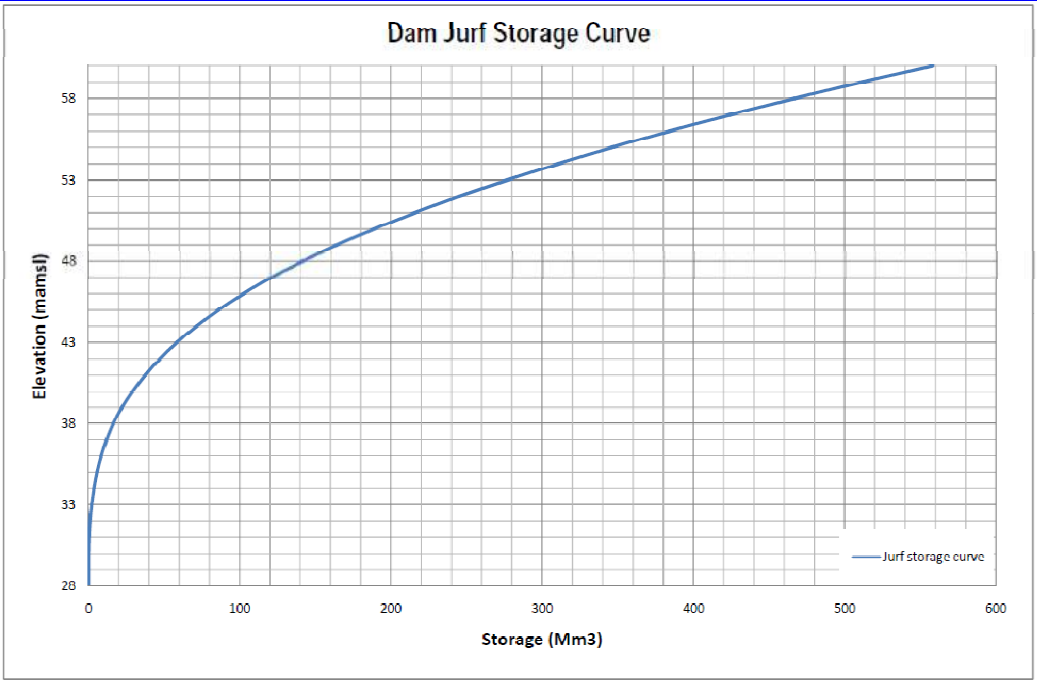


Figure 4-6 – Jurf Dam Storage Curve

The lowest point of the reservoir is located in the central part of the dam axis at an elevation of about 28 m amsl. During preliminary design, the consideration of a dead storage was made by implementing the low level outlet (culvert spillway) at an elevation of 34 m amsl. This corresponds to a dead storage of 3.71Mm^3. This shall be put in comparison to the sill level of the broad crested weir at 40.5m amsl which corresponds to a storage of about #32.8Mm^3.

The following table summarises the relevant values

Table 4-2 - Storage Capacity Values

Water Elevation	Corresponding Water Depth (m)	Storage Volume (Mm3)
34 (Culvert Spillway Inlet)	6	(Dead Storage) 3.7
40.5 (Ogee Crest level)	12.5	32.8
44.2 (10'000yrs flood level)	16.2	71.5
47.4 (PMF level & NOC level)	19.4	120.9

4.4.4 Spillway Design and Flood Routing

A. Spillway Nature

Various alternatives and configurations were studied at preliminary design phase. From the results of the geotechnical investigations, consideration of the bottom outlet and excavation of the left bank to place the auxiliary spillway can be made.

The following arrangement has been retained for detailed design purposes:

Table 4-3 - Retained spillway arrangement from preliminary design

Main Spillway	
Nature	Reinforced concrete culvert spillway
Location	Placed at the right hand side of the auxiliary spillway over the left abutment.
Inlet elevation	Initially 33 m amsl
Number of barrel	2 U
Width of cell	5 m
Height of cell	5 m
Auxiliary Spillway	
Nature	Mass concrete ogee crest.
Location	Placed over the left abutment
Length	300 m
Crest elevation	40.5 m amsl
Downstream slope	1:1
Upstream slope	Vertical

The auxiliary spillway was considered as a broad crested weir in the hydraulic and flood routing calculation to consider the possible drawn effect on the left hand side. A coefficient of 1.704 was retained for rating curve establishment.

Importance of the 3D mathematical model is proven in this configuration and would be able to adjust our hydraulic rating curve either for the culvert or the auxiliary spillway.

B. Auxiliary Spillway Crest

A 300 meters wide ogee crest spillway will be implemented on the left side of the culvert spillway. It will operate during very large flood event.

The hydraulic performance of an ogee spillway is affected by the following parameters:

- approach depth;
- upstream face angle;
- ogee shape;
- contraction due to piers and abutments;
- possible submergence effect from downstream.

Approach depth

The spillway has an approach channel which will help conveying water to the control structure. The

bottom elevation was set to be 40.5 m amsl, so the approach depth is 1m over its left portion and increasing to 3.5m. The last value is considered for computation to ensure the right shape is used throughout the complete section.

NB: the left portion with only 1 meters approach will work as normal weir and would be drown during high flood event. The hydraulic capacity of such structure is difficult to assess and 3D model would give solution closer to reality.

Ogee shape and upstream face angle

The ogee shape was set according to the guidelines from USBR. The equation for the profile downstream the highest point is

$$\frac{y}{H_0} = K \cdot \left(\frac{x}{H_0}\right)^n$$

where H_0 is the design head corresponding to 1,000 years flood (Q=3639m^3/s). The coefficient K and n were chosen according to the following figure and in the hypothesis of vertical upstream face.

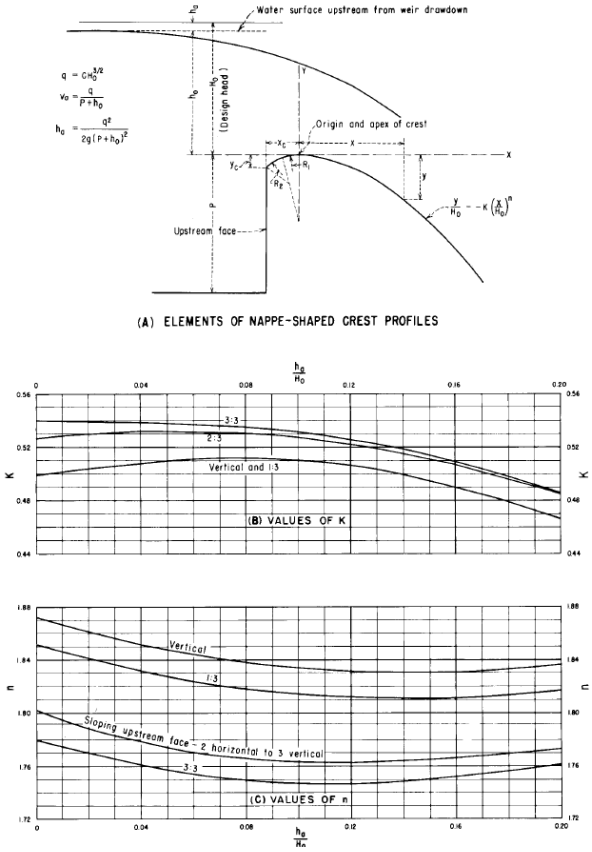


Figure 4-7. Reference scheme for the ogee design and chart for the coefficient of the downstream profile (Source: USBR, "Design of small dams" - 1987)

The upstream portion of the profile is made by a composition of arcs, which geometrical features are described in the following chart.

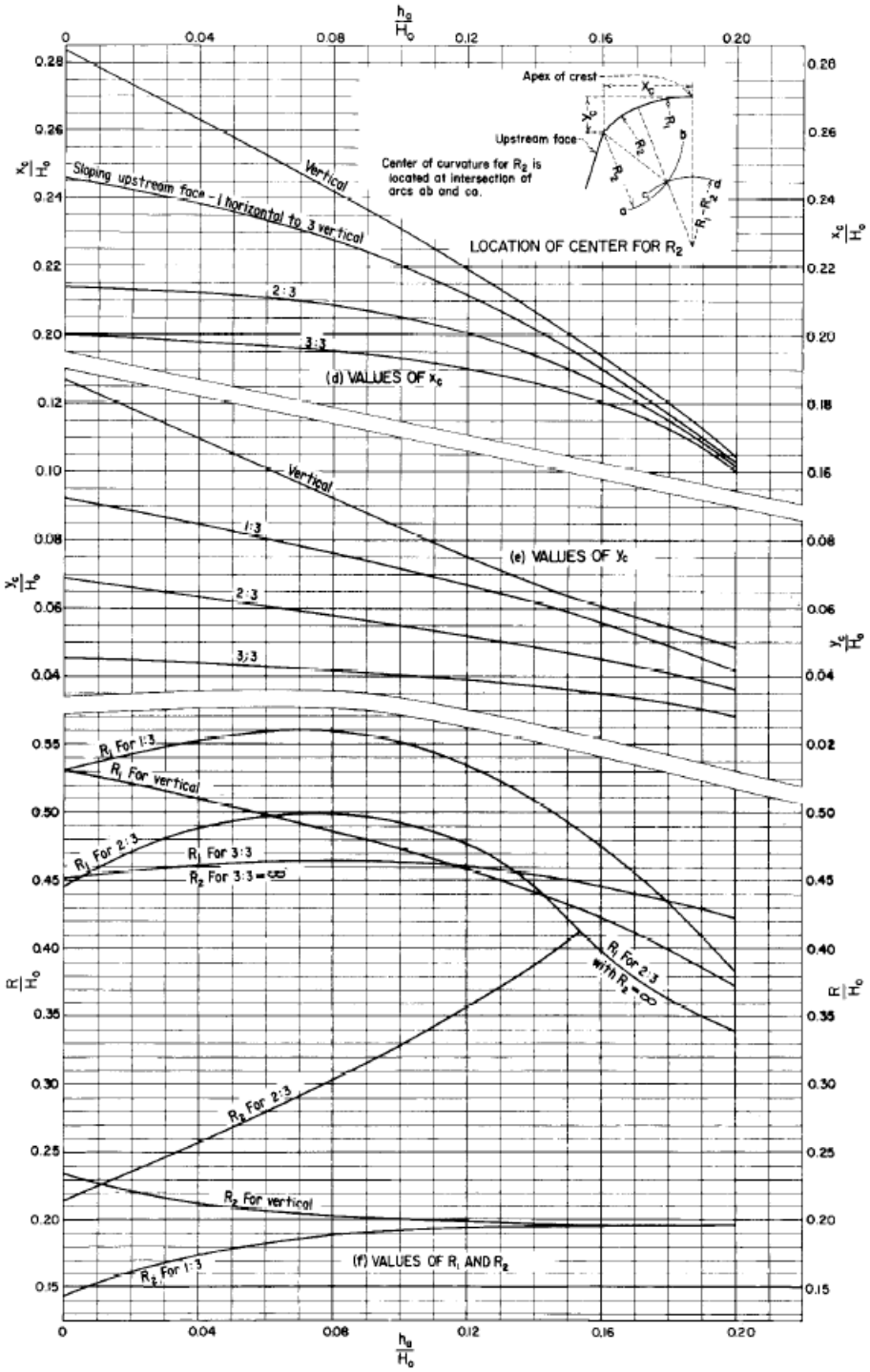


Figure 4-8. Factor for the definition of the upstream crest profile

(Source: USBR, "Design of small dams" - 1987)

Contractions due to piers and abutments

The contractions of the flow sections due to abutments and possible piers are calculated by the following formula:

$$L' = L - 2 \cdot H_0 \cdot (N \cdot K_P + K_a)$$

L' = net length of the crest

L = total length of the spillway sill

H_0 = design head

N = pier number

K_p, K_a = contraction coefficient for piers and abutments

In this case no piers are forecast, so the contraction is due only to the abutments. The coefficient Ka is to be 0.2, in the hypothesis of squared abutments with headwalls 90 degrees to the direction of the flow.

The shape of the ogee has been designed for the 10'000yrs flood outflow corresponding to a design head H_d=3.14m and net length of L'=299m

The ogee profile will be as follows:

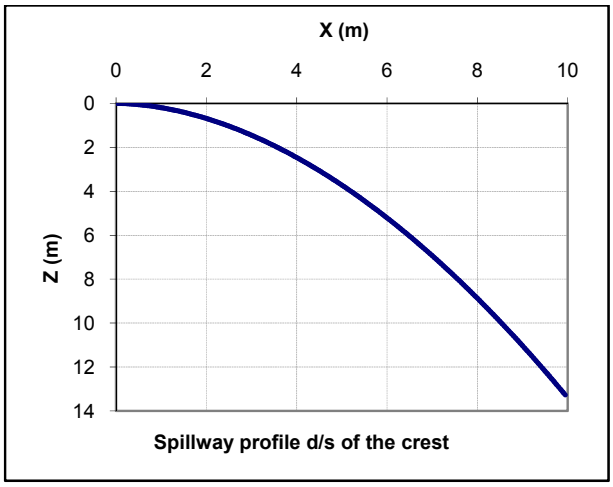


Figure 4-9 - Jurf Dam Auxiliary Ogee Crest Profile

Considering the downstream slope of 1:1 the matching point will set at :

Table 4-4 - Matching point with downstream slope

X	3.45	m
Y	38.62	m

Following the usual USBR guidelines for ogee crest shape, the upstream quadrant answered to difference radius depending on the retained design height. The following shows the different coordinates and adopted radius over this portion.

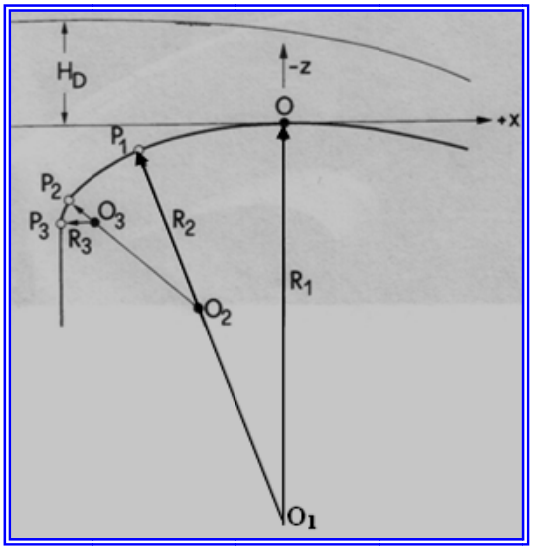


Table 4-5 - U/S Quadrant of Ogee - 300m wide

	X (m)	Y (m)
O1	0.00	0.89
O2	-0.19	0.39
O3	-0.43	0.24
P1	-0.31	0.06
P2	-0.49	0.21
P3	-0.50	0.24

C. Spillway Optimization

During this phase, some optimisation was initiated for hydraulic purposes. Indeed, the preliminary design of wadi Jurf dam possesses a culvert spillway with an arbitrary level at 5 meters of the lowest point of the reservoir in order to minimise the storage and provide a certain degree of storage routing. At the outlet, the slope is shallow and initially a very minor slope was foreseen in the culvert. In addition, the outlet required a large excavation to reach the natural wadi bed.

A small sensitivity analysis was performed over the slope to be implemented within the culvert to see the effect. During this one, no downstream condition were taken into consideration.

The initial condition (Preliminary Design) was as follows:

- 2 barrels of 5mx5m set at 33mamsl;
- No slope;
- Entrance head loss coefficient =0.5
- Outlet loss coefficient =1
- Length =50m
- 300m auxiliary spillway at 40.5mamsl

It has been decided to raise the Culvert sill elevation at 34 m.a.m.s.l.

This small sensitivity analysis over the culvert slope will be The dam height will not be affected by this small changes and will remains at it is. However this allows a reduction of excavation downstream the culvert spillway and the PMF flood values remains at 47.4mamsl which is fixing the dam crest.

In order to obtain the similar flood design criteria, the slope of 1% is appropriate. The following results are obtained.

Table 4-6 - Hydraulic Refinement - 1% slope Culvert

-Bottom Outlet: Main: -2 Bottom Outlets 5mx5m set @ 34mamsl (6 meters above Lowest point) SLOPE 1%; -Emergency Spillway to obtain design criteria reduction L=300m Z=40.5mamsl					
	300.00	300.00			
Considered Spillway Length	L=300 meters Emer /Double B.O				
Return Period	**100**	**500**	**1000**	**10000**	**PMF**
Inflow volume (m^3)	57391530	96410118	112858872	168963360	353806176
Inflow peak discharge (m^3/s)	**2322.9**	**3923.9**	**4598.8**	**6890**	**14966.5**
Combined Outflow Volume (m^3)	53188794	92195532	108641118	164738112	349572810
Combined Outflow (m^3/s)	**603.4**	**1780.5**	**2290.8**	**3951.3**	**9630.8**
Bottom outlet Peak Discharge (m3/s)	**234.7**	**265.6**	**278.5**	**311.9**	**386.6**
Spillway Peak Discharge (m3/s)	**368.7**	**1515**	**2012.3**	**3639.3**	**9244.2**
Maximum reservoir level (m.a.s.l.)	*41.3*	*42.6*	*43*	***44.2***	***47.4***
Hieght above Bottom Outlet sill	*7.3*	*8.6*	*9*	*10.2*	*13.4*
Hieght above Emergency Spillway Crest (m)	*0.8*	*2.1*	*2.5*	*3.7*	*6.9*
Specific discharge of Emergency Spillway (m3/s/ml)	*1.2*	*5.2*	*6.7*	*12.1*	*30.9*
Peak discharge reduction at Dam Site (%)	74%	54.6%	50.2%	42.7%	35.7%
Flood Volume reduction at dam site (%)	7%	4.4%	3.7%	2.5%	1.2%

In order to refine our hydraulic model and ensure the spillway and bottom outlet are not under drowning state, a study involving the downstream tailrace was performed.

Several hydraulic models were established, with Hec-Geo Ras and Flo-2D software but only the flow from the bottom outlet was studied.

Jurf dam possesses a spillway positioned over the left abutment which might require a particular attention in term of hydraulic condition. This spillway is actually discharging into a narrow gorge which will contract the flow an increase the depth of water.

The spillway is composed of complex of culvert spillway with concrete broad crested spillway. In order to provide relevant information for the purpose of the physical model of the spillway i.e. a precise rating curve at the downstream boundary of the physical model and the depth of water expected within the water course.

4.5 Sedimentation

Jurf dam will be subject to sedimentation. It has a very wide catchment characterised with mountains and fines materials. A high rate of sedimentation is expected at this location even if the dam does not store the flood event and start the release during the event.

Sedimentation is a phenomenon which is very difficult to assess accurately without actual measurements during flood events. Since the Sultanate of Oman is subject to infrequent flood events records of sediment load during these events are not readily available. Consequently empirical formulae developed for the Middle East were used in the assessment of total sediment likely to be deposited in the reservoirs.

In addition the 50 % probability yields of the wadis were calculated to compare with the empirical formulae used.

A. Empirical Formulae

In order to estimate the total expected sedimentation at the reservoirs the following sedimentation relationships were considered.

Global Average (Mahmood 1987);

Asian basin Rate (White 1993);

UAE Ministry of Agriculture & Fisheries Empirical Formulae;

Empirical formulae;

It is believed the Rankl formula (2001) would provide a better estimate but this requires local data of the catchment and results of monitored sediment loads Since this information is not available we used the four above mentioned empirical formulae to assess the rate of sedimentation of these catchments.

B. The Global Average Rates

Mahmood 1987, conducted a detailed study of sediment transport. The study covered a wide variety of the world's drainage basins. The global averaged sediment yield was estimated to be 190 t/km2/yr. (i.e. 120$m^3/km^2/yr$). Bulk density taken as 1600kg/m^3.

C. Average Rates of Asian Basins

White (1993) estimated the averaged sedimentation yield for Asian basins to be of the order of 290/t/yr (i.e. 180$m^3/km^2/yr$). Bulk density taken as 1600kg/m^3.

D. The UAE Empirical Formula

The wadi bed is often dry and the Ministry of Agriculture and Fisheries of UAE provided an empirical formula which can be used for such catchments. The formula is given below:

$Q_s = 292.6\ A^{-0.12}$

Where

Q_s is annual sediment yield in m^3/km^2

A is the catchment area in km^2

E. Empirical Formulae

A common relationship used in Oman provides for a sedimentation rate of S=100 m^3/year/km^2.

Therefore S (m^3/year) = 100 x Catchment Area (km^2)

The following table summarises the calculated sedimentation values at the dam locations using these

relationships.

JURF DAM LOCATION	Catchment (km²)	Annual sediments yield (m^3/km^2)	Total accumulation (m^3) After a period of years		
			10	20	50
UAE	715	133	950744	1901488	4753720
Mahmood		120	858000	1716000	4290000
Asian Basin Rates		180	1287000	2574000	6435000
Empirical Formulae		100	715000	1430000	3575000
Average			952686	1905372	4763430

F. Probabilistic Approach

A probabilistic approach to likely sediment yield at the dam locations was done to compare with the empirical formulae. The table below shows the flood volumes and peak discharge rates for various return period events

Table 4-7 - Flood Volumes and Peak Discharge Rates – Jurf Dam

Jurf Dam Location							
Return Period	1000yrs	100yrs	50yrs	25yrs	10yrs	5yrs	2yrs
Discharge Q (m3/s)	4599	2323	1473	882	374	136	3.2
Volume V (Mm^3)	112	57	37	23	10	4	0.1

The risks of each return period being exceeded were calculated and are tabulated below. By definition the 2 year flood has a 50 % probability of occurring in any single year. Consequently the 50 % probability of the cumulative number of events, greater than the 2 year event, during the 100 year expected life of the structure is calculated to be 50. Similarly the 50 % probability of other discrete return periods are calculated and for the largest two return periods only fractions of the floods are considered to retain the cumulative number of events at 50. The results of the calculation are tabulated below.

Figure 4-10 - Cumulative probability of each rainfall event

The table below summarises the number of expected events during the 100 year life of the dam.

Return Period of Event	Probability of Exceedence in 100 year life	Number of events exceeding return period	Net number of events for each return period	Peak discharge
2	1.00	50	30	3.2
5	1.00	20	10	136.0
10	1.00	10	5	374.0
25	0.98	4	3	882.0
50	0.87	2	1	1473.0

Return Period of Event	Probability of Exceedence in 100 year life	Number of events exceeding return period	Net number of events for each return period	Peak discharge
100	0.63	1	.73	2323.0
1000	0.10	0	.27	4599.0
CUMULATIVE TOTAL		50	50.00	

The sediment discharge rates for the different peak discharge rates associated with each return period is then calculated using rating curves developed by USACE and contained in their River Hydraulics Manual. The rating curve was extrapolated for the high peak discharge associated with the 1000 year event and the sediment yield is summarised below.

Figure 4-11 – Sediment Yield of each Rainfall Event

Return Period of Event	Peak discharge (m^3/s)	Total Flood Volume (Million m^3)	Sediment Yield (T)
2	3.2	4	349
5	151.7	40	146594
10	447.6	52	698309
25	1100.8	69	1963216
50	1857.2	37	1525856
100	2938.8	36	2349400
1000	5835.3	30	3312883
Total		270	9'996'607
Sediment yield in T per km^2			13'981
Sediment yield in T per km^2 per year			140

Using the same bulk density used in the empirical formulae the mean annual sediment yield is calculated as 87 m^3/km^2/year, which is similar to the formula commonly used in Oman.

without maintenance over the dam and considering the above rate of sedimentation, 51yrs will be needed to fill the dead storage volume with sediment materials.

A 5 yrs plan removal might be necessary and a yearly monitoring procedure to be implemented.

4.6 Jurf DAM Design

From the conceptual design phase, it was clear that this dam location is geologically complicated and spoke for a flexible structure. During this phase, geological survey shows that active faults might be crossing the dam site at the left abutment as well as remaining salt dome pocket. The last one represents more important concerns and will be verify and be targeted during geotechnical investigations.

According to ICOLD Bulletin 112, the definition of a fault is the following:

'A fault, reasonably identified and located, known to have produced historical fault movements or showing geologic evidence of displacement and which, because of its present tectonic setting, can undergo movement during the anticipated life of the dam.'

Active fault can impact the dam structure in an adverse way if movement is created. ICOLD attempted to give guidelines for dams on faults in 1998. This was complemented during the 14th World Conference on Earthquake Engineering. The mitigation measures consist in the following:[2]

- Impervious core made of Ductile with high failure strain to minimize the propagation of the rupture zone;
- Thicker filters and transition zones;
- Wide dam crest;
- Flat slopes;
- Generous Freeboard;
- Material selection and compaction of rockfill etc..;

These above several points guided the selection of the dam nature and its main figures.

The second concerns related to the potential presence of a salt dome results in recommendations of an extensive geological survey and geotechnical investigations to target this area underneath the dam axis prior initiating the drilling works.

- **Dam Nature**

The foundations consist of granular material over the main portion of the dam axis. Each abutment revealed some rock formation. The nature of the dam to be implemented is a complex of Earthfill /

[2] *Potentially Active Faults in the Foundations of Large Dams, PART II: Design Aspects of Dams to resist Fault Movements.* **M. Wieland, R.P Brenner, A. Bozovic.** Beijing, China : The 14th World Conference on Earthquake Engineering, 2008, October 12-17.

Rockfill Embankment associated with a watertighness element.

Due to the presence of active fault, Jurf dam shall be equipped with a ductile core in order to withstand reasonable displacement without significant loss or damage to the watertight element. For this dam alternative, the choice of bituminous concrete core was retained and found appropriate. It can auto-healed if cracks appear or relative displacement occurred.

The core will rest over a concrete slab in order to ensure the connection with the lower part within the foundation. Different properties of bituminous core will be foreseen. Where faults are revealed to us, specific joint will be carried out in order to allow differential settlement. The bituminous core will be drained downstream within the transition layer.

In addition, separation will be carried out every 200m to ensure the collected water can be monitored and analysed.

In addition, conservative slopes of 2.3 in 1 on the upstream and 1.8 in 1 at the downstream were retained. The choice of 1.8:1 was selected to comply with spillway excavation and the rock fill mechanical properties.

Implementation of transition layer upstream and downstream the bituminous core is advisable to ensure the maintaining of stability in case of differential displacement occurs.

The dam crest was retained with width of W=6.8 meters as per guidance of “Design of Small Dams”

The following figure shows the retained cross section A:

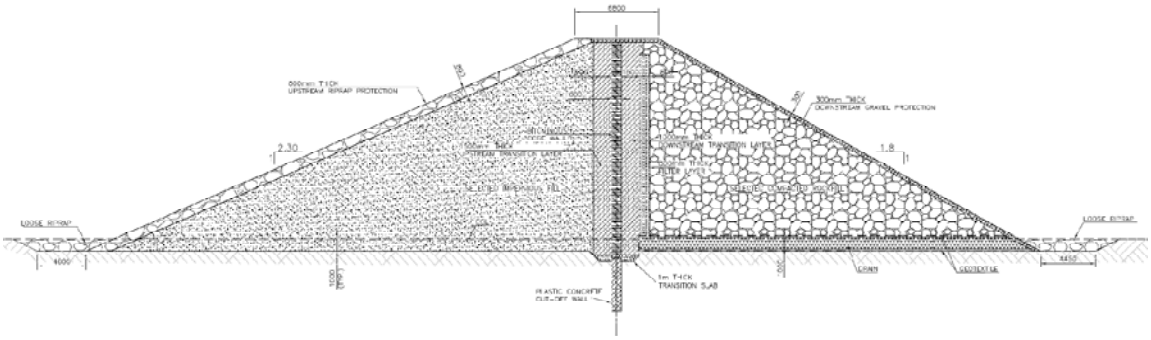


Figure 4-12: Cross Section – Bituminous Core

- **Seepage control**

Both abutment will necessary be treated to avoid any contouring of the water, specially the right one that might present some karstic features. The core shall be anchored in a deep manner through the abutment and grouting will be designed accordingly. Particular attention will be paid during geotechnical investigations.

The left abutment will certainly excavated and equipped with the auxiliary spillway. Grouting will be necessary as well and a particular attention will be paid to any revealed faults. The spillway shall integrated some special features to allow small displacement.

Drainage will be provided under Rockfill materials and will collect any seepage water coming out from the foundations. This water shall be collected and monitored.

- **Main Spillway**

As described earlier, the spillway will consists of 2 barrels of 5*5m culvert placed at the left abutment founded on the visible rock layer.

The entrance sill elevation will be set at 33mamsl and will allow a significant flood reduction;

In addition to this main structure, an auxiliary spillway is foreseen over the left abutment, excavation to a level of 39.5 mamsl is required. The nature of the spillway is a broad crested weir discharge in a natural gorge downstream.

No dissipation structure is foreseen for this structure since it is believed that the rock formation is competent enough to withstand the hydraulic jump and the supposed flow regime.

The length of the spillway will be 300m.

- **Outlets**

Due to the possible presence of remaining pocket of salt over this dam site, the Consultant recommends that the dam reservoir shall be empty as soon as the flood passed. After routing effect via the culvert spillway, the reservoir will be almost empty. At this stage and without knowledge of the foundation, the Consultant considered that culvert spillway sufficient.

In case sign of slat formation is revealed, it is believed that providing a bottom outlet to empty the remaining volume of the reservoir might be needed in order to limit the infiltration and the possible dissolution leading to foundation instability below the dam.

4.7 Stability Analysis of the Embankment

A preliminary Stability Analysis was performed for each dam cross-section alternatives A & B that present the most crucial aspects in term of stability (i.e. highest cross section).

The analysis was carried out with the help of SLIDE software, finite element software.

The mechanical and hydraulic properties as well as the seismic coefficients of the model were selected without extensive knowledge of the foundation, and therefore retained as safe value according to the expert judgement.

The study is performed to check the stability of the Jurf Dam and the corresponding Factor or Safety under various loading case scenario directly extracted from the usual recommendation and worldwide practice. (Based on ICOLD, FEMA and USACE).

Depending on the results, the geometry of the dam shall be adjusted in order to comply with the required safety factor ensure a great degree of safety during usual flood, extreme event, and seismic event.

Bishop approach's was used to estimated the safety factors for the all the relevant loading case scenario. This method was found conservative compared to the other available in the literature.

4.7.1 Geometry

In order to be exhaustive, the main cross section were checked under the usual case. The Bituminous core cross section is as follows:

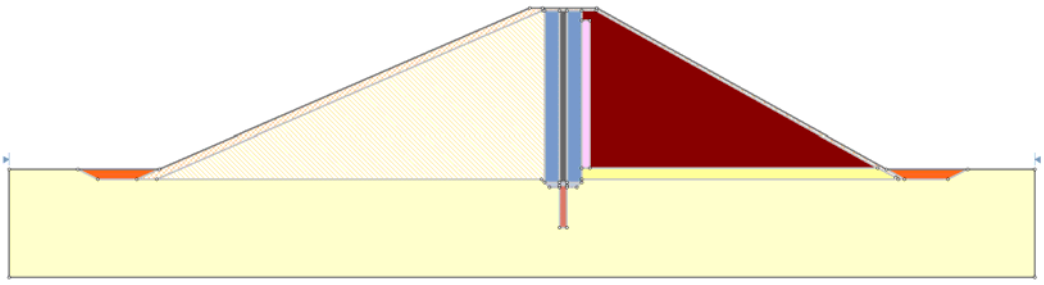


Figure 4-13 – Slide Model – Bituminous Cross Section

4.7.2 Materials Properties

Without extensive knowledge of the foundation and its mechanical characteristics, a judgement has made and conservative soil properties values has been retained. This ensures a safe design for slope

stability under different loading cases. Both alternatives were investigated. The following table shows the retained design parameters.

Table 4-8 – Mechanical Properties – Dam Components

Material	Cohesion c [kPa]	Internal Friction angle φ [°]	Unit Weight Dry / Saturate [kN/m^3]
Foundation Layer	5	20	19
Earthfill Shell (Dense)	0	35	22
Rockfill Material	0	40	21
Plastic Concrete Core	500	40	24
Bituminous Core (Asphalt)	120	24	23
Clay Core (Stiff)	C_u=40 $C_{drained}$ 10	24	Y_d=16 Y_s=18
U/S Transition Layer	0	33	22
D/S Transition Layer	0	33	22
Drain	0	40	22
Filter	0	40	22
Rip Rap	0	44	21
Gravel Protection	0	44	21

These values will be revised after analysis of the geotechnical investigations to ensure the design parameters used in the final analysis is representative of the actual materials to be use din construction. Once the design parameters are finalised these values will be used to optimise the embankment section.

4.7.3 Seismic Coefficient

The peak ground accelerations on rock were retained according to Oman Highway Design Manual procedure and to specific studies developed for the Sultanate of Oman. In order to take into account the site effects and the interaction with the type of structure analyzed, the seismic coefficients were modified by considering a flexible structure placed over soil formation. At this stage we do not consider the soil as liquefiable. Therefore:

- Return Period for OBE is 475 years (10% in 50 years):

$$PGA_{475\ years\ return\ period}(Duqm) \cong 0.03\ g$$

- MCE is evaluated with DSHA – Deterministic Approach:

$$PGA_{84\%-\mathrm{MCE}}(Duqm) \cong 0.1\ g$$

Conclusion on design seismic parameters for a rock site.

As previously enounced, the SEE can be taken either as the MCE or MDE ground motions. Usually the most unfavorable ground motion parameters have to be taken. For the time being there are not information about the MDE, while for MCE yes. Therefore, we will consider the following:

- *SEE ≡ MCE* → $PGA_{MDE} \cong 0.1\ g$ *at the rock site;*
- *OBE* → $PGA_{OBE} \cong 0.03\ g$ *at the rock site;*

Conclusion on design seismic parameters for Jurf Dam site.

At this stage proper values for the characterization of soil type conditions are not available, conservative values will be assumed:

- For expected rock ground – Type A ground (No amplification of seismic acceleration);
- For expected soil ground - Type D ground (amplification of seismic acceleration with a factor 1.8).

In the pseudo-static method the values presented in the following table shall be used in the design calculations and are dependent on the type of structure and soil as follows:

Table 4-9 – Seismic Parameters - Duqm

Pseudo-static Analysis				
Type of structure	Ground Type	Level of Seismic Event	Horiz. Accel. [g]	Vert. Accel. [g]
Concrete Massive	Rock	OBE	0.03	0.015
		MCE	0.1	0.05
	Soil	OBE	0.054	0.027
		MCE	0.18	0.09

Type of structure	Ground Type	Level of Seismic Event	Horizontal Coefficient	Vertical Coefficient
Earthfill	Rock	OBE	0.015	0.0075
		MCE	0.05	0.025
	Soil	**OBE**	**0.027**	**0.0135**
		MCE	**0.09**	**0.045**

It should be kept in mind that:

- The horizontal coefficient is defined as: $k_h = 0.5\ S\ \frac{PGA}{g}$;
- The vertical coefficient is defined as:$k_v = \pm\ 0.5\ k_h$;
- The vertical acceleration is defined as the half of the vertical.

The following coefficients were then retained:

Table 4-10 – Retained Seismic Parameters

Pseudo-static Analysis				
Type of structure	Ground Type	Type of seism	Horiz. Accel. [g]	Vert. Accel. [g]
Earthfill/Embankment	Soil	OBE	0.027	0.0135
		MCE	0.09	0.045

4.7.4 Loading Cases

For overall stability, the combination cases are classified as follows, by decreasing corresponding factors of safety:

Normal Condition of Loading N: The Normal condition of loading includes all loads to which the structure is considered to be subjected either permanently or for a considerable length of time.

Unusual Condition of Loading U: The Unusual condition of loading includes in addition to the Normal loads the abnormal temporary loads which will probably apply at least once in the life of the structure.

Exceptional or Extreme Condition of Loading E:

The Extreme condition of loading will include in addition to the normal loads, the loads which might apply to the structure with a probability of occurrence clearly less than 0.5 during the life of the structure (the return period of such event is at least twice the life of the structure). An exceptional condition of loading will also be a combination of two unusual conditions of loading. It must be noticed that two exceptional events cannot be combined.

The loading combinations for earthfill dams can be summarized as follows:

- ✓ **Load Condition 1: Unusual load condition – End of Construction**
- ✓ **Load Condition 2: Usual load condition – Normal operations FSL**
- ✓ **Load Condition 3: Unusual load condition – Flood discharge MWL**
- ✓ **Loading Condition 4: Extreme load condition – OBE during construction**
- ✓ **Loading condition 5: Unusual load condition – FSL and OBE**
- ✓ **Load condition 6: Extreme load condition –MCE with empty reservoir**
- ✓ **Load condition 7: Extreme loading condition – Rapid Drawdown.**

Both Alternative are flexible structure and shall comply with usual loading conditions. The stability loading cases according the USACE manual EM 110-2-1902 must be verified and are as follows:

Load Cases	Description	Factor of Safety (FoS) [1]
1	Empty Reservoir	1.3
2	Reservoir at MWL	1.4
3	Reservoir at FSL	1.5
4	Empty Reservoir + OBE	1.3
5	Reservoir at FSL + OBE	1.1
6	Empty Reservoir + MDE	≥ 1
7	Rapid Drawdown	1.3

Since the upstream prism is different from the downstream one, it is essential to analyse both faces for the relevant load cases. The results of these analyses are included in the appendices.

4.7.5 Stability Results

Load Cases	Description	Factor of Safety (FoS) [1]	Analysis Safety Factor	
			Upstream	Downstream
1	End of Construction	1.3	1.64	1.54
2	Reservoir at MWL (329.7mamsl)	1.4	4.33	1.54
3	Reservoir at FSL (327.2mamsl)	1.5	1.75	1.54
4	Empty Reservoir + MCE	≥ 1	1.28	1.25
5	Reservoir at MWL (329.7mamsl) + OBE	1.1	3.88	1.45
6	Reservoir at FSL (327.2mamsl) + OBE	1.1	1.62	1.45
7	Rapid Drawdown	1.3	1.7	-

The Jurf Dam with bituminous core is considered stable in every studied loading case. The rapid drawdown was carried out considering long term retention and consequently do not represent reality but is conservative.

4.8 Jurf Dam Construction process

As preliminary figures, the proposed dam is consisting of an earthfill embankment associated with bituminous core and a plastic concrete cut-off.

The upstream prism will be made from wadi alluvium taken from the reservoir area by mechanical mean. The downstream prism will be executed with reused rockfill materials coming from spillway excavation positioned over the left abutment.

The rockfill materials will be excavated by mechanical mean and tested sieved in order to appropriate physical properties for stability purposes. This material will also be mined to obtain appropriate rip rap for dam slope protection.

The concrete bottom outlet will be carried out at the early stage in order to be used for flood diversion structure. A temporary cofferdam will be integrated to the dam in order to be able to work in dry

condition downstream.

Prior any placement of material, the foundation will be opened up to the desired depth. Preparation of the surface will be made, compaction, scarification. Then, positioning of the guide wall will be made for the cut-off. The cut-off will be carried out by tremie pipe method and involved placing of bentonite for stability purpose. This bentonite will be closely monitored and reused along the complete realization of the plastic concrete cut-off.

The dam will then be constructed in different steps. Placing of embankment, then compacting and scarified to ensure proper cohesion between each layers. At the same time, the bituminous core will be carried out. This operation will be repeated until the dam crest elevation is reached.

4.9 Dam Monitoring implementation

It is proposed to provide a series of topographical pegs with the reservoir to monitor the sedimentation rate throughout the project life. The Consultant recommends a survey of this equipment every 5 years or after each significant flood.

In addition, the drainage layer will be discharging the percolated water (if any) in a network of pipes where monitoring will be possible thanks to calibrated V-notch. In view of the dam perspective (Flood protection), it is expected that the percolated waters would be very low. When assessing the flowrate if any, it is also recommended to assess the turbidity of the water which could be synonymous of internal erosion when high. Particular attention will be paid at the junction between the concrete structure and the embankment where preferential seepage water can be seating.

In addition, topographical pegs will be positioned over the embankment in order to assess any settlement and instability over the face of the dam. Similar device will be positioned along the spillway crest and the bottom outlet structure.

In the sultanate of Oman, there is no regulation upon the monitoring of the dams. This would be achieved by the dam owner (Either SEZAD or the Ministry of Water Resources).

5. BASELINE ENVIRONMENT SETTING

5.1 Overview

This chapter describes the baseline conditions in the study area and provides summarized information on the physical, biological and socio-economic environment. The purpose of this chapter is to facilitate the evaluation of impacts assessed in following stage.

5.2 Demographic Data

According to the 2010 population census, the total population of Al Wusta Governorate was 42.111, 19.043 Omani and 23.068 Expatriate.

Wilayat Duqm that includes the village of Duqm at the 2010 presented 11,217 inhabitants, corresponding to 26,6% the Wilayat. Duqm town has a total estimated population of 9,202 male and 2,015 female inhabitants.

The national census indicates that the total population of Duqm city is composed by 3,820 Omanis and 7,397 foreign expatriates.

Unit	2010	2003	الـوحـــدة
Total Population	**42,111**	**22,983**	**جملة السكان**
■ Omani	**19,043**	**16,861**	■ عُمانيون
■ Expatriate	**23,068**	**6,122**	■ وافـدون
Total Households	**4,070**	**3,157**	**جملة الأسر**
■ Omani Households	**2,696**	**2,284**	■ اسر معيشية عمانية
■ Expatriate Households	**1,264**	**694**	■ اسر معيشية وافدة
■ Collective Households	**110**	**179**	■ اسر جماعية
Total Housing Units	**6,387**	**4,233**	**جملة المساكن**
■ Occupied Housing Units	**4,033**	**3,125**	■ وحدات سكنية مأهولة

Figure 5-1: Wusta Population – Census 2010

Wilayat	2010				2003				الولاية
	الأسـر Households		المساكن Housing Units		الأسـر Households		المساكن Housing Units		
	%	No. العدد	%	No. العدد	%	No. العدد	%	No. العدد	
Hayma	11.1	451	11.2	717	11.0	348	11.9	507	هيـمـاء
Mahawt	49.0	1,995	41.8	2,670	47.6	1,504	41.1	1,738	محـــوت
Ad Duqm	22.4	912	27.4	1,750	21.9	690	22.9	969	الـدقم
Al Jazer	17.5	712	19.6	1,250	19.5	615	24.1	1,019	الجـازر
Al Wusta Region	100	4,070	100.0	6,387	100	3,157	100	4,233	المنطقة الوسطى

Figure 5-2: Wusta Households and Housing Units – Census 2010

Wilayat	Total		المجموع		Expatriate		وافدون		Omani		عمانيون		الولاية
	2010		2003		2010		2003		2010		2003		
	%	No. العدد	%	No. العدد	%	No. العدد	%	No. العدد	%	No. العدد	%	No. العدد	
Hayma	24.9	10,473	14.0	3,207	37.1	8,553	22.5	1,378	10.1	1,920	10.8	1,829	هيماء
Mahawt	29.7	12,488	42.1	9,687	9.0	2,084	18.2	1,113	54.6	10,404	50.9	8,574	محوت
Ad Duqm	26.6	11,217	18.6	4,269	32.1	7,397	13.7	839	20.1	3,820	20.3	3,430	الدقم
Al Jazer	18.8	7,933	25.3	5,820	21.8	5,034	46.6	2,792	15.2	2,899	18.0	3,028	الجازر
Al Wusta Region	100	42,111	100	22,983	100	23,068	100	6,122	100	19,043	100	16,861	المنطقة الوسطى

Figure 5-3: AL Wusta Population and Percentage – Census 2010

Wilayat	Total		المجموع	Expatriate		وافدون	Omani		عمانيون	الولاية
	المجموع Total	إناث Female	ذكور Male	المجموع Total	إناث Female	ذكور Male	المجموع Total	إناث Female	ذكور Male	
Hayma	10,473	1,178	9,295	8,553	243	8,310	1,920	935	985	هيماء
Mahawt	12,488	5,302	7,186	2,084	243	1,841	10,404	5,059	5,345	محوت
Ad Duqm	11,217	2,015	9,202	7,397	149	7,248	3,820	1,866	1,954	الدقم
Al Jazer	7,933	1,622	6,311	5,034	192	4,842	2,899	1,430	1,469	الجازر
Al Wusta Region	42,111	10,117	31,994	23,068	827	22,241	19,043	9,290	9,753	المنطقة الوسطى

Figure 5-4: AL Wusta Population by Wilayat– Census 2010

5.3 Local Economy

The Duqm SEZ is a model of an integrated economic development composed of 8 zones: a sea port, industrial area, new town, fishing harbor, tourism zone, a logistics hub and an education & training zone, all of which are supported by a multi-modal transport system that connects it with nearby regions (the Arabian Gulf countries, Middle East, East Africa and Southeast Asia).

Duqm development undertakes the future construction of Modern Port & Dry Dock, International Airport, New Town complex, Industrial Areas, Fishing Harbor & Industry, Transport System, Power & Utilities and Tourism Zones (Hotels & Resorts).

The major employment generators for Duqm are expected to be the Oil Refinery, the Sea Port, Tourism, the Fishing Port, and the Airport.

Up to 2017, Duqm developments will provide a total of 4,126 permanent direct jobs in projects such as the Duqm airport, the cement terminal project, the Duqm refinery and Duqm Ship repair yard.

The recent investments done to build the City Duqm Hotel and the Crown Plaza is also providing local & foreigner employment, but, most of all, allowing the development of the area in terms of tourism.

The small scale economy of the Duqm city is mainly based on: Government Servants, Private Servants, Retired Government Servants, Trading, Fishing, Shopkeepers, Laborers, Cultivators and Pastorals. Duqm is oriented towards agriculture, fishing and raising stock (goats), as shown in the following Figures. Housing conditions are also one of the major/important indicators for the assessment of living standard. The houses in the Study Area are made with cement blocks, fully equipped with all amenities including house overhead water tanks. Most people owns a private vehicle and uses this mean of transport to reach work in the center town.

Figure 5-5: Camel farm in Duqm

Figure 5-6: Raising goats in Duqm

Figure 5-7: Fishing activities in Duqm

5.4 Land Use

The Duqm master plan intends to accommodate a 13,00 hectares of wide-ranging mix land to develop urbanized areas of the city while preserving natural assets and ensuring the potential grow.

Duqm's developable areas will be planned strategically to accommodate these uses in a way that will maximize their productive value while allowing the city to grow in a compact, logical way that can support development in context with its unique natural setting.

Urbanized areas will be planned strategically, with a range of other uses to be accommodated in remaining areas. Duqm's unique topography and setting provide a range of environmental conditions conducive to particular arrangements for these remaining uses – and their design will be prioritized where they make the most sense.

Duqm can accrue significant value out of the special use zones, which will accommodate recreational, natural, and productive uses. Flexibility will be a major objective in planning these zones so that as Duqm grows it will be able to accommodate the changing needs of the city without sacrificing its unique environmental heritage.

The current land use map shown below, indicates the developed within Duqm city. For the actual time, the area where the project of the proposed project is to be developed in Wadi Jurf has no major occupation in terms of land use terminology. Some construction activities are in the on-going stage in the vicinity of the area and some small farms are visible along the channels on a small scale.

The bellow figure represents the adopted land use zoning for the entire Duqm Royal decree area as of September 2013.

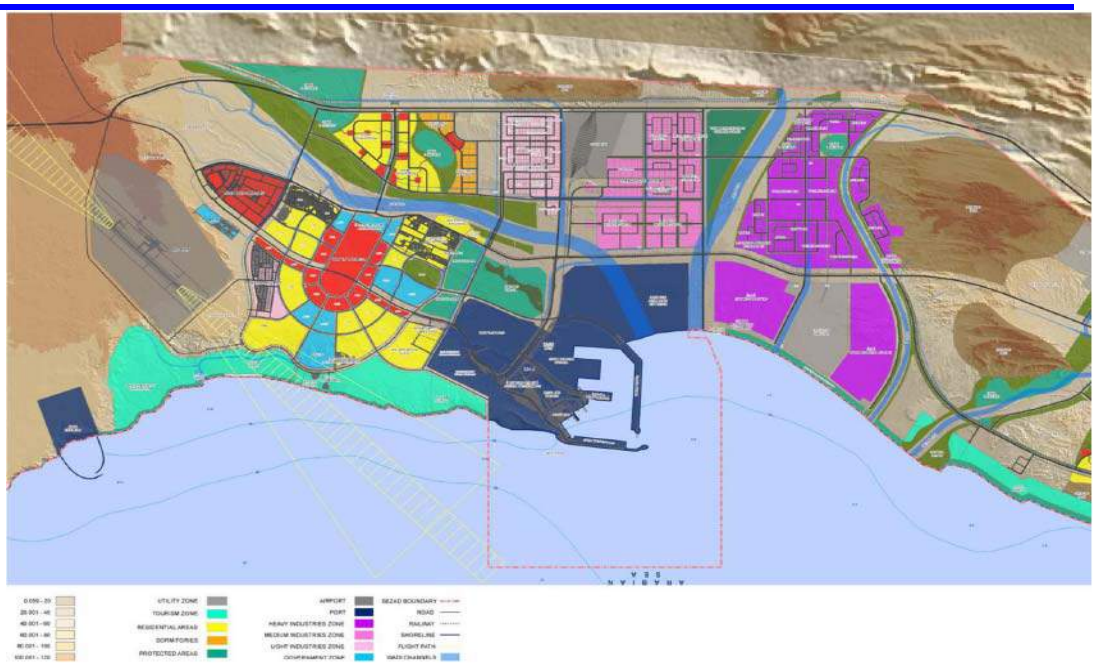


Figure 5-8: Land Use map approve by September 2013

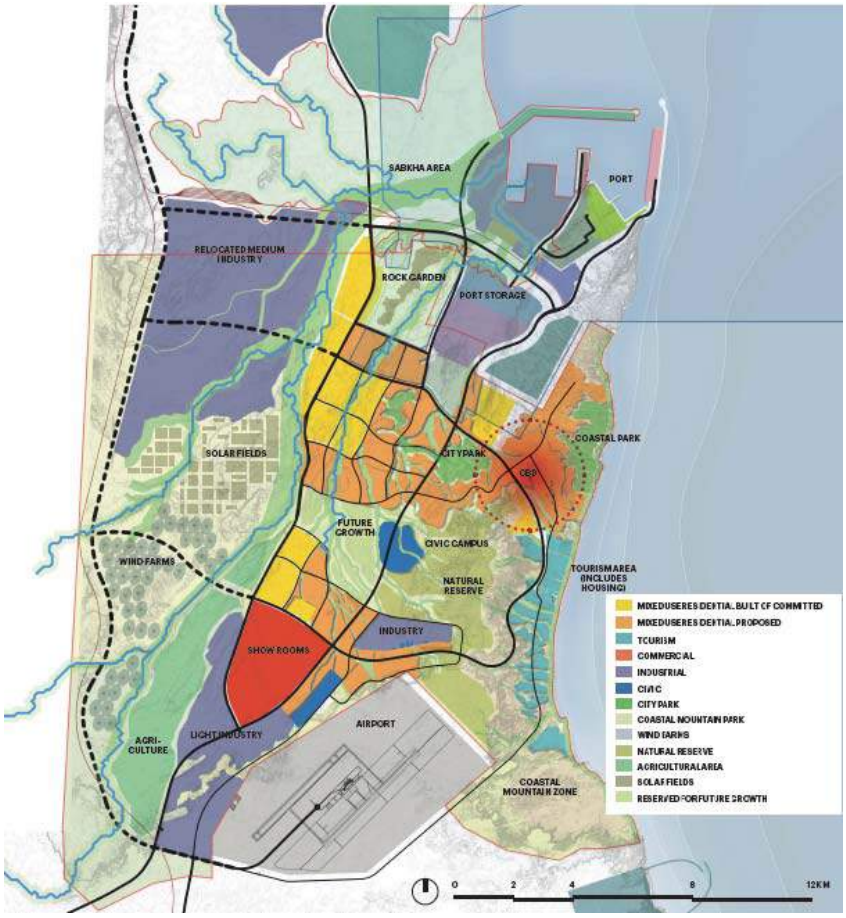


Figure 5-9: Land Use map approved by September 2013 – project developments

Although the project area is currently untouched in terms of construction activities, major projects are to be developed, with the development of Duqm Town, the airport area and the medium and light industrial area in the vicinity of the proposed project. The SEZAD Masterplan predicts innovative developments, namely, wind farms, solar fields, commercial area & showrooms, along with the implementation of the industrial areas, in the surroundings of the wadi Say and Wadi Jurf dams and channels. As a sort term strategy for the project area, Duqm will see the rising of a road system at national and local scale serving the abovementioned areas in Duqm.

Figure 5-10: Built and Planed Roads in Duqm

The Proposed Land Use in Duqms' Master Plan

As a more detailed understanding of the site, its topography, soil conditions and ecosystems evolves; the SEZAD master plan for the industrial areas to the north and east of the royal decree area proves to be difficult and costly to be implemented in a number of areas:

- The zone laid out to accommodate medium industry to the west of the port is situated to a large extent on soil that is unsuitable for regular development.
- The soil in the area where the wadi discharges in the sea is silt and clay, resulting in increased cost of construction in this area.

The layout of the area zoned for heavy industry northwest of the port is equally being reviewed, particularly the proposed stormwater drainage system.

Ways of adjusting this layout in order to integrate natural stormwater channels into the development areas are being explored to reduce construction cost and upfront infrastructure investment required to implement the current solution.

Preserving existing natural stormwater routes and the extensive Sabkha area west of the port from development not only allows for cost reduction and easier implementation but also has the

added benefit of preserving sensitive ecological areas of local regional and international significance.

The Sabkha is created by the confluence of several wadi streams carrying nutrients from further in land to the sea. Sea water is infiltrating the area from the coast, creating a unique habitat for migrant birds and making Duqm an important stopover for birds traveling between Asia and Africa.

The major landuse shifts away from the previous plan propose to

- Move the zone for Medium industry further to the south were light industry is currently located.
- Locate the light industry close to the airport at the southern edge of the Duqm Town boundary.
- Reconfigure the Heavy Industry zone to be integrated within the current stormwater channels

Figure 5-11: Proposed land use map for Duqm.

The proposed site wide planning strategy proposes a strategic rearrangement of land uses that takes into account the topographical and environmental constraints.

This strategy also aims to create development that is as compact as possible within the current set of constraints and defines clear edges between developed land and open space. The strategic plan for the economic zone as a whole is structured in 3 distinct development nodes separated by major open space systems:

The airport cluster to the south.

The port city in the heart of Duqm where the most intense mix of uses, the highest density of residents and a genuine city centre will emerge in proximity to yet sufficiently buffered from port activities and medium industry.

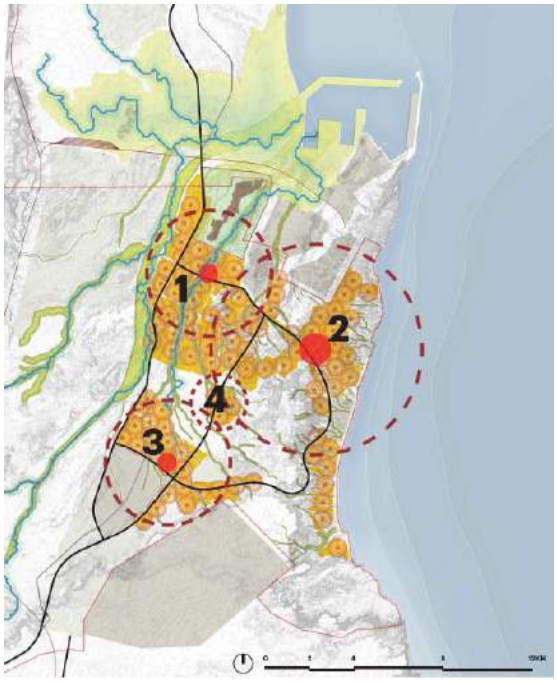
The heavy industrial zone to the north, focused on production, close to the port but at a comfortable distance to residential neighborhoods to the south and separated from the city centre by an unspoilt generous natural reserve that will help to maintain Duqm's role as a prime stopover destination for migrant birds.

The project area, although is still untouched, will be subject to drastic changes within the future developments, highlighting the importance of building an adequate channel capable of providing flood protection and natural drainage of the existing wadis.

The City Centers

In terms of urban design, Duqm will be developed based on a clear hierarchy approach of urban centers of population density and activities, land use and urban character. Applying this differentiation, 3 major zones were planned to have a unique roles:

A. Duqm Village Centre
B. Coastal City Centre
C. Airport Centre
D. Civic Center



Unique uses and public amenities will be located that cater for Duqm Town as a whole will be located in town centers. Such as a:

- Central business district,
- Regional retail,
- Major souk,
- Eid Mosque,
- Governors' house and offices

They will be most accessible by public transport and the places where higher density housing would be most logically positioned.

A civic campus in the heart of Duqm Town will provide a location for facilities of city wide importance such as a regional hospital, university or other large educational and sports facilities.

Comprehensive Public Transport Network

Duqm's public transport network is to be comprehensive with multimodal interchanges.

The transport infrastructure will be built to accommodate the latest transport technology to facilitate efficient operate of the entire network.

Such technology may include:

Priority signaling at junctions;

Bus priority lanes;

Fleet management;

Real time service information at all public transport stops and interchanges

Intermodal communications;

Trip planning

Mobile applications

Figure 5-12: Public Transportation Network

5.5 Physical Infrastructure and Basic Amenities

Drinking Water

A reverse osmosis (RO) water desalination plant, with an initial daily capacity of 10,000 m3, has been completed. Based on current levels of water consumption in Oman, this amount would be sufficient for a city with a population of 35,000 inhabitants.

Two large reservoirs were completed and a third is in the design stage. The government of Oman is committed to meet the expected demand for potable water with the construction of the the third reservoir.

Nevertheless the water supply system is not yet serving the total population of Ad Duqm, since the house are not connected to a water distribution network, being supplied by water tanker trucks.

Electricity

An entire electricity supply of 67 MW project was completed, most of the houses in the Study Area are served with electricity. Electric supply is also used for lifting water from tanks to water storage towers.

The local power company has constructed a diesel power station with a total installed capacity of 100 megawatts (MWs). Power will be generated at 11 kilovolts (kV); this would be stepped up to 33kV using three step-up transformers. Power is distributed throughout Duqm via an underground cable network. Seven substations have been built to serve the port, airport, duqm city, light industry and the hotel complex areas. Plans are underway to build a much larger gas-

fueled power plant (500-1000MWs) to meet Duqm's future needs; a reverse osmosis (RO) water desalination plant, with an initial daily capacity of10, 000 m3, has been completed.

Sanitation / Drainage Facilities
Based on current levels of water consumption in Oman, this amount would be sufficient for a city with a population of 35,000. Further expansion of the RO plant along with the water distribution network is underway to meet the rising demand.

Two large reservoirs completed and a third is in the design stage. The government of Oman is committed to meeting the expected demand for potable water and electricity in the zone has been completed.

Houses have standard sanitary fittings in bathrooms and toilets and had arrangements for proper sewage and septic tank storage facilities. Municipal administration has fleet of sewage disposal tankers which regularly collect sewage water from house storage tanks to the final disposal. Recently, the construction of a 2,000 m^3/day sewerage treatment plant was concluded.

Telephone
Not all the houses are served with lined telephone facility while the majority uses mobile phones.

Mode of Transportation
Private cars are present in Duqm village. Most of the project area is served by track roads.

Other Facilities
Bank, Post Office, Markets, Hotels and other facilities are available in Ad Duqm town.

5.6 Education

At present, Duqm has several government educational facilities providing basic education in Arabic to the existing Omani population. In the future, private educational institutions will be invited to provide multi-lingual schools that meet international standards and address the needs of expatriates as well as local residents. As part of Duqm's vision of creating a viable local community, institutions for higher education and vocational training as well as research and development centers will be established.

The two major objectives of the educational institutions will be to: (1) provide local manpower with the skills required to qualify for jobs in future industries and services and (2) provide engineering and troubleshooting services to local industries. An advanced Marine Research Center is planned that will conduct cutting-edge studies and provide technical support for the local fishing industry.

5.7 Health Facilities

The Government attaches a very high priority to the improvement of health facilities so as to translate the economic success into social benefits. The seventh Five-Year Health Development Plan (2006-2010) has envisaged one health centre for every 10,000 of the population in the urban and heavily populated areas and seeks to provide easily accessible health centers for scattered population localities. The following table summarizes of the Sultanate of Oman the available information from the Ministry of Health concerning the health facilities in Al Wusta region. As regard to the health facilities, these are almost free for Omani residents.

Facility	No. of Beds	Services	Wilayat
Hayma hospital	40	D, R, L	Hayma
Duqm hospital	8	D, R, L	Duqm
Wadi Hitam Health Center	2	D, L	
Ras Madrakah Health Center	2	D, L	
Mahawt Health Center	4	D, L	Mahawt
Al Khaluf Health Center	2	D	
Sarab Health Center	2	D	
An Najdah Health Center	2	D	
Al Jazir Hospital	20		Al Jazir
Al Lakbi Health Center	2		
Rima Health Center	0		

D - Maternity beds; R - Radiological Procedures; L - Laboratory Facilities

In addition to the public health care provided by government hospital in Duqm, private sector medical practitioners and specialists are expected to take advantage of area's demographics and corporate clienteles to augment the scope of medical services provided by the Ministry of Health

5.8 Role of Women

The role of women assumes a larger dimension due to increased activity in the entire socio-economic and socio-cultural fields in the Study Area. The study of the target area has shown that a majority of the men are willing to allow the women to work outside home. This could create important source of income for the women and also for her family as a whole.

5.9 Identification of Resettlement Issues

The project doesn't predict the need of occupation of private residential areas, since there are no houses to be relocated from the dam axis or reservoir were the channels will be built.

Nevertheless, there may be a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the project area before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.

During construction, some temporary areas will be affected to establish campsites, deposit areas and even borrow areas. The contractor will settle 1 area to establish the campsite where the construction material and logistic will take place. It is suggested this campsite to be upstream the dam and close as possible to the main road, in a flat area, avoiding the occupation of other areas with no access built and improving response in case of any emergency situation.

Also during construction phase, the excavation activities may generate surplus of soil that will have no use for the construction of dam. This excavation material will be stockpiled on a temporary area near the project in a flat area, avoiding being run off from water or wind. This temporary stockpiled area is allocated to the stock material that SEZAD may to use for their future projects needs.

At this stage of the project it is not possible to assume the exact amount of material to stockpile or to borrow as the size of the dams are still under approval of SEZAD, but the predictable quantities for deposit area are 200 000 m^2 downstream the Jurf dam. Once approved the dimension of the dams, the volume and the exact location of these areas can be confirmed for the borrow areas, quarries and the deposit, but the contractor will need permission/ approval from SEZAD.

Within the project, particular attention was paid in order to minimise the impacts of the projected features over the existing and foreseen features.

Part of the Oryx Sanctuary Reserve will be permanently affected by the Jurf dam reservoir at its full supply level within an approximated area of 526 345 m^2, as it is need to construct the dam axis and that will partially inundate the reserve when FSL is reached.

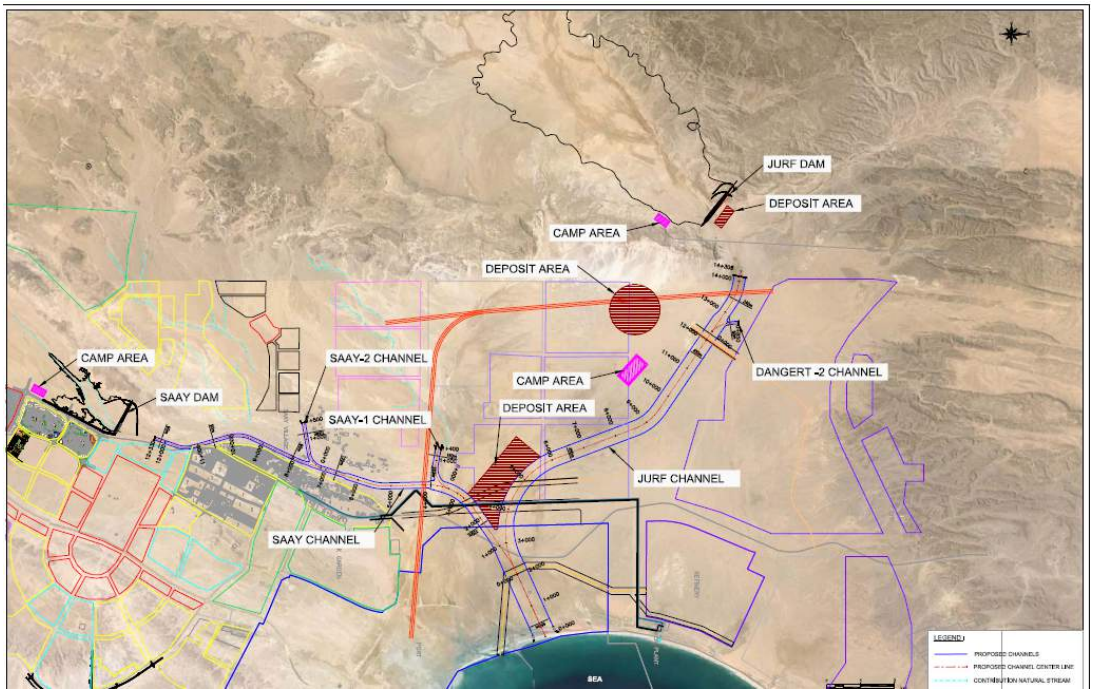


Figure 5-13: Identification of resettlements

5.10 Tourism

Tourism is one of the most important economic sectors upon which the Sultanate relies for income. The attention by the government to the Tourism Sector is manifested in its persistent efforts for formulation and implementation of development plans for this sector. Ministry of Tourism is already motivating the tourism in the region, by promoting mostly the beaches, famous for their cleanliness and the purity of their waters. This has resulted in an increase of marine plants which give the water its green color. Many birds pass this area during their annual migration. On land, the moderate climate, influenced by the annual autumn season in Dhofar, helps the growth of a variety of plants and rare mammals such as the Arabian Oryx and the Nubian ibex. In addition to all this natural wealth, the area abounds in a large number of oil and gas fields, making it rich on every score.

At the moment 2 hotels are accommodating businessmen and tourists visiting Ad Duqm, The Crown Plaza and the Duqm city Hotel, and others are being planned for the region.

5.11 Archaeology – Cultural Heritage

With a civilization of almost thousands of years, Oman has a great treasure of archaeological, historical and cultural information and facts. The country has thousands of archaeological and historical sites including over 500 forts and towers.

Oman, can boast of largest collection of archaeological sites including highly revered ones by Muslims, Christians and Jews alike, and ancient historical sites. Many of the heritage sites are included in the UNESCO World Heritage list.

Duqm's unique topography is complemented by several areas of geological significance that contribute to the heritage value of Oman. Natural processes and historic human settlements have left behind artifacts and rock formations that will give the development some of its most salient tourism value and local meaning.

The Rock Garden

Formed in an underground freshwater aquifer over 46 million years ago, the Rock Garden is part of Duqm´s heritage. Covering an area of 3 Km^3 of limestone and sandstone rocks shaped by the wind, water, frost by natural actions, the Rock Garden is one of the most important sites of the Sultanate of Oman.

The Rock Garden, also known as the Duqm Stone Park, is a unique collection of sandstone and limestone rock formations, remnants of an underground aquifer. Composed of primarily soft rock, near the Port, maintaining this area free from development is essential to preserving Duqm's cultural heritage and growing the site's ecotourism potential.

Nowadays the Rock Garden is considered one of the Duqms most visit tourism attraction and the Duqm matser plan proposes the preservation of this natural monument and transform in into a genuine destination where visitors can explore and learn about archeology, geology and the local history.

The rock garden boundary is defined by major roads on 3 sides and a narrow development strip east of National Road 32.

The Duqm Mater Plan proposes the Rock Garden as:

- Access point for visitors will be created at strategic locations where cars can be parked and footpaths lead into the Rock Garden.
- A soft mode of vehicular transport within the rock garden such as golf carts could be considered on selected routes.
- Pathways along the main wadi that runs through the area will connect different archaeological sites and links into the newly emerging district south of the rock garden.

- The southern edge of the rock garden fronting this new district will be lined by a dense forest of trees as a tree nursery is planned to be established here, irrigated by treated sewage effluent from a sewage treatment plant located within the nursery and screened from view.
- This will create a high value edge for residential properties fronting this park and a green environment that won't be found anywhere else in the city
- A number of research, cultural and educational facilities will be located at this southern and primary entrance into the Rock Garden:
    - Geological Research Centre
    - Interpretive/Community Centre
    - Natural History and Art Museum

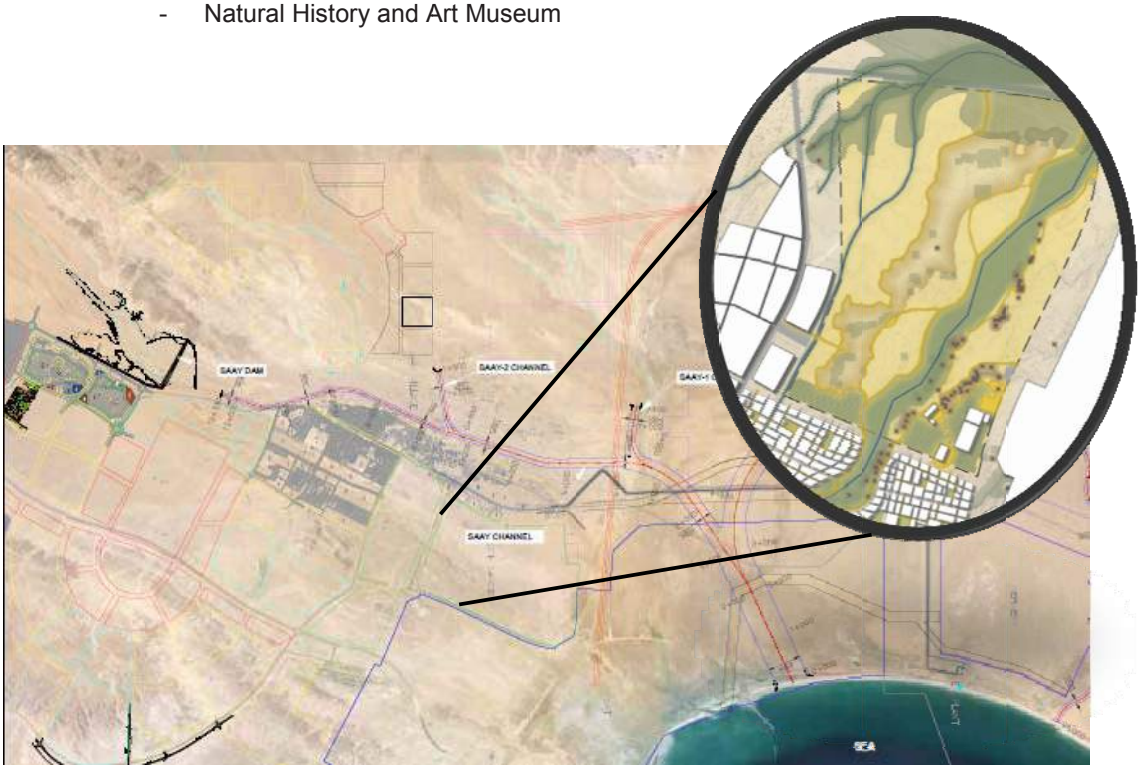


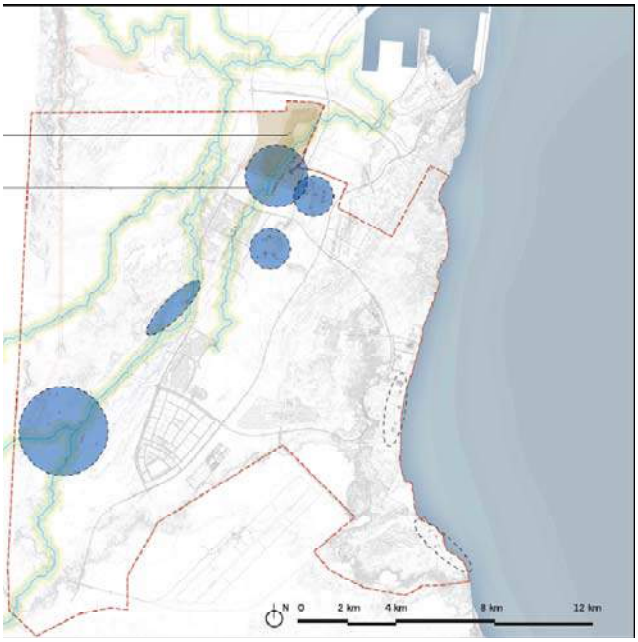
Figure 5-14: The Rock Garden Area

The proposed project doesn't cross or disturb the natural Rock Garden.

Archeology

Al Duqm is rich with archaeological remnants from several Stone Age settlements. The 2007-08 Central Oman Paleolithic Survey (COPS) provided a detailed partial analysis of many areas of the site with particularly notable findings.

The 2007-08 analysis was not a complete study, however, and efforts to prepare a comprehensive archaeological plan for Al Duqm are ongoing. The city plan uses the 2007-08 analysis as a baseline for conservative inferences about the site's archaeological heritage. Areas noted for particular collections of significant findings will be preserved and incorporated into public parks and preserves. Development planning draws value from these sites in helping to give the city a cultural distinctiveness.



Site visits were performed to evaluate the Wadi Jurf in terms of archeology findings probability during the constructiojn and no archeologucal or heritage spot were found.

Conclusions

In general, along the Jurf Dam there are no evidences of archeological or heritage traces. In these specific areas there is no presence of tombs, fossils or shells that normally are found in the region. Therefore, no archeological or heritage sites will disturbed by the project implementation.

Nevertheless, the project and the surrounding area of it seems to be a archeological and geological heritage key and there is a need to preserve as many of these sites from any potential damage, casual collection of fossil, rock and mineral specimens.

5.12 Climatic Conditions

5.12.1 Seasons

The Sultanate of Oman is characterized by hyper-arid climate generally with hot summers and mild winters. In Oman generally there are two seasons, a long dry summer with soaring harsh temperature between April and November and a relatively short winter period with mild to warm temperature and some winter rainfall typical of Mediterranean pattern.

5.12.2 Temperature

According to the available data, the average yearly temperature varies to extremes during the seasons, while maximum may rise to 46º C in summer daytime. Minimum temperature may go down to 11º C on winter nights. The average dry bulb temperature record for the period of 2003 to 2011 (at Duqm station) is also given below and it's 26 º C.

Stations		2010	2009	2008	2007	2006	2005	2004
Temperature (C°)								
Diba	Max.	47	49	46	44	47	47	47
	Min.	7	10	8	8	10	12	12
Rustaq	Max.	47	48	47	47	48	48	47
	Min.	11	10	6	8	9	10	9
Nizwa	Max.	48	48	47	48	48	49	46
	Min.	6	7	5	7	8	9	7
Samail	Max.	46	48	47	47	47	48	46
	Min.	8	9	6	9	8	11	8
Ibri	Max.	49	50	49	49	48	49	47
	Min.	9	8	7	9	7	8	7
Buhla	Max.	47	47	47	47	46	48	45
	Min.	7	8	6	8	8	9	8
Adam	Max.	49	50	50	50	50	49	48
	Min.	8	8	7	9	9	10	9
Ibra	Max.	47	48	48	48	48	47	47
	Min.	8	8	5	8	8	8	7
JabalShams	Max.	29	28	26	26	26	27	27
	Min.	-6	-8	-6	-2	-4	-3	2
Joba	Max.	47	48	49	49	48	48	47
	Min.	8	7	8	10	10	11	17
Duqum	Max.	46	48	48	48	49	—	48
	Min.	11	6	6	10	12	—	11

Figure 5-15: Average Temperature

Source: Statistic Book 2011

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Au	Sep	Oct	Nov	Dec	Mean
2003										25.1	25.8	22.8	24.3
2004	22.0	22.6	25.4	30.7	31.5	32.2	28.2	26.6	27.4	25.5	25.5	23.3	26.7
2005	21.3					27.6		23.5	27.8	26.1	25.5	22.4	24.7
2006	21.5	22.9	25.2	29.1	31.5	31.1	28.6	27.9	28.4	27.3	25.5	22.6	26.8
2007	20.5	24.6	25.4	30.1	32.0	31.6	30.4	27.7	28.2	26.1	25.6	23.7	27.2
2008	21.4	20.2	25.2	29.4	31.4	32.3	28.7	27.3	28.4	27.3	23.5	18.3	26.1
2009	18.0	22.8	25.5	28.1	31.9	32.0	30.1	28.4	28.2	27.2	24.9	24.0	26.7
2010	21.2	23.2	26.1	30.7	32.5	31.2	28.9	27.7	27.8	28.3	25.2	21.8	27.1
2011	21.0	22.8	25.9	28.1	30.8								25.1
Mean	20.9	22.7	25.5	29.4	31.7	31.1	29.2	27.0	28.0	26.6	25.2	22.4	26.1

Figure 5-16: Dry bulb temperature at Duqm Meteorological station (Monthly Mean)

Source: Directorate General of Meteorology and air navigation

5.12.3 Rainfall

Rainfall data was provided by Directorate General of Civil Aviation & Meteorology for the Duqm master plan study. The total recorded rainfall in Duqm over the last ten years was 174mm, with an average annual depth of 17mm (see Figure below).

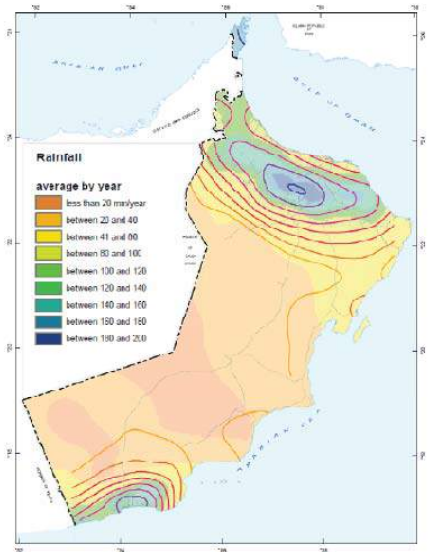


Figure 5-17: Rainfall Map of Oman

5.12.4 Evaporation

No data available on site regarding evaporation. As per the Consultant's achieved projects in similar areas of the Sultanate of Oman the potential annual evaporation has been taken as per 2,000mm.

5.12.5 Humidity

According to the Directorate General of Meteorology and Air Navigation of the Sultanate of Oman, Monthly Maximum & Minimum Humidity (%) for Duqm meteorological station is 70,5% maximum in August and a minimum of 53.6% in March as given in the following table. This data is based on observations from 2003 until 2011, where the average Relative Humidity for this period per year is 62%.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2003										74.0	66.6	67.3	67.5
2004	68.5	56.7	57.1	57.5	56.3	60.9	70.3	70.1	69.5	67.9	69.1	61.3	63.5
2005	59.7					80.0		83.3	68.8	62.0	64.3	63.0	63.6
2006	56.2	69.6	57.8	59.0	60.5	65.3	64.8	67.7	68.4	68.0	65.7	60.0	63.4
2007	60.1	61.4	58.3	55.4	60.4	64.8	60.5	69.4	67.5	61.5	64.1	59.6	61.9
2008	58.9	53.9	52.2	55.8	61.0	53.4	65.9	67.1	65.8	63.1	62.3	46.9	58.9
2009	60.4	62.4	56.7	59.0	54.6	57.9	63.5	68.4	67.0	66.2	64.9	62.4	62.0
2010	57.2	63.2	46.6	53.9	58.9	65.2	67.0	67.8	67.7	65.4	56.2	56.2	60.7
2011	62.3	52.8	46.6	60.9	60.1								56.2
Mean	60.4	60.0	53.6	57.3	58.8	63.9	65.3	70.5	67.8	66.0	64.2	59.6	62.0

Figure 5-18: Relative Humidity at Duqm meteorological station

Source: Directorate General of Meteorology and air navigation

5.12.6 Precipitation

The Directorate General of Meteorology and Air Navigation of Sultanate provided the bellow information regarding the variation of the precipitation for the period of 2003 to 2012 at Duqms´ Meteorological station. According to this data, the average precipitation in Duqm is 11,2mm per year for the 10 year period, the average maximum value observed was 3,8mm for the month of December and it´s verified absence of precipitation along the years especially during the months of July, August, September and November.

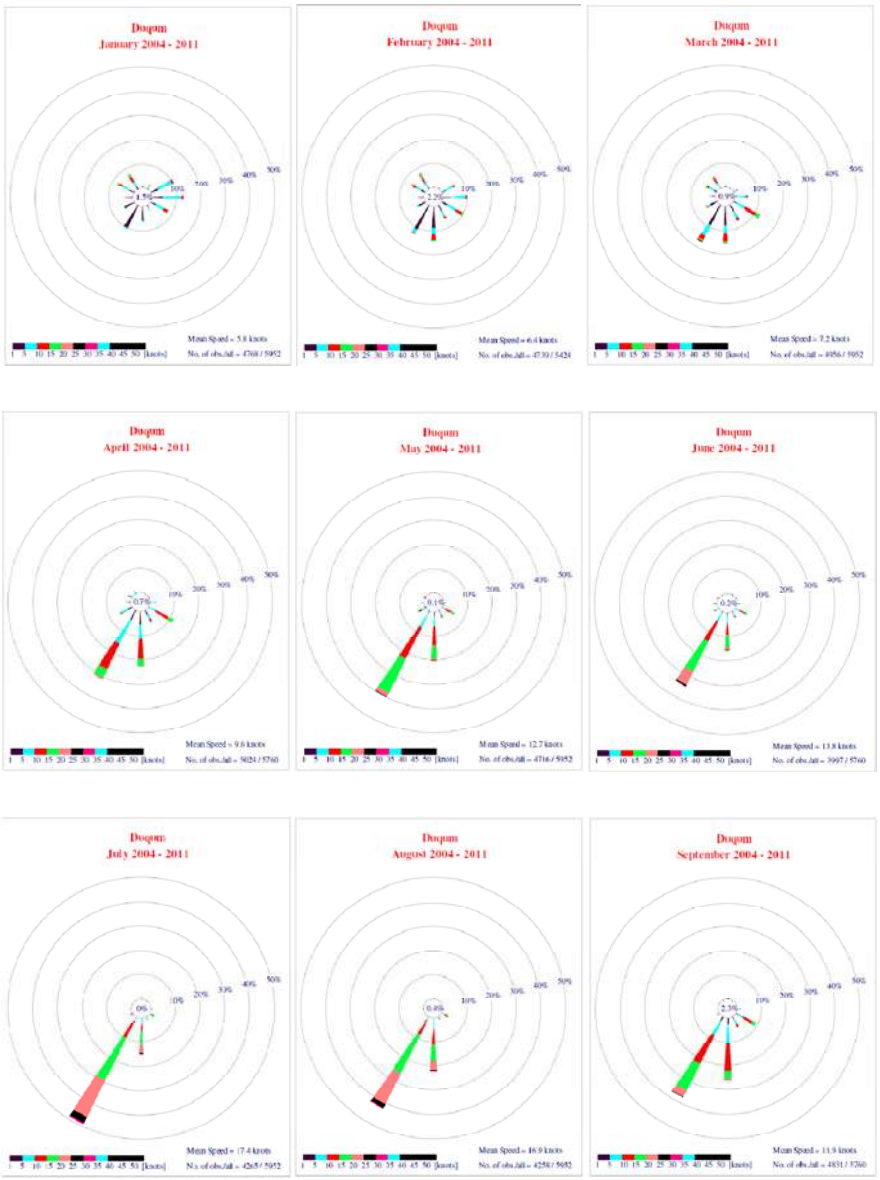
Year	Jan	Feb	Ma	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2003										0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	25.0
2005	0.0					0.0		0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6
2008	2.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	15.8	0.0	0.0	18.4
2009	0.6	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	4.4
2010	0.0	7.2	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	12.0
2011	0.0	0.0	0.0	23.4	16.4								39.8
Mean	0.4	1.1	0.1	3.3	2.3	0.7	0.0	0.0	0.0	2.0	0.0	3.8	11.2

Figure 5-19: Precipitation at Duqm meteorological station

Source: Directorate General of Meteorology and air navigation

5.12.7 Wind

The wind rose study reveals that Duqm has predominantly strong winds from south and southwest with extremely strong incidence from the months of April until September.



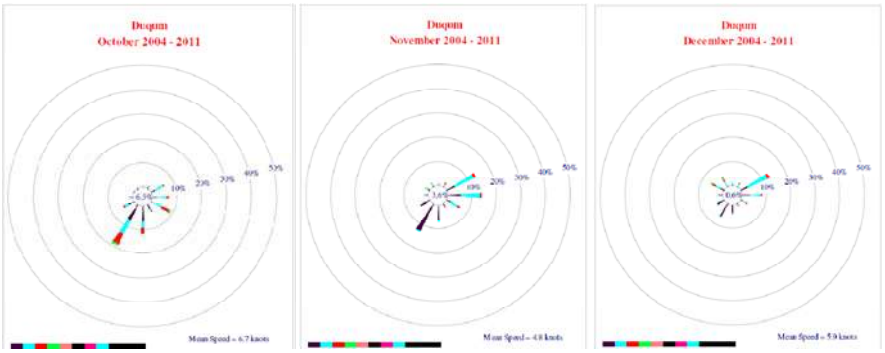


Figure 5-20: Wind speed at Duqm meteorological station

Source: Directorate General of Meteorology and air navigation

5.13 Air Quality

Following the land use maps for the Duqms' Master Plan, the project area will be under great project developments, such as the power plant and the oil refinery. As soon as the industrial activities commence, the air quality change accordantly to the nature and time of exposure of these activities. The regulation and control of these activities is expected, but these will be the major contributors for the air quality in the project area, not only form the operational point of view, but also from the traffic increase in the surrounding area.

An air quality monitoring study was undertaken by 5 Oceans in July 2011 which covered the wider area of the Al Duqm Master Plan area. This study focused on the following air pollutants: sulphur dioxide (SO2), nitrogen dioxide (NO2) and volatile organic compounds (VOCs). These pollutants were monitored using an indicative monitoring technique (diffusion tubes) for a short period (approximately one month). Results of this survey indicated that pollutant concentrations were low with respect to international thresholds. Given the absence of existing industry in the area, pollutant concentrations recorded are likely to represent a true reflection of the background ambient levels in the region.

HMR consultants deployed continuous ambient air quality monitoring station (CAAQMS) at three locations across the Al Duqm wider masterplan area. These locations were selected on the basis of proximity to sensitive receptors and future land use. The CAAQMS monitoring is scheduled to capture nine months of air quality data (three months at each location). It is planned that the CAAQMS would continue to capture data at the first location for a total period of 30 days. At the end of this period, the CAAQMS would be moved to the second location for a period of 30 days followed by another 30 days of data capture at the third location, thus providing the winter season air quality data for each location. The air quality monitoring program is designed to capture data for one month during each of the three distinct seasons of winter, summer and autumn. The three monitoring locations can be seen in the accompanying Figure.

Figure 5-21: Air quality studies location

The first available results from CAAQMS- 1 for the period November 14th - 28th 2012 are presented in the table below. The maximum concentrations of all pollutants for the various averaging periods are within applicable limits for all three standards considered.

Results at CAAQMS-2 during February – March 2013 indicate that NO2, PM10 and O_3 data are higher in the month of March than in February 2013. The higher values can be attributed to increased vehicular movement due to an increase in port activity in the month of March, when the commercial quay was inaugurated for operations. As a result, there are instances of exceedance in concentrations of O_3, SO_2 and PM_{10} in comparison with the standards while all other pollutants are well within limits.

Hydrogen Sulphide (H_2S) in Jurf Dam

It was intersected in the following boreholes, BH-JD-06, BH-JD-09 and BH-JD-20, a hydrogen sulphide gas released through the water. This gas is usually related with carbonate-evaporitic sequences where the lithological association has influence in the genesis of H_2S gas because the sulphate comes from evaporates and is the carbonated rocks that catalyze the reduction reactions; on the other hand this gas can be also produced through decomposition of organic matter in anoxic environments and Jurf presents a morphology and stratigraphy that allows us to infer that this was a closed sea similar to a dead sea where the high concentration of salt leaded to an anoxic environment with decomposition of organic matter and H_2S production.

The hydrogen sulphide gas can occur under free gas or dissolved in the water of formation among the interface of oil or gas. Considering the different depths where the gas was intersected we believe that he is under free gas among some porous limestone. This fact can

be proved while looking to the boreholes where some rounded small holes can be founded confirming the presence of free gas and no evidence of water erosion or oxidation. Moreover the existent H_2S among the interface of oil and gas is usually intersected at bigger depths.

Hydrogen sulfide is a colorless gas and has a strong odor of rotten eggs. Hydrogen sulfide is soluble in certain polar organic solvents, notably methanol, acetone, propylene carbonate, sulfolane, tributyl phosphate, various glycols, and glycol ethers. It is also soluble in glycerol, gasoline, kerosene, carbon disulfide, and crude oil. Aqueous solutions of H2S are not stable; absorbed oxygen causes the formation of elemental sulfur and the solutions become turbid rapidly.

H_2S can be toxic, but its strong odor usually allows for detection long before it reaches extreme levels. H_2S is flammable and poisonous. Such concentrations are not common, but if the gas is released in a confined area it can cause nausea, illness, and—in extreme situations—death.

The effects of H_2S in humans can be acute and/or chronic. The weight-of-evidence from the human and animal studies suggests that the effects of H2S are dose-dependent. The exposure-response relationship for acute effects, particularly CNS and respiratory, can be very steep.

The Environment Protection Agency (EPA) released a toxicological review on the H_2S. Levels in the range of 500 to 1,000 ppm (695 to 1,390 mg/m3) are life-threatening and can cause immediate unconsciousness followed by serious and debilitating neurologic and respiratory sequelae. Lower levels have been associated with lung function deficit and eye, nose, and throat irritation. Precise determination of acute effect levels is precluded by the lack of accurate monitoring data since nearly all cases were those involving acute accidental overexposure. Levels dangerous to human health may not be detected by odor since high levels of H2S can paralyze the olfactory nerves making detection impossible. Little is known of the concentration-response relationship at low levels of chronic exposure. Occupational studies have been confounded by exposure to other substances and inadequate monitoring to establish cause-effect relationships. Controlled exposure studies in laboratory animals indicate that the portal-of-entry (the nasal tract) and neurologic tissues are both targets for H2S toxicity. Based on the clear nature of their adversity (demonstrable histopathology), information available on exposure-dose-response and the commonality of the underlying mechanism (irritation) between animals and humans, and indications that such effects also occur in humans chronically exposed to hydrogen sulfide, nasal tract effects were chosen as the critical effect and used to develop an inhalation reference concentration (RfC).

Another study performed by the Committee on Acute Exposure Guideline Levels; Committee on Toxicology; National Research Council revealed some data relating the time of exposure versus concentration of H_2S and its consequences, as exposed in the below table.

Classification	10 min	30 min	1 h	4 h	8 h
AEGL-1 (Nondisabling)	0.75 ppm (1.05 mg/m^3)	0.60 ppm (0.84 mg/m^3)	0.51 ppm (0.71 mg/m^3)	0.36 ppm (0.50 mg/m^3)	0.33 ppm (0.46 mg/m^3)
AEGL-2 (Disabling)	41 ppm (59 mg/m^3)	32 ppm (45 mg/m^3)	27 ppm (39 mg/m^3)	20 ppm (28 mg/m^3)	17 ppm (24 mg/m^3)
AEGL-3 (Lethality)	76 ppm (106 mg/m^3)	59 ppm (85 mg/m^3)	50 ppm (71 mg/m^3)	37 ppm (52 mg/m^3)	31 ppm (44 mg/m^3)

It's obvious that the effects of H_2S vary according to the time of exposure, health conditions, gas concentration, from of life (human, animal or vegetation).

During geotechnical investigation H_2S was encountered in 2 boreholes. The realest of gas for the 1st borehole dissipated in hours and the 2nd in a few days indicating the gas reservoir are limited in size and not interconnected. A result of the geotechnical and geophysics investigation does not indicated any noticeable reservoir within the investigated area. In view of the above, we believe the H_2S within the foundation of the dam is limited in extend.

Although we believe the H_2S is limited in extend, mitigation measure will be implemented during excavation to prevent hazardous to the life of humans, animal and flora in the site.

In the meantime, water test are being performed in laboratory to determine the presence of H_2S in its content and the results will be provided at the end of the stage.

Conclusions on the Air Quality

In summary, there is no major air quality problem located in the project area as per the time being, since the study area is wide open, with natural habitats and absence of major air pollution sources, such as industry or big traffic roads.

The only concern is turned to the potential existence of H_2S at the Jurf dam axis area and this will be taken into consideration in the Environmental Management Plan and through the suggestion of preventive actions and mitigation measures.

Due to the absence of vegetation dust can be seen when winds blow in that area. It is assumed that current air quality conditions in the Project Area satisfy a "Moderate" air quality classification according to World Bank criteria.

Similarly, particulate matter emissions in the Study Area are very low as the intensity of vehicular traffic is very low or absent, so ambient air is clear.

5.14 Noise

Noise is defined as an unwanted sound that has an adverse effect on the human beings and their environment, including land, structures and domestic animals. Noise can also disturb natural wildlife and ecological systems. The health effects resulting from increased noise stress include mainly: permanent or temporary hearing loss; sleep interference; human annoyance; communication interference resulting in worker's reduced efficiency; impairment of mental and creative types of work performance etc.

A variety of sources produce noise potentially hazardous to hearing, depending upon the intensity and duration of exposure. The noise hazards are invariably associated with human activity, such as construction equipment/machinery, industry, household appliances, vehicular traffic, including particularly trucks fitted with pressure horns and two-stroke engine traffic.

When Al Duqm Town is developed, there will be a number of surrounding land uses, such as industry, an airport and a port that will provide a significant source of environmental noise. Traffic will additionally form a source of potential noise disturbance. There are a number of mitigation measures that can be pursued and could include the use of buffers between residential areas and noise polluting land uses, the use of bunds and separation of sources of impact and possible receptors.

HMR consultants carried out noise monitoring within the proximity of future sensitive receptors in October-November 2012, including the Al Duqm Town Zone. The data is considered representative of the winter season. During the summer months, it was reported that noise levels may be higher as a result of stronger winds.

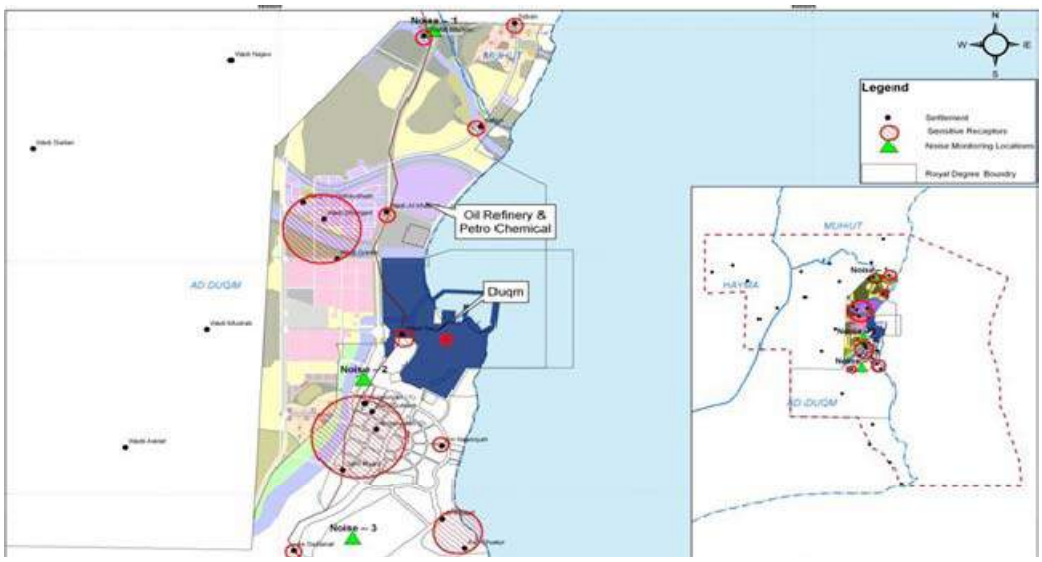


Figure 5-22: Noise Assessment study

The noise levels recorded at monitoring locations 2 (within Al Duqm New Town zone, to the north) and 3 (south of the Duqm Town Zone) were above the Omani limits for rural/ residential areas during daytime in October, as shown in the bellow table. This may have been attributed to wind conditions during the measurements and general increase in anthropogenic activities at Duqm Township and the planned airport site. It is anticipated that noise levels will increase with further development of industrial and commercial land uses. Notably, this will include the development of the Industrial Zone to the west and north of the development, the port to the north of the site and the airport to the south.

Monitoring Locations	UTM Co-ordinates		Current Description	Future	MD79/94 Daytime dB (A)		Oct	Nov
	Easting	Northing			Current	Future		
Noise – 1	571647	2199973	Rural Residential	Industrial/ commercial	45	70	41.3	45.5
Noise – 2	566410	2170025	Rural Residential	Residential	45	60	55.1	52.4
Noise – 3	565592	2156303	Rural Residential	Industrial/ commercial	45	70	62.7	44.6

The noise assessment wasn't performed in any point near the Wadi Jurf Dam and Jurf Channel, so it's not possible to present precise conclusions.

Nevertheless, during site visits, some anthropogenic activities mostly related with construction were observed, namely in the surroundings of Wadi Jurf.

In general, the project area is not too disturbed, only slightly disturbed due the presence of ongoing construction, presence of residential and commercial. It can be considered that the impact of the construction of the dams and its channels on sensitive receptors will not be too significant. Nevertheless, mitigation measures will be suggested ahead to prevent the local residents from suffering from potential impacts.

5.15 Hydrology

Duqm contains a complex network of tributaries and wadis, as well as a coastline with many distinctive physical features.

Duqm, while subject to very minimal annual rainfall, is subject to larger intermittent storms with the potential to create strong regional flows. The coastline is subject to several factors that may influence development, including tidal fluctuation, storm surges, tectonic uplift, sea level rise, and wave-run-up that accompanies major cyclones.

Wadis

Duqm is traversed by a rigorous network of natural tributaries and stormwater wadis. Preserving these largely in their original form will harness them as effective stormwater conveyance corridors as well as leveraging the landscape assets that will help protect their value to the site as a character and value-adding amenity.

Coastline

Duqm's coast is defined by a diverse mix of beaches, cliffs, rocky areas, and khawars. These provide a range of conditions that offer different levels of suitability to development as well as result in different zones that will be susceptible to coastal environmental hazards.

For the hydrology study refer to the paragraph 4.3.5 in the previous pages.

5.16 Geology

5.16.1 Geological Regional settings

The Duqm area is a junction of several major geological domains where the formations ranging from Late Precambrian to Miocene in age are represented, but numerous breaks are presents due to interruption of deposition during tectonic phases with faulting and removal by erosion of rocks mainly of extensive shelf type.

The area of Duqm has a complex structure owing to polyphase deformation, bordered by a downfaulted coastal belt. The surrounding outcrops of Jurf were affected by the left-lateral Haushi-Nafun Fault a strike-slip fault on which the movement took place during the Laramide Orogenica phase, and which gave rise to a complex drag folds.

Jurf Dam is located along a wide and flat area and according with the geological map of Duqm and Madraca on a scale of 1:250 000, this area will intersect units since Late Permian until Tertiary and late Quaternary, intersecting several geological units from different group formation, namely:

- **Sabkhah deposits (Qby-z)** – deposits from the Quaternary composed by clay-silt deposits and fine grained sand with gypsum crystals. Having no or very little run-off, the depressions give rise to the repeated formation of salt and gypsum crusts over a thickness of several centimetres;

- **Huqf Group** - This comprises five Late Proterozoic-Cambrian formations that can be defined in two major sedimentary cycles. The first cycle gives origin to **Abu Mahara Formation** (**Pc*Є amh***) composed in Jurf area by grey dolomite on the base and coarse-grained sandstone grading upward to yellow silty shale; and the second cycle gives origin to **Khufai Formation** (**Pc*Є khf***) composed by massive, light to grey dolomite with chert.

- **Thamana Group** – This comprises supratidal to lagoonal facies to shallow-marine facies. Thamama Group deposits are the oldest Msozoic sedimentary rocks constituting the first great carbonate shelf. Thamama Group is divided by **Jurf Formation** (**Kjr**) that crops widely in Wadi Jurf, along the western homocline composed by thin-bedded dolomitic limestone and brecciated dolomite with friable sandstone in the base; and **Qishn Formation** (**Kqh**) that overlies Jurf Formation is composed by thick-bedded calcarenitic to micritic limestone and thin marly intervals, being divided into two parts, a lower part where the marl is predominant and a upper part where the marl is a subordinate to the limestone.

- **Aruma Group** – this group comprises a complex assemblage of different formations. In the studied region the various facies constituting the Aruma Group were deposited in the Campanian during and just after the thrusting of the Hawasina and Samail nappes in northern Oman and this area can be divided by two major formations, **Samhan Formation (K*sh*)** composed by siltstone and clay at the base and sandstone grading upward to bioclastic limestone, this unit was deposited as the sea began to transgress the continent and corresponds to a very shallow carbonate platform; and **Fiqa Formation** (**K*fq***) composed by massive white chalk and green marl, silty chalk and formed by the deposition on a bathyal environment. Fiqa Formation in general uncomfortably overlies the Samhan Formation.

- **Hadhramaut Group** – this group is an extensive sequence of typical carbonate shelf deposits comprising different formations where the most important to our study is **Umm er Radhuma Formation** (**E*ur***) composed by yellowish bioclastic and calcarenitic limestone, this formation was deposited in inner shelf to middle shelf palaeoenvironments.

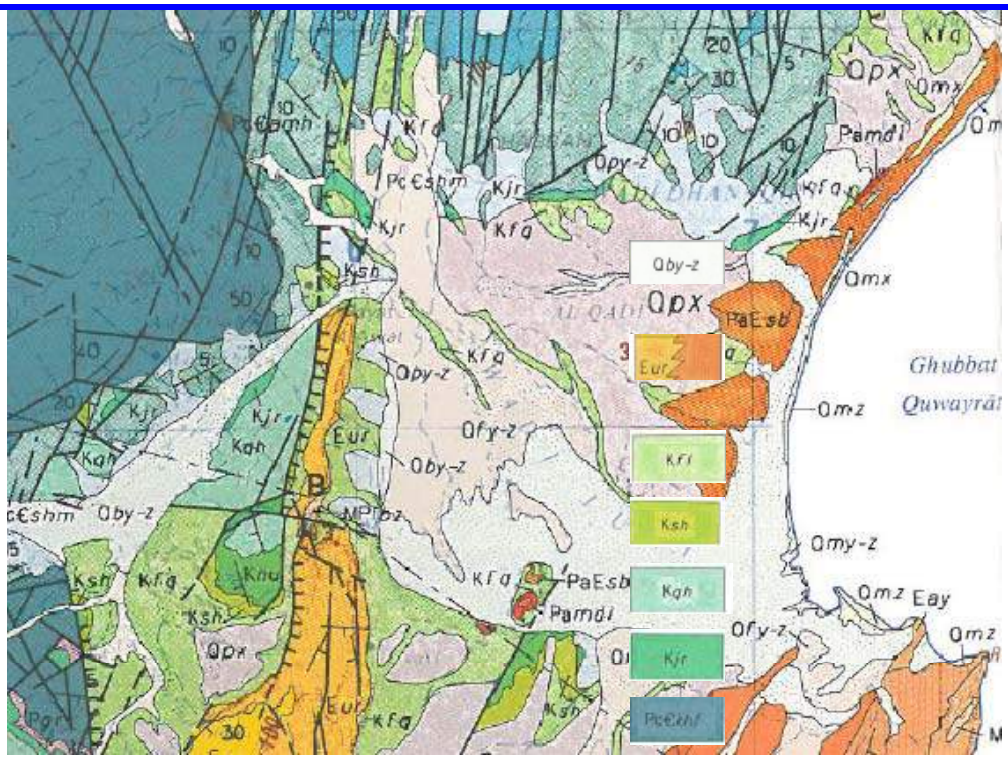


Figure 5-23: Geological framework – sheet NF 40-7C; 1986 (no scale associated)

- **Geological survey**

In order to assess the existing conditions along the dam area, we carried out a geological survey during the month of December and May. It was intended to observe in geological terms the local of the dam and verify the existence of any local geological contacts, structural conditions, lithological alterations, relief alteration and identify the most problematic places.

Due to the complexity of the area, the geological survey shall be complemented in deep details after geotechnical results will confirm or refute the potential movement over the area.

Dam axis

Along the various surveys that were made during this phase on Jurf dam, it was possible to observe that this is a difficult area of understanding, due to all the different geology but also because of the complex tectonics that we observe along the dam axis, especially near left abutment.

It is possible to identify two distinct zones along the dam axis; the first area can be defined from the right abutment with approximately 1km in direction of the left bank falling at the dam axis middle course. The second area can be defined from this last point until the left abutment.

This first area in a morphological point of view is a flat area without any relevant tectonic

features, crossing small rocky outcrops near the right abutment. The type of rocks and the in situ disposal demonstrates a genesis in a restricted to supratidal conditions with deposition of strongly alternating dolomite and marl in fine layers. This layer outcrops on the foot of white cliffs composed by interbedded marl with calcarenitic and overlies a big layer of white chalk with limestone interbedded grading to white marl. Along the dam axis this first area crosses mainly sabkhah deposits where is possible to see the salt presence due to the evaporation process. During the survey we observed an existent excavation where we confirmed that the water table is close to the surface and also that is composed by salty water. Looking along the reservoir morphology we infer three different fault alignments that can cross the dam axis. These alignments must be targeted with the geotechnical investigation over the dam axis where sandy deposits render it invisible.

The second area presents a difficult structural and tectonic interpretation. This is an area reshaped by numerous fault systems that were possible to identify on site. In a geological point of view, the dam axis will cross mainly sandstone, limestone and green marl grading to claystone. These units are in contact, mostly through failure; and are related with Laramide Orogenica phase. During the survey, it was possible to verify the re-crystallization process of most part of the faults being filled with quartzite giving the indication of non-activity and according with the existent bibliography, refer to the Aptian, although there is at least one fault were is possible to observe the step along the fault line with perfect striations showing the displacement along the movement. This one must be studied and targeted during the geotechnical investigation to understand the existence or not of re-crystallization in depth and conclude on its possible recent activity.

The activity of faults is a controversy issue because in a geological point of view an active fault is defined as a fault that had activity in the Holocene, in other words that had activity in the last 2 My, but can also be described in a neotectonic point of view considering an active fault as a fault related with seismic events in the last centuries. The problem of the last description is that most part of the old records of seismicity is through historical records of each country and can induce to some wrong considerations because the records were only achieved in habited places and on the case of Oman the record of seismic events is a recent achievement.

Another feature revealed in the second area is the presence of salt along the sedimentary layers, mostly along the sandstone layer. The salt along the sediments might imply a pre-existing sedimentary basin with a restricted connection to the sea. This is common in the south part of Oman and it is frequently associated to chaotically structured dolomite, shale, anhydrite and gypsum originally interbedded with the salt. This structure was revealed and mapped during the surveys. The present day salt edge might result from basinward salt dissolution accompanying repeated uplift of the Huqf-Dhofar axis.

Figure 5-24: Geology Survey in Wadi Jurf

Left Abutment

The left abutment has a morphology reshaped by different tectonic events and as consequence the geology has a difficult understanding. The outcrop is steep and presents a rock mass weathered and highly fractured affected by old normal faults and joints related with the numerous faults along the dam axis. Along the dam axis survey, it is possible to verify vertical joints to the principal faults that come across the abutment and also normal faults that cut the rock mass in the left abutment.

In a stratigraphic point of view, the left abutment is composed on the base by massive light grey

dolomite with sandstone and intervals of sandy dolomite, that alternate with beds of brecciated, anhydrite-bearing dolomite in which desiccation structures are common, presenting a reddish weathering horizons. This formation was deposited in a shallow marine environment, developing evaporitic tendencies leading to a break in sedimentation and the emergence of an exposed surface. Overlying this unit we have grey dolomite and coarse grained sandstone that can present in some areas sandstone interbedded with some clay levels with high fraction of ilite and esmectite and some kaolinite and quartz.

The concerns that must be targeted with the geotechnical investigation is the thickness of anhydrite and gypsum being this is an element susceptible to water dissolution leading to localised development of underground cavities and erosion of existent joints. However, according to the survey and scientific knowledge related to this material, it is not expected to have an important thickness of this layer. Due to a probable relationship with breaks in the sedimentation, it is needed to confirm the possible existence of interbedded layers in depth.

Another consideration is related with the faults. Even if we believe that the major faults are old and inactive, it is advisable to map them carefully at a proper scale and target them during the geotechnical investigation. Particular attention in the geological assessment will be paid to the Maradi fault and whether it intersects the dam or reservoir.

The existence of salt must be studied along the superficial layers because according to the survey, it is believed that there is a water path along the sandstone layer that carries the salt inside the rock mass. This might be problematic to the future dissolution of the dam foundation if it is revealed.

Right Abutment

The right abutment presents a distinguished deposition characteristic from supratidal conditions that intersect different sedimentary geological units. In a structural point of view the area does not have sign of major tectonic events presenting a horizontal to sub-horizontal stratigraphy.

We can observe at the foot of the abutment a thin bedded dolomitic limestone and brecciated dolomite with some sandstone at its base, this unit is underlying a white calcarenitic to micritic limestone with thin marly intervals. These two units are in contact with a very white, fairly soft, massive chalk with subordinate beds of week-bedded, green to grey marly chalk. This last unit composed by massive white chalk is overlapped by a yellowish bioclastic and calcarenitic limestone.

As described, the abutment is composed by thin layers of interbedded sedimentary units, with different morphology. The units that are more flat do not present major signs of weathering or fracturation, although the units that outcrop with a more steep morphology present shapes caused by wind erosion. Another important characteristic is the brecciated bioclastic limestone

that overlies the thin bedded units, that presents a nodular shape with important empty voids and presents to be highly to moderately weathered (W5/4).

The concerns that must be targeted within the geotechnical investigation is the existence of gypsum because this is an element susceptible to water dissolution leading to localised development of underground cavities and erosion of existent joints. These cavities can become unstable and collapse and even Jurf dam is not a dam with storage perspective, the water leakage through foundations might lead to internal regression erosion by dissolution that will imply instabilities. Another consideration is related with karst structures that are also formed from the dissolution of soluble rocks including limestone, dolomite and gypsum. Nearly all surface karst features are formed by internal drainage, subsidence, and collapse triggered by the development of underlying caves. Rainwater becomes acidic as it comes in contact with carbon dioxide in the atmosphere and the soil. As it drains into fractures in the rock, the water begins to dissolve away the rock creating a network of passages.

On the surface, tectonic movements and sheer stress are not observed, only an inferred contact between the thin bedded dolomitic limestone and the white chalky cliffs.

Reservoir Area

The reservoir area lies on a wide and flat area mostly covered by sahbkah deposits, sand and conglomeratic deposits near the dam axis while upstream the reservoir area presents outcrops of claystone mostly along the left side.

The reservoir area is heterogeneous and during the survey, it was possible to identify what we believe is a collapsed area along the left side including part of the dam axis. This area presents bedding planes towards the wadi center and several faults along different areas of the area. Looking to the entire area we believe that we are facing a graben with elongated fault blocks that have been raised and lowered, respectively, relative to the surrounding area as a direct effect of faulting with a vertical movement difficult to estimate. The blocks are bounded on both sides by steep dipping normal faults, along which movement has been essentially equal, resulting in blocks that are scarcely tilted. Faults forming grabens generally dip toward each other and we believe that this was caused by lateral tension.

According to the topography, it is believed that there are two different fault systems connected to one major fault along the wadi bed that caused de principal tension movement leading to the potential collapse of the left side. This fault is believed to be covered by the sahbkah deposits which render it impossible to identify it on the surface. This influence area of the fault should be targeted during the seismic profiles.

This probable collapsed area is covered by salty sediments and we verify that the salt appears near the contact zone between sandstone and dolomite, moreover it is possible to observe a water flow coming from upstream as resurgence.

Moving upstream identification outcrops of claystone has been made along the reservoir area that can be tested and used as embankment material if the clay presents the appropriate physical and mechanical characteristics.

We conclude that the right and left abutments possess completely different geology and morphology. While in the right side the rock fall must not considered a problem due to the flat outcrops, the left side must be investigated in order to indentify instable blocks and the possibility of rock fall, specially near the dam axis, although moving upstream the reservoir area is wide we believe that the rock fall must not be considered a problem upstream on the reservoir.

GEOLOGICAL ASSESSMENT OF THE GEOTECHNICAL INVESTIGATION

To confirm the geological survey and to study in detail the underground of the dam area we decide to performed geotechnical investigation, namely 20 boreholes and 17 trial pits and also seismic profiles to allow us to make assumptions of the geological conditions in depth considering eventual geological contacts or faults and also to estimate and analyze the material that can be used to the dam construction.

Boreholes

Looking to the geological interpretation of the dam axis the boreholes confirmed the complexity of the geology and also the heterogeneity among the sedimentary units without signs of lateral facies evolution as a consequence of the several tectonic episodes that occurred along Jurf area.

We distinguish different sedimentary environments divided by tectonic episodes. It is important to refer that most of the recovered cores present interbedded brecciated limestone as a result of big movements and also features as mylonites resulting from the metamorphism along faulted areas, sheer stress features and also foliation mainly in fine grained rocks like shale.

The first sedimentary environment is defined along the west side of the dam axis and left abutment, where boreholes BH-19, BH-14, BH-07, BH-06 and BH-20 intersect a outcrop composed by dolomitic limestone highly to moderately weathered and highly fractured with bands and nodules of chert. The fractures are mainly horizontal and sub-vertical, although some level are highly fractured where is impossible to identify the fracturation pattern. These boreholes present signs of recrystalization (BH-07) and small faults. Analyzing BH-08 the core presents a different geology intersecting a highly weathered and highly fractured dolomitic limestone but without any chert inclusions, moreover is possible to observe small faults along the core and some sheer stress consistent with a existent fault.

Immediately after, BH-05, BH-13, BH-15, BH-04 and BH16 present a sedimentary environment with a stratigraphy more regular composed by layers of marl and fractured limestone, although BH-05 presents 19 m of shale on the top similar to the shale intersected on the bottom of BH-13. These identical layers with several meters of gap between them give us the indication of a normal fault. BH-15, BH-04 and BH-16 are geologically similar but it is also possible to observe some steps between layers allowing us to infer the existence of listric faults involving a number of "en echelon" faults that sole into a low-angle master detachment dipping to SE and that is why the gaps between layers are visible.

Observing BH-16 and BH-18 we can make a correlation between the shale intersected at 39 m in BH-16 with the one intersected in BH-18 and due to this we can infer the existence of an inverse fault causing the uplift of the shale unit towards east direction.

Towards east, the dam axis intersects fine grained rocks, namely shale, intersected by BH-18 and BH-03 where is possible to observe the transition from grey and greenish shale to brown shale. BH-18 also presents strong tectonic features between 30 and 35 m where is possible to observe mylonites and recrystalization, allowing us to infer the existence of a fault along this unit.

On the east side of the dam axis and right abutment were performed BH1 and BH2 that intersected sandy limestone with inclusions of gypsum. While BH1 intersects in depth sandy limestone, BH 2 intersects also mudstone and marl presenting signs of an existent fault as per indication of the highly fractured levels.

During the excavation works should be performed an accurate analyzes of the fracturation pattern along the dam axis and abutments in order to have a good understanding of the rock mass.

Figure 5-25: Recrystalization due to metamorphism in BH-07. & faults along the core in BH-08.

Figure 5-26: Mylonites and recrystalization present in BH-18

It was intersected in the following boreholes, BH-JD-06, BH-JD-09 and BH-JD-20, a hydrogen sulphide gas released through the water. This gas is usually related with carbonate-evaporitic sequences where the lithological association has influence in the genesis of H_2S gas because the sulphate comes from evaporates and is the carbonated rocks that catalyze the reduction reactions; on the other hand this gas can be also produced through decomposition of organic matter in anoxic environments and Jurf presents a morphology and stratigraphy that allows us to infer that this was a closed sea similar to a dead sea where the high concentration of salt leaded to an anoxic environment with decomposition of organic matter and H_2S production.

The hydrogen sulphide gas can occur under free gas or dissolved in the water of formation among the interface of oil or gas. Considering the different depths where the gas was intersected we believe that he is under free gas among some porous limestone. This fact can be proved while looking to the boreholes where some rounded small holes can be founded confirming the presence of free gas and no evidence of water erosion or oxidation. Moreover the existent H_2S among the interface of oil and gas is usually intersected at bigger depths.

DESIGN IMPLICATIONS AND PARTICULAR ASPECTS

The design of the dam must consider the following aspects:

- The local geology is mainly formed under marine environment leading to the formation of evaporites as chalk and gypsum. These types of evaporites, mainly gypsum are elements susceptible to water dissolution leading to localised development of underground cavities and erosion of existent joints.
- On the surface the evaporites present small layers with thickness of 5 cm, although they were not intersected in depth along the performed boreholes we should consider the possibility of punctual presence along the dam axis.
- The presence of H2S (hydrogen sulphide)
- The presence of salt (NaCl) along the sandstone layers must be considered due to the dissolution that the salt can cause in the dam foundation

Design implications and particular aspects

The design of the dam must consider the following aspects:

- The local geology is mainly formed under marine environment leading to the formation of evaporites as chalk and gypsum. These types of evaporites, mainly gypsum are elements susceptible to water dissolution leading to localised development of underground cavities and erosion of existent joints. Setting a potential threat for the dam establishment, this must also be investigated.
- The thickness of evaporites and how they are interbedded in depth. On the surface the evaporites present a small layer with thickness of 5 cm and if these layers occur interbedded in depth can be problematic because there are susceptible of being washed away during the time causing future collapse of the structure.
- The presence of thick layers of clay with swelling behaviour, that depending upon the supply of moisture in the ground, these soils will experience changes in volume. Foundation soils which are expansive can cause lifting of the foundation during periods of high moisture. Conversely during periods of falling soil moisture, expansive soil will "collapse" and can result in a settlement.

5.17 Water Resources

5.17.1 General Features

In order to proceed to the zoning and geotechnical and geophysical characterization of the Jurf dam was programmed.

These types of structures requires the quantification and analyses of the geotechnical data and a quantitative analyze to ensure that we meet the basic requirements, may be used routine procedures in site investigation and even in laboratory tests.

The primary and chronological components of this work are:

- Geophysics campaign results with reflection based analysis WET (Wave-path Eikonal Tomography);
- Borehole positions and rotary core drilling;
- Performing in situ mechanical tests (including SPT, CPT)
- Performing water test (e.g.: Lugeon /Constant Head)
- Executing all the relevant laboratory testing according to the Standards;
- Reinstatement of the natural ground.

The investigations required include geophysical tests to provide an overview of the underlying geological conditions. Further geotechnical investigations include borehole excavation, trial pits, sampling of materials from these excavations and laboratory tests on these samples. These physical tests are located to target areas where geophysics highlighted problematic geological features and anomalies which could affect the geotechnical characteristics. (faults, cavities, weak layers etc.)

Trial pits on the being excavated either for the purpose of identifying a borrow area/quarry, or to determine the foundation conditions along the alignment. Trial pits in other areas are being undertaken for the purpose of identifying a borrow area/quarry for the dams construction.

Trial pits shall be excavated in the alluvial flood plain for the purpose of determining the soil properties for the construction of the dams. In situ density, field grading and permeability testing will be required in most of the trial pits.

Drilling is to be completed using a rotary drilling rig capable of advancing holes, of the diameters specified within Appendix 1, to at least 80 m below natural surface level. The drilling rig shall be capable of the following:

- HQ Triple Tube Wireline Coring to no less than 80 m,
- Rotary Percussion to no less than 80 m,
- ODEX/SIMCAS to no less than 80 m.

As per the time being, the geotechnical investigation is undergoing, so it's not yet possible to interpret the obtained data from theses campaigns. Nevertheless, the available data is presented in the subchapter 5.14.2 and more data will be provided as the investigations proceed.

The following table summarizes the boreholes and trial pits planned for the geological and geotechnical studies. Also, as reference, the bellow Figure includes the exact location of the trail pits and boreholes of these campaigns.

Table 5-1: Number of boreholes & Trial Pits

Location	No. Of Boreholes	No. of Trial Pits
Jurf Dam	**19**	**17**

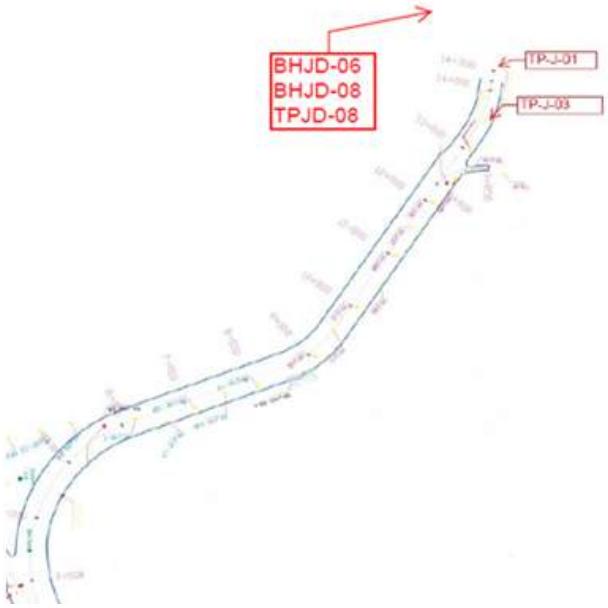


Figure 5-27: Location of geotechnical investigation and Trial Pits with available data

As mentioned, the geological and geotechnical interpretation of the results will be performed when the geotechnical investigation is finalized. Nevertheless, for the reference of this report the Client made some valuable information available regarding geotechnical investigations performed along the project area.

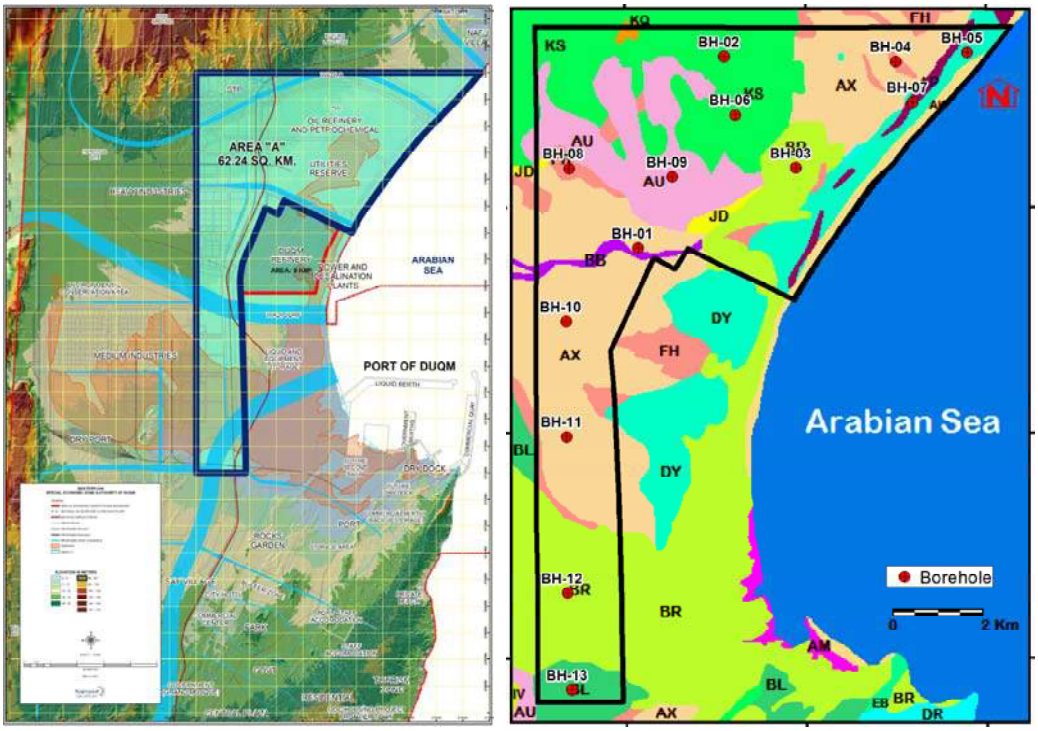


Figure 5-28: Maps showing the area "A" at the Port of Duqm region.

A total of thirteen (13) boreholes were drilled to depths range between 10 m to 19.5 m below the ground surface. The locations of all the drilled boreholes were marked on the site by the EMC representatives and plotted in Figures above. Drilling was performed using EK 200S and DESCO hydraulic drilling rigs. The method of drilling was rotary drilling with Bentonite mud circulation. Field test data and observations of all boreholes were presented in the Lonestar drilling report provided by the Client. A qualified EMC field geologist supervise the drilling to ensure data confidence and to verify sampling procedures.

Standard Penetration Tests (SPT) were conducted at two meters intervals or wherever the soil conditions are appropriate for SPT in accordance with BS: 1377 Part 9:1990 Method of Test for Soil for Civil Engineering Purposes. The test involves driving a 50 mm outside diameter thick walled sampling tube (Split-Barrel Sampler) into the bottom of the borehole with successive blows of 63.5 kg (140 lb) hammer falling freely from 760 mm height. The sampler is driven through three successive intervals of 150 mm each and the number of blows required to penetrate each interval is recorded. The initial 150 mm is intended to ensure "seating" of the sampler such that it penetrates beyond the zone of influence of any soil disturbance at the base of the borehole. The total number of blows to drive the sampler over the final 300 mm is termed as the "N" value, and is considered as an indicative of the in-situ relative soil density. Where a penetration of 300 mm was not achieved, due to the density or degree of cementing of the deposit, the distance driven and number of blows are recorded on the borehole logs. If gravels or cobbles are present, a standard cone is fixed on the open end of the tube. Disturbed SPT and bulk samples collected during drilling were retained in sealed, labeled plastic bags.

Rock coring was performed using T6-101/NQ Wire line core barrel producing nominal core diameter of 47.5 mm. Core runs were restricted to a maximum of 1.5 m long in order to optimize core recovery. During rotary coring water mixed with bentonite was used as the flushing medium and care was taken to adjust the pressure in order to optimize core recovery. Even though the use of drilling water make it difficult to observe ground water depth during drilling in some of the boreholes, careful attention was paid during boring to determine whether ground water was present within the deposits penetrated and ground water levels were recorded. Core samples were carefully transferred from the core barrel to purpose-built wooden core boxes. Consecutive core runs were separated within the core boxes with labelled core spacers. Careful attention was paid during boring to determine whether groundwater was present within the deposits penetrated and groundwater levels were recorded. The individual borehole logs and photographs of the samples were presented in Lonestar drilling report.

Groundwater Conditions

Ground water table was encountered in all borings except BH-02, BH-05, BH-06, BH-09 and BH-10. The ground water level varied from 1.5 to 5.6 m below the existing ground surface as recorded during the field exploration. Repeated measurement of ground water in BH-10 shows that it is dry hole, therefore, the ground water depth reported in BH-10 appears to be from water introduced during drilling.

Groundwater levels in the piezometers are summarized in. Based upon evaluation of ground water measurement, it appeared that ground water, at the time of field exploration, was flowing toward the southeast direction. A detailed drawing of the ground water elevation and flow direction will be determined following the surveys of piezometer elevation by SEZAD and will be included in the final report. The following tables summarise the results in BH-10, BH-11, BH-12 and BH-13, the boreholes mostly present in the intersection of both wadis and in wadi Say.

Table 5-2: Summary of subsurface conditions

BH N0.	Depth	Subsurface Strata Description
BH-10	0.0 – 2.0	Interbedded layers of medium dense to dense, silty gravelly sand/ silty gravel
	2.0 - 3.5	Very dense silty very gravelly sand
	3.5 - 4.5	Very stiff slightly sandy clay
	4.5 - 18.0	Very weak to weak chalky marl, underlain by marl from 13.3-18.0m
BH-11	0.0 – 0.5	Loose slightly gypsiferous, very silty/ clayey, gravely sand
	0.5 – 2.9	Loose to medium dense, gypsiferous, calcareous, very silty sandy gravel
	2.9 – 19.5	Very weak to weak, chalky marl, underlain by marl from 12.0n – 19.5m
BH-12	0.0 – 5.4	Interbedded layers of medium dense very silty, very gravelly sand/ very silty sandy gravel
	5.4 – 15.5	Very weak to weak bioclastic marl
BH-13	0.0 – 0.5	Light orange and pink, slightly silty, very gravelly sand
	0.5 – 4.4	Extremely weak to very weak calcareous claystone
	4.4 – 10.0	Very weak to weak bioclastic silty marl

Table 5-3: Ground water depth in the boreholes of the project area

Borehole No.	Depth (m)	Depth of Groundwater Table (m)
BH-10	18.5	6.5
BH-11	19.5	4.55
BH-12	15.5	2.9
BH-13	10	1.47

Soil

In addition to visual soil description a total of forty grab (40) soil samples were collected and submitted to the laboratory for particle size distribution analyses to better define soil type and contents. Nine (9) out of the forty soil samples, where silt and clay percentage exceed 15%, were selected for Atterberg Limits test to determine the plasticity degree. Additionally, soil samples from the borehole drilling program were selected for laboratory testing as follows: 14 samples for particle size distribution, eight samples for Atterberg Limits, four samples for moisture density relationship, six samples for unconfined compression strength, two samples for swell pressure, four samples for point load test, two samples for gypsum content, and six samples for chemical analytical testing to determine corrosivity potential. The laboratory testing has been performed in accordance with the relevant international standards as indicated in the following Figure.

Test Description	Standard
Particle size distribution test	BS 1377: Part 2
Atterberg Limits	BS 1377: Part 2
Moisture content	BS 1377: Part 2
Moisture Density Relationship Of Soil	BS 1377 P4 1990/ AASHTO T-180
Unconfined Compressive Strength & Point Load Test	ASTM D7012 & ASTM D. 5731 - 95 / ISRM
Swell Pressure	BS1377: Part 7
Soil Chemical Analysis: pH, Sulphate, Chloride. & Gypsum	BS 1377: Part 3/ BS 812: part 118:1988 & Agricultural Handbook No: 60 US Dept. of Agriculture
Water Chemical Analysis	APHA Method

Figure 5-29: Laboratory Tests with their Test Specifications

5.17.2 Groundwater Quality and Use

Groundwater was encountered in most boreholes, while some boreholes were dry during drilling. Groundwater level measurements and sampling were obtained in the monitoring wells installed in boreholes BH-01, Bh-03, BH-05, BH-07, and BH-13. The water levels ranged from about 1.47 to 3.47 meters below the ground surface.

The chemical analyses of ground water samples indicate the highest total dissolved solids (TDS) of 101180 mg/l in BH-03 and least TDS of 8290 mg/l in BH-05. Similarly, the highest in chloride, sodium, calcium, total hardness and conductivities are found in BH-03 and the least in BH-05. These results for BH-03 appear to be consistent since BH-03 is in close proximity of the coastal line where sea water intrusion is present as evidences by Sabkha ground. While BH -05 is located on higher terrain, it is also close to the coast therefore the ground water chemistry may be affected by the introduction of drilling water since drilling was problematic at this location. Generally the TDS and other indicators for salinity are high in all the GW samples. The dominate anions in each well sample are chloride, sulfate and bicarbonate and the dominate

cations are sodium, calcium, and magnesium. The major natural sources of chloride are sea water and sedimentary rocks. The recommended concentration limit of chloride in drinking water is 250 mg/l (Todd 1980). The main natural sources of sulfate are gypsum, anhydrite and oxidation of sulfide ores. The recommended concentration limit of sulfate in drinking water is 250 mg/l (Freeze and Cherry, 1979). Limestone and dolomite form the main natural sources for bicarbonate. Concentration of bicarbonate in natural water usually less than 500 mg/l, but may exceed 1000 mg/l in water highly charged with carbon dioxide (Todd, 1980). The major natural sources of sodium include: feldspars (albite), clay minerals, evaporites such as halite (NaCl) in addition to industrial wastes. The maximum permissible concentration for sodium in drinking water is 400 mg/l. The major natural sources of magnesium include: amphiboles, olivine, pyroxenes, dolomite, magnesite and clay minerals. In natural water magnesium ion usually occur in concentration less than 50 mg/l unless the water is brackish or saline (Todd, 1980). The major natural sources of sodium include: feldspars (albite), clay minerals, evaporites such as halite (NaCl) in addition to industrial wastes. The maximum permissible concentration for sodium in drinking water is 400 mg/l. The major natural sources of magnesium include: amphiboles, olivine, pyroxenes, dolomite, magnesite and clay minerals. In natural water magnesium ion usually occur in concentration less than 50 mg/l unless the water is brackish or saline (Todd, 1980). The chemical analyses of GW samples are summarized in the below Tables-8 and details are presented in Lonestar report.

SUMMARY OF LABORATORY TEST RESULTS

Sample Identification			Particle Size Distribution			Atterberg Limits			Classification based on Atterberg limits only
BH/TP No.	Sample No	Depth	Gravel	Sand	Silt/Clay	Liquid Limit	Plastic Limit	Plasticity Index	
		(m)	(%)	(%)	(%)	(%)	(%)	-	-
AS01-0	LMCIV/843184/1	GL-0.70	25	58	17	22	NP	NP	ML
AS02-252	LMCIV/843184/2	GL-0.70	62	24	14	-	-	-	-
AS03-1110	LMCIV/843184/3	GL-0.70	65	26	9	-	-	-	-
AS04-1920	LMCIV/843184/4	GL-0.70	30	59	11	-	-	-	-
AS05-2570	LMCIV/843184/5	GL-0.70	52	37	11	-	-	-	-
AS06-3120	LMCIV/843184/6	GL-0.70	15	73	12	-	-	-	-
BS01-0	LMCIV/843184/7	GL-0.70	50	38	12	-	-	-	-
BS02-1180	LMCIV/843184/8	GL-0.70	26	71	3	-	-	-	-
BS03-1350	LMCIV/843184/9	GL-0.70	8	27	65	37	25	12	MI
BS04-2980	LMCIV/843184/10	GL-0.70	12	87	1	-	-	-	-
BS05-4710	LMCIV/843184/11	GL-0.70	44	52	4	-	-	-	-
CS01-0	LMCIV/843184/12	GL-0.70	15	82	3	-	-	-	-
CS02-658	LMCIV/843184/13	GL-0.70	30	52	18	24	NP	NP	ML
CS03-1140	LMCIV/843184/14	GL-0.70	31	57	12	-	-	-	-
CS04-3800	LMCIV/843184/15	GL-0.70	11	72	17	23	NP	NP	ML
CS05-5360	LMCIV/843184/16	GL-0.70	39	57	4	-	-	-	-
CS06-5500	LMCIV/843184/17	GL-0.70	58	37	5	-	-	-	-
CS07-5910	LMCIV/843184/18	GL-0.70	49	45	6	-	-	-	-
DS01-0	LMCIV/843184/19	GL-0.70	0	6	94	39	21	18	CI

Figure 5-30: Analysis for the grab soil samples and Atterberg limits

Sample Identification			Particle Size Distribution			Atterberg Limits			Classification	Swell pressur	Compaction		Unconfined Compressive strength	Point Load	
BH/TP No.	Sample No	Depth	Gravel	Sand	Silt/Clay	Liquid Limit	Plastic Limit	Plasticity Index			MDD	OMC		Moisture Content	PLI
		(m)	(%)	(%)	(%)	(%)	(%)	-	-	KN/m^2	Mg/m^3	(%)	N/mm^2	(%)	Mpa
BH-01	RGEO-13081/1	GL-0.50	21	73	6	23	NP	NP	ML		1.97	6.60			
BH-02	RGEO-13081/5	GL-0.25	26	61	13	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/6	0.55	-	-	-	-	-	-	-	-	-	-	75.3	-	-
BH-03	RGEO-13081/8	GL-0.50	26	69	5	22	NP	NP	ML	-	1.96	6.50		-	-
	RGEO-13081/9	0.50-0.95	2	74	24	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/10	5.0-5.45	13	52	35	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/11	7.74	-	-	-	-	-	-	-	-	-	-	4.4	-	-
BH-04	RGEO-13081/14	5.50	-	-	-	-	-	-	-	-	-	-	-	0.5	0.1
BH-05	RGEO-13081/15	1.50	-	-	-	-	-	-	-	-	-	-	-	0.1	0.1
	RGEO-13081/16	5.0-5.45	2	59	39	90	54	36	MV	-	-	-	-	-	-
BH-06	RGEO-13081/17	GL-0.30	19	77	4	23	NP	NP	ML		1.95	6.90	-	-	-
	RGEO-13081/18	0.50-0.74	37	45	19	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/19	4.00	-	-	-	-	-	-	-	-	-	-	-	0.7	0.1
BH07	RGEO-13081/21	6.40	-	-	-	-	-	-	-	-	-	-	10.3	-	-
BH-08	RGEO-13081/22	GL-0.45	27	66	7	45	29	16	MI	-	-	-	-	-	-
BH-09	RGEO-13081/25	GL-0.30	36	58	6	22	NP	NP	ML	-	2.03	6.1	-	-	-
	RGEO-13081/27	2.50	-	-	-	-	-	-	-	-	-	-	-	0.3	1.9
	RGEO-13081/28	8.50	-	-	-	-	-	-	-	-	-	-	13.7	-	-
BH-10	RGEO-13081/29	1.35-2.0	44	39	17	49	29	20	MI	-	-	-	-	-	-
BH-11	RGEO-13081/31	2.0-2.45	22	64	14	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/32	3.45	-	-	-	-	-	-	-	-	-	-	1.4	-	-
BH-12	RGEO-13081/35	1.45-1.90	32	62	6	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/36	8.93	-	-	-	-	-	-	-	-	-	-	3.3	-	-
BH-13	RGEO-13081/37	0.50-0.95	27	68	5	-	-	-	-	-	-	-	-	-	-
	RGEO-13081/38	1.50-2.0	-	-	-	-	-	-	-	1145.0	-	-	-	-	-

1. Classification above is based on atterberg limits only

Figure 5-31: Summary of laboratory geotechnical test results

Sample Identification			Chemical Analysis			
BH/TP No.	Sample No	Depth (m)	pH	Cl (%)	SO3 (g/l)	Gypsum (%)
BH-01	RGEO-13081/1	GL-0.50	8.3	<0.01	0.03	<002
BH-02	RGEO-13081/3	0.25-0.50	9.3	<0.01	0.04	-
BH-03	RGEO-13081/9	0.50-0.95	7.3	2.28	0.5	-
BH-04	RGEO-13081/13	0.50-0.95	7.4	0.38	1.7	-
BH-05	RGEO-13081/15A	1.50-3.0	8.0	0.02	0.04	-
BH-06	RGEO-13081/17	GL-0.30	7.8	0.14	0.3	-
BH-07	RGEO-13081/20	0.95-2.0	8.0	0.10	0.19	-
BH-08	RGEO-13081/22A	0.45-2.0	8.0	<0.01	0.04	-
BH-09	RGEO-13081/26	0.95-1.50	8.8	0.02	0.06	-
BH-10	RGEO-13081/29	1.35-2.0	6.7	0.22	1.60	2.2
BH-11	RGEO-13081/31	2.0-2.45	7.7	<0.01	0.7	-
BH-12	RGEO-13081/34	0.45-1.45	8.3	<0.01	0.04	-
BH-13	RGEO-13081/39	2.0-2.45	6.7	0.20	0.1	-
Chemical analysis mentioned above is done on soil samples for water soluble chlorides & sulphates						

Figure 5-32: Summary of laboratory chemical analyses

TEST	TEST METHOD	MDL	RESULTS (WATER SAMPLES)				
			BH-03	BH-05	BH-07	BH-01	BH-13
pH Value @ 25oC	APHA 4500 H+B	0.1	6.7	7.7	7.3	7.3	7.2
Conductivity @ 22.2, mS/cm	APHA 2510 B	0.1	129.8	12.1	36.9	33.6	15.05
*Alkalinity as CaCO3 mg/L	APHA 2320 B	1	362	249	374	85	79
*Total Dissolved Solids dried@ 180° C, mg/L	APHA 2540 C	5	101180	8290	24800	22940	9570
Chlorides, mg/L	APHA 4500 Cl^- B	1	59783	3376	12308	12308	5240
Sulfates, mg/L	APHA 4500 SO4 C	1	1679	1889	2939	1943	811
Fluoride, mg/L	HACH 8029	0.01	1.5	2.08	2.18	2.09	1.39
Nitrate, mg/L	HACH 8171	0.01	6.7	0.8	1.9	1.3	2.1
Phosphates, mg/L	HACH 8048	0.01	1.04	0.7	0.83	1.01	0.67
Bicarbonates, mg/L	APHA 2320 B	1	441	304	457	104	97
Carbonates, mg/L	APHA 2320 B	1	<1	<1	<1	<1	<1
Calcium, mg/L	APHA 2340 B	1	2712	439	1097	917	678
Magnesium, mg/L	APHA 2340 B	1	4224	101	543	483	222
Sodium, mg/L	APHA 3120 B	0.02	30995	2520	6872	6090	2501
Potassium, mg/L	APHA 3120 B	0.02	1538	75.3	127	127	55
Iron, mg/L	APHA 3120 B	0.003	0.3	0.7	1.21	0.13	0.085
Zinc, mg/L	APHA 3120 B	0.004	2.7	3.88	0.24	0.25	0.345
Copper, mg/L	APHA 3120 B	0.002	0.1	0.01	0.02	<0.002	0.025
Manganese, mg/L	APHA 3120 B	0.002	0.625	0.02	0.47	0.31	0.195
Calcium Hardness as CaCO3, mg/L	APHA 2340 B	1	6766	1095	2736	2289	1692
Magnesium Hardness as CaCO3, mg/L	APHA 2340 B	1	17413	417	2239	1990	915
*Total Hardness as CaCO3, mg/L	APHA 2340 C	1	24179	1512	4975	4279	2607

Figure 5-33: Summary of laboratory chemical analyses of groundwater

Table 5-4: Renardets' results on pH & Total Dissolved Solids

	pH @ 25°C with APHA 4500-H method*	*Total Dissolved Solids (mg/L) with APHA 2540 C method*	*Date tested*
TP-J-13	7.5	18020	30/12/2014
TP-J-01	7.3	5630	30/12/2014
BHJD-06	6.7	39990	31/12/2014
BHJD-08	7.3	14410	31/12/2014
TPJD-08	7.6	10500	31/12/2014

5.18 Waste

Al Duqm Town will be the residential and commercial heart to the wider Al Duqm City Masterplan, providing the accommodation and services required to support the industrial and logistical functions of the new port complex. The Waste Management Plan (WMP) required to support the Al Duqm Town complex will need to ensure a masterplan design that achieves if not exceeds client expectations.

The United Nations (UN) Environment Programme has credited Oman with having an excellent record in environmental conservation, pollution control and maintenance of ecological balance. It had also been stated that Oman has one of the most rigorously "green" governments in the world.

Oman has ratified international treaties related to environmental protection and waste management, including the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal and the UN Framework Convention on Climatic Change.

Current Practices

The Oman Environmental Services Holding Company (OESHCO) has a remit to restructure the waste management sector in Oman. OESHCO is a relatively new entity, established in 2007 with legal status granted two years later in August 2009. Key initiatives include the drive to improve waste management systems in Oman, with the support of private companies via privatisation of some systems. They have a vision to move Oman to a zero waste status, which seeks to minimise the reliance on landfill and improve opportunities for residents and business to reduce and recycle more waste.

Waste management systems in Oman are still in a basic state, but improving. Muscat generates an estimated 660,000 tonnes of waste per year, which is disposed of in one of three landfills. The condition of these sites is below good international standards.

Waste collection systems are basic, and the lack of reliable infrastructure has prevented waste

from being collected in some locations. From the available information in the Duqms' master plan, from the development area the following key points have been gained:

- Current waste management facilities for the liquid and solid non-hazardous waste for the development area are inadequate and waste is being stored and treated inappropriately. The only waste management facilities are unmanaged landfills and scattered tipping areas. There are no long-standing facilities for the management of hazardous waste near the Al Duqm Town development;
- Facilities to deal with and dispose of hazardous liquid waste do not exist in the vicinity of the Al Duqm Town development. The provision of recycling facilities, strategic waste handling and landfill facilities capable of handling domestic, normal and special waste is essential;
- Oman has a total of 350 "landfill" sites, only two of which are understood to be engineered. Neither of the engineered landfills are within usable proximity to the development site;
- There is no segregation of waste at the generation point or at the dumpsites throughout Oman. Waste is dumped in the open in large piles, and is inevitable scattered by winds; and
- Waste generation taking place on the proposed development site is limited to a settlement of fishing villages in the area of the site. The area is prone to littering of fishing nets and gears, fish net floats, plastic, metals, organic waste such as fish and refuse from large vessels.

Planned Waste Management Infrastructure

There are plans to develop an integrated Waste Management System for the Duqm area. The Duqm Industrial and Free Zone Masterplan calls for a landfill to be constructed and operated within the Duqm Industrial Development Zone (IDZ) to provide safe and environmentally responsible disposal of municipal solid waste (MSW), hazardous waste, and construction and demolition waste generated in the Duqm area. The IDZ is part of the broader masterplan for Duqm and has been guided by a number of Ministerial Departments with the aim of creating a sustainable economic hub at Duqm.

It is stated that the proposed Duqm Landfill will be an engineered landfill site that will be capable of safely and effectively disposing of solid waste generated in the Duqm area in an environmentally responsible manner.

The landfill will be engineered with a single composite liner and will be designed constructed and operated in accordance with USEPA guidelines and international best practices. It will be constructed in phases, as and when landfill capacity is required. Total land area set aside for the project is 409 hectares. The facility will have separate areas designated for municipal and nonhazardous commercial solid waste, construction and demolition waste, and industrial special and hazardous waste.

Additionally, although the exact location or timescale is unknown, OESHCO has indicated plans to develop an additional 16 engineered landfills which may be in proximity to the Duqm master plan development.

5.19 General Ecology

Terrestrial Ecology

The two most important areas near to the town are the sabkha and coastal habitat to the north in the area of the new port development and the Arabian Oryx reserve to the west. Although these are both outside the boundaries of the Duqms´ master plan and both already have the potential to be impacted by other development and activities, the proposed Al Duqm New Town will place additional pressure on these sites.

The design of the town master plan should focus on retaining and protecting the most valuable ecological habitats and features and, where this is not possible, providing replacement habitat. Wildlife corridors should be maintained and damaging activities controlled as far as possible. The master plan should aim to accommodate habitat of value to birds, particularly migrants, and limit pressure on the reserve areas.

Important ecological features such as wadis and coastal areas that provide habitat for migratory birds should be protected from development, with a development free buffer around them.

Habitats

Al Duqm's climate and coastal location determine the habitats present in the region. Vegetation is fed by the summer monsoon rains and by dew from coastal fog, meaning that the coastal zone is relatively well vegetated, compared with the arid desert regions further inland. The highly saline coastal environment also contributes to the nature of habitats present.

The habitats present in and around the Al Duqm town area can be broadly grouped into three main types:

- Coastal habitats and Sabkha (salt flats): these areas contain a mixture of wetlands (e.g. lagoons), very saline areas with little vegetation, and less saline areas with some vegetation. These habitats support internationally important species and, of the three main habitats, are the least common in the region
- Wadis and gravel plains: the water provided by wadis supports a diverse range of vegetation, typified locally by open acacia woodlands, low shrubs and ephemeral grasses. Wadis act as wildlife corridors, along which mammals and birds travel; and
- Hills, slopes and escarpments: these habitat types support the least vegetation and wildlife, although where water is retained in fissures and depressions, there is likely to be a higher density of vegetation.

Other habitat types in the local area include small saline or brackish springs, rocky coastal headlands, and sand dunes. Areas grazed by livestock are also present; these tend to have reduced vegetation and be less bio diverse.

Two internationally important wildlife sites are in close proximity to the proposed town area:

- An Arabian Oryx reserve lies approximately 5km west of the proposed town. The reserve contains a diverse range of habitat types and supports numerous internationally/regionally important and rare species, including the Arabian Oryx. The site was included on UNESCOs World Heritage List in 1994 but became the first site to be deleted from this list in 2007, due to Oman's decision to reduce the area of the protected site by 90% and because of a decline in Oryx numbers due to poaching and habitat degradation; and
- Duqm Important Bird Area, designated in 2001, comprises the coastal and sabkha habitat immediately north of the proposed town, which has been recognized as an internationally important site for migratory birds. Unfortunately, completion of Al Duqm port development will destroy this site.

Species

Faunal populations in semi-arid areas tend to be spread out, occupying large areas at low densities. Many species are also nocturnal or are otherwise hidden or camouflaged, due to the climate and limited vegetation cover. This makes it difficult to obtain accurate data on species present on site.

Numerous species have been recorded within the local area, due to the diverse range of habitats, including carnivorous and other large mammals (e.g. red fox, ibex and Arabian Oryx), smaller mammals (e.g. hedgehogs and bats), rodents (e.g. jirds and gerbils), various reptiles, and numerous birds.

Oman lies at the centre of the Asia-East Africa migratory bird flyway and the coast provides an important feeding ground. The sabkha and coastal lagoon areas to the north of the town area, in particular, support large numbers of migratory birds including rare species, as recognized by the international designation of the site as an Important Bird Area. The species present vary with the time of year: some species winter on the Duqm coast, while others pass through in spring or autumn.

At certain times of the year, however, Siberian Gull and Caspian Gull make up approximately 95% of the total number of birds on the coast. Non-coastal habitats, especially those in the Oryx reserve also support important bird populations such as the houbara bustard, for which the area is the most important breeding site in Oman.

Marine Ecology

Habitats

The coast to the east of Oman experiences pronounced upwelling of nutrient rich cold water, especially during monsoon season. A diverse range of habitats are present locally including coral reefs, mangroves, seagrass beds, seaweeds, soft sediment communities and rocky intertidal habitats.

Species

The range of coastal habitats and nutrient upwelling means that the marine environment supports a high diversity of species. Because of this, the fishing industry makes an important economic contribution to the region and the region is used by internationally significant species including migratory birds, turtles and marine mammals. 21 species of whales and dolphins have been identified off the coast of Oman, including a significant population of humpback whales.

Turtles, which are of international conservation concern, use the coastal waters; and four of the five species recorded locally nest on beaches along the coast. The beaches where nesting green turtles have been identified, but no data on other species is available.

Although environmental regulations exist to control fishing, these are not always well enforced, and overfishing is a problem for some species. In addition, fishing practices such as indiscriminate hauling and non-targeted catches result in the dumping of large numbers of fish. Migratory birds play an important part in the marine ecosystem, by preying upon fish species and their droppings provide nutrients to the marine environment. Any disruption to migratory birds, for example the loss of an Important Bird Area due to the port development, could therefore alter marine ecosystems and potentially impact upon fisheries.

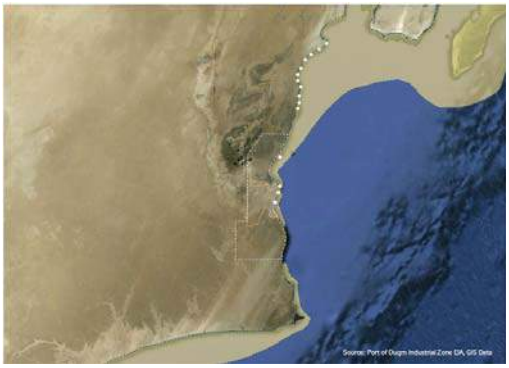
The development of the port will also affect marine habitats directly where dredging or construction takes place. Port activities, particularly the transfer of oil, are likely to result in some pollution of the marine environment. Other developments such as desalination plants, similarly, will damage coastal and marine habitats and could result in changes in sea water quality.

The above points are not directly specific to Al Duqm New Town, but are relevant in terms of increased pressure on local ecological resources and habitats from multiple developments.

Protected Areas

The Turtle Areas

Oman is home to the largest nesting aggregations of the endangered green and loggerhead turtles in the world. Sea turtles are among the oldest and most important marine animals in Omani waters.



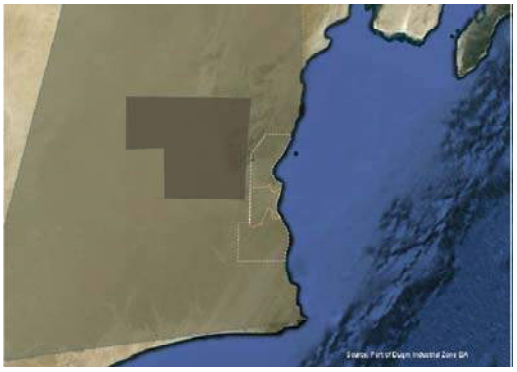
However, they are vulnerable to increased hunting and habitat loss with growing developments along the coast.

Significant measures should be taken to protect the waters and beaches upon which sea turtles depend.

The entirety of the Duqm coast is used by green and loggerhead turtles as a feeding ground, and three beaches within the project boundary are noted as particular nesting sites for these turtles. The welfare of the turtles is threatened by potential physical and light pollution at the site.

Arabian Orix sanctuary

The original Arabian Oryx Sanctuary covered a large swath of land in the Omani central desert and coastal hills. This sanctuary contained the first free-ranging population of Arabian oryx since the species was declared extinct in the wild in 1972.



The sanctuary is located in the central plateau of Jiddah and is separated from the eastern Hills by the sabkah flatlands of the Huqf depression.

The sanctuary was also home to the largest wild population of the endangered Arabian Gazelle. Given its global ecological significance, the sanctuary was designated as a UNESCO World Heritage Site in 1994.

However, due to poaching and habitat degradation, the site was delisted in 2007. Al Duqm has the incredible potential to protect these globally-important animals and their habitat by promoting compact developments and smart growth patterns.

The Arabian Oryx is an endangered species with special protection status within the nearby Arabian Oryx Sanctuary, which lies just northwest of the Duqm site. That sanctuary, created in 1994, originally encompassed the entirety of the Duqm site, but was subsequently reduced in size. Still, the Arabian Oryx is an important piece of Duqm's wildlife profile.

Over 140 species of plants have been recorded in the protected area, including 12 endemic. While some species are short-lived, after rain the longer living species are supported by the fogs. Simr scatters, ghaf and Al Salam grow in numerous shallow sandy depressions know as haylat. These tree species provide suitable habitat for birds and nectar for insects.

At least 15 species of mammals have been recorded in the sanctuary, such as the Arabian Orix and the Arabian Gazelle. The Nubian Ibex lives on the huqf escarpment and in the eastern hills. Also present in the sanctuary, the Golden Eagle with the last wild breeding population of Houbara Bustard known in Arabia.

Bird Areas

Al Duqm is an important area for native and migratory birds;100,000s of birds feed, rest, and nest along its sandy beaches, khawars, and inland hills.

The Ghubbat Quwayrat (sabkha just north of the port) has been designated as an Important Bird Area by BirdLife International.

Twice a year billions of birds migrate vast distances across the globe. Many birds that breed in the mid-Palaearctic embark on a much longer south-westerly migration to Africa rather than spend the northern winter directly to the south.

By travelling westwards along the East Asia/East Africa Flyway, migrating birds avoid the formidable obstacles presented by the Tibetan plateau and Himalayas, which effectively bar direct migration to the south.

The much larger landmass of Africa is also able to sustain a greater influx of visiting birds than the comparably small Indian Subcontinent.

Along the way, many of these migrating birds travel along the southern edge of the Arabian Peninsula and rely on Oman's 33 Important Bird Area's.

Other animal significance

The waters off of the Duqm coast are home to significant numbers of humpback whales and many parts of the site are used by migratory birds. These will contribute to Duqm's unique ecotourism profile.

5.19.1 Fauna

The identified fauna of the Jurf dam consists of Domesticated Mammals, Reptiles and Amphibians, Insects, Butterflies, Birds and Fowls (Avifauna).

Particular aspect of the project is the area of the Orix Sanctuary that is going to be occupied by the left abutment and the west part of the Jurf dam axis. This area shelters protected species such as the Arabian Gazele and the Arabian Orix and by all means must be considered as sensitive area.

It's possible that some species were present but not indentified, since the fauna in the area is extremely sensitive and normally camouflages or takes shelter out of human sight.

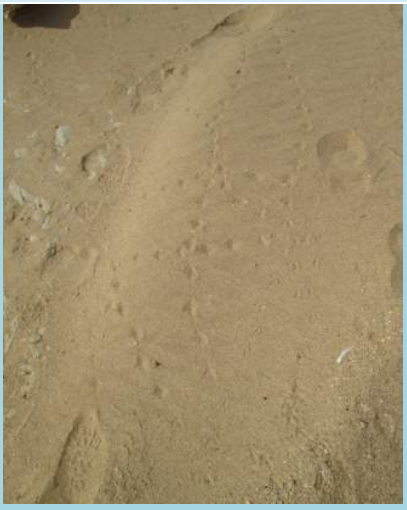
Fauna Identified	Photographic Record
Arabian Gazele	

Arabian Orix	
Camel	
Goats trail	 

Ants	
Felidae trail	
Grasshopper	

Dragonflies	
Butterfly	
Hedgehog trail	

Donkey	
Salt water snails	 
Spiders Nests	

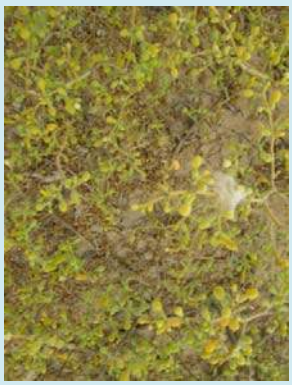
Dor bugs	
Birds	
Snakes, Spiders	Seen, but not recorded
Lizards	Seen, but not recorded
Birds (Egyptian Vulture, crows)	Seen, but not recorded

5.19.2 Flora

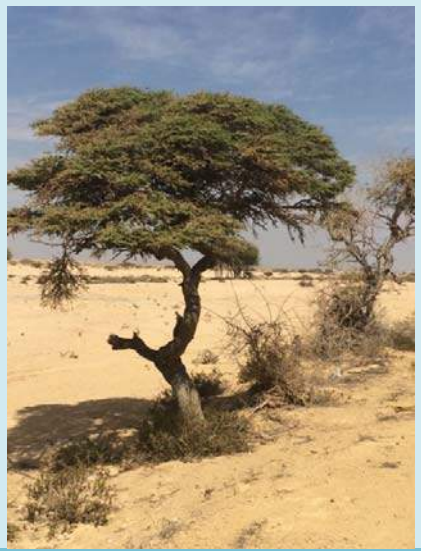
The project area embraces two types of habitats:

- Coastal habitats and Sabkha (salt flats): these areas contain a mixture of wetlands (e.g. lagoons), very saline areas with little vegetation, and less saline areas with some vegetation. These habitats support internationally important species and, of the three main habitats, are the least common in the region

- Wadis and gravel plains: the water provided by wadis supports a diverse range of vegetation, typified locally by open acacia woodlands, low shrubs and ephemeral grasses. Wadis act as wildlife corridors, along which mammals and birds travel; and

Flora Identified	Photografic Record
Zygophyllum qatarensis	 
Palm Trees	
Tephrosia nubica	 

Flora Identified	Photografic Record
Acacia spp	
Juncus	
Heliotropium bacciferum	 

Flora Identified	Photografic Record
Acacia	 
Parasite Tree	 
Ziziphus spina-christi	

Flora Identified	Photografic Record
Acacia tortilis	 
	
Fagonia indica	 

Flora Identified	Photografic Record
Suaeda vermiculata	 
Heliotropium calcarum	 

6. CLIMATE CHANGE

6.1 Overview

Climate change is a variation in average weather conditions, which include temperature, wind pattern, and precipitation. The earth's atmospheric temperature is mainly dependent on the concentration of greenhouse gases (GHG) that includes water vapours, CO_2, CH_4, N_2O, and CFCs. The rapid industrialization and urbanization has resulted in the increase of GHGs mainly CO_2 due to combustion of fossil fuels.

It is important to emphasize that GHG emissions are not actual impacts in themselves; they are better viewed as the root cause of a change to an environmental resource (impact).

This chapter is included in the EIA study in compliance with MECA's *Guidelines for the Preparation of Climate Affairs Chapter in the Environmental Impact Assessment for the Project* (2013) (hereinafter referred to as *MECA's 2013 Guidelines on Climate Affairs Chapter*). As stipulated in the Guidelines, the chapter on climate affairs shall be divided into the following sub-sections:

a) Scope of Assessment

b) Contact Details

c) Climate Change Issues

d) Climate Change Baseline Data Set-up

e) Climate Change Risk and Impact Assessment

f) Identifying Alternatives and Mitigation Measures

g) Climate Affairs Risk Reduction Plan (CARRP)

h) Summary and Conclusions – this has been included by the Consultant to provide an overall synopsis of the climate change issues of the proposed Project as well as to note down some information on GHG emissions estimate's quality assurance and quality control.

In the conduct of this GHG emissions assessment, it should be noted that the GHG emissions during the construction phase are ***guesstimates based on available, accessible, and verified figures***, usually from published and peer-reviewed journals and international guidelines, guidance and data resources.

In this chapter, the methodological guidance was primarily taken from the *2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* and *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and European Monitoring and Evaluation Programme / European Environment Agency (EMEP/EEA) Guidebook (formerly referred to as the EMEP CORINAIR Guidebook). The use of the most recently published calculation methodologies by the IPCC, as contained in the *2006 IPCC Guidelines*, is fully in line with the *IPCC Good Practice Guidance* for methodological choice to improve rigor and accuracy. In addition, the improvement in using the latest methodological guidance from the IPCC has been recognized by the UNFCCC's Subsidiary Body for Scientific and Technological Advice in the conclusions of its 30th Session[3].

As described, most of the inventory's calculations are linked to verifiable data sources. This process makes it easier for third-party verifiers as well as MECA to follow and corroborate calculations. It also makes it easier to update calculations when source data is added since updates automatically calculate through to the appropriate output (through Renardet's GHG emissions spreadsheet made using Microsoft Excel).

All original GHG files and supporting material examples are included in Appendix B for ease of verification and reference. Inclusion of all documentation from beginning to end allows for complete transparency for quality assurance and quality control.

6.2 Scope of Assessment

Concurrent with *MECA's 2013 Guidelines on Climate Affairs Chapter*, this GHG management assessment provides a review of the applicable baseline conditions, industry profile, and a summary of the proposed project GHG emissions during construction and normal operations.

The GHG management assessment would involve the proposed construction of Jurf dam, located in Wadi Jurf, in the city of Duqm in Al Wusta Governorate.

GHG management estimates usually incorporate emissions of CO_2, CH_4, and N_2O in units of CO_2-e. CO_2-e estimates are calculated by multiplying the emissions rate of each substance by its global warming potential (GWP) relative to CO_2.

In the assessment, only direct emissions (Scope 1) have been considered and Tier 1 as the methodology for the calculation of the GHG emissions, since emission factors for specific

[3] These Subsidiary Body for Scientific and Technological Advice (SBSTA) conclusions state, "The SBSTA acknowledged that the 2006 IPCC Guidelines contain the most recent scientific methodologies available to estimate emission by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, and recognized that Parties have gained experience with the 2006 IPCC Guidelines. The SBSTA also acknowledged that the information contained in the 2006 IPCC Guidelines enables Parties to further improve the quality of their GHG inventories." See http://unfccc.int/resource/docs/2009/sbsta/eng/03.pdf.

activities and for the Sultanate of Oman are currently not available. Moreover, actual construction activities can only be accurately determined by the construction contractor.

6.3 Contact Details

Organization and contact details for issues related to climate affairs are provided below:

Proponent	Special Economic Zone at Duqm (SEZAD)
Contact Person	Dr. Sayf Al Hinai
Position	Manager, Water Management Systems
Postal Address	P.O. Box 25, P.C. 130, Bareeq Al Shatti, Muscat, Oman
Physical Address	Bareeq Al Shatti, Oman
Phone	+968 24507537
Fax	+969 24587575
Email	shinai@duqm.com

6.4 Climate Change Issues

The climate affairs issues included in this EIA Study are the following:

- Whether the Project may significantly change GHG emissions
- Definition of scope of any necessary GHG assessment (climate mitigation concerns)
- Key climate change adaptation concerns and how they interact with the other issues assessed in the EIA
- Proper implementation on the existing restriction on ODS

6.4.1 Potential Areas for Mitigation by the Project

Construction Activities

As mentioned on the detailed EIA study, the project doesn't predict the need of occupation of private residential areas, since there are no houses to be relocated from the dam axis, reservoir or from the wadi bed were the channels will be built.

Nevertheless, there are a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the channel alignment before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.

During construction, some temporary areas will be affected to establish the campsite, deposit areas and even borrow areas. The contractor will settle 1 areas to establish the campsite where the construction material and logistic will take place. It is suggested this campsite to be upstream each dam and close to the main road to serve the channels, in a flat area, avoiding the occupation of other areas with no access built and improving response in case of any emergency situation.

Also during construction phase, the excavation activities may generate surplus of soil that will have use for the construction of dams and the channels. This excavation material will be stockpiled on a temporary area near the project in a flat area, avoiding being run off from water or wind.

Part of the Oryx Sanctuary Reserve will be permanently affected by the Jurf dam reservoir at its full supply level within an approximated area of 526,345 m^2, as it is need to construct the dam axis and that will partially inundate the reserve when FSL is reached.

Some construction impacts will occur only temporarily during the actual construction period (e.g., construction work activities, stockpiling and laydown areas) and could be remediated after construction is completed (e.g., revegetation of temporary laydown areas). There is sometimes an opportunity to schedule construction to avoid impacts to important resources (e.g., scheduling of earthworks during dry season to minimize dust).

For the proposed Project, *only the Project construction contractor could provide detailed construction activities that will be involved*. However, for the purposes of the GHG management emissions calculations, the following activities are assumed: excavation, drilling, coring and related activities and methods; land surface clearing and grading plan; energy, water, and material needs; outdoor lighting; laydown areas; construction workers' camp; and soil stockpiling.

As presented in Table 6-2, GHG emissions are expected, mostly, in the use of fossil fuels in the operation of heavy equipment vehicles, generators for lighting, use of vehicles by workers, and in construction camps (use of generators, gas for cooking, etc.). It is estimated that for every liter of diesel used in a motor vehicle or construction equipment, an average of 2.737 kg of CO_2 is released from the exhaust. Use of diesel fuel has higher GHG emissions per liter, however, diesel engines are designed to be more fuel efficient. It is also important to note that GHG emission from vehicles vary depending on a range of factors including vehicle type, vehicle age and engine specifications.

During the construction phase GHG emissions will also be released from vegetation clearing (loss of carbon sequestration potential) and the use of construction materials (embodied energy).

Note: While the transport of materials to site and unloading materials will result in a proportion of these emissions occurring onsite (i.e., a direct or Scope 1 emission) the majority of the emissions relating to the transport of materials occur offsite. To minimize the risk of double accounting and simplify data collection the emissions associated with the transport of materials are classified as 100% Scope 3 emissions, thus, they are not controlled by the Project proponent and *not included* in the assessment.

Operation Activities (mainly maintenance works)

The following table sets out the routine maintenance activities for the proposed drainage system.

Table 6-1 Maintenance Summary and Schedule Table4

Component	Maintenance Activity	Frequency
Embankment	Vegetation control	Twice per year, minimum
	Rodent control	Check once per year, perform as required
	Minor earthwork, erosion repair	Check once per year, perform as required
	Erosion protection	As required
Principal Spillway	Vegetation control	Twice per year
	Minor earthwork, erosion repair	Check once per year
	Erosion protection	Check once per year

[4] Adopted from Connecticut Department of Environmental Protection (2001), *Guidelines for Inspection for Inspection and Maintenance of Dams*. Retrieved on 3 May 2015 at http://www.ct.gov/deep/lib/deep/water_inland/dams/guidelinesforinspectionandmaintenanceofdams.pdf.

Component	Maintenance Activity	Frequency
	Concrete repair	As required
Emergency Spillway	Vegetation control	Twice per year
	Minor earthwork, erosion repair	Check once per year
	Erosion protection	Check once per year
	Concrete repair	As required
Intake / Outlet Structures	Trashrack cleaning	After every major storm
	Mechanical operation	Once per year
	Internal conduit inspection	Once per year
	Concrete features inspection	Once per year
Masonry Walls	Vegetation control	Twice per year
	Missing stones	As required
Miscellaneous Safety and Access Features	Vehicle / pedestrian access route(s) maintenance	Once per year
	Fences, locks, signs inspection	Once per year

From the description of the construction and operation activities above, the potential areas for mitigation by the Project are provided for as Table 6-2.

While the clearing of vegetation (which is a carbon sink) is not a true GHG emission, the net impact is that less carbon dioxide is being removed from the atmosphere and the net effect is that an equivalent amount of CO_2 will remain as a result. Hence, clearing of vegetation is considered as a Scope 1 emission.

The disposal of vegetation will result in GHG emissions, in addition to those related to the loss of a carbon sink. Where vegetation is reused or left to decompose naturally onsite, the rate at which GHGs are emitted is very slow and considered negligible.

Table 6-2 Potential Areas for Mitigation by the Project

Project Activities and Physical Works	Potential Effects on Existing GHG Emission Levels
Construction	
Site preparation / vegetation removal	Site clearing will reduce the carbon sink by removing trees.
Earth moving equipment	Liquid fossil fuel combustion
▪ Onshore construction ▪ Vehicle traffic ▪ Dredging ▪ Marine construction ▪ Worker commune trips	Combustion of fossil fuels by land-based and marine-based heavy duty equipment will generate GHG emissions.
Diesel generators during construction activities and worker's campsites	Combustion of diesel- or gas-based generators or equipment will generate GHG emissions
Use of air-conditioning in construction workers/employees' vehicles, offices and workers' camp	Use of equipment containing ODS
Construction and demolition debris/waste	Release of methane in landfills
Operations	
Maintenance of the drainage network/system	Combustion of fossil fuels by heavy duty equipment will generate emissions

6.4.2 Climate Change Risk and Vulnerabilities by the Project

The following is a summary of potential climate-related hazards by the Project:

a) Sea-level rise (SLR) (plus local land movements)

b) Sea / water temperatures

c) Water availability

d) Storm including storm surge and high winds

e) Flood

f) Dust storms

g) Coastal erosion

h) Soil erosion

6.5 Climate Change Baseline Data Set-up

The baseline on GHG emissions is developed according to Appendix 1 of MECA's Guidelines on Climate Change Chapter and which includes the following:

a) Project Area Information

- GIS-based maps for Project area (topography) (in Chapter 4.1)
- Exposure data (details of population, assets, land use, etc.) (in Chapter 5.2 to 5.11)
- Climate change risk data (past records of floods, cyclones, temperature, sea level rise, etc.) (in Chapter 5.12 to 5.16)
- Vulnerability data (people, construction types, wealth indicators, may also include available GHG emissions data from various sectors and examples of mitigation response options in developing countries)

b) Ozone Depleting Substances

c) Greenhouse Gas Emissions

Vulnerability Data

In 2010, the per capita annual income grew from US$16.9 thousand to about US $25.4 thousand, equivalent to a nominal growth rate of about 6% per year (Human Development Report, 2011). While most of the jobs continue to be in the government sector, the share of private sector jobs has climbed to nearly 40% of total jobs in 2010, compared to less than 30% in 2003. Education has steadily reached more and more households in the Sultanate of Oman. Illiteracy rates have fallen precipitously from over 30% of the population in 1993 to under 12% in 2010.

Indicator		1993	2003	2010
Total Population	Thousand people	2,018,074	2,340,815	2,773,479
Per Capita Income	PPP, US$	12,671.54	16,895.39	25,438.71
Urban Population	% of total	71.7	71.5	75.0
Population by gender	Gender Ratio	140.2	127.8	138.8
Population less than 15 years old	%	41.0	33.8	27.8
Population between 15-64 years old	%	56.7	63.6	69.5
Population 65 and older	%	2.3	2.6	2.7
Illiteracy	% of total population	30.5	15.9	11.7
Total labor force	Thousand people	704,798	873,466	1,245,573
Employed Omanis, Public Sector	%	NA	62.6	53.3
Employed Omanis, Private Sector	%	NA	27.4	39.7

Figure 6-1 Key Demographic Indicators for Sultanate of Oman (2010 Census)

MECA's *Guidelines on Climate Change Affair Chapter* does not stipulate the range (in terms of distance from the Proposed Project site) for the GHG management assessment, thus, this study only consider what has been considered in the development of the land-use map for the proposed Project which is within the 5-10 km radius from the Project site.

It should be noted that GHG management assessment in this volume considers only what the current development is in the Project area and does not include what are expected to be developed or planned.

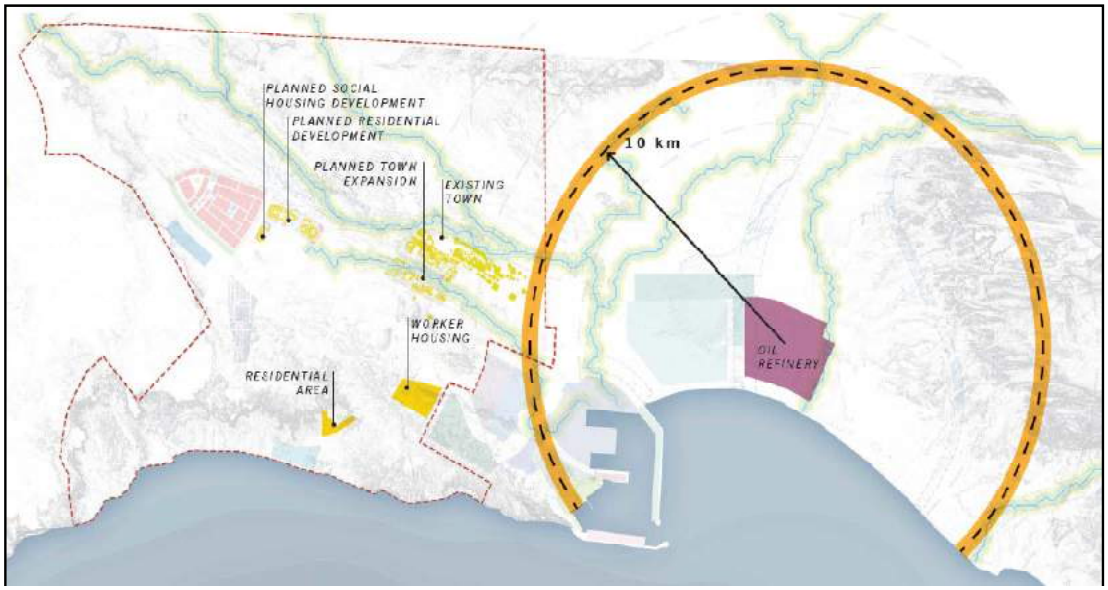


Figure 6-2 Proposed Developments vis-à-vis Jerf Dam Location

The Proposed Project as an Asset

It was rather challenging to define and assess the consequences to society pertaining to the loss of each asset once the Project is implemented. This part of the exercise was qualitative in nature as the limited time and budget for the Project did not permit a quantitative valuation. Socioeconomic data for the areas where assets where located were gathers from the 2010 National Census in an attempt to identify the more vulnerable populations. These included total population, population under 18 or over 65, population where Arabic is a second language, and poverty levels.

It was not possible to conduct a full economic valuation of each asset. Therefore, in determining how valuable an asset might be, the following list was considered in the aggregate (adopted from OMPO, 2011: 14):

- Level of use
- Societal Value of Asset - Use of asset for evacuation, civil defense activities, and emergency functions
- Degree of redundancy
- Cost to replace
- Economic loss

- Environmental impacts
- Cultural value
- Loss of life
- Recovery time needed

Renardet, the EIA Consultant, adopted a 3-tier low, moderate, high ranking system to classify vulnerability. These measurements were considered with respect to the climate change factors that presented the highest vulnerability and had the greatest likelihood of occurrence. These categories were defined as follows:

- Low ranking: Repair of asset needed, but can work around it
- Moderate Ranking: Asset is temporarily unusable and in need of repair
- High Ranking: Total catastrophic loss

Table 6-3 Importance of the Project's Asset Group to Society

Asset Value Category	Vulnerability Ranking
Societal Value of Asset	Low
Level of Use	Low
Degree of Redundancy	Low
Cost to Replace	Medium
Economic Loss	Medium
Environmental Impacts	High
Cultural Value	Low
Loss of Life	Low
Recovery Time Needed	Medium

6.5.1 Ozone Depleting Substances (ODS)

The only devices likely to contain Ozone Depleting Substances (ODS) are the air conditioners in vehicles and buildings as well as in construction camps. Window or split air conditioners will be installed in the office and administration building and during construction. Standard air conditioners commercially available in the local market through authorized distributors will be sourced. The window/split air conditioners will be sourced, serviced, and maintained by authorized suppliers and service centres in Oman. The suppliers and service centres are expected to comply with the requirements of MD 243/2005.

Operational air conditioning requirements related to the Project construction activities will increase due to modest additional staff and waste handling requirements. A construction camp will be made to accommodate about 175 workers. Characteristic air conditioning and cooling plant to be installed at the offices and/or construction camps and accommodate the workforce is summarized in Table 6-4.

Further, standard fire extinguishers will be sourced from approved local suppliers and such fire extinguishers are not expected to contain any ODS.

Controlled substances listed in MD 243/2005 or equipment, appliances, and products containing such substances will not be used during any stage of project activities.

The Project is estimated to use a total of about 179.10 kg of refrigerants for the entire construction period. The amount of refrigerant use during the operation or maintenance phase of the Project is negligible.

From Table 6-5, it is estimated that during the construction phase by the Project there will be about **66.329 metric tonnes of CO_2-e emissions**.

Table 6-4 Estimates of ODS' Quantities in the Proposed Project

Description	Remarks
Types of ODS Used in all stages of the industrial process	HFC 134a ; R-407c; HFC 152a
Quantities of ODS used in all stages of the Project during construction and operation	179.10 kg (177.5 kg construction and 1.6 kg operation)
Numbers and kinds of equipments that contain ODS	▪ air conditioners (buildings and vehicles) (R-407c); ▪ chillers / refrigerators (HFC-134a or HFC-152a) ▪ employees/workers' transportation and construction equipment and vehicles (HFC-134a)
Any alternatives for ODS has been used	n/a
Project plan for the usage of ODS alternatives and the avoidance of any ODS release to the atmosphere	Selection and procurement of goods that is compliant with MD 243/2005
Procedure to adhere to the requirements of the Regulations for the Control and Management of the Ozone Depleting Substances issued by MD 243/2005	Selection and procurement of goods that is compliant with MD 243/2005

Table 6-5 GHG Emissions Estimates from ODS-Containing Equipment

Item Description	Quantity		Ave. Size	Operating Emission Factor[a]	Refrigerant	GWP[a]	CO_2e emissions (metric tons)	
	Const.	Oper.	(kg)				Const.	Oper.
A/C systems (split and window-type)	50	0	2.0	10%	R-407c	1,526[b]	36.624	0.000
Refrigerators / Chillers	20	0	0.10	15%	HFC-134a or HFC-152a	1,300[b]	0.585	0.000
Vehicles	60	2	0.80	20%	HFC-134a	1,300[b]	29.120	0.416
Note: The estimation is for Jurf Dam only.					**Total**		**66.329**	**0.416**

Note: Const. – construction; Oper. – operation
Source: a – GWP: Global Warming Potential
b – 2006 IPCC Guidelines for National Greenhouse Gas Inventories
c – WRI (2005)[5]
d – fire extinguishers is assumed not to contain any ODS

[5] World Resources Institute (2005), *Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration and Air-conditioning Equipment (Version 1.0) - Guide to Calculation Worksheets*, World Building Council for Sustainable Development.

6.5.2 Green Gas Emissions

Overview

Table 6-6 provides a summary of the general considerations in the GHG emissions calculations of the Project's construction activities. It is assumed that the GHG emissions during the operation stage of the Project are negligible as earlier discussed and that the proposed development is not considered as a major project.

Table 6-6 General Considerations in GHG Emissions Calculation

Activity / Description			Remarks / Information Sources
1	Construction Period	January 2016 – December 2017 (24months; 552 total days; 5,520 total hours)	276 days per year @ 10 hours per year
2	No. of Workers	175	
3	Construction Camp	Onsite, 20,000,000 m^2	
4	Construction Working Hours	10 hours/day; 276 days/year	
5	Water / Wastewater	50 gallons/capita/shift (189.271 liters/capita/day)	American Water Works Association[1]
6	Diesel Generator		
	▪ 280 kW/350 kVA for site	2 units @ 74.9 liters of diesel/hour at full load, operating at 10 hours/day	Able Sales[2]
	▪ 160 kW / 200 kVA for a 300 m^2 office space	1 units @ 42.8 liters/hour of diesel at full load	Able Sales
7	Solid Waste Generated		
	▪ Construction & Demolition Waste	2.8 lb/person/day = 1.27006 kg/person/day	U.S. EPA[3]
	▪ Workers / Employees	0.94 kg/capita/day (small wilayat)	be'ah, 2013: Appendix C4
8	Construction Site Vehicles: considered a Large Project (US$ 10 – 100 Mn)	▪ 3.40 kL diesel/construction month (70%) ▪ 5.32 kL petrol/construction month (30%)	Transport Authorities Greenhouse Group (TAGG)[4]

	Activity / Description		Remarks / Information Sources
9	Demolition and Earthworks	2,000,000 m^3 of soil	
	▪ Earthworks	0.097 kL diesel/construction month	TAGG
	▪ Vegetation removal	1.4 kL diesel/hectare; 400 t/hectare	TAGG
10	Construction Plant and Equipment		TAGG
	▪ Crane (hydraulic)	7.9 kL diesel /construction month	TAGG
	▪ Loader	1.6 kL diesel /construction month	TAGG
	▪ Material handlers	3.0 kL diesel /construction month	TAGG
	▪ Material transfer vehicle	11.9 kL diesel /construction month	TAGG
	▪ Roller, steel	9 kL diesel /construction month	TAGG
	▪ Water truck, 4,000 Gal	14.2 liters diesel/hour	Intermodal Container Transfer Facility (ICTF) – Joint Powers Authority (JPA)
	▪ Fuel Truck, 2000 Gal	6.81 liters diesel/hour	ICTF-JPA
	▪ Others	3.4 kL diesel / construction month; 5.32 kL petrol/construction month	Assumed that 30% of all the other vehicles used (usually by workers) are petrol-fueled cars
11	Solvent Use (during Project's Construction Phase)	NMVOC: 2,700 g/person/year	EMEP/EEA Chapter 2D.3.a Domestic Solvent Use including Fungicide[5]

Note: 1–Last accessed on 18 April 2015, available at http://www.ecy.wa.gov/programs/wr/cro/images/pdfs/gpm_estimate.pdf.
2–Last accessed on 18 April 2015, available at https://www.ablesales.com.au/source/Diesel%20Generator%20Fuel%20Consumption%20Chart%20in%20Litres.pdf.
3 – U.S. EPA [Online] Available at http://www.epa.gov/wastes/nonhaz/industrial/cd/basic.htm.
4–Last accessed on 20 April 2014, available at http://www.rms.nsw.gov.au/documents/about/environment/greenhouse-gas-assessment-workbook-road-projects.pdf.
5–Last accessed on 21 April 2014, available at http://www.eea.europa.eu/publications/emep-eea-guidebook-2013.

A. GHG Emission from Energy Sources

a) Stationary Combustion Processes

Stationary combustion processes by the proposed Project are likely to be cause by diesel generators for electricity generation during the construction period of 24 months. There are no combustion processes during the operation phase of the Project as it primarily involves maintenance works and is considered to be negligible.

During the construction phase, it is estimated that two (2) diesel generators of 160 kW and 280 kW will be operating at full load for 10 hours per day, for the entire construction period of 24 months (552 days; 5,520 hours).

Total emissions due to stationary combustion processes during the construction phase of the Project: **5.7587 metric tonnes CO_2-e**.

Table 6-7 Stationary Combustion Process GHG Emissions Estimates

Year	CO_2	CH_4	NO_x
Jan 2016 – Dec 2017	2.7791	0.02541	0.0079
Jan 2017 – Dec 2042	0.000	0.000	0.000
Total	**2.7791**	**0.02541**	**0.0079**

In metric tonnes CO_2-e.

b) Mobile Combustion

As presented in Table 6-6, the proposed Project is considered to be a 'Large Project' and based on TAGG's default quantity factors for site offices and vehicles, consumption of diesel and petrol are at 3.40 and 5.32 kL for every construction month. In the assessment, it is assumed that 70% of the construction site vehicles are diesel-based and the remaining are petrol-based cars.

During the construction phase of the Project, it is estimated to consume about 1,061.935 kL of diesel fuel and 38.304 kL of petrol.

For details of the computation, please see Appendix B.

With regard to the estimates for the Construction Plant and Equipment, the construction equipment considered were only for the *actual* construction of the drainage channel since the site preparation works have been already considered in the Demolition and Earthworks category, thus, avoiding double counting.

The total CO_2-e emissions in metric tonnes are: 52.4434.

Table 6-8 Mobile Combustion Process GHG Emissions Estimates

Year	CO_2	CH_4	NO_x
Jan 2016 – Dec 2017			
Diesel	2.7759	0.0765	0.1168
Petrol / Motor Gasoline	0.0904	0.00969	0.0423
Jan 2017 – Dec 2042	0.000	0.000	0.000
Total	**2.8663**	**0.08619**	**0.1591**

In metric tonnes.

c) Fugitive Emissions from Oil & Gas Natural Gas System

The proposed Project involves the development of a drainage network and flood protection schemes, thus, no fugitive emissions from oil and natural gas systems are expected.

Table 6-9 Fugitive Emissions from Oil & Natural Gas System

Year	CO_2	CH_4	NO_x
Jan 2016 – Dec 2017	0.000	0.000	0.000
Jan 2017 – Dec 2042	0.000	0.000	0.000
Total	**0.000**	**0.000**	**0.000**

In metric tonnes.

d) Land Use and Land Use Change

There are no managed tree plantations in the proposed Project site, however, desert vegetation will be removed and cleared as part of the development, they are considered to be negligible.

Table 6-10 GHG Emissions from Land Use and Land Use Change

Year	CO_2	CH_4	NO_x
Jan 2016 – Dec 2017	0.000	0.000	0.000
Jan 2017 – Dec 2042	0.000	0.000	0.000
Total	**0.000**	**0.000**	**0.000**

In metric tonnes.

e) Details of GHG Emissions Calculation

The GHG emissions calculation details have been provided for as Appendix B. Table 6-11 provides for a summary of the emissions factors used and quantities of fuels (motor gasoline and diesel) consumed by the Project.

Table 6-11 Details of GHG Emission Calculation

Type of Activity	Methodology According to IPCC	Emission Factor kg CO_2/litre		Total Quantity of Fuel for Combustion	Total Emissions[a] (t CO_2-e)
Stationary Combustion Processes	Tier 1	NO_x – 0.0074 CH_4 – 0.0239 CO_2 – 2.614		1,063.152 kL of diesel fuel for generators	5.7588
Mobile Combustion	Tier 1	Diesel	▪ 2.614 CO_2 ▪ 0.072 CH_4 ▪ 0.110 N_2O	1,061.935 kL	52.4434
		Gas	▪ 2.36 CO_2 ▪ 0.253 CH_4 ▪ 1.105 N_2O	38.304 kL	
Fugitive Emissions from Oil and Natural Gas System	n/a	n/a		n/a	n/a
Others	n/a	n/a		n/a	n/a

Note: a – total emissions were due from construction activities in a period of 18 months. Emissions during the operation phase is considered to be negligible.

B. GHG Emissions from Industrial Processes of the Proposed Project

There are no industrial processes expected from the proposed Project.

Table 6-12 GHG Emissions from Industrial Processes of the Proposed Project

Year	CO_2	CH_4	NO_x
Jan 2016 – Dec 2017	0.000	0.000	0.000
Jan 2018 – Dec 2042	0.000	0.000	0.000
Total	**0.000**	**0.000**	**0.000**

In metric tonnes.

Table 6-13 Details of GHG Emission Calculation from Industrial Processes of the Proposed Project

Type of Activity	Methodology According to IPCC	Emission Factor	Total Production	Total Yearly Emissions (t CO_2-e)
Industrial Processes	n/a	n/a	n/a	n/a

C. GHG Emissions from Solvent Use

Solvent use by the proposed Project primarily occurs during the construction stage of the Project as in the case for the other activities of this GHG emissions assessment.

Small quantities of solvents may be used during the construction phase such as painting, utensil cleaning, etc. During the operation phase of the Project, which is primarily be maintenance works for at least twice per annum, the GHG emissions from during this stage is considered negligible.

As described, the proposed Project will provide a workers' camp onsite for about 175 workers for the entire 24-month construction period.

The total GHG emissions are estimated to be 3.46815 metric tonnes CO_2-e.

Table 6-14 GHG Emissions from Solvent Use

Year	CO2	CH4	NOx	SF6	HFC	PFC
Jan 2016 – Dec 2017	3.46815	0.000	0.000	0.000	0.000	0.000
Jan 2017 – Dec 2042	0.000	0.000	0.000	0.000	0.000	0.000
Total	**3.46815**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

In metric tonnes.

Table 6-15 Details of GHG Emission Calculation from Solvent Use

Type of Activity	Methodology According to IPCC	Emission Factor	Quantity of Solvents	Total Yearly Emissions (t CO_2-e)
Solvent Use	Tier 1	2,700 g/person/year NMVOC 3.67 conversion factor g CO2/ g NMVOC	945 kg NMVOC	2.3121

D. GHG Emission from Solid Waste Generating from the Project

Based on be'ah's 2013 Final Municipal Waste Survey, Duqm is considered as a 'small wilayat' and has an average waste generation of 0.94 kg/capita/day, while the estimated construction and demolition waste generated onsite is 122.688 metric tonnes.

It is also assumed that the wastes are sent to landfill without gas recovery.

Table 6-16 GHG Emissions from Solid Waste Generated by the Project

Year	CO2-e
Jan 2016 – June 2017	
Workers / Construction Camp	0.4982
Construction and Demolition Waste	122.688
July 2017 – Dec 2042	0.000
Total	**123.1862**

In metric tonnes.

Table 6-17 Details of GHG Emission Calculation – Solid Waste Generated by the Project

Type of Activity	Methodology According to IPCC	Emission Factor[a]	Total Quantity of Solid Waste	Total Yearly Emissions (t CO_2-e)
Solid Waste Generation	Tier 1	Landfilled waste without gas recovery: ▪ Paper and Cardboard: 2.52 kg CO2-e/kg ▪ Garden and food: 0.945 kg CO2-e/kg ▪ Wood: 1.89 kg CO2-e/kg ▪ Textile: 2.52 kg CO2-e/kg ▪ C&D Waste: 1.03 kg CO2-e/kg	▪ C&D: 122,687.80 kg ▪ Construction Campsite Waste Total: 498.1871 kg ▪ Food: 171.23 kg ▪ Paper & Cardboard: 97.55 kg ▪ Park & Garden: 4.15 kg ▪ Wood: 20.236 kg ▪ Textile: 19.199 kg	126.8666

Source: a – New Zealand's Greenhouse Gas Inventory 1990-2009. Retrieved from www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2011/index.html. Emission factors for plastics, metals and glass are not presented here because their decomposition does not directly produce GHG emissions.

A. GHG Emissions from Wastewater Treatment in the Project

There is no wastewater treatment in the proposed Project and the wastewater generated during the construction period has already been incorporated in the GHG emissions assessment from solid waste generated in Section A.D.

Table 6-18 GHG Emissions from Wastewater Treatment in the Project

Year	CH_4	N_2O
Jan 2016 – Dec 2017	See Table 6-16	
Jan 2018 – Dec 2042		
Total	**000**	**000**

In metric tonnes.

Table 6-19 Details of GHG Emission Calculation – Wastewater Treatment in the Project

Type of Activity	Methodology According to IPCC	Emission Factor	Total Quantity of Wastewater	Total Yearly Emissions (t CO_2-e)
Wastewater Treatment	n/a	n/a	n/a	n/a

A. Reporting Total Amount of GHG Emissions

Currently, there is no ceiling limit set for CO_2 emissions (mass) rates in the Sultanate of Oman. However, for the proposed Project's GHG emission and vis-à-vis' the U.S. Environmental Protection Agency (U.S. EPA), the calculated GHG emission is way below the 40 CFR Part 98 or the Greenhouse Gas Reporting Program (GHGRP) mandatory reporting limit of 25,000 metric tonnes of CO_2-e per year.

As detailed from previous GHG calculation Sections, Table 6-20 is a summary of the total amount of GHG emissions calculated from various Project activities described.

The proposed Project is estimated to have a total GHG emission of about 188.5369 metric tonnes of CO_2-e.

Table 6-20 Reporting Total Amount of GHG Emissions by the Proposed Project

Reporting Period	CO_2	CH_4	N_2O	SF6	HFC	PFC
Jan 2016 – Dec 2017	2,912.28	25.4955	8.0264	0.000	0.000	0.000
Jan 2017 to Dec 2042	0.000	0.000	0.000	0.000	0.000	0.000
Total	**2,912.28**	**25.4955**	**8.0264**	**0.000**	**0.000**	**0.000**

In metric tonnes.

6.5.3 Cumulative Impact on Climate Change

While the proposed Project is one the proposed asset to the planned landuse or overall masterplan of Duqm Special Economic Zone Authority's drainage network and protection schemes, it is known that one of the future land uses within the 10 km radius of the Project site is considered to be heavy industrial area (i.e., planned oil refinery, see Figure 6-2). Thus, proposed

future developments within the vicinity of the Project area is expected to contribute to cumulative GHG emissions.

Nevertheless, the total direct and indirect emission associated with the proposed Project would not contribute to cumulative regional and/or global GHG emissions. As mentioned, GHG emissions are only significant during the construction stage of the proposed drainage network and GHG emission during the operation phase is considered to be insignificant.

6.6 Climate Change Risk and Impact Assessment

MECA's Guidelines on Climate Change Chapter involves five (5) main steps:

a) Assess historical and current climate change-related trends and risks and vulnerabilities

b) Assess future projected climate change impacts

c) Assess and prioritize key future climate change risks and vulnerabilities

d) Climate Risk Management (CRM)

e) Climate change risk and vulnerability matrix

In the assessment for items (a) and (b), the information was gathered from World Bank's Climate Change Portal.[6] For the assessment of future climate change risks and vulnerabilities (item c) were not considered in the assessment as the proposed development is not considered as a major project.

[6] http://sdwebx.worldbank.org/climateportal/

6.6.1 Historical and Current Climate Change-related Trends and Risks and Vulnerabilities

These involve analyses and summaries of historical time series climate change data for not less than past 25 years and current data on project area and the nature of change over time.

Data and information on current air temperature, humidity, population, and demographics are provided for in the previous sections of the EIA.

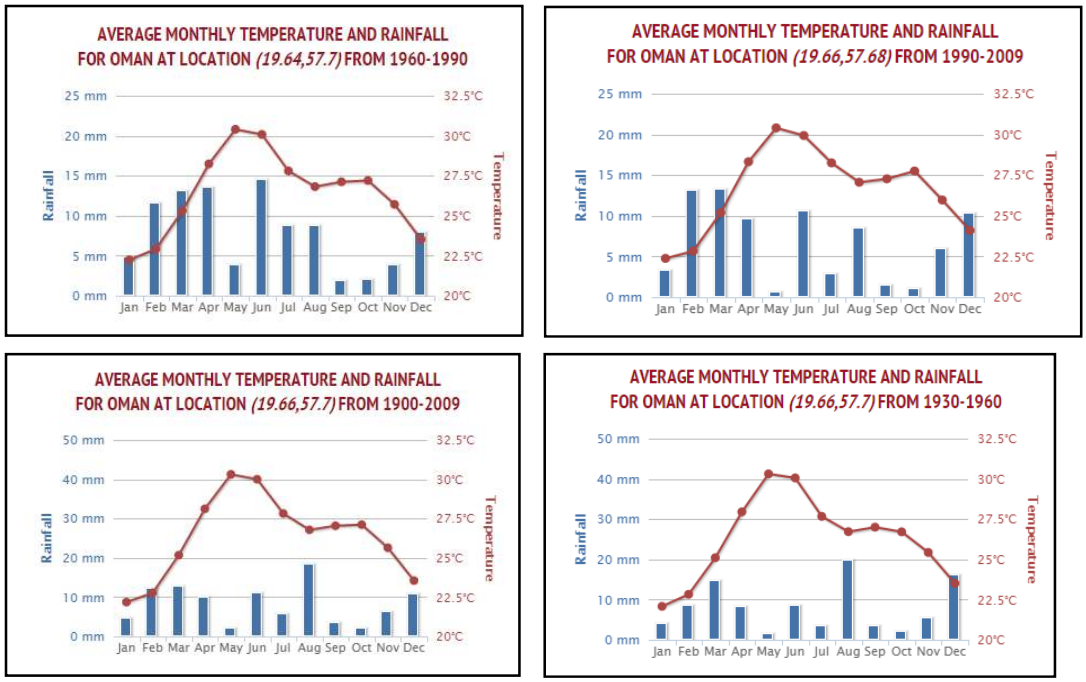


Figure 6-3 Oman Temperature and Rainfall Data

6.6.2 Future Projected Climate Change Impacts

As per *MECA's 2013 Guidelines on Climate Change Affairs Chapter*, this data will from existing global and regional climate models, using downscaled data and scientific reports where available.

The figures below were captured from World Bank's Climate Change Knowledge Portal, however, future projected limited to rainfall and temperature since the proposed development is not considered a major project, also site-specific information is only available for these variables. In this regard, the selection of the scenario was made arbitrarily, and for presentation purposes, the scenario selected is the A2 storyline. A2 storyline – is a case of rapid and successful economic development, in which regional average income per capita converge – current distinctions between "poor" and "rich" countries eventually dissolve.

Time Period selected was 2040 – 2059 and the GFDL-CM2.1 model. For more description of sources and model descriptions, please refer to World Bank Climate Change Knowledge Portal[7].

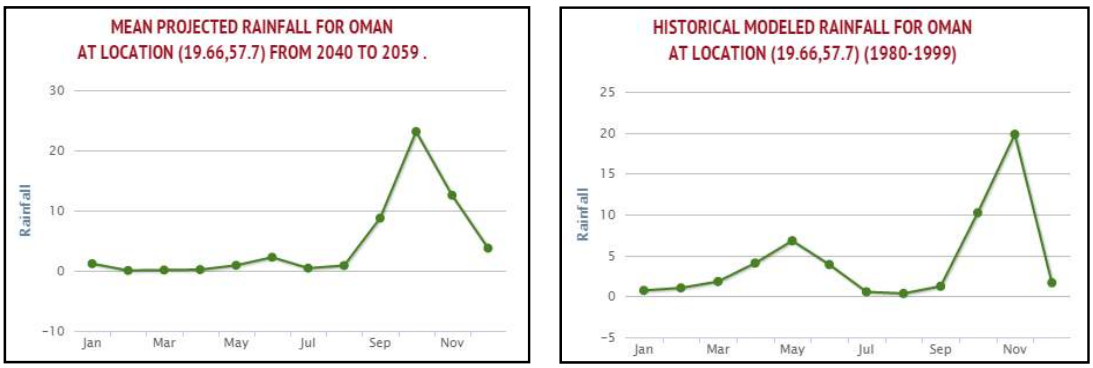


Figure 6-4 Mean Projected Rainfall for the Project Site

Model: GFDL-CM2.1, Statistic: Mean, Scenario: A2

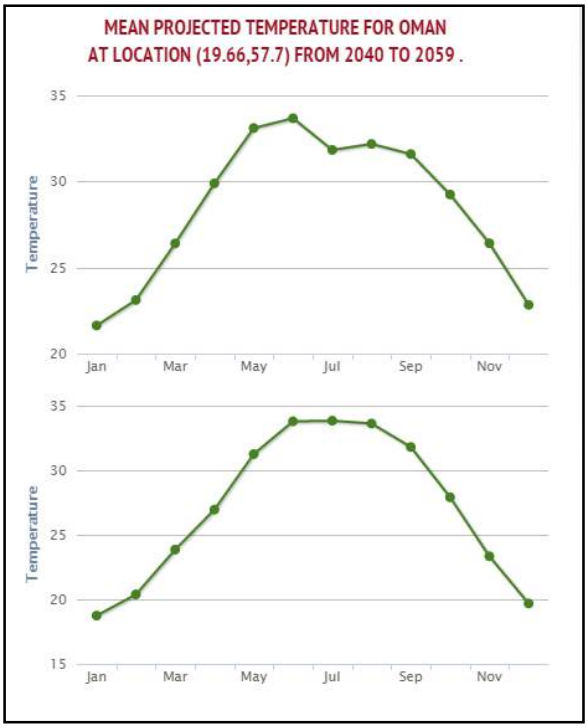


Figure 6-5 Mean Projected Temperature for the Project Site

Model: GFDL-CM2.1, Statistic: Mean, Scenario: A2

[7] http://sdwebx.worldbank.org/climateportal/documents/Metadata-Portal.pdf#page=1

Impacts on the Proposed Project

This section discusses the potential for impacts to construction and operation of the proposed Project from the expected future climate changes described above.

The climate modeling results described in the preceding sub-sections show that there are relatively small differences between projected temperature and rainfall changes across the region and/or Project area.

The construction of the proposed drainage network is planned to occur in January 2016 and if construction occurs on that schedule, climate conditions during the 1- to 2-year construction period would not be expected to differ much from current conditions, even under worst-case modeling scenarios.

6.6.3 Climate Risk Management

The Climate Risk Management (CRM) is an updateable directory of the climate risks that are faced by the Project. A score (from 1 – 5) is then assigned to each risk for both likelihood and severity for next 50 years. The risk score is then a factor of likelihood and severity. Risks are identified across 5 sectors identified by the Project as representing the activities across the region: (a) infrastructure; (b) business and industry; (c) agriculture and fisheries; (d) biodiversity; and (e) socio-economic.

The Likelihood Scale utilized in this assessment is provided in Table 1 of Appendix B.

According to MECA's *Initial Communication Under the United Nations Framework Convention on Climate Change* (2013: 57), the Al Wusta Governorate is most vulnerable under high sea level rise scenarios, i.e., greater than 2 meters, with potentially up to roughly 280 m^2 of total land inundated.

Table 6-21 Project's Climate Risk Management

Sector	Sub-Sector	Climate Driver	Risk Process	Potential Consequence	Likelihood	Consequence[a]	Risk[b]	Associated Development Objective
Infrastructure	Built environment	▪ Summer ▪ Floods ▪ Sea level rise ▪ Storm surge ▪ Population growth ▪ Increased urban footprint ▪ Urbanization leads to land use and land cover change	▪ Additional protection ▪ More complete monitoring and ▪ Urban heat island effect ▪ Extreme events	▪ Increased expenditure on infrastructures, better building designs ▪ Temporary loss of land and land activity ▪ Air pollution ▪ Natural disaster ▪ More intense rainfall resulting in inflow and infiltration into wastewater networks	1	2	2	▪ Conserve and restore natural areas onsite ▪ Provide permanent protection for open space on the Project site ▪ Use building materials with recycled content
	Energy	N/A	N/A	N/A	1	1	1	
	Water resources	▪ Summer ▪ Warmer water ▪ Floods	▪ Higher or lower stream flows and water tables ▪ Ecosystem stress and less biodiversity	Temporary loss of land and land activity	1	2	2	▪ Vegetation to be part of stormwater management to encourage carbon sequestration, to lessen urban heat island and

Sector	Sub-Sector	Climate Driver	Risk Process	Potential Consequence	Likelihood	Consequence[a]	Risk[b]	Associated Development Objective
			▪ Productivity property values and quality of life issues					more shade. ▪ Design water efficient landscaping
	Information and Communication Technology	N/A	N/A	N/A	1	1	1	N/A
	Transport	N/A	N/A	N/A	1	1	1	N/A
	Tourist facilities (including beaches)	Extreme air temperature	Raising sea levels and temperature	Threatens coastal, island destinations and marine sites	1	1	1	N/A
Biodiversity	Marine Ecosystems	N/A	N/A	N/A	1	1	1	N/A
	Flora and Fauna	Extreme air temperature	▪ Water availability and sea/water temperatures ▪ Changes in groundwater levels, flood plains and increased peak flows leading to decline in water quality	Loss of native vegetation and death of animals and its habitats	1	1	1	Increased vegetation and/or green cover (from 20% to 25%)

Sector	Sub-Sector	Climate Driver	Risk Process	Potential Consequence	Likelihood	Consequence[a]	Risk[b]	Associated Development Objective
			▪ Shifts in distributions of plant and animal species					
	Mangroves	N/A	N/A	N/A	1	1	1	N/A
	Corals	N/A	N/A	N/A	1	1	1	N/A
Industry and business	All business activities	N/A	N/A	N/A	1	2	2	N/A
Agriculture and fisheries	Crops and livestock	N/A	N/A	N/A	1	1	1	N/A
	Transport, storage and trade	N/A	N/A	N/A	1	1	1	N/A
	Crops	N/A	N/A	N/A	0	1	0	N/A
	Crops and fisheries	N/A	N/A	N/A	0	1	0	N/A
	Fisheries	N/A	N/A	N/A	0	1	0	N/A
Socio-economic	Jobs and employment	N/A	N/A	N/A	1	1	1	N/A
	Health and well-being	Increase in temperature	N/A	High temperatures increasing incidence of food and water-borne diseases	1	1	1	N/A

Sector	Sub-Sector	Climate Driver	Risk Process	Potential Consequence	Likelihood	Consequence[a]	Risk[b]	Associated Development Objective
	Cultural heritage	N/A	N/A	N/A	1	1	1	N/A
	Economic prosperity	N/A	N/A	N/A	1	2	2	N/A

Notes: N/A – Not Applicable

a – See Table 1 of Appendix A

b - Risk = Likelihood x Consequence

For more details, see ClimWatAdapt's Inventory of Adaptation Measures available at .

6.6.4 Climate Change Risk Matrix on the Project

From Table 6-21, the impacts on the Project are summarized as in Table 6-22. The Likelihood or Frequency of the identified risks and impacts are described in Appendix B.

Table 6-22 Climate Change Risks Matrix on the Project

Type of Risks	Frequency / Degree of Vulnerability[a]:	Climate Change Impacts Due to Identified Vulnerability[b]	Risk Magnitude[a]	Remarks
Natural Disasters such as cyclone, earthquake	1	1	1	-
Sea Level Rise	1	2	2	-
Temperature	1	1	1	-
Heavy Rains	1	1	1	-
Flash Flooding	1	2	2	-

Notes: a – See Table 1 of Appendix B
b – See Equation 1 of Appendix B

6.7 Identifying Alternatives and Mitigation Measures

The Project is designed for extreme events such as floods, cyclones, storms, and rains. These are events that can happen under normal circumstances irrespective of potential climate change conditions such that the required design parameters for such conditions are well established. Therefore the requirement for any needed adaptations to climate change is low for this project. The emergency response plan will contain the necessary actions to be taken in case of extreme weather conditions.

6.7.1 Climate Affairs Mitigation Measures

As earlier described there are no operation activities once the Project has been constructed and developed. The operational activities are mainly maintenance activities, which are minimal and should be considered within the operational activities (mostly, use of motor vehicles for the maintenance activities and works) of the Project proponent, the Duqm Special Economic Zone Authority.

In this regard, the proposed climate affairs mitigation measures were focused during the construction phase of the proposed development. It should also be noted, that in the EIA study prepared together with this volume, there were also mitigation measures that themselves reduce GHG emissions.

At any rate, the GHG emissions during the construction phase of the Project will be minimal due to the following factors:

Use of standard engines and exhaust pipes;

The construction equipment and machineries will comprise of standard internal combustion engines to ensure optimal efficiency; and

The emissions from these equipment and machineries will be vented through standard exhaust pipes.

Moreover, the GHG emissions inventory as provided for in Section **Error! Reference source not found.**, while primarily are guesstimates and it is impossible to predict exactly how the climate will change and how these changes will affect the proposed development, it is possible to identify and implement strategies that will lessen the potential impacts of climate change on the infrastructure. Table 6-23 shows the proposed potential mitigation measures for the various climate change issues for the various Project phases.

Table 6-23 Climate Affairs Mitigation Measures

Main Issues	Project Phase	Potential Impact	Potential Mitigation Measures
Direct GHG Emissions	Design	Increased GHG emissions	▪ Develop a detailed carbon management plan detailing goals and target. ▪ Reduce fuel and electricity use.
	Construction	Exhaust emissions from construction vehicles	Consider replacing conventional fuel types (petrol and diesel) with bio-fuels, when available.
	Construction		Use high-efficiency motors in equipment that is continuously operated.
	Construction		Ensure that vehicles and equipment are mechanically sound, regularly serviced and fitted with appropriate emission control equipment.
	Construction		Implement work scheduling that: ▪ Minimize equipment idle time and double handling of material; ▪ Optimize machinery use to avoid unnecessary fuel usage.
	Construction		Minimize haul distances.
	Design	GHG emissions from electricity used for lighting and cooling of the site.	Design energy efficient site office(s).
	Construction		Procure and install energy efficient fixtures and fittings (e.g., energy efficient lights in the site office/s).
	Construction		Construct during the day to reduce the need for floodlighting during night works on cooler season.
Direct emissions related to energy	Design	Production processes (embodied energy of construction materials)	Identify local sources of recycled materials.
	Construction		Use recycled materials where possible (e.g., recycle wastes from demolition of existing

Main Issues	Project Phase	Potential Impact	Potential Mitigation Measures
		resulting in GHG emissions.	structures, where possible).
	Construction		Use locally produced materials.
	Construction		Give preference to products with low embodied energy.
	Design		Consider adopting a design that requires fewer materials.
	Construction	Cumulative GHG Emissions from the construction processes.	Work with third parties (suppliers, distributors, and contractors) to reduce emissions (e.g., through recycling materials).
	Design	Exhaust emissions from vehicles	Optimize the road design to promote steady and constant traffic movement (reduce stop/start).
	Construction		Minimize gradient changes along the alignment.
	Design	GHG emissions from electricity used for lighting (streetlights).	Investigate energy efficient street lighting options.
	Construction		Install the most energy efficient lighting technology suitable for the road requirements.
Carbon Sinks	Design	Loss of carbon sequestration potential.	Develop a re-planting strategy, when possible and applicable.
	Construction		Plant / re-establish vegetation with high carbon sequestration potential (carbon sinks).
	Construction		Plant vegetation that occurs naturally in the location.
Alternative to reduce ODS	Construction	Release of ODS	Use of alternative refrigerants
	Construction		Use of old refrigerators and air conditioners are disposed of safely by giving them to a recycling yard.

6.7.2 Planned GHG Sinks (Green Cover)

While any kind of vegetation implementation is always considered good practice in any infrastructure developments, the proposed Project, considering its size and magnitude, will provide minimal flora species, such as grass and shrubs, and the expected green cover or GHG reduction from these are considered insignificant.

Table 6-24 Percentage of GHG Sinks (Green Cover)

Total Area of the Project (m^2)	Proposed Area for Green Cover/ Plantation (m^2)	Percentage of Green Cover to Total Area of Industry	Expected GHG Reduction
6 600 000	n/a	n/a	n/a

6.8 Climate Affairs Risk Reduction Plan

6.8.1 Roles and Responsibilities of the Project Team

It is recommended that the application of a climate resilience toolkit, e.g. European Commission[8], be overseen by a Climate Resilience Manager (CR Manager).

The CR Manager should be appointed by the project manager (PM) responsible for overall development of the Project and should be an existing member of the Project development team. Please refer to the main EIA study for the proposed Project team.

Clearly, in any given project, the allocation of responsibilities may be distributed differently according to what makes most sense for the project team. In addition, only relevant responsibilities need to be fulfilled. Finally, it should be noted that the adaptation measures proposed are yet to be implemented by Duqm SEZA's project team after MECA's review and approval of the proposed adaptation measures.

6.8.2 Monitoring Plan for the Key Climate Affairs Variables

The proposed monitoring plan for the Project has been based on widely-accepted guiding principles and adaptation action, thus, it has been made fit for purpose.

The risks posed by climate change have the potential to impact on the service delivery of the proposed drainage network infrastructure. As such it is important that the Project Proponent to work together with local authorities and agencies to ensure that these risks are managed effectively.

The risks identified in this plan will be managed through the Project Proponent's risk management system and will be reviewed at least every year. Each risk will be assigned to the team that is primarily responsible for managing it. A cross directorate team should be established to monitor the Project Proponent's progress on the delivery of the adaptation actions. The cross directorate team must be supported by the Governance team, who will provide risk management advice, and the Sustainability team, who will provide advice on the latest climate science. The Project Proponent Management Team and Duqm SEZA Chairman/CEO will be ultimately responsible for ensuring the strategy is delivered.

Figure 6-6 shows the details of the governance structure.

[8] European Commission (2012). *Guidelines for Project Manager: Making Vulnerable Investments Climate Resilient*. Last accessed on 20 April 2015 at http://climate-adapt.eea.europa.eu/c/document_library/get_file?uuid=81fdc9d1-c840-409e-8060-82862cf65017&groupId=18.

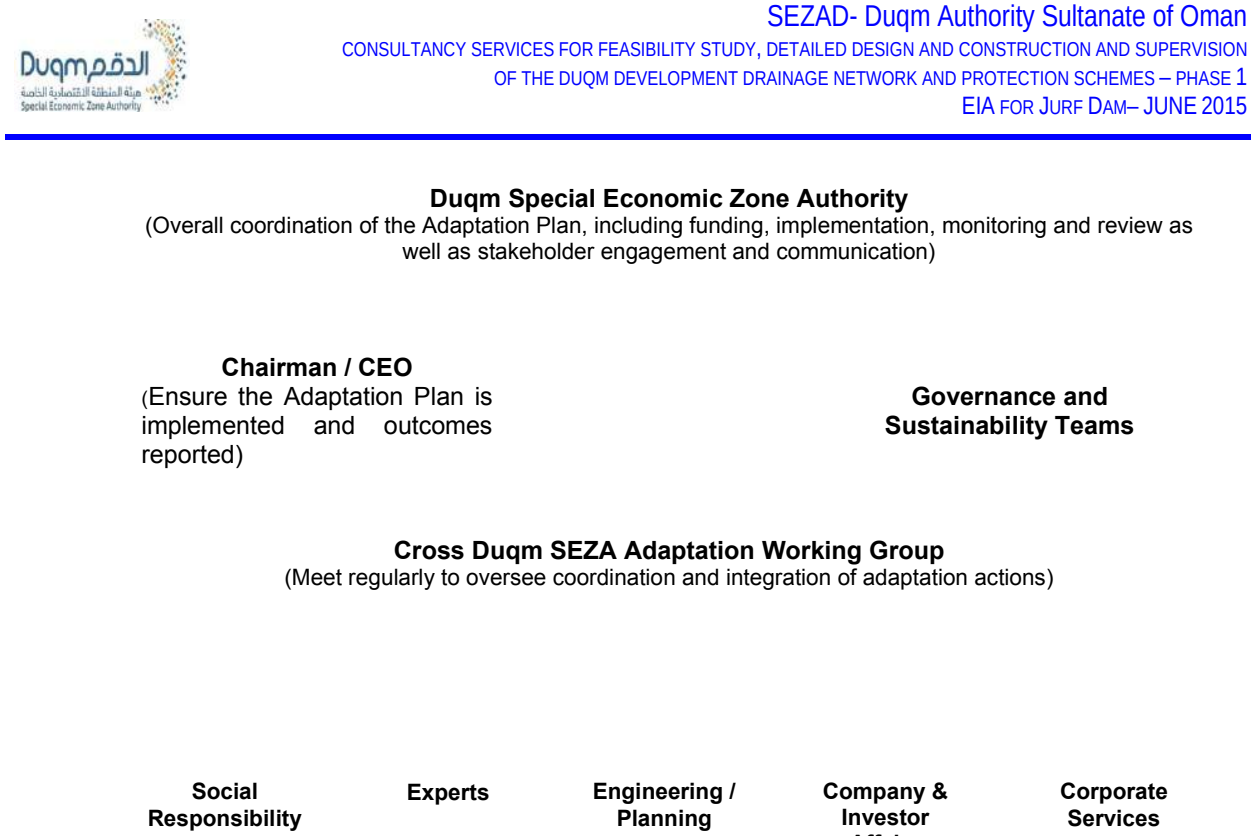


Figure 6-6 Summary of Roles and Responsibilities within the Project Proponent Team for the Climate Change Adaptation Plan

This plan is a living document, most especially, during the construction phase of the proposed Project. As this adaptation plan is for the Project, many of the proposed actions focus on improving our understanding of climate risks and integrating climate change into existing activities.

Regular and ongoing reporting of the Project's climate change adaptation performance is critical to inform decision making and motivate changes in behavior. To ensure that decision-makers, staff and the community are aware of Duqm SEZA's progress in implementing the adaptation actions outlines in this strategy, internal reporting will be undertaken once every year or when needed. However, considering that the drainage channel, while important to the overall masterplan and development of the Duqm SEZA community, its climate change emissions and impacts are minimal.

External reporting is the discretion of the Project Proponent and/or as advised by MECA.

The Climate Affairs Risk Reduction Plan (CARRP) of the proposed Project is as shown in Table 6-25, which are primarily the proposed adaptation measures for the Project.

The CARRP framework has been based on *MECA's 2013 Guidelines on Climate Affairs Chapter*.

With regard to key strategies to build Project's risk reduction plan and building climate risk reduction plan in key sectors, Duqm SEZA has adopted environmental sustainability policies for all of its projects.

Table 6-25 Proposed Climate Affairs Risk Reduction Plan

Main Issues	Adaptation Measures
Protection of the Ozone Layer	▪ Use of ODS in compliance with the Montreal Protocol and with MD 243/2005
Rainfall, wadi flooding, flash floods, and sea level rise	▪ Re-creating functional floodplains ▪ Managing point source pollution to reduce water quality risks ▪ Harvesting rainwater to reduce water demand, lower risk of flooding (i.e., harvesting water buffers the amount of precipitation entering drainage systems), and collect water for toilet flushing, car washing, irrigation, etc. ▪ Using 'cool' or 'porous' pavements ▪ Preserving land that is required for current and future flood risk management ▪ Observe national (when available) or international standards for sustainable drainage systems[9]
Storms and winds	▪ See DEFRA (2011)[10]
Landslides	▪ Consider the management of slope stability in communities landslide risk reduction measures by taking the outputs of the community-based mapping process (slope process zone map and initial drainage plan) and developing a detailed drainage plan for implementation[11]
Climate Change Study	▪ Establish climate change monitoring stations ▪ Improve forecasting system of extreme events

[9] An example of an international standard is by DEFRA, UK (2011) National Standards for Sustainable Drainage Systems – Designing, Constructing, Operating and Maintaining Drainage for Surface Runoff. Retrieved on 28 April 2015 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82421/suds-consult-annexa-national-standards-111221.pdf.

[10] *Ibid*.

[11] See Anderson, M.G. and Holcombe, E. (2013). *Community-Based Landslide Risk Reduction: Managing Disasters in Small Steps*, p 213-259, http://dx.doi.org/10.1596/9780821394564_CH06.

6.9 Summary and Conclusions

Climate change is a reality that will have an impact on the design life of the proposed Project. In particular, hotter temperatures events that will impact the usability and durability of the proposed Jurf Dam. Although, the extent of climate change impacts is unknown, steps can be taken to reduce the consequence of climate change on the proposed development.

The assessment was undertaken based on MECA's *2013 Guidelines on Climate Affairs Chapter* and other widely-accepted guidance and guidelines (e.g., IPCC, EMEP/EEA, etc.).

There is a consensus within the scientific community that GHG emissions are altering global climate, but that the effect is due to multitude of emissions sources and is not related to an individual activity or project (CEAA, 2003; IPCC, 2013). GHG emissions from the Project are expected to represent a small fraction of national and global GHG emissions:

- Project construction GHG emissions are estimated to amount to 132.02 metric tonnes CO_2e within the two-year construction period;
- Project operations GHG emissions are estimated to amount to 0.00 CO_2e per year.

7. POTENTIAL ENVIRONMENTAL IMPACTS WITH PROJECT ENVIRONMENT

This chapter identifies the potential impacts due to the implementation of the proposed Dam of Project on the physical, ecological and social environment of the Project Area. The chapter also identifies measures that will help to mitigate the project's adverse environmental effects and to enhance the positive impacts.

7.1 Project Impact Matrix

Impact matrix for both with and without mitigation measures for the selected Project has been developed and shown in Table 6.1 and Table 6.2 respectively. In this table both adverse and beneficial impacts on various environmental and social parameters have been indicated by assigning level of impact in the form of high, medium, low adverse or beneficial or insignificant/none. In subsequent paragraphs, mitigation measures have been proposed for only adverse negative impacts on different environmental parameters.

7.2 Land Resources

This section explains how the proposed project will affect the land use, soil erosion and contamination, and describes the mitigation measures to manage these impacts.

7.2.1 Impact on Land Use and Resources

Construction Stage

- The proposed Project will involve acquisition of land on permanent basis. The areas affected by the project comprehends:
    - The Jurf dam, the reservoir area
    - Stockpile area for SEZADs' future projects
    - Constructor campsite for the dam.
    - Oryx Sanctuary in a part of the Jurf dam axis and the reservoir

  Nevertheless, there are a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the channel alignment before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.

  During the site visits, no power lines were identified along the project area that need to be relocated.
- Soil erosion may occur in the workshop areas as a result of improper runoff drawn from the equipment washing-yards and improper management of construction activities at semi hilly areas and natural streams.

- Dumping of waste/excavated material on hill slopes will overload and overstress the top of the slope and upon saturation these loose dumps may slide down.
- Extraction of stones from the Wadi bed for use in construction may lead to destabilization of the slope and enhance soil erosion.
- Soil may get contaminated from the spillage of chemicals like fuels, solvents, oils, paints and other construction chemicals and concrete. This normally happens when these materials are transported in open or loosely capped containers.
- The possible contamination of soil by oils and chemicals at camp sites, workshop areas, and equipment washing-yards may limit the future use of land.
- Improper dumping of solid waste from the camps and construction activities may degrade the land.

Operation Stage

- Borrow pits and other landscape depressions if left open, may prove hazardous to human beings, livestock and wildlife.
- Open pits containing water are potential sources of mosquito breeding if left stagnant, and can create health problems.

7.2.2 Mitigation Measures

The mitigation measures which will be carried out during construction as well as during operation stages for land resources are as under:

Construction Stage

- As referred earlier, there will be land acquisition and the compensation cost has been included in the cost estimate for the Client's approval. The construction commencement will be resulting of the Ministry of Housing "no objection certificate".
- In case of borrow material, existing quarries will be used for aggregate material or if excavated from new sites, prior approval will be sorted from the competent authority.
- Permit shall be obtained from SEZAD for borrow pits
- Project facilities should be located in open flat areas located near the dams and near road access, avoiding constant transport by trucks. The facilities are not allowed inside sensitive areas, such as the Orix Sanctuary, Turtle Reserve or Rock garden, and will be at a minimum distance of 500 m from any sensitive areas, such as the birds and turtle nest and feeding area.
- Prior to the commencement of construction activities, the contractor will submit a development plan to the Engineer-in-charge and SEZAD for its scrutiny and approval.
- Good engineering practices will help to control soil erosion both at construction sites and in peripheral areas, particularly in borrow/ deposit areas and a long haul tracks.
- Appropriate measures for slope protection, i.e. vegetation cover and stone pitching, etc will be used at embankments.
- The contractors will be required to instruct and train their workforce in the storage and handling of materials and chemicals that can potentially cause soil contamination.

- Solid waste generated during construction and at campsites will be transported to the nearest existing landfill (as final destination) site or authorised dumpsite.
- For permanent affected area of the Oryx Sanctuary Reserve, the Contractor must request for permission for land acquisition to the Oryx sanctuary Reserve prior to work commence.

Operation Stage

- Ditches or borrow pits that cannot be fully rehabilitated will be landscaped/converted into fishponds to minimize erosion and to avoid creating hazards for people and livestock.
- Proper monitoring of the soil erosion and landslide prone areas will be carried out during operation phase and soil conservation measures (if needed) will be carried out like provision of physical structures e.g. gabion walls or retaining walls, etc.

7.3 Water Resources

7.3.1 Impact on Water Resources

Construction Stage

- To meet the water requirements for camp site and construction activities, local water supplies may be exploited thus bringing its use into competition with local use.
- Groundwater resources may be contaminated by fuel and chemical spills, or by solid waste and effluents generated by the activities and facilities at the construction campsites.
- Natural streams may become silted by borrow material in the runoff from the construction area, workshops and equipment washing-yards.
- Soil erosion may occur at quarry areas, and it may contaminate the groundwater resources if unmanaged excavation.

Operation Stage

- According to the design operation specifications once the reservoir level is at full supply the dam outflow valve must be opened by the operation and maintenance staff in order to regain the full reservoir capacity for the next flood. This means that the increased quantity of water will last only for a short period without any climate modification.

7.3.2 Mitigation Measures

Construction Stage

- In the Project Area the availability of water from existing water works will be assessed before its utilization for the construction activities and this will be the responsibility of SEZAD.

- Availability of water for campsite facilities and construction purposes will be ensured by the Contractor prior to start of construction activities. However, before exploitation of water, permission would have to be taken from the concerned authority.
- Treatment facility of sewage and any other industrial/ chemical wastewater generated at the site shall be provided during construction phase by the contractor.

Operation Stage

- Proper monitoring of the dam is to be performed during operation stage to avoid the obstruction of the channel and consequent lack of sediment supply to the beach.
- As referred earlier the reservoir will be drained after every flood so no impact on the climate and no mitigation measure required.

7.4 Waste Water

7.4.1 Impact on Water & Soil

Construction Stage

- To activities on camp site and construction activities may generate effluents that may contaminate water resources and soil. The effluent may be generated from equipment spills (oil, grease), toilets, kitchens, washrooms, workshops, washing ramps, warehouse for chemicals, fuel area, waste handling/ deposit areas. With regard to the characteristics of the effluents, it is difficult to estimate the chemical composition of the various effluent streams as the campsite is not yet determined by the contractor

Operation Stage

- No waste water will generated during operation stage due the absence of permanent facilities for maintenance.

7.4.2 Mitigation Measures

Construction Stage

- The Contractor will prepare a campsite map defining all the above mentioned areas (if any) and the treatment facilities to be installed and monitored to prevent any surface run-off of the generated effluents
- Treatment facility of sewage and any other industrial/ chemical wastewater generated at the site shall be provided during construction phase by the contractor.
- The treated effluent from the facility shall conform to land discharge standards specified in MS 145/93. The treated effluent must be monitored as per then monitoring plan.
- In case of installing an STP, the water from it shall be used to the extent possible for construction activities and dust suppression

- Construction equipment and vehicles will be water washed periodically to remove any accumulated dirt. No detergents will be used. Washing will be done in a designated area (washing ramp) and the washings will be collected into a settling tank in order to separate suspended solids and oil & grease;
- The clarified effluent will be sent to an onsite sewage treatment plant (STP) / nearest municipal STP for further treatment and disposal; and the separated oil will be skimmed off or removed using soaking pads and the collected oil will be disposed as hazardous waste. The settled solids from the bottom of the tank will be removed periodically and disposed in accordance with regulations.
- Storage areas of hazardous wastes / hazardous materials will be enclosed to protect from rains and storm water. If storm water is suspected to be contaminated, it will be collected in collection pits and prevented from entering surface drains. Normally run-offs from areas where hazardous substances (oils and chemicals) are stored will not occur. If there are any accidental spillages of hazardous substances on the soil, such areas will be immediately remediated to avoid the run-offs being contaminated.
- Liquid waste from the camps including oil, grease etc. will be transported through mobile trucks to the nearest available/existing disposal. Measures for disposal of solid waste are already discussed in land use section.
- The Contractor will prepare an Emergency plan, including training and responsibilities on actions to be taken for:
    - Responding promptly to exterior spills to prevent waste materials from entering the surface water system.
    - Cleaning up liquid spills such as oils, paints, and pesticides with absorbent material rather than hosing them into drains. Although the Project generally do not accept these liquids, they might find their way into the waste stream in small quantities

Operation Stage

- No mitigation measures were considered due the absence of waste water generated during operation phase.

7.5 Waste

7.5.1 Impact on Water & Soil

Construction Stage

- To activities on camp site and construction activities may generate solid wastes that may contaminate water resources and soil.

- Due to the nature and complexity of the construction activities, it is not practical to quantify the non hazardous or hazardous wastes since the details on construction activities, quantities of materials, excavation, quantities of solvents, paints and scrap generation rates, etc., are not available. The types of wastes typically generated during construction and the methods of handling and disposal are presented in following Table.

Table 7-1: Waste Typically Generated

Waste type & Source	*Waste Stream Characteristics*	*Site Control*
	Non-Hazardous Waste	
Domestic waste comprising office waste, kitchen waste, etc.	Continuous Biodegradable and non-biodegradable solid waste from administration and building and control rooms	▪ Appropriate waste collection and storage facilities will be provided ▪ Will be segregated and stored in a secluded area ▪ Non-recyclable wastes will be disposed of at municipal disposal site
Metal and wood scrap and packaging materials	Intermittent Recyclable	▪ Will be recycled as feasible ▪ Remaining materials will be stored at segregated storage area and disposed at municipal waste disposal area
Sludge from the sanitary treatment system	Periodic Biodegradable waste	The sludge will be collected in the storage area and disposed of at the nearest municipal dumpsite
	Hazardous Wastes	
Waste oils and oily sludge, waste chemicals, solvents and maintenance activities	Intermittent Contaminated with hydrocarbons and chemicals	▪ Will be stored in segregated, bunded areas ▪ Waste oil will be sent to authorized waste oil recyclers ▪ Waste solvents and chemicals, if feasible, will be sent back to the suppliers or disposed of in accordance with the MSDS
Containers of hazardous materials like oil, paint, chemicals, etc.	Intermittent Hazardous due to the presence of hydrocarbons and chemical residues	▪ Will be stored in the hazardous waste disposal for a maximum period of 3 months ▪ Will be returned to the suppliers of the corresponding material, if possible
Contaminated soils due to accidental spills and leaks of diesel, lube oil, solvents, paints, chemicals, etc.	Unique occurrence Soil contaminated with hydrocarbons, heavy metals, etc.	▪ Excavated contaminated soil to be stored in appropriate storage area with impervious lining, buds and spill containment facilities ▪ Will be sent to land farm or the hazardous waste treatment facility, once the facility is operational
Used equipment and spares	Intermittent Contaminated equipment	▪ Will be stored in enclosed and dedicated storage area at site and will be decontaminated and recycled as feasible

	and spares	or disposed of as directed by the MECA
Unused and off-spec materials such as waste paints, chemicals and solvents	Intermittent Contaminated with acids, alkalis and hydrocarbons	▪ Will be returned to the supplier, if feasible ▪ Will be segregated and stored at site in a line and bunded area ▪ Will be disposed of according to the MSDS

Operation Stage

- No waste will generated as result of the operation due the absence of permanent facilities for maintenance.

7.5.2 Mitigation Measures

Construction Stage

- All the solid waste generated from construction site, workers camps and staff colony of project should be controlled by proper solid waste management system to avoid contamination, odour and aesthetic problems at the site.
- Hazardous waste shall be handled, stored and disposed according to MD 17/93, MD 57/2002
- Solid waste generated during construction and at campsites will be transported to the nearest existing landfill site.
- Storage areas of hazardous wastes / hazardous materials will be enclosed to protect from rains and storm water. If storm water is suspected to be contaminated, it will be collected in collection pits and prevented from entering surface drains. Normally run-offs from areas where hazardous substances (oils and chemicals) are stored will not occur. If there are any accidental spillages of hazardous substances on the soil, such areas will be immediately remediated to avoid the run-offs being contaminated.
- Segregation of hazardous from non-hazardous wastes must be practiced. Separation of recyclable and non recyclable waste must be introduced and recycling practices must be implemented when possible. The hazardous materials will be stored in a designated area.
- Liquid waste from the camps including oil, grease etc. will be transported through mobile trucks to the nearest available/existing disposal. Measures for disposal of solid waste are already discussed in land use section.
- The Contractor will prepare an Emergency plan, including training and responsibilities on actions to be taken for:
    - Responding promptly to exterior spills to prevent waste materials from entering the surface water system and soil.

- Cleaning up liquid spills such as oils, paints, and pesticides with absorbent material rather than hosing them into drains. Although the Project generally do not accept these liquids, they might find their way into the waste stream in small quantities

- Based on the above, the agreement letter with be'ah for handling and disposing of the same at their facility shall be provided. If not provide the alternative treatment facility/ disposal method for the generated hazardous wastes.

Operation Stage

- Proper monitoring of the dam reservoir is to be performed during operation stage to avoid the obstruction of the channel and consequent lack of sediment supply to the beach

7.6 Ambient Air Quality and Noise Level

7.6.1 Impacts

Construction Stage

- Air quality will be affected by the fugitive dust and emissions from the construction machinery, and vehicular traffic during the construction phase. Exhaust emissions from the machinery will generate gases such as CO, CO_2, SO_2 and NO exceeding the limits of the Omani standards and will directly affect the ambient air quality Emissions may be carried over long distances, depending on wind speed and direction, the temperature of the surrounding air, and atmospheric stability.
- Fugitive dust will also be generated from quarry areas during the rock blasting and crushing.
- The possible presence of Hydrogen Sulfide in the Jurf dam area must be considered, since H_2S is a flammable gas that is toxic at extremely low concentrations. Inhalation at certain concentrations can lead to injury of death of humans and animals.
- The Contractor camp is located near the project area therefore there will be some slight negative impact on workers due to the noise generated by the construction machinery during the project construction stage.

Operation Stage

- During operation stage there will be no impact because there is no equipment to be allocated to the maintenance of the dams or channels.

7.6.2 Mitigation Measures

The following measures will be implemented to mitigate the impacts on the ambient air quality and noise level:

Construction Stage

- Good engineering practices will be used during the rock blasting (if required) at quarry areas to minimize the impact of dust emissions.
- If required, the existing quarries will be used to borrow the aggregate materials.
- If used, crushers and concrete batching plants will be equipped with dust control equipment such as fabric filters or wet scrubbers to reduce the level of dust emissions.
- Vehicles and other construction machinery will be properly tuned and maintained, so as not to emit any smoke.
- When not in use for extended periods of time, construction equipment, DG sets and vehicles will be turned off.
- Location of DG sets and other emission generating equipment will be established considering the predominant wind direction, avoiding disturbance with emissions affecting residential areas.
- The Environmental Quality Standards as per Ministerial Decision Nos. 118/2004 for air shall be strictly followed by the contractor in order to minimize the air in the Study Area.
- The Environmental Quality Standards as per Ministerial Decision Nos. 79/94 and 80/94 for noise in public and working environment respectively shall be strictly followed by the contractor in order to minimize the air and noise pollution in the Study Area.
- Where necessary, dust emissions will be reduced by a regular sprinkling of water for keeping the dust settled, at least twice a day.
- Haul-trucks carrying construction materials will be kept covered with tarpaulin to curtail the impact on air quality.
- If practical, stockpiling of excavated material will be regularly sprinkled and covered and delivered as needed during the course of construction.
- Mufflers and silencers will be provided on machines to keep noise to a minimum level.
- SEZAD will set up a system to monitor the noise level in the Study Area in accordance with the Omani standards (if available), reporting the results periodically to SEZAD.
- Mufflers and silencers will be provided on machines to keep noise to a minimum level.
- Regarding the presence of H_2S:
    - All workers, sub-contractors visitor must be provided with training before site works, namely for the following subjects:
        - Identification of the characteristics, sources, and hazards of Hydrogen Sulfide.
        - Proper use of the Hydrogen Sulfide detection methods used on the site.
        - Recognition of, and proper response to, Hydrogen Sulfide warnings at the workplace.
        - Symptoms of Hydrogen Sulfide exposure.

- Proper rescue techniques and first-aid procedures to be used in a Hydrogen Sulfide exposure.
- Proper use and maintenance of personal protective equipment. Demonstrated proficiency in using Personal Protection Equipment (PPE) should be required.
- Worker awareness and understanding of workplace practices and maintenance procedures to protect personnel from exposure to hydrogen sulfide.
- Wind direction awareness and routes of egress.
- Confined space and enclosed facility entry procedures.
- Locations and use of safety equipment.
- Locations of safe briefing areas.
- Use and operation of all Hydrogen Sulfide monitoring systems.
- Emergency response procedures, corrective action, and shutdown procedures.
- Effects of Hydrogen Sulfide on the components of the Hydrogen Sulfide handling system.
- The importance of drilling fluid treating plans prior to encountering Hydrogen Sulfide.

o In the event of suspecting the presence of H_2S on site, workers must keep away from the area, use the PPE and report to superior. The site must be identified as potential H_2S presence.

o A contingency plan must be designed by the contractor and all the workers must be aware of it.

o One of the first emergency measures is to allow the H2S to disperse by air, once it reaches the surface.

o If worked is performed on areas where the H_2S is a potential presence, monitoring site equipment must be use to control the concentration of the gas.

o Eating, drinking and smoking are strictly forbidden in these areas.

Operation Stage

- SEZAD will set up a system to monitor the air quality and noise level in the Study Area in accordance with the Omani standards (if available). The system will cover protocols for sampling and analysis, assessment of air quality at sensitive locations, reporting, and information sharing. If it's necessary to enhance the air quality of the Study Area, a tree plantation program could be initiated by the SEZAD on priority basis.

7.7 Explosives

7.7.1 Impacts

Construction Stage

Explosives will have significant negative impact on the safety of workers, residents, livestock and birds in the Project Area. This activity may generate high frequency noise levels, but for a short period only and will adversely affect the health of the workers and livestock. Injuries and accidents often occur due to this activity. Serious attention is required and safe operating procedures be followed. The negative impact may be of high magnitude for the workers working adjacent to the area where explosives will be used.

7.7.2 Mitigation Measures

Construction Stage

Effective measures shall be adopted to minimize the hazards related with explosives. Explosive material shall be stored in a safe place and at a safe distance from the settlements and the construction camps. Warning signs shall be placed near the explosives storage areas. Before any explosion, the people shall be informed well before and if required, evacuation of livestock /residents shall be carried out. Transportation, storage, handling and operation of explosives shall be conducted as per Omani rules and regulations.

Before all blasting operations commence every borehole to be charged shall be checked H2WS concentration. Only when it has been ascertained that the H_2S concentration is non hazardous can the holes be charged and detonated.

Coordination with the concerned authority shall be done for creating awareness/ evacuation, if required, during use of explosives/ blasting operations

Permits/NOC shall be obtained from ROP for use, handling and transport of explosives

The Contractor will select the type of explosives (if any) and must comply with the Omani regulation RD 46/95 and RD 82/77 for storage, handling and safety management of the explosive material.

7.8 Ecological Environment

The impact on flora and fauna and corresponding mitigation measures are described in the following paragraphs:

7.8.1 Impacts on Flora and Fauna

Construction Stage

- During construction fine dust particles will cover the scattered vegetation leaves, choking breathing parts (stomata) thus hindering CO_2 assimilation by plants to the detriment of their health.
- Oil spills, unintended mixing of noxious chemicals etc into the groundwater will be a serious hazard to Flora, Fauna and Birds. Affected area will become unfit for livestock and oil on surface will have a disabling threat to Avifauna.
- Granary and food stores at labour camps will attract rodents like mice, rats; shrew, gerbils etc. thus multiply harmful rodents which is a moderate negative impact. However, these animals at the same time are an important component of Ecosystem Trophic Chain.

- Oryx Sanctuary and the Turtle beach are sensitive and protected areas that may suffer some impact from territory invasion, due the cut of vegetation, nesting season disturbance, vandalism, etc. The lost of these unique species can be the lost of biodiversity, but most of all, of an unique natural treasure of the Sultanate of Oman

Operation Stage

- Natural sedimentation and waste brought with the strong winds may affect the natural flow of the Wadi. Apart from obstructing the wadi, it can also influence the sand sedimentation on the sea outlet and the natural flow at the beach area

7.8.2 Mitigation Measures

Construction Stage

- For the vegetation lost due to clearing of the strip/ piece of land for machinery path, hutments and labour camps, the area cleared shall be replanted with local flora after construction is over.
- Mitigation measures for dust control, oil spill, chemicals, liquid waste and noise is already stipulated in the physical environment section (above).
- Labour will be strictly forbidden to cut any vegetation. Gas/paraffin hearths be provided to labour for cooking etc.
- Granary and stores be properly secured and safeguarded against rodents.
- Thin film of dust on leafs and vegetation can be removed by Jet-spray of water every afternoon along both sides of machinery path.
- Before submergence/ during construction trees and bushes should be removed from wadi bed and areas to be affected by uprooting and pulling away the plants/trees
- Steps for immediate removal and safe disposal of solid waste will be taken so that wild animals could not eat the harmful eatables.
- NOC shall be obtained from the concerned authority for the protected areas in the project influence area including the Oryx Sanctuary
- Oryx Sanctuary and Turtle beach:
    - Special care must be paid to these sensitive areas as these habitats are protected and any disturbance can cause a high adverse impact. Works to be developed inside the Oryx Sanctuary must be approved by the Oryx sanctuary Reserve, this authority should be informed in writing of any intention to work inside their territory and the contractor must have a written permission in case the permission is granted.
    - Feeding, lay hold or hunting any animal inside these areas is strictly forbidden

- Any cutting of the vegetation has to be with the projects needs, never as per the workers personal actions
- Workers must never disturb nests or take eggs from the turtles.

Operational Stage

- After construction old/unusable stores/unnecessary dumping/solid waste etc will be removed from site as quickly as possible for safety of wild life and terrestrial animals.

7.9 Socioeconomic and Cultural Environment

7.9.1 Social and Cultural Impacts

Construction Stage

- Unmonitored construction activities, e.g. blasting or excavation may create an accident risk for the local residents particularly their children and their livestock.
- Induction of outside workers in the Contractor labour may cause cultural issues with the local community.
- Disturbance to the privacy of the local women due to the induction of outside workers as local persons are very sensitive about the privacy of their women.
- Workers to be made aware about local culture and traditions to avoid socio-cultural issues
- Employees and contractors to minimize their interaction with local residents and their disturbance in the community by timing the operations and transits through local communities to avoid disturbing worship, school, and other community gatherings

Operation Stage

- The proposed Project will involve acquisition of land on permanent basis. The areas affected by the project comprehends:
  - The Jurf dam, the reservoir area
  - Stockpile area for SEZADs' future projects
  - Constructor campsite for dam.
  - Oryx Sanctuary in a part of the Jurf dam axis and the reservoir
- Nevertheless, there are a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the project area before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.
- The Project Area is mainly wild or being used as grazing land by goats. During construction only a small percentage of the grazing area is expected to be disturbed due to implementation of the Project.

7.9.2 Mitigation Measures

Construction Stage

- If required, blasting will be carried out during the fixed hours (preferably during the mid-day). The timing will be made known to all the people within 500 m from the blasting site in all directions. People, except those who actually light the fuse shall be evacuated from the area within 200m of the blasting site in all directions at least 15 minutes before blasting.
- Women privacy will need to be taken into account by the Contractor. Contractor will instruct his labour force to avoid trespassing near the dwellings of the local people.
- Employment shall be provided to the local people, in consultation with the Wali, during the construction phase, to the extent feasible.
- There is no possible mitigation measure to avoid the disturbance in the grazing areas.
- Regular spray on water along with other necessary measures shall be carried out to control vectors. Contractor will make sure that effective housekeeping measures will be taken into account in order to avoid unhygienic conditions within the camp areas.
- The Contractor will be required to maintain close liaison with the local communities to ensure that any potential conflicts related to common resource utilization for the project purposes are resolved quickly.
- Contractor will take care of the local community and sensitivity towards the local customs and traditions will be encouraged.
- Workers to be made aware about local culture and traditions to avoid socio-cultural issues
- Employees and contractors to minimize their interaction with local residents and their disturbance in the community by timing the operations and transits through local communities to avoid disturbing worship, school and other community gatherings.
- The contractor will be required to maintain close liaison with local communities to ensure that any potential conflicts related to common resources utilization for the project purposes are resolved quickly
- A field dispensary will be established to provide Medicare facilities and preventive medicines at camp site.

Operation Stage

- Alternate roads and graded paths be planned to restore communication network, in case of road cut.
- Alternate paths and crossing points will be provided to livestock for easy access to areas open to grazing, if necessary.

7.10 Archaeology and Heritage

7.10.1 Heritage and Cultural Impacts

Construction Stage

- Due to unmonitored construction activities such as blasting, excavation or filling of the soil some archaeological site may be disturbed or lost forever.

Operation Stage

- No activities for the operation phase are potentially harmful for archaeological or cultural sites

7.10.2 Mitigation Measures

Construction Stage

- Workers to be provided a briefing on recognizing archeological artifacts and how to respond when such sites are found. Proper training must be provided to all the workers performing earth works, such excavation, blasting, transport, filling, so that no impacts are accidentally caused to the natural heritage on site.
- NOC from MHC to be obtained, for the campsite, dam and drainage channel route, prior to construction

Operation Stage

- Operation phase does not predict any interaction with the sites, but this should be avoid in case any need to access the project and make use of the archaeological sites.

7.11 Environmental and Socio-Economic Beneficial Impacts

- The aim of the project is to provide a significant degree of flood protection to the free zone area under development. The construction of attenuation dams and flood conveyance channels is likely to form the principal components of such flood protection measures. Dams will be situated upstream of the target area and channels shall be designed to convey the remaining water safely through the development area.
- During the construction period, the local workers will get opportunity to work as semi-skilled or as just labourer, hence will get experience of construction works and human resource will thus be developed at local level for future development activities.

Table 7-2: Project Interaction matrix without mitigation

ENVIRONMENTAL COMPONENTS	PHYSICAL ENVIRONMENT										BIOLOGICAL ENVIRONMENT									SOCIAL ENVIRONMENT											
	Acquisition of Land	Acquisition of Temp. land / crop losses	Soils (Erosion/Stability/contamination)	Archaeological Monuments	Public/Private Utilities	Energy/Mineral Resources	Surface Water	Groundwater	Air Quality	Noise	Crops/vegetation	Aquatic Ecosystem	Terrestrial Ecosystem	Endangered Species	Migratory Species	Beneficial Plants	Beneficial Animals	Pest Plants	Disease Vectors	Public Health	Resource/Land Use	Accessibility	Employment	Worker safety	Public safety	Temporary Disruption of People	Resettlement/compensation	Community Stability	Cultural & Religious Values	Tourism And Recreation	Living Standards
PROJECT RELATED ACTIVITIES	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
Construction Phase																															
1. Excavation	MA	0	MA	MA	0	MA	0	0	MA	MA	MA	0	MA	MA	LA	LA	LA	0	0	LA	LA	LA	MB	LA	LA	LA	0	0	0	0	MB
2. Placement of material	0	0	0	0	0	LA	0	0	LA	LA	0	0	0	0	0	LA	LA	0	0	LA	LA	LA	MB	LA	0	0	0	0	0	0	MB
3. Loading & hauling	0	0	LA	0	0	0	0	0	MA	MA	0	0	MA	0	0	0	LA	0	0	LA	0	0	MB	LA	0	MA	0	0	0	0	MB
4. Construction Related Traffic	0	0	0	0	0	0	0	0	MA	MA	LA	0	MA	0	LA	LA	LA	0	0	LA	0	LA	LB	LA	MA	MA	0	0	0	0	MB
5. Construction Camp	0	0	MA	0	MA	MA	LA	MA	MA	LA	0	0	LA	0	0	LA	MA	0	0	LA	MA	LA	0	0	0	LA	0	0	0	0	MB
6. Compaction	0	0	0	0	0	0	0	0	0	MA	0	0	LA	0	0	LA	LA	0	0	0	LA	0	LB	LA	0	LA	0	0	0	0	0
7. Blasting/crushing	0	0	MA	0	MA	LA	0	MA	MA	HA	0	0	MA	MA	MA	0	MA	0	0	MA	0	0	LB	HA	HA	MA	0	0	0	0	MB
8. Concrete placement	0	0	MA	0	0	0	0	0	0	MA	0	0	MA	0	0	0	LA	0	0	MA	0	0	LB	LA	0	LA	0	0	0	0	MB
9. Use of chemicals	0	0	HA	0	0	0	0	LA	LA	0	0	0	LA	0	0	MA	MA	0	0	0	MA	0	0	MA	LA	0	0	0	0	0	0
10. Solid waste disposal	0	0	MA	0	0	0	0	0	0	0	0	MA	0	MA	MA	0	0	0	0	LA	0	0	0	0	0	LA	0	0	0	0	0
11. Use of heavy machinery	0	0	0	0	0	0	0	0	MA	MA	0	0	MA	0	0	0	MA	0	0	LA	0	0	LB	LA	LA	LA	0	0	0	0	MB
12. Vehicle/equipment maintenance	0	0	0	0	0	0	0	LA	0	0	0	0	LA	0	0	LA	MA	0	0	0	0	0	MB	0	0	0	0	0	0	0	MB
Weighted Overall	***MA***	***0***	***MA***	***0***	***MA***	***MA***	***0***	***MA***	***MA***	***MA***	***MA***	***0***	***MA***	***0***	***0***	***MA***	***MA***	***0***	***0***	***MA***	***MA***	***LA***	***MB***	***MA***	***MA***	***MA***	***0***	***0***	***0***	***0***	***MB***
Operation Phase																															
Local Effects																															
1. Reservoir operation	MA	0	0	MA	0	0	HB	HB	0	0	HB	0	HB	0	0	HB	HB	0	0	0	0	0	LB	0	LA	0	LA	HB	0	0	HB
2. Increased vehicular movement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Waste generation	0	0	0	0	0	0	0	0	0	0	0	MA	0	0	LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Increased quantity of water	0	0	0	0	0	0	HB	HB	0	0	HB	0	HB	0	0	HB	HB	0	0	HB	0	0	0	0	0	0	0	0	0	0	HB
5. Pesticide spraying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Increased commercial activity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Increased influx of tourists	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weighted Overall	***MA***	***0***	***0***	***0***	***0***	***0***	***HB***	***HB***	***0***	***0***	***HB***	***0***	***HB***	***0***	***0***	***HB***	***HB***	***0***	***0***	***HB***	***0***	***0***	***LB***	***0***	***LA***	***0***	***LA***	***HB***	***0***	***0***	***HB***
Overall Project	***MA***	***0***	***LA***	***0***	***LA***	***LA***	***MB***	***LB***	***LA***	***LA***	***LB***	***0***	***LB***	***0***	***0***	***LB***	***LB***	***0***	***0***	***LB***	***LA***	***LA***	***MB***	***LA***	***MA***	***LA***	***LA***	***MB***	***0***	***0***	***HB***

High Adverse:	HA		Low Beneficial: LB
		0	Medium Beneficial: MB
Medium Adverse:	MA		High Beneficial: HB
Low Adverse:	LA		

Table 7-3: Project interaction matrix with mitigation

ENVIRONMENTAL COMPONENTS	PHYSICAL ENVIRONMENT										BIOLOGICAL ENVIRONMENT									SOCIAL ENVIRONMENT											
	Acquisition of Land	Acquisition of Temp. land / crop losses	Soils (Erosion/Stability/contamination)	Archaeological Monuments	Public/Private Utilities	Energy/Mineral Resources	Surface Water	Groundwater	Air Quality	Noise	Crops/vegetation	Aquatic Ecosystem	Terrestrial Ecosystem	Endangered Species	Migratory Species	Beneficial Plants	Beneficial Animals	Pest Plants	Disease Vectors	Public Health	Resource/Land Use	Accessibility	Employment	Worker safety	Public safety	Temporary Disruption of People	Resettlement/compensation	Community Stability	Cultural & Religious Values	Tourism And Recreation	Living Standards
PROJECT RELATED ACTIVITIES	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
Construction Phase																															
1. Excavation	0	0	LA	0	0	LA	0	0	LA	MA	LA	0	MA	0	0	LA	LA	0	0	LA	LA	LA	MB	LA	LA	LA	0	0	0	0	MB
2. Placement of material	0	0	0	0	0	LA	0	0	LA	LA	0	0	0	0	0	LA	LA	0	0	LA	LA	LA	MB	LA	0	0	0	0	0	0	MB
3. Loading & hauling	0	0	LA	0	0	0	0	0	LA	MA	0	0	MA	0	0	0	LA	0	0	LA	0	0	MB	LA	0	MA	0	0	0	0	MB
4. Construction Related Traffic	0	0	0	0	0	0	0	0	MA	MA	LA	0	MA	0	0	LA	LA	0	0	LA	0	LA	LB	LA	LA	MA	0	0	0	0	MB
5. Construction Camp	0	0	LA	0	LA	LA	0	LA	LA	LA	0	0	LA	0	0	LA	LA	0	0	LA	LA	LA	0	0	0	LA	0	0	0	0	MB
6. Compaction	0	0	0	0	0	0	0	0	0	MA	0	0	LA	0	0	LA	LA	0	0	0	LA	0	LB	LA	0	LA	0	0	0	0	0
7. Blasting/crushing	0	0	LA	0	LA	LA	0	MA	MA	MA	0	0	MA	0	0	0	MA	0	0	MA	0	0	LB	MA	LA	MA	0	0	0	0	MB
8. Concrete placement	0	0	LA	0	0	0	0	0	0	MA	0	0	LA	0	0	0	LA	0	0	LA	0	0	LB	LA	0	LA	0	0	0	0	MB
9. Use of chemicals	0	0	LA	0	0	0	0	LA	LA	0	0	0	LA	0	0	LA	LA	0	0	0	LA	0	0	MA	LA	0	0	0	0	0	0
10. Solid waste disposal	0	0	LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LA	0	0	0	0	0	LA	0	0	0	0	0
11. Use of heavy machinery	0	0	0	0	0	0	0	0	MA	MA	0	0	LA	0	0	0	MA	0	0	LA	0	0	LB	LA	LA	LA	0	0	0	0	MB
12. Vehicle/equipment maintenance	0	0	0	0	0	0	0	LA	0	0	0	0	LA	0	0	LA	LA	0	0	0	0	0	MB	0	0	0	0	0	0	0	MB
Weighted Overall	***0***	***0***	***LA***	***0***	***LA***	***LA***	***0***	***MA***	***MA***	***MA***	***LA***	***0***	***MA***	***0***	***0***	***LA***	***MA***	***0***	***0***	***MA***	***LA***	***LA***	***MB***	***MA***	***LA***	***MA***	***0***	***0***	***0***	***0***	***MB***
Operation Phase																															
Local Effects																															
1. Reservoir operation	0	0	0	0	0	0	HB	HB	0	0	HB	0	HB	0	0	HB	HB	0	0	0	0	0	LB	0	LA	0	0	HB	0	0	HB
2. Increased vehicular movement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Waste generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Increased quantity of water	0	0	0	0	0	0	HB	HB	0	0	HB	0	HB	0	0	HB	HB	0	0	HB	0	0	0	0	0	0	0	0	0	0	HB
5. Pesticide spraying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Increased commercial activity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Increased influx of tourists	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weighted Overall	***0***	***0***	***0***	***0***	***0***	***0***	***HB***	***HB***	***0***	***0***	***HB***	***0***	***HB***	***0***	***0***	***HB***	***HB***	***0***	***0***	***HB***	***0***	***0***	***LB***	***0***	***LA***	***0***	***0***	***HB***	***0***	***0***	***HB***
Overall Project	***0***	***0***	***LA***	***0***	***LA***	***LA***	***MB***	***LB***	***LA***	***LA***	***LB***	***0***	***LB***	***0***	***0***	***LB***	***LB***	***0***	***0***	***LB***	***LA***	***LA***	***MB***	***LA***	***LA***	***LA***	***0***	***MB***	***0***	***0***	***HB***

High Adverse:	HA		Low Beneficial: LB
		0	Medium
Medium Adverse:	MA		Beneficial: MB
Low Adverse:	LA		High Beneficial: HB

8. ENVIRONMENTAL MANAGEMENT PLAN

8.1 Introduction

For the effective implementation and management of the mitigation measures, an Environmental Management Plan (EMP) has been prepared and is presented in this section. This EMP satisfies the requirements of the Royal Decree 10/82 "The Conservation of Environment and Prevention of Pollution" and Royal verdict 114/2001.

8.1.1 Objectives of the EMP

The EMP has been prepared with an objective of the following but not limited to it.

- Outlining the mitigation measures required for avoiding or minimizing the potential impacts assessed by EIA.
- Developing a monitoring mechanism and identifying the requisite monitoring parameters to confirm effectiveness of the mitigation measures recommended in the EIA.
- Defining roles and responsibilities of the Project proponent for the implementation of EMP and identifying areas where these roles and responsibilities can be shared with other parties involved in the execution and monitoring of the Project.
- Defining the requirements necessary for documenting compliance with the EMP and communicating it to all the concerned regulatory agencies.
- Prescribing the mechanism with which consultation with stakeholders during the project will be maintained.

8.2 Legislation and Guidelines

The main environment related legislation is the Royal Decree No. 10/82 and its amendment titled "Law on Conservation of Environment and Prevention of Pollution" This decree is now replaced by 114/2001. This law is enforced by the MECA. In addition, "Guidelines for Obtaining Environmental Permits" has been developed and approved by Directorate General of Environmental Affairs, MECA, which has been further subdivided into eight different groups named industrial projects, mining projects, agricultural projects, food projects, service projects, marine and coastal projects, tourism projects, and light industries. Our project falls in the category of Services Project.

The legislative guidelines other than the Decree 10/82 regarding preservation and conservation of the environmental resources also exist. The relevant amongst them include Royal Decree 63/85 (conservation of environment and prevention of pollution); Royal Decree 82/88 (deals with licenses and permits for drilling wells and utilizing water); Ministerial Decision 5/86 and 11/93 deal with the conservation of the environment and for the management of solid non-hazardous waste respectively); Ministerial Decision 18/93 (deals with the management of hazardous waste); Ministerial Decision 145/93 (wastewater re-use and discharge); Ministerial Decision 79/94 (Issuing regulations for noise pollution control in the public environment); Royal Decree 2/80 (provides authority for the protection of national heritage); Ministerial Decision 128/93 (Forbidden to cut trees); Royal Decree 75/98 (Its an amendment to 111/96 and deals with fines with wildlife issues such as chasing, injuring etc).

The major legislation is the submission of Environmental Impact Assessment Report for obtaining the permit.

Keeping in view the above laws and regulations, it is mandatory for a proponent to get an application from the MECA and submit it duly filled in for getting the clearance in the form of an Environmental Permit.

8.3 Organizational Structure and Roles and Responsibilities

8.3.1 Organizational Structure

The proposed project includes the following five organizations:

- Duqm Authority (SEZAD) as the Project Proponent and owner of the EMP.
- SEZAD olds the responsibility of monitoring the execution of the EMP.
- Ministry of Environment and Climate Affairs (MECA) as EMP Administrator, the body directly responsible for the implementation and execution of EMP, working in liaison with SEZAD, and Environmental Management Council (EMC).
- Project Contractors including the civil works and drilling contractors as the executor of the EMP.
- EMC as the monitor of the execution of the EMP.

8.3.2 Roles and Responsibilities

Duqm Authority (SEZAD)

As Project proponent, SEZAD is responsible for ensuring the implementation of EMP. SEZAD will be responsible for overall environmental performance during the proposed project. SEZAD will work in liaison with DG of Environment Affairs, in Duqm Governorate and EMC. SEZAD in coordination with MECA will ensure that coordination with project stakeholders on environmental and social matters as required by the EMP is maintained throughout the operation.

SEZAD in coordination with MECA and the contractors will ensure that the mitigation measures mentioned in the Mitigation Management Matrix (MMM) attached are adhered to and organizational HSE Management Systems are implemented during the construction and operation of the proposed project. The Contractors will abide by the relevant contractual provisions relating to the environment.

Directorate General of Environment Affairs, Duqm Governorate (DGEA)

DGEA will own the position of project administrator. This body will be directly responsible for effective implementation and monitoring of EMP according to Mitigation Management Matrix (MMM), which is given in subsequent sections and will work in liaison with SEZAD and EMC. The DGEA will also be responsible for collaboration with any other concerned authority over their concerns about the tourism potentials of the Project Area.

The Director Environment, DGEA looks over the sections of environmental permits, air and noise pollution, water pollution, soil and waste management, marine pollution & coastal zone management and Director Natural Resources DGEA owns the responsibility of natural reserved areas section and natural nation's reserves section. All these sections will work in direct contact with EMC and will also interfere with contractor and will make sure the effective environmental management according to EMP.

DGEA keeping involved SEZAD and the Contractors will prepare Contingency Plan (if required) to deal with any emergency situations. EMC will check if this plan is in place and effective in addressing the threat.

The above DGEA role and responsibilities can also be assumed by Duqm Authority, since by Royal Decree 119/2011 SEZAD the entity established to authorize and issue its regulations.

The Project Contractors

For the proposed project, SEZAD will appoint Contractors for the construction, drilling, and other project activities. The Contractors will be responsible for the implementation of, or adherence to, all the provisions of the EIA and EMP and with any environmental and other code of conduct required by SEZAD. Overall responsibility for the Contractor's environmental performance will rest with the person holding the highest management position within the organization. The Contractor will have a HSE setup responsible for overall compliance with environmental laws.

Environmental Management Council (EMC)

To fulfill the monitoring requirements set by this EMP, SEZAD in consultation with Renardet will appoint an EMC, which will comprise the staff from SEZAD, DGEA, and any other authority to be included. Director Water Resources SEZAD, Director Environment, Duqm Governorate, Director Nature Conservation and Duqm Governorate will be the essential part of EMC body. The EMC will be responsible for carrying out monitoring according to the requirements of the EMP and the monitoring programme developed by the EMC. The person holding the highest management position in the EMC organization will be responsible for EMC's adherence with the monitoring requirements specified in the EMP and will be responsible for the activities of the EMC. EMC will monitor the Contractor's adherence to EMP.

If any aspects of the Project components are changed, EMC will categorise that change in accordance with the Change Management Plan provided in this EMP and take appropriate measures thereon.

8.4 Mitigation Management Matrix

The mitigation management matrix (MMM) is considered as a core element of EMP. It will be used as the management and monitoring tool for the implementation of EMP. It is highlighted that although the responsibilities for executing and monitoring the mitigation measures has been delegated to different persons/organizations, SEZAD will hold the primary responsibility for ensuring the full implementation of EMP. The mitigation management matrix is tabulated in the bellow table.

CC: *Construction Contractor*
EMC: *Environmental Management Council*
SEZAD: *Duqm Authority*
DEEA: Directorate General for *Environmental Affairs*

Table 8-1: Mitigation Management Matrix

Sr #.	***Impact***	***Mitigation Measure***	***Responsibility***			***Action/ Parameter/ Monitoring Method***	***Timing***
			Construction		***Operation***		
			Execution	*Monitoring*	*Monitoring*		
1.	Soil erosion/contamination	• In case of borrow material, existing quarries will be used for aggregate material or if excavated from new sites, prior approval will be sought from the competent authority. • Permit shall be obtained from SEZAD for borrow pits • Project facilities should be located in open flat areas located near the dams and the channel and near road access, avoiding constant transport by trucks. The facilities are not allowed inside sensitive areas, such as the Orix Sanctuary, Turtle Reserve or Rock garden, and will be at a minimum distance of 500 m from any sensitive areas, such as the birds and turtle nest and feeding area. • Prior to the commencement of construction activities, the contractor will submit a development plan to the Engineer-in charge and MECA/SEZAD for its scrutiny and approval. • As far as possible, waste/barren land i.e. areas not under agricultural, residential or forestation use, and natural areas with a high elevation will be used for borrow material and setting up project facilities. • Good engineering practices will help to control soil erosion both at construction sites and in peripheral areas, particularly in borrow areas and a long haul tracks. • Appropriate measures for slope protection, i.e. vegetation cover and stone pitching, etc will be used at embankments. • The contractors will be required to instruct and train their	***CC***	***EMC/CC/ DGEA***	***EMC/ DGEA***	Soil cover and possibility of soil erosion should be monitored regularly.	During construction & operation

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		workforce in the storage and handling of materials and chemicals that can potentially cause soil contamination. • Ditches or borrow pits that cannot be fully rehabilitated will be landscaped/converted into fishponds to minimize erosion and to avoid creating hazards for people and livestock. • Proper monitoring of the soil erosion and landslide prone areas will be carried out during operation phase and soil conservation measures (if needed) will be carried out like provision of physical structures e.g. gabion walls or retaining walls, etc. For permanent affected area of the Oryx Sanctuary Reserve, the Contractor must request for permission for land acquisition to the Oryx sanctuary Reserve prior to work commence.					
2.	Water quality	• The availability of water from existing water works at Duqm will be assessed before its utilization for the construction purposes and this will be the responsibility of SEZAD. • Availability of water for campsite facilities and construction purposes will be ensured by the Contractor prior to start of construction activities. However, before exploitation of water, permission would have to be taken from the concerned authority. Treatment facility of sewage and any other industrial/ chemical wastewater generated at the site shall be provided during construction phase by the contractor. • Proper monitoring of the dam is to be performed during operation stage to avoid the obstruction of the channel and consequent lack of sediment supply to the beach • As referred earlier the reservoir will be drained after every flood so no impact on the climate and no mitigation measure required		***EMC/CC/ DGEA***	***SEZAD/ DGEA***	EMC should monitor the quantity and quality of water and take action to defeat the disease vectors.	During construction & Operation.
3.	Air quality	• Good engineering practices will be used during the rock blasting at quarry areas (if required) to minimize the impact of dust emissions.	***EMC/CC/ DGEA***	***EMC/ DGEA***	***SEZAD/ DGEA***	Monitoring should be carried out	During construction

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		• If required, the existing quarries will be used to borrow the aggregate materials. • If in use, crushers and concrete batching plants will be equipped with dust control equipment such as fabric filters or wet scrubbers to reduce the level of dust emissions. • Vehicles and other construction machinery will be properly tuned and maintained, so as not to emit any smoke. • When not in use for extended periods of time, construction equipment, DG sets and vehicles will be turned off. • Location of DG sets and other emission generating equipment will be established considering the predominant wind direction, avoiding disturbance with emissions affecting residential areas. • The Environmental Quality Standards as per Ministerial Decision Nos. 118/2004 for air shall be strictly followed by the contractor in order to minimize the air in the Study Area. • Where necessary, dust emissions will be reduced by a regular sprinkling of water for keeping the dust settled, at least twice a day. • Haul-trucks carrying construction materials will be kept covered with tarpaulin to curtail the impact on air quality. • If practical, stockpiling of excavated material will be regularly sprinkled and covered and delivered as needed during the course of construction. • Regarding the presence of H2S: - All workers, sub-contractors visitor must be provided with training before site works, namely for the following subjects: o Identification of the characteristics, sources, and hazards of Hydrogen Sulfide.				and documentation should be done.	During operation

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		o Proper use of the Hydrogen Sulfide detection methods used on the site. o Recognition of, and proper response to, Hydrogen Sulfide warnings at the workplace. o Symptoms of Hydrogen Sulfide exposure. o Proper rescue techniques and first-aid procedures to be used in a Hydrogen Sulfide exposure. o Proper use and maintenance of personal protective equipment. Demonstrated proficiency in using Personal Protection Equipment (PPE) should be required. o Worker awareness and understanding of workplace practices and maintenance procedures to protect personnel from exposure to hydrogen sulfide. o Wind direction awareness and routes of egress. o Confined space and enclosed facility entry procedures. o Locations and use of safety equipment. o Locations of safe briefing areas. o Use and operation of all Hydrogen Sulfide monitoring systems. o Emergency response procedures, corrective action, and shutdown procedures. o Effects of Hydrogen Sulfide on the components of the Hydrogen Sulfide					

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		handling system. o The importance of drilling fluid treating plans prior to encountering Hydrogen Sulfide. - In the event of suspecting the presence of H2S on site, workers must keep away from the area, use the PPE and report to superior. The site must be identified as potential H2S presence. - A contingency plan must be designed by the contractor and all the workers must be aware of it. - One of the first emergency measures is to allow the H2S to disperse by air, once it reaches the surface. - If worked is performed on areas where the H2S is a potential presence, monitoring site equipment must be use to control the concentration of the gas. - Eating, drinking and smoking are strictly forbidden in these areas. • Air quality monitoring.					
4.	Noise pollution	• Mufflers and silencers will be provided on machines to keep noise to a minimum level. • The Environmental Quality Standards as per Ministerial Decision Nos. 79/94 and 80/94 for noise in public and working environment respectively shall be strictly followed by the contractor in order to minimize the air and noise pollution in the Study Area. • SEZAD will set up a system to monitor the noise level in the Study Area in accordance with the Omani standards (if available), reporting the results periodically to SEZAD.	***CC***	***EMC/CC/ DGEA***	***EMC/ SEZAD/ DGEA***	Monitoring of noise level	During construction & Operation.
5.	Explosives (if required)	• Effective measures shall be adopted to minimize the hazards related with explosives. Explosive material should be stored in a safe place and at a safe distance from the	***CC***	***EMC/CC***			During construction

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		settlements and the construction camps. Warning signs shall be placed near the explosives storage areas. Before any explosion, the people shall be informed well before and if required, evacuation of livestock /residents shall be carried out. Transportation, storage, handling and operation of explosives shall be conducted as per Omani rules and regulations. • Before all blasting operations commence every borehole to be charged shall be checked H2S concentration. Only when it has been ascertained that the H2s concentration is non hazardous can the holes be charged and detonated. • Coordination with the concerned authority shall be done for creating awareness/ evacuation, if required, during use of explosives/ blasting operations • Permits/NOC shall be obtained from ROP for use, handling and transport of explosives • The Contractor will select the type of explosives (if any) and must comply with the Omani regulation RD 46/95 and RD 82/77 for storage, handling and safety management of the explosive material.					
6.	Ecological environment	▪ For the vegetation lost due to clearing of the strip/ piece of land for machinery path, hutments and labour camps, the area cleared will be replanted with local flora after construction is over. ▪ Mitigation measures for dust control, oil spill, chemicals, liquid waste and noise is already stipulated in the physical environment section (above). ▪ Labour will be strictly forbidden to cut any vegetation. Gas/paraffin hearths be provided to labour for cooking etc. ▪ Granary and stores be properly secured and safeguarded against rodents. ▪ Thin film of dust on leafs and vegetation can be removed by Jet-spray of water every afternoon along both sides of machinery path.	***CC***	***EMC/CC/ DGEA***	***EMC/ SEZAD/ DGEA***		During construction & Operation.

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		▪ Before submergence/during construction trees and bushes should be removed from the wadi bed and area to be affected by uprooting and pulling away the plants/trees. ▪ Steps for immediate removal and safe disposal of solid waste will be taken so that wild animals could not eat the harmful eatables. ▪ After construction old/unusable stores/ unnecessary dumping/solid waste etc will be removed from site as quickly as possible for safety of wild life and terrestrial animals. ▪ Proper monitoring of the dam reservoir, channel and sea outlet is to be performed during operation stage to avoid the obstruction of the channel and consequent lack of sediment supply to the beach. ▪ NOC shall be obtained from the concerned authority for the protected areas in the project influence area including the Oryx Sanctuary ▪ Oryx Sanctuary and Turtle beach: - Special care must be paid to these sensitive areas as these habitats are protected and any disturbance can cause a high adverse impact. Works to be developed inside the Oryx Sanctuary must be approved by the Oryx sanctuary Reserve, this authority should be informed in written of any intention of work inside their territory and the contractor must have a written letter in case the permission is granted. - Feeding, lay hold or hunting any animal inside these areas is strictly forbidden - Any cut of the vegetations has to be with the projects needs, never as per the workers personal actions - Workers must never disturb nests or take eggs from the turtles.					

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
7.	Socio-economical/cultural	• If required, blasting will be carried out during the fixed hours (preferably during non-prayer time). The timing will be made known to all the people within 500 m from the blasting site in all directions. People, except those who actually light the fuse shall be evacuated from the area of 200 m from the blasting site in all directions at least 15 minutes before blasting. ▪ Women privacy will need to be taken into account by the Contractor. Contractor will instruct his labor force to avoid trespassing near the dwellings of the local people. ▪ Employment shall be provided to the local people, in consultation with the Wali, during the construction phase, to the extent feasible. ▪ Regular spray on water along with other necessary measures shall be carried out to control vectors. Contractor will make sure that effective housekeeping measures will be taken into account in order to avoid unhygienic conditions within the camp areas. ▪ Contractor will take care of the local community and sensitivity towards the local customs and traditions will be encouraged. ▪ Workers to be made aware about local culture and traditions to avoid socio-cultural issues ▪ Employees and contractors to minimize their interaction with local residents and their disturbance in the community by timing the operations and transits through local communities to avoid disturbing worship, school, and other community gatherings • There is no possible mitigation measure to avoid the disturbance in the grazing areas. • A field dispensary will be established to provide Medicare facilities and preventive medicines at camp site. • Alternate roads and graded paths be planned to restore	***CC***	***EMC/CC/ DGEA***	***EMC/ SEZAD/ DGEA***		During construction & Operation.

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		communication network. • Alternate paths and crossing points will be provided to livestock for easy access to areas open to grazing. • The Contractor will be required to maintain close liaison with the local communities to ensure that any potential conflicts related to common resource utilization for the project purposes are resolved quickly.					
8.	Archaeology	• Workers to be provided a briefing on recognizing archaeological artefact s and how to respond when such sites are found. Proper training must be provided to all the workers performing earth works, such excavation, blasting, transport, filling, so that no impacts are accidentally caused to the natural heritage on site. • NOC from MHC to be obtained, for the campsite, dam and drainage channel route, prior to construction • Operation phase does not predict any interaction with the sites, but this should be avoid in case any need to access the project and make use of the archaeological sites.	***CC/EMC***	***EMC/CC/ DGEA***	***SEZAD/ DGEA***	Presence of Archaeological and Natural Heritage during earth workings	During construction & Operation.
9.	Solid waste	• All the solid waste generated from construction site, workers camps and staff colony of project should be controlled by proper solid waste management system to avoid contamination, odour and aesthetic problems at the site. • Hazardous waste shall be handled, stored and disposed according to MD 17/93, MD 57/2002 • Solid waste generated during construction and at campsites will be transported to the nearest existing landfill site. • Storage areas of hazardous wastes / hazardous materials will be enclosed to protect from rains and storm water. If storm water is suspected to be contaminated, it will be collected in collection pits and prevented from entering surface drains. Normally run-offs from areas where hazardous substances (oils and chemicals) are stored will	***CC/EMC***	***EMC/CC/ DGEA***	***SEZAD/ DGEA***	Disposal in the nearest existing landfill site	During construction & Operation.

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		not occur. If there are any accidental spillages of hazardous substances on the soil, such areas will be immediately remediated to avoid the run-offs being contaminated. • Segregation of hazardous from non-hazardous wastes must be practiced. Separation of recyclable and non recyclable waste must be introduced and recycling practices must be implemented when possible. The hazardous materials will be stored in a designated area. • Liquid waste from the camps including oil, grease etc. will be transported through mobile trucks to the nearest available/existing disposal. Measures for disposal of solid waste are already discussed in land use section. • The Contractor will prepare an Emergency plan, including training and responsibilities on actions to be taken for: • Responding promptly to exterior spills to prevent waste materials from entering the surface water system and soil. • Cleaning up liquid spills such as oils, paints, and pesticides with absorbent material rather than hosing them into drains. Although the Project generally do not accept these liquids, they might find their way into the waste stream in small quantities • Based on the above, the agreement letter with be'ah for handling and disposing of the same at their facility shall be provided. If not provide the alternative treatment facility/ disposal method for the generated hazardous wastes. • Proper monitoring of the dams reservoir is to be performed during operation stage to avoid the obstruction of the channel and consequent lack of sediment supply to the beach					
10.	Sewage and Wastewater	• Considerable amount of wastewater and sewage is likely to be generated from the construction site and workers camp site. Proper treatment of this generated wastewater should be ensured prior to its final disposal.	***CC/EMC***	***EMC/CC/ DGEA***	***SEZAD/ DGEA***	Disposal in nearest existing landfill site	During construction & Operation.

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		• The Contractor will prepare a campsite map defining all the above mentioned areas (if any) and the treatment facilities to be installed and monitored to prevent any surface run-off of the generated effluents • Treatment facility of sewage and any other industrial/ chemical wastewater generated at the site shall be provided during construction phase by the contractor. • The treated effluent from the facility shall conform to land discharge standards specified in MS 145/93. The treated effluent must be monitored as per then monitoring plan. • In case of installing an STP, the water from it shall be used to the extent possible for construction activities and dust suppression • Construction equipment and vehicles will be water washed periodically to remove any accumulated dirt. No detergents will be used. Washing will be done in a designated area (washing ramp) and the washings will be collected into a settling tank in order to separate suspended solids and oil & grease; • The clarified effluent will be sent to an onsite sewage treatment plant (STP) / nearest municipal STP for further treatment and disposal; and the separated oil will be skimmed off or removed using soaking pads and the collected oil will be disposed as hazardous waste. The settled solids from the bottom of the tank will be removed periodically and disposed in accordance with regulations. • Storage areas of hazardous wastes / hazardous materials will be enclosed to protect from rains and storm water. If storm water is suspected to be contaminated, it will be collected in collection pits and prevented from entering surface drains. Normally run-offs from areas where hazardous substances (oils and					

Sr #.	Impact	Mitigation Measure	Responsibility			Action/ Parameter/ Monitoring Method	Timing
			Construction		Operation		
			Execution	Monitoring	Monitoring		
		chemicals) are stored will not occur. If there are any accidental spillages of hazardous substances on the soil, such areas will be immediately remediated to avoid the run-offs being contaminated. • Liquid waste from the camps including oil, grease etc. will be transported through mobile trucks to the nearest available/existing disposal. Measures for disposal of solid waste are already discussed in land use section. • The Contractor will prepare an Emergency plan, including training and responsibilities on actions to be taken for: o Responding promptly to exterior spills to prevent waste materials from entering the surface water system. o Cleaning up liquid spills such as oils, paints, and pesticides with absorbent material rather than hosing them into drains. Although the Project generally do not accept these liquids, they might find their way into the waste stream in small quantities					

8.5 Site Restoration Plan

The main areas to be considered for site restoration include the construction area, camp sites, tracks, storage areas etc. These areas will be restored to its original condition with the maximum possible effort. The restoration work comprises the removal of temporary construction works and removal of any fence installed, levelling of areas (wherever required), etc. The following procedures will be adopted for the restoration of the site:

- All temporary construction built for the dam construction will be removed.
- All the toxic and hazardous chemicals/materials will be completely removed from the site. Efforts will be made to completely remove the spills during the construction.
- All fencing and gates will be removed and pits will be backfilled.
- Whole site will be covered with the original soil and re-vegetation will be done, wherever required.

8.5.1 Post Closure Monitoring

The post closure monitoring will be done with an objective of determining the level of residual impacts of the project on the physical, ecological and socio-economic receptors of the Project Area. The monitoring is required to be conducted by EMC in consultation with communities for a period of at least 15 days. EMC will provide photographic evidence of the restoration area to verify the proper restoration.

8.6 Environmental Monitoring Program

Monitoring will be carried out to ensure compliance with the requirements of the EIA. The MMM provided in previous section will be used as a management and monitoring tool. Monitoring will be the responsibility of all organizations involved in the operation i.e. SEZAD, EMC and the Contractors. The Contractors will report compliance with the MMM to EMC and SEZAD for verification.

At least two field monitors from EMC will remain on-site for monitoring during construction. Any non-compliance observed by EMC will be recorded in non-compliance recording forms and discussed during the daily environmental meeting. The below table provides the environmental monitoring program during the construction and operational stages of the proposed project.

Table 8-2: Monitoring during Construction and Operational Stages

Parameter	Frequency	Remarks
Construction Stage		
1. Waste	Fortnightly	**Visual checks to assess the waste disposal methods**
2. Air Quality (Ambient)	Fortnightly Continuous monitoring during works	**Instrumental measurements of SO_2, NOx, CO_x, $PM_{2.5}$ and PM_{10}.H_2S** **H_2S when detected on site during construction activities**
3.Surface groundwater quality and wastewater	Monthly Fortnightly	**Monitoring and testing of water** **Monitoring of wastewater from treatment facilities following the MD 145/93 quality parameters**
4.Noise and vibration	Fortnightly	**Measurement of the noise levels due to construction activities, movement of equipment and vehicles**
5. Health and Safety	Monthly	**Monitoring of the occupational health and safety aspects of the workers**
6. Flora &Fauna	Monthly	**Visual checks to assess the situation, especially in the orix sanctuary reserve, coastal area for birds and turtle.**
Operational Stage		
1.Surface and groundwater quality	Quarterly	**Monitoring of the surface and groundwater from various sources.**
2. Ecology (Flora & Fauna)	Bi-annually	**Monitoring of flora, fauna and other ecological resources (To be planned & checked by SEZAD).**
3. Socio-economic surveys	**Annually**	**Impacts on cultural values due to the increase in exposure to outside culture (To be planned & checked by the DGEWRM).**

8.6.1 Environmental Monitoring Cost

The environmental impacts have been identified through studies carried out in several field. For an effective monitoring system in fields such as Air, Noise, Water and Ecology, environmental monitoring cost has been worked out for both the project stages (construction and operation). The unit cost as stipulated in the following table has been worked out in view of the prevailing rates in Sultanate of Oman. Detail is given as below:

Table 8-3: Environmental Cost for Construction Period of One Year

Sr. #	Mitigation Area	Description	Cost (RO)	Budget Component	Details
1	**Monitoring Cost**				
	Air quality, noise and water monitoring.		12,000	Project Budget	Various field & lab tests will be conducted by Sub-Consultant and Environmental Monitoring Consultants (EMC). Cost to be included in P&G.
	Ecological monitoring*	Flora & Fauna Monitoring		Project Budget	Walk through surveys will be conducted to check the actual physical conditions of Flora & Fauna. Monthly cost to be included in P&G. Cost to be worked out and borne by the Client.
	Subtotal		12,000		
2	**Training Cost**				
	Staff Training				Cost to be worked out and borne by the Client.
	Subtotal				
	Total Cost		**12,000**		

Note: The mentioned Figures do not include monitoring of H_2S in the Jurf Dam site as it should be done when according to the projects activities and the gas presence.

Table 8-4*: Environmental Cost for Operation Period of One Year*

Sr. #	Mitigation Area	Description	Cost (RO)	Budget Component	Details
1	**Monitoring Cost** Water monitoring. Ecological monitoring*	Flora & Fauna Monitoring			Field & Lab tests will be conducted by the Client. Cost to be borne by the Client. Walk through surveys will be conducted to check the actual physical conditions of Flora & Fauna. Cost to be borne by the Client.
2	Training Cost **Staff Training**				**Cost to be worked out and borne by the Client.**

8.6.2 Post-Project Monitoring

After completion of the Project, post-project monitoring will be carried out. The objective of this monitoring will be to determine the level of residual impacts of the project on physical, biological and socio-economic receptors of the Project Area. The monitoring may be carried out within one month after the end of all activities in the Project Area. The post-project survey report will be submitted within 14 days after completion of the survey. As part of the post-project monitoring field monitors will also check restoration of sites restored at that time according to the requirements of the EIA.

8.7 Communication and Documentation Plan

8.7.1 Kick-off Meeting

One kick off meeting will take place at the Contractor's site office before the start of construction. The purpose of the kick off meeting will be to demonstrate to the regulator and monitors that all requirements prior to the start of the individual project activities have been met and the EMC, proponent and its team including the contractors are ready to start the project as per the requirements of the EIA/EMP.

8.7.2 Meetings and Reports

Fortnightly meetings will be held during the construction at the construction camp. The purpose of the meeting will be to discuss the conduct of the operation, non-compliances noted by EMC and their remedial measures. The meeting will be chaired by the representative nominated by SEZAD. The meeting will be recorded in the form of a Fortnightly Environmental Report (FER) prepared by EMC.

The report as a minimum will include:

- Summary of project activities during last fifteen (15) days;
- EMC monitors and SEZAD and contractors environmental representatives present onsite;
- Summary of monitoring activities;
- Non-compliances observed and mitigation measures taken or required.

The FER will be communicated to the MECA, EMC, MOT and Contractor's Representative. Copies will be distributed to all relevant site personnel and a hard copy will be retained at the EMC site office.

The meeting will be attended by the following people:

- MECAR Director of Inspection and Environmental Control/ SEZAD
- Contractor Health, Safety and Environment Officer
- EMC

8.7.3 Monthly Environmental Report

A Monthly Environmental Report (MER) will be prepared by EMC summarizing the project activities and results of activity and effects monitoring. The MER as a minimum will include the following:

- Summary of Project Activities
- Schedule of EMC monitoring team
- Summary of monitoring activities
- Statistical record of non-compliances observed during the month
- Record of mitigation measures taken or pending
- Record of social complaints
- Record of Change Management
- Record of water consumption
- Record of fuel consumption

The MER will be prepared by the EMC and communicated to the SEZAD, MECA, Contractor, and the concerned wildlife Department (if required) within 8 days of the beginning of the next month. A hard & soft copy of the report will be retained at the EMC site office.

8.7.4 Social Complaints Register

The contractor and EMC will maintain a register of complaints received from local communities and measures taken to mitigate these concerns. All community complaints received will be sent to the SEZAD for its review.

8.7.5 Change Record Register

All changes to the EMP or to the project will be handled through the Change Management Plan as given in this EMP.

8.7.6 Non-Compliance Record Register

The EMC will maintain a non-compliance record register to record all non-compliances observed during construction drilling. A copy of the register will be appended with each MER.

8.7.7 Final Monitoring Report

A final monitoring report will be prepared by EMC after the post project monitoring.

The report should address the following:

- Introduction;

- Scope, Methodology, and Monitoring Team;
- Details of the Project Activities;
- Natural Resource Use by the Project;
- Record and Statistical Analysis of Non-compliances;
- Effects of the Project on Wildlife, Communities and Physical Resources;
- Recommendations for Future Projects.

8.7.8 Photographic Record

EMC will maintain a photographic record of all areas to be used during the project. As a minimum the photographic record will include the photographs of weir sites, access tracks, camp sites, and monitoring of different categories during and after the construction.

8.8 Change Management Plan

The EIA and the EMP have been developed based on the best possible information available at the time of the EIA study. However, it is possible that during the construction and operational stages additional mitigation measures based on the findings of environmental monitoring may have to be included in the EMP in the form of Change Management Plan. In such cases following actions will be taken:

- A meeting will be held between SEZAD, the concerned Contractor and the EMC representatives. During the meeting the proposed addition to the EMP will be discussed and agreed upon by all parties.
- Based on the discussion during the meeting, a change report will be produced collectively, which will include the additional EMP clause and the reasons for the addition.
- The report will be signed by all parties and will be finalized at the site office. A copy of the report will be sent to SEZAD, Contractor and EMC head offices.
- All relevant project personnel will be given information of the addition. These additions will be reported in the MER by EMC.

8.9 Training Program

Environmental training will form part of the environmental management system. The training will be directed towards all personnel for general environmental awareness.

8.9.1 Training Program

The EIA and EMP training will be carried out for the staff depending upon the training needs being assessed for the Project. EMC will prepare the outline program and manual for carrying out the training of the staff.

8.9.2 Training Log

A training log will be maintained by EMC. The training log will include;

- Topic
- Date, time and location
- Trainer
- Participants

8.9.3 Training Needs Assessment

In addition to the training specified in the training log special/ additional trainings will be provided during the project activity. The criteria to assess the need of training will be based on the following:

- When a specified percentage of staff is newly inducted in the project.
- When any non-compliance is repeatedly reported refresher training will be provided regarding that issue.
- When any incident/accident of minor or major nature occurs.
- Arrival of new contractor/sub contractor
- Start of any new process/activity

8.9.4 Training Material

EMC will develop and prepare training material regarding environmental awareness, sensitivity of the area, EIA, EMP and restrictions to be followed during the project. Separate training material will be developed and cost of the training will be worked out by the Client.

9. CONCLUSIONS AND RECOMMENDATIONS

The implementation of the proposed project will generate a number of negative impacts, especially during the construction stage, but these impacts are only temporary. The major impacts are summarized below:

- Soil erosion may occur in the workshop areas as a result of improper runoff drawn from the equipment washing-yards and improper management of construction activities at semi hilly areas and natural streams..
- Soil may get contaminated from the spillage of chemicals like fuels, solvents, oils, paints and other construction chemicals and concrete. This normally happens when these materials are transported in open or loosely capped containers. Improper dumping of solid waste from the camps and construction activities may degrade the land.
- Borrow pits and other landscape depressions if left open, may prove hazardous to human beings, livestock and wildlife.
- Surface and subsurface water resources may be contaminated by fuel and chemical spills, or by solid waste and effluents generated by the kitchens and toilets at construction campsites.
- The main ecological impacts during the construction are:
    - Cutting of few scattered trees
    - Oil spills, unintended mixing of noxious chemicals etc into groundwater will be a serious hazard to Flora, Fauna and Birds;
- Induction of outside workers in the Contractor labour may cause cultural issues with the local community and disturbance to the privacy of the local women.
- The proposed Project will involve acquisition of land on permanent basis. The areas affected by the project comprehends:
    - The Jurf dam and the reservoir area
    - Stockpile area for SEZADs' future projects
    - Constructor campsite for the dam.
    - Oryx Sanctuary in a part of the Jurf dam axis and the reservoir

Nevertheless, there are a few small animal shelters that may be relocated, mainly because the owners often move the shelters according to their needs and they may move some onto the project area before construction starts. At the moment, the project does not consider the relocation of the animal shelters, but should be consider such relocation in the BoQ.

During the site visits, no power lines were identified along the project area that need to be relocated.\

Recommendations:

In the light of identified negative impacts at construction and operation stages of the proposed project, it is recommended to implement the Mitigation Management Matrix (refer to section 7) and monitoring mechanism. The matrix shows the mitigation measures that need to be taken into account against the negative impacts. This will make the project environmental friendly.

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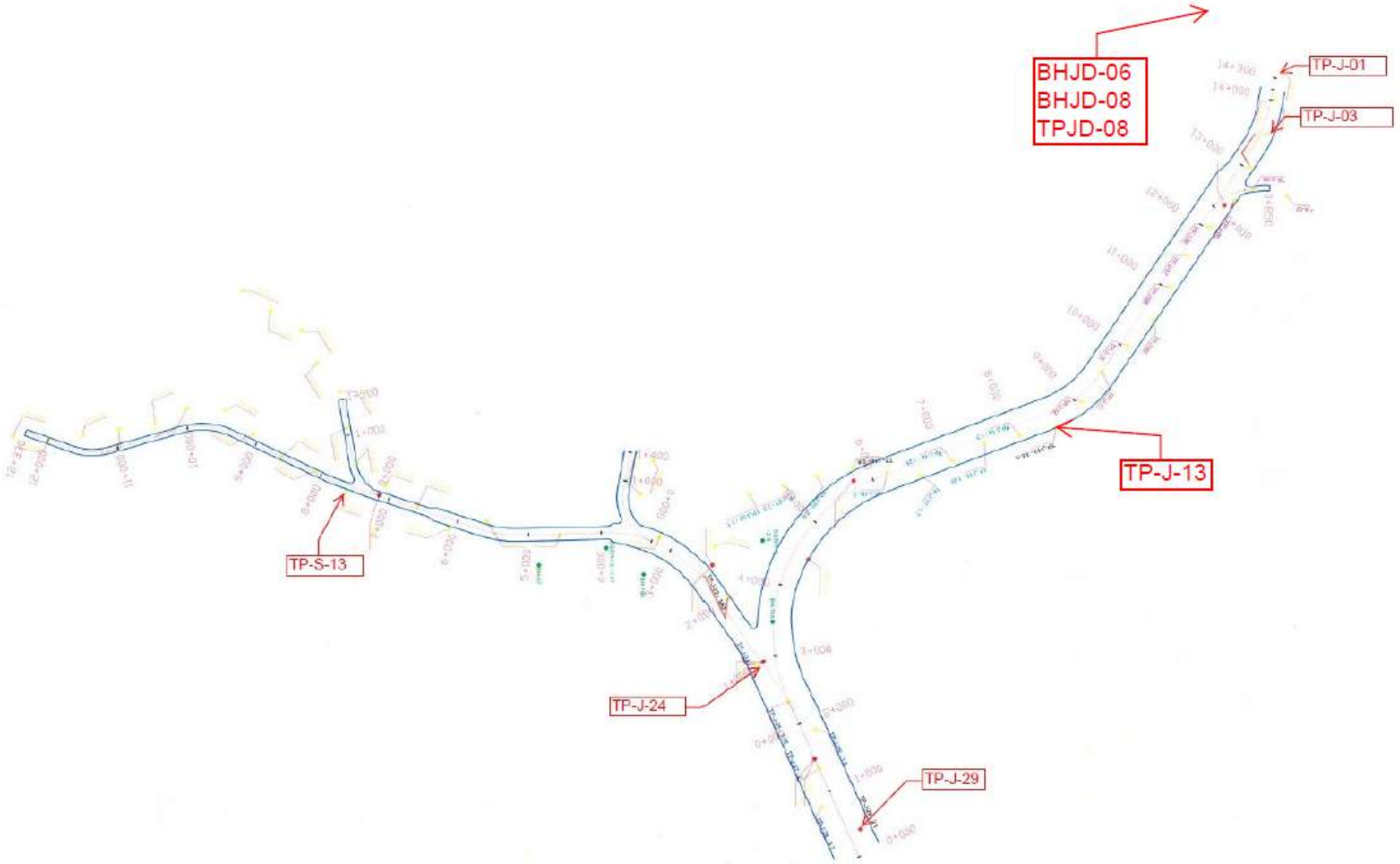
ANNEXURE A – PRELIMINARY DESIGN DRAWINGS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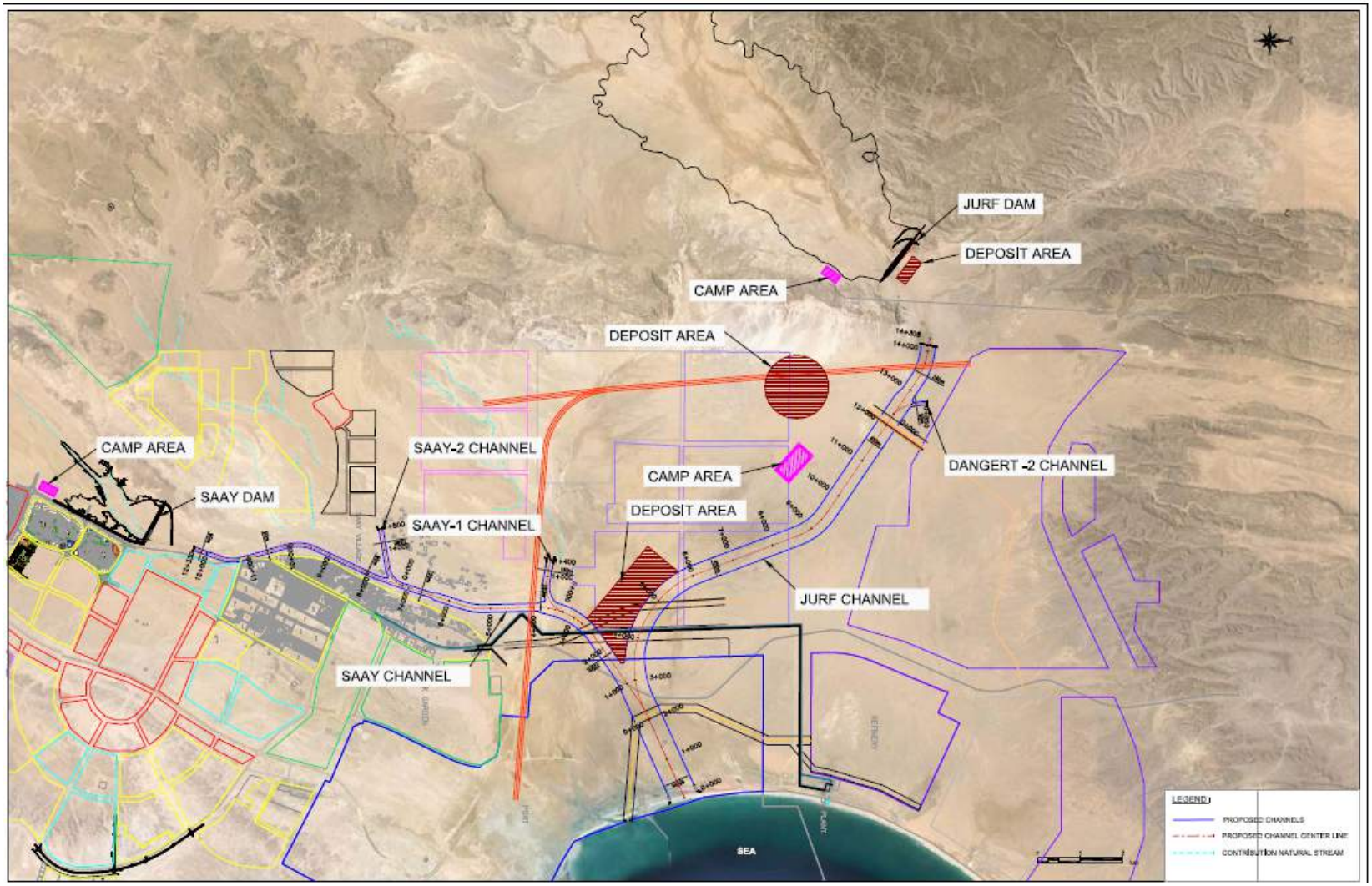
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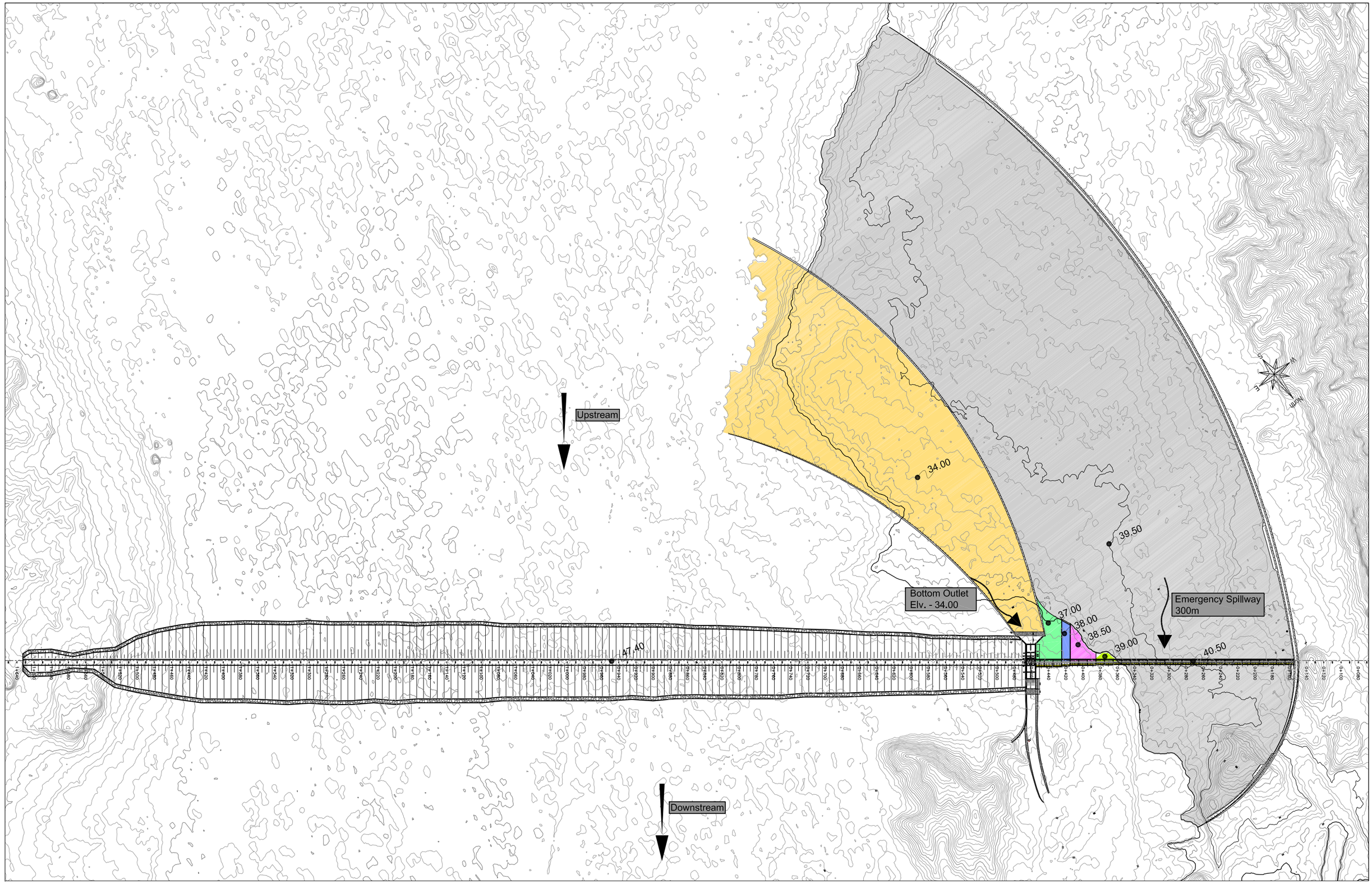

CLIENT:

Duqm
هيئة المنطقة الاقتصادية الخاصة
Special Economic Zone Authority

CONSULTANT:

RENARDET S.A. & PARTNERS
Consulting Engineers LLC.

PROJECT NAME:

Consultancy Services for Feasibility Study, Detailed Design and Construction Supervision of the Duqm Development Drainage Network and Protection Schemes Phase 1

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JURF DAM
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DESIGNED: AMY
CHECKED: AMY
APPROVED: BH

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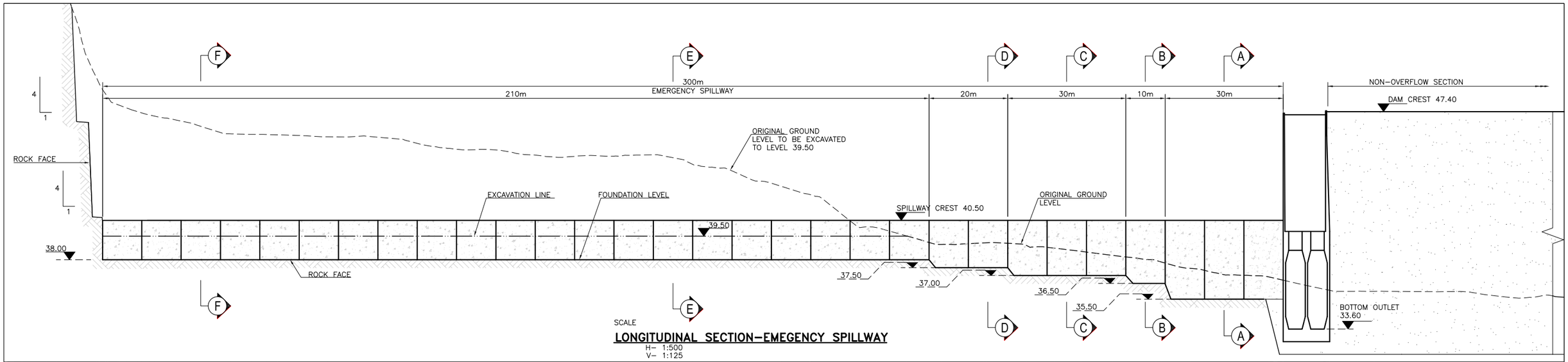

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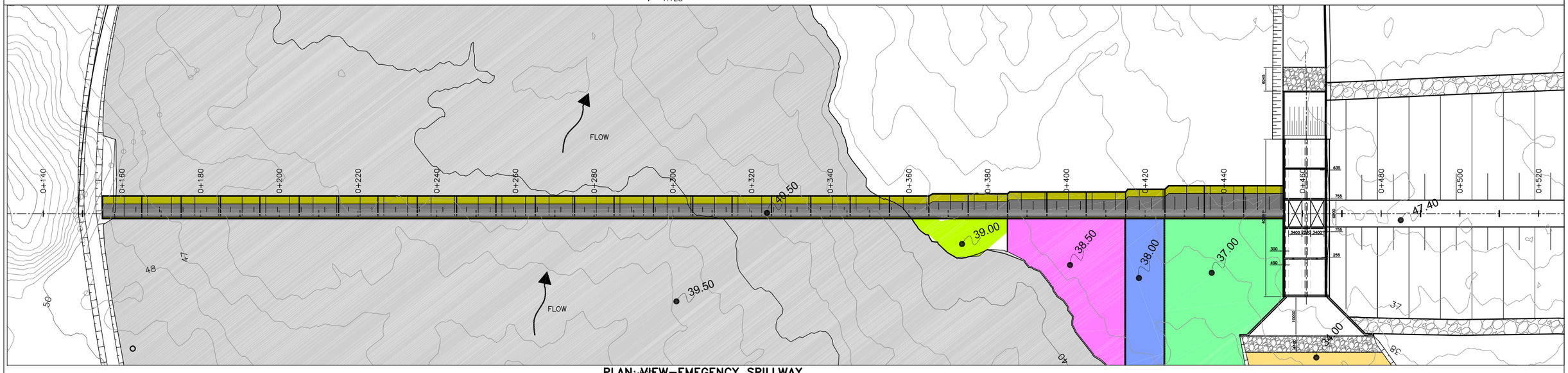

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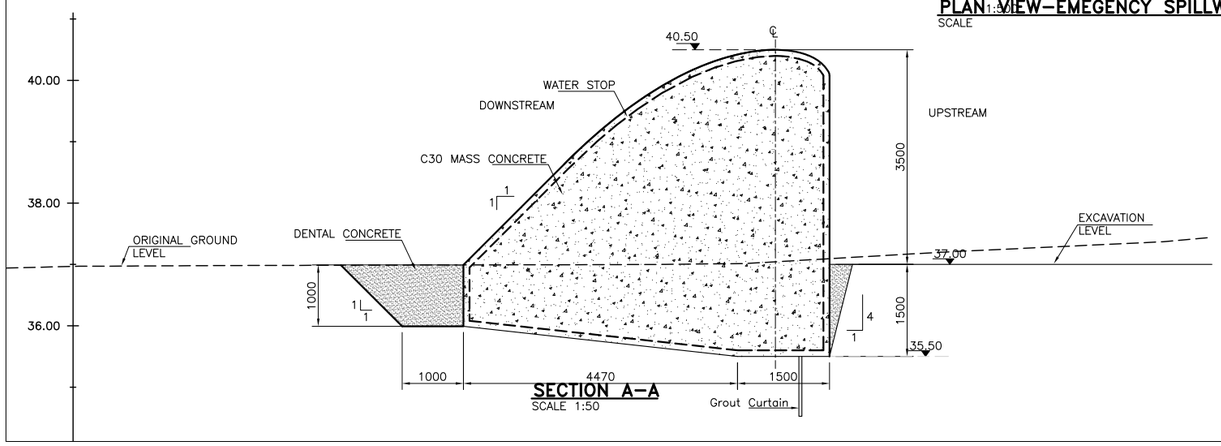

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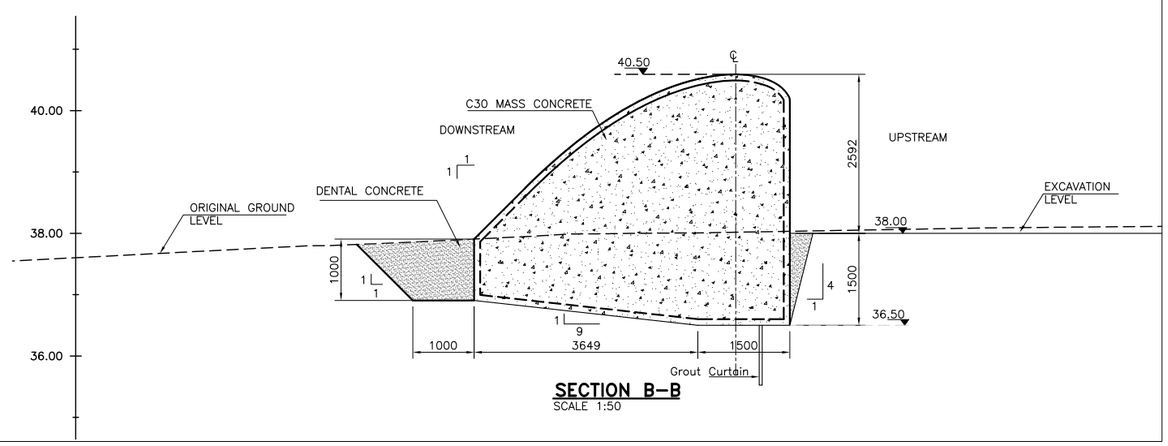
SECTION A-A



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SECTION B-B

CLIENT:

Duqm
هيئة المنطقة الاقتصادية الخاصة
Special Economic Zone Authority

CONSULTANT:

RENARDET S.A. & PARTNERS
Consulting Engineers LLC.

PROJECT NAME:

Consultancy Services for Feasibility Study, Detailed Design and Construction Supervision of the Duqm Development Drainage Network and Protection Schemes Phase 1

DRAWING TITLE:

PRILIMINARY DESIGN
JURF DAM
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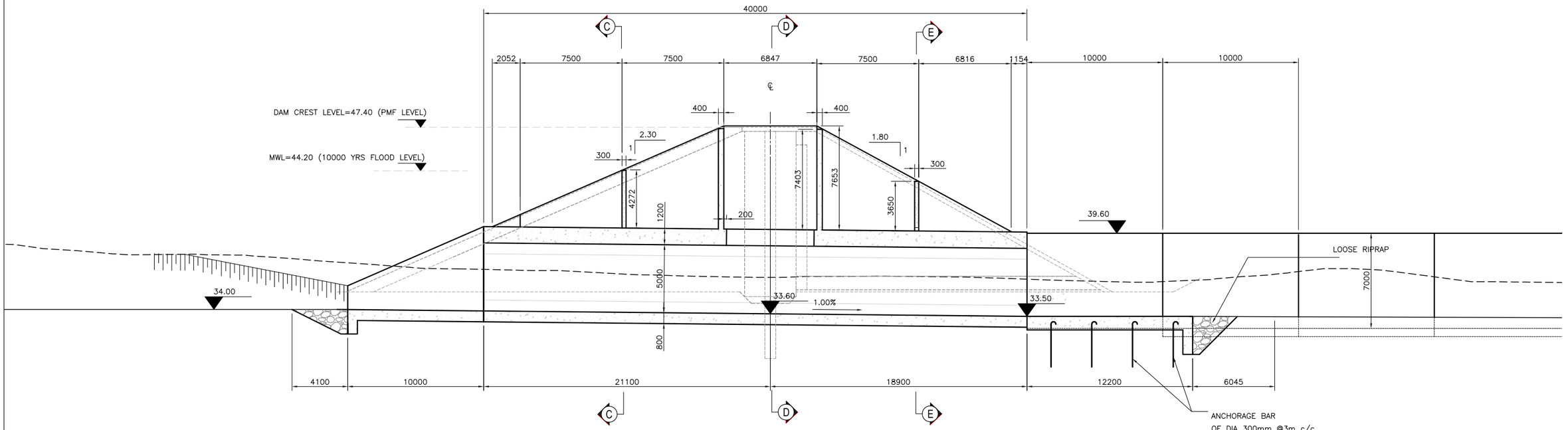

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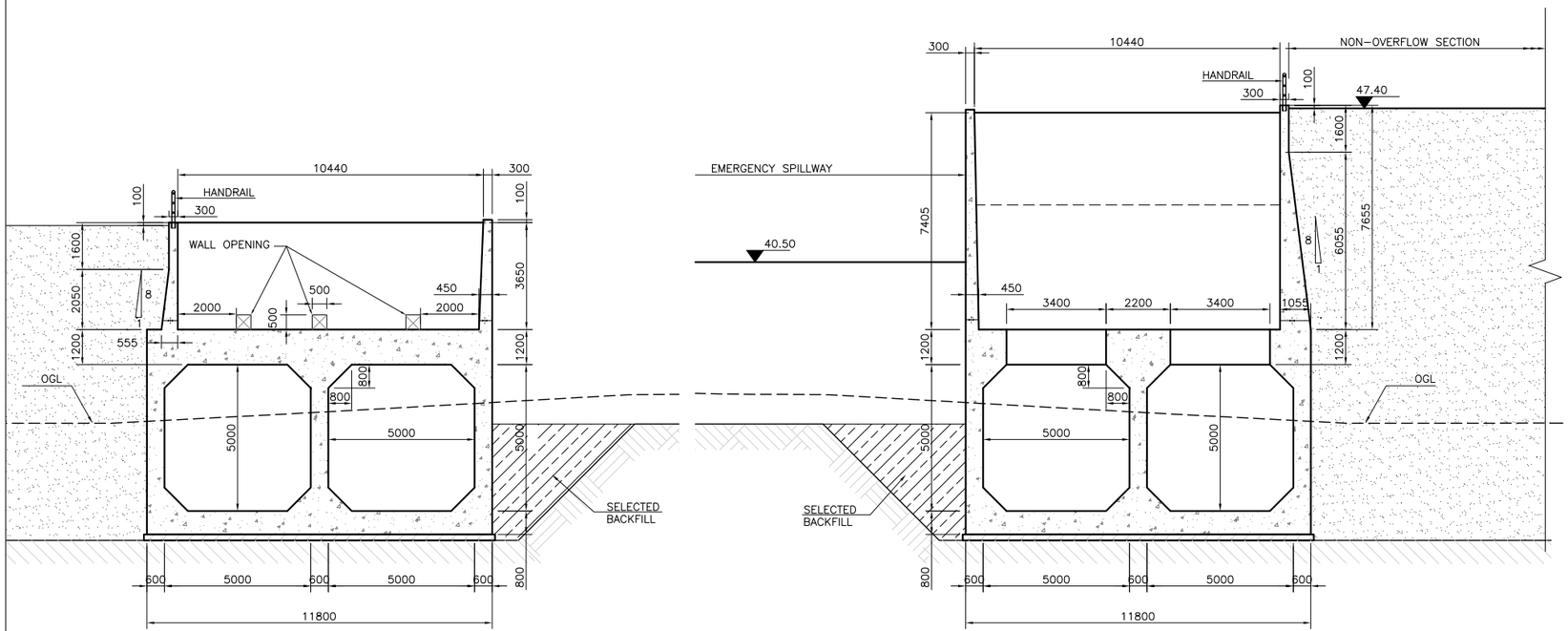

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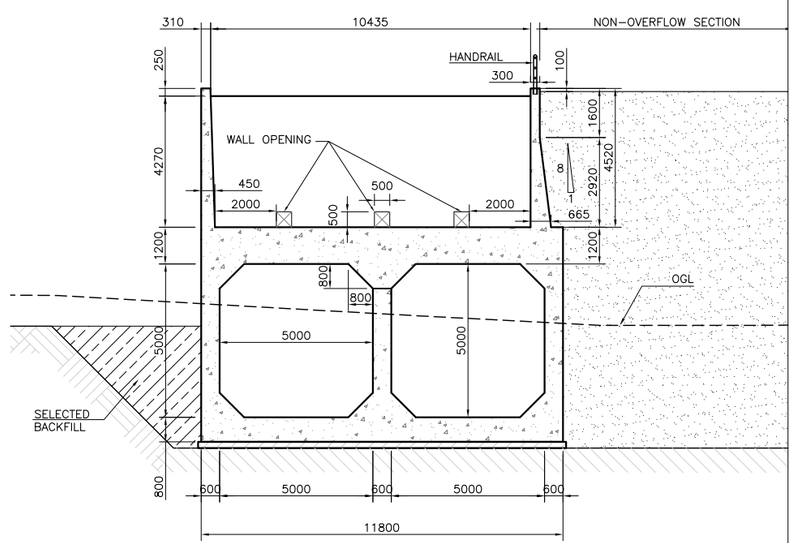

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CLIENT: Duqm هيئة المنطقة الاقتصادية الخاصة Special Economic Zone Authority

CONSULTANT: RENARDET S.A. & PARTNERS Consulting Engineers LLC.

PROJECT NAME: Consultancy Services for Feasibility Study, Detailed Design and Construction Supervision of the Duqm Development Drainage Network and Protection Schemes Phase 1

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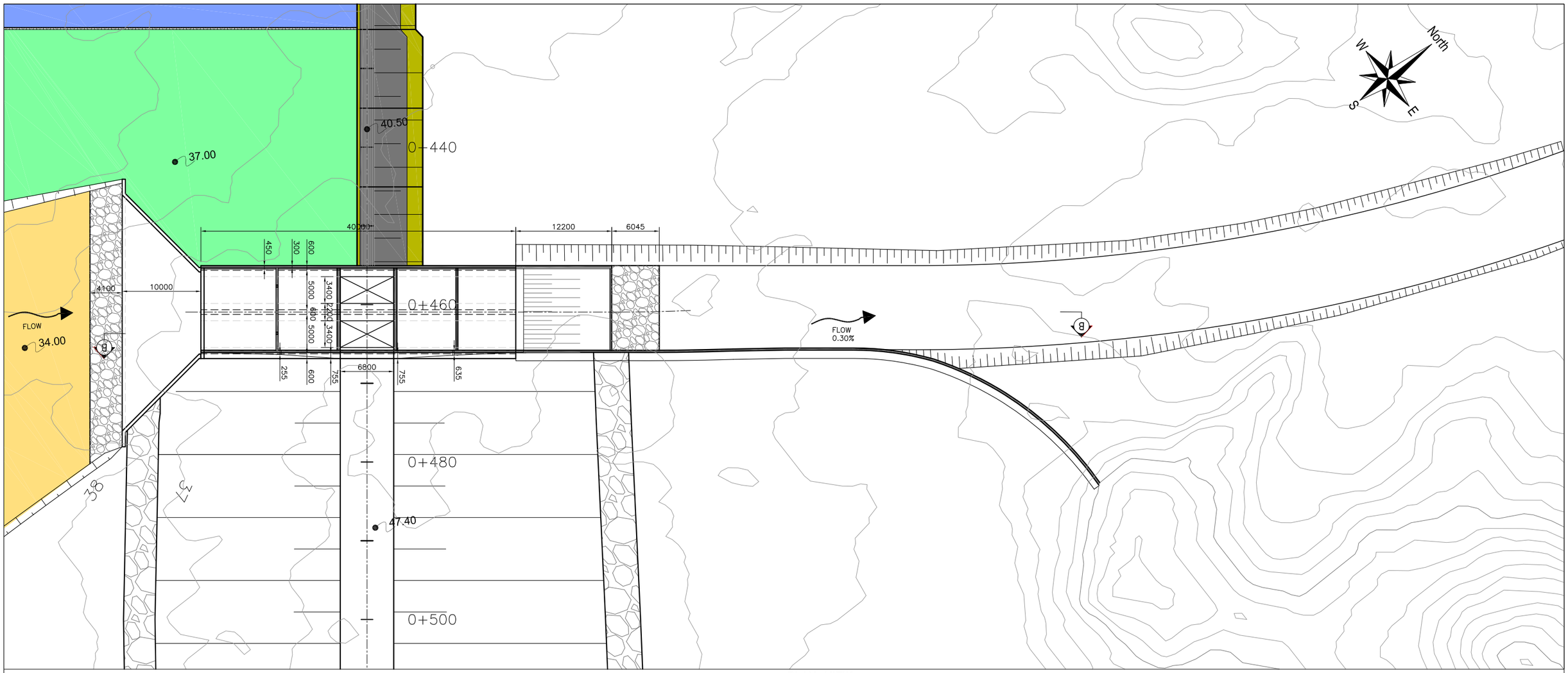
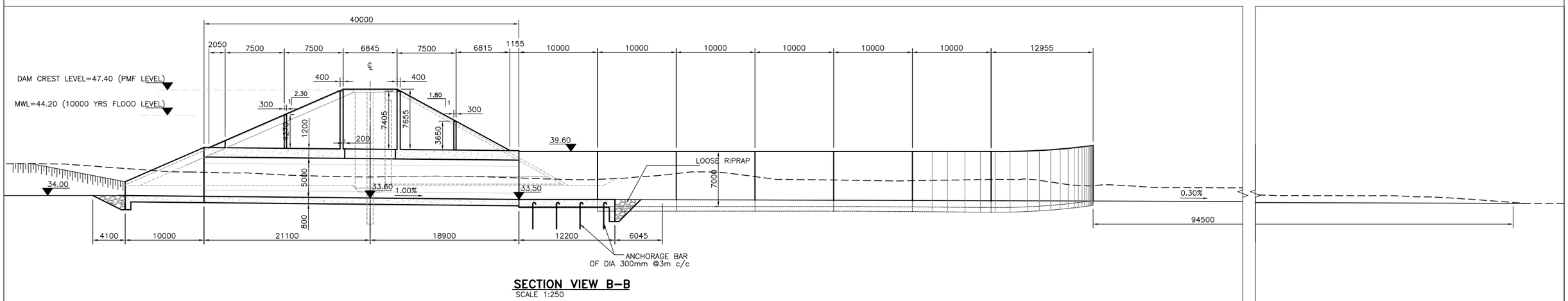


PLAN VIEW
SCALE 1:250



SECTION VIEW B–B
SCALE 1:250

CLIENT: Duqm – هيئة المنطقة الاقتصادية الخاصة – Special Economic Zone Authority

CONSULTANT: RENARDET S.A. & PARTNERS Consulting Engineers LLC.

PROJECT NAME:
Consultancy Services for Feasibility Study, Detailed Design and Construction Supervision of the Duqm Development Drainage Network and Protection Schemes Phase 1

DRAWING TITLE:
PRILIMINARY DESIGN
JURF DAM
BOTTOM OUTLET PLAN & LONG SECTION _ALTERNATIVE-1

NO	REVISION DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED	DATE

DRAWN: CH
DESIGNED: AMY
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DRAWING NO: 1333-JURF-CWK-05
SCALE: AS SHOWN @ A1
DATE: APRIL 2014
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ANNEXURE B – CLIMATE CHANGE AFFAIRS INFORMATION AND DETAILED COMPUTATIONS

A. Global Warming Potential

The Global Warming Potential (GWP) factors for a 100-year horizon are given in the following table (IPCC Fourth Assessment Report, 2007). The same figures are used in the GHG emissions calculations of the proposed Project. The HFCs on this table are non-ozone depleting HFC refrigerant or has an insignificant ozone depleting potential.

The GWP of GHGs

Gas	Chemical Name	GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
HFC	R-407c	1,526
Norflurane (INN)	HFC-134a	1,300
1,1-Difluoroethane	HFC-152a	140

B. Stationary and Mobile Combustion Sources

A fuel-based approach is applied to calculate GHG emissions. The approach typically requires the collection of activity data, in the form of the type and quantity of fuel consumed for combustion purposes.

In order to calculate CO_2 emissions using fuel type, fuel consumption and emissions factor data, the following equation is applied:

Equation 1 CO_2 Emissions Formula

$$CO_2 Emissions = \sum Amount\ of\ Fuel\ Consumed \times Emission\ Factor\ of\ CO_2$$

where:

CO_2 Emissions, in terms of tonnes of CO2-e, is summed over all types of fuel used;

Amount of fuel consumed is in terms of volume (e.g., liters) or mass (e.g., kg) for particular fuel;

Emissions Factor of CO_2 = Net Calorific Value of the Fuel x Carbon Factor of Fuel x Fraction of Carbon Oxidized x (44/12)

Equation 2 CH_4/N_2O Emissions Formula

$$CH4\ or\ N2O\ Emissions = \sum Amount\ of\ Fuel\ Consumed \times Emission\ Factor\ of\ CH_4\ or\ N_2O \times Relative\ GWP$$

where:

CH_4 / N_2O Emissions, in terms of tonnes of CO_2-e, is summed over all types of fuel used;

Amount of fuel consumed is in terms of volume (e.g., liters) or mass (e.g., kg) for particular fuel;

Emission Factor of (CH_4 / N_2O) = Net Calorific Value of the Fuel x Specific (CH_4 / N_2O) Conversion Factor; and

Relative GWP = Relative Global Warming Potential (GWP) of CH_4 / N_2O

GHG Emissions from Stationary and Mobile Combustion Computation

Description	Computation	
Total number of construction months	24	
Hours of work	5200 hours (@10hours/day for 2 years)	
Stationary Sources		
2 – 280 kW Generator	74.9 diesel liters/hour	74.9 * 5520 = 826896 L
1 – 160 kW Generator	42.8 diesel liters/hour	42.8 * 5520= 2362562 L
Total diesel consumption	826,896 + 236,256 = 1,063,152L	
Diesel Emission Factors & GWP	CO2 : 2.614 kg/liter CH4 : 0.072 kg/liter N2O : 0.11000 kg/liter	Emissions x GWP = CO2-e CO2: 1 CH4: 25 N2O: 298
	1,063,152* 2.614 = 2779.079 kg CO2	2084.309 * 1 = 2779.079 kg
	1,063,152* 0.0239 = 25.4093 CH4	19.057 * 25 = 635.233 kg
	1,063,152* 0.00740 = 7.867325 kg N2O	5.9005 * 298 = 2344.463 kg
Stationary Combustion Total CO2-e	(2779.079 + 635.233 + 2344.463) / 1000 = 5.758775 metric tonnes	
Mobile Sources		
Determination of Fuel Quantity		
Demolition and Earthworks	Total area = 100 hectares	
▪ Earthworks	0.097 kL diesel/construction month	0.097 * 24= 2.328 kL diesel fuel
▪ Vegetation removal	1.4 kL diesel/hectare; 400 t/hectare	1.4 * 100 = 140 kL of diesel fuel
Construction Plant and Equipment		
▪ Crane (hydraulic)	7.9 kL diesel /construction month	7.9* 24 = 189.6 kL of diesel fuel
▪ Loader	1.6 kL diesel /construction month	1.6* 24 = 38.4 kL of diesel fuel
▪ Material handlers	3.0 kL diesel /construction month	3.0* 24= 72 kL of diesel fuel
▪ Material transfer vehicle	11.9 kL diesel /construction month	11.9* 24= 285.6 kL of diesel fuel
▪ Roller, steel	9 kL diesel /construction month	9 * 24 =216 kL of diesel fuel
▪ Water truck, 4,000 gal	14.2 liters diesel/hour	14.2 * 24 = 54.8688 kL of diesel fuel
▪ Fuel truck, 2,000 gal	6.81 liters diesel/hour	6.81 * 24= 26.314 kL of diesel fuel
▪ Others: Petrol-fueled vehicles	5.32 kL petrol/construction month	5.32 * 24 = 38.304 kL of petrol fuel
▪ Others: Diesel-fueled vehicle	3.4 kL diesel / construction month	3.4 * 24 = 57.12 kL of diesel fuel
Total Quantity of Petrol Fuel	38.304 kL	
Total Quantity of Diesel Fuel	2.328 + 140 + 189.6 + 38.4 + 72 + 285.6+ 216 + 54.8688 + 26.314 +57.12 = 1082.231 kL	
Diesel Emission Factors	CO2 : 2.614 kg/liter CH4 : 0.072 kg/liter N2O : 0.11000 kg/liter	

Description	Computation	
Petrol Emission Factors	CO_2: 2.36 kg/liter CH_4: 0.253 kg/liter N_2O: 1.105 kg/liter	
Diesel GHG Emissions	1,082.231 L * 2.614 = 2828.951 kg CO_2	
	1,082.231 L * 0.072 = 77.921 kg CH_4	
	1,082.231 L * 0.11 = 119.045 kg N_2O	
Petrol GHG Emissions	38,304 * 2.36 90.397 kg = 0.090397 tonnes	
	38,304 * 0.253 = 9.6909 kg = 0.009691 tonnes	
	38,304 * 1.105 = 42.32592 kg = 0.0423 tonnes	
Diesel: CO_2-e emissions	Emissions x GWP = CO_2-e CO_2: 1 CH_4: 25 N_2O: 298	
	2828.951 * 1 = 2828.951 kg = 2.82 tonnes	
	77.92061 * 25 = 1948.015 kg = 1.95 tonnes	
	93.134028 * 298 = 35475.52 kg = 35.475 tonnes	
Petrol: CO_2-e emissions	90.39744 * 1 = 90.397 kg = 0.09039 tonnes	
	9.690912 * 25 = 242.2728 kg = 0.2423 tonnes	
	42.32592 * 298 = 12613.124 kg = 12.613 tonnes	
Mobile CO_2-e emissions	(2828.951 + 1948.015 + 35475.52 + 90.39744 + 242.2728 + 12613.124) / 1000 = 53.19828 t CO_2 e	
Total CO_2-e emissions from Mobile and Stationary Sources	**53.19828 tonnes CO_2-e**	

C. HFC and PFC Emissions from Refrigeration / Air Conditioning Equipment

Equation 3 CO_2e Emissions from HFC/PFC

$$CO_2e\ of\ Refrigerant = N \times A \times B \times C \times GWP$$

where:

CO_2-e emissions in metric tonnes;

N = number of units

A = Amount of HFC / PFC at the beginning of the reporting period, in kg;

B = Operating Emissions Factor, % of capacity/year (see Table 7.9, Chapter 7 of the 2006 IPCC Guidelines) (0.5% for domestic refrigeration; 10% for residential and commercial A/C; 20% of vehicle's A/C);

C = number of years operation, years

GWP = GWP of refrigerant

GHG Emissions from Refrigerants Calculations

Description	Computation	
Number of construction worker	175	
Construction period	2 years (276 days/year @ 10 hours/day) = 552 days = 5,520 hours	
Number of A/C systems during construction	60 (Ave. Size = 2 kg; R-407c GWP: 1,526; Operating EF: 10%)	(60* 2 * 10% * 1,526) / 1000 = 36.624 tonnes
Number of Chillers / Refrigerators	15 (Ave. Size = 0.1 kg; HFC-134a GWP: 1,300; Operating EF: 15%)	(15 * 0.1 * 15% * 1,300) / 1000 = 0.585 tonnes
Number of Vehicles during Construction	70 (Ave. Size = 0.8 kg; HFC-134a GWP: 1,300; Operating EF: 20%)	(70 * 0.8 * 20% * 1,300) / 1000 = 29.120 kg
Number of Vehicles during Operations	2 (Ave. Size = 0.8 kg; HFC-134a GWP: 1,300; Operating EF: 20%)	(2 * 0.8 * 20% * 1,300) / 1000 = 416 tonnes
Total CO_2-e emissions	36.624 + 0.585 + 29.120 + 0.416 = **66.745 tonnes CO_2-e**	

D. GHG Emissions from Solvent Use

Equation 4 NMVOC Component Emission

NMVOC component emission = population x consumption x fraction emitted
The fraction emitted is assumed to be 1.0 (EEA Europa, 1999: B600-3[12]).

Equation 5 CO_2-e Emissions from Solvent Use

CO2-e = g NMVOC * Conversion Factor
where: Conversion factor = 3.67 g CO_2 / g MNVOC[13]

GHG Emissions from Solvent Use Calculations

Description	Computation	
Number of construction workers	175	
Construction period	2 years (276 days/year @ 10 hours/day)	
Emission Factor	2700 g/person/year of NMVOC	175 *2 * 2700 = 945,000 g NMVOC for 1.5 years
Fraction Emitted	1.0	
CO_2 conversion factor	3.67 g CO_2	945,000 * 3.67 / 1000 = 3.46815 t CO_2
GWP of CO_2	1	3.46815 * 1 = 3.46815t CO_2-e
Total CO_2-e emissions	**3.46815 t CO_2-e**	

E. GHG Emissions from Solid Waste

GHG Emissions from Solid Waste

[12] Available at http://www.eea.europa.eu/publications/EMEPCORINAIR/group06.pdf.
[13] NERI Technical Report No. 768 (2010: 28) Available at http://www2.dmu.dk/Pub/FR768.pdf.

Description	Computation	
Number of Workers	175	
Construction period	2 years = 552 days (276 days/year @ 10 hours/day)	
Construction and Demolition Waste		
C&D Waste Generation Rate	2.8 lb/person/day = 1.27006 kg/person/day	U.S. EPA
	127.006 *175 * 552 = 122,687.80 kg C&D Waste	
Emission Factor[14]	1.03	122,687.8 * 1.03 = 126,368.4 kg CO_2-e = 126.37 tonnes CO_2-e
Construction Workers' Campsite		
Waste Generation Rate	0.94 kg/capita/day	be'ah, 2013: Appendix C4
Waste Characteristics	Food: 33%	33% * 0.94 * 552 days = 171.2304 kg
	Paper & Cardboard: 18.8%	18.8% * 0.94 * 552 days = 97.5494 kg
	Parks & Garden: 0.8%	0.8% * 0.94 * 552 days = 4.15104 kg
	Wood: 3.9%	3.9% * 0.94 * 552 days = 20.23632 kg
	Textiles: 3.7%	3.7% * 0.94 * 552 days = 19.19856 kg
Emissions Factor	Garden and Food: 0.945 kg	0.945 * (171.2304 + 4.15104) = 200.0594 kg CO_2-e
	Wood: 1.89	1.89 * 20.236 = 38.24664 kg CO_2-e
	Paper and Textiles: 2.52	2.52 * (97.5494 + 19.1986) = 294.205 kg CO_2-e
Construction Camp Total Emissions	200.0594 + 38.24664 + 294.205 = 498.1871 kg CO_2-e	0.4982 tonnes CO_2-e
Total GHG Emissions from Solid Waste (During Construction)	126.37 + 0.4982 = **126.867 tonnes CO_2-e**	

F. Climate Risk Management

Likelihood Categories Describing the Occurrence of Each Impat

Rating		Recurrent events	Single event
Almost certain	5	Could occur several times per year	More likely than not – probability greater than 50%
Likely	4	May arise about once per year	As likely as not – 50/50 change
Possible	3	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely	2	May arise once in 10 years to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare	1	Unlikely during the next 25	Negligible – probability very small, close to

[14] New Zealand's Greenhouse Gas Inventory 1990-2009. Retrieved from www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2011/index.html.

Rating	Recurrent events	Single event
	years	zero

Source: Queensland Climate Change Centre of Excellence, Department of Environment and Resource Management (2011: 11), Climate Change Risk Management Matrix: A Process for Assessing Impacts, Adaptation, Risk and Vulnerability.

The Climate Risk Management (CRM) was based on the Likelihood, Consequence, and Risk categories and used the following formula:

Equation 6 Risk Rating Formula

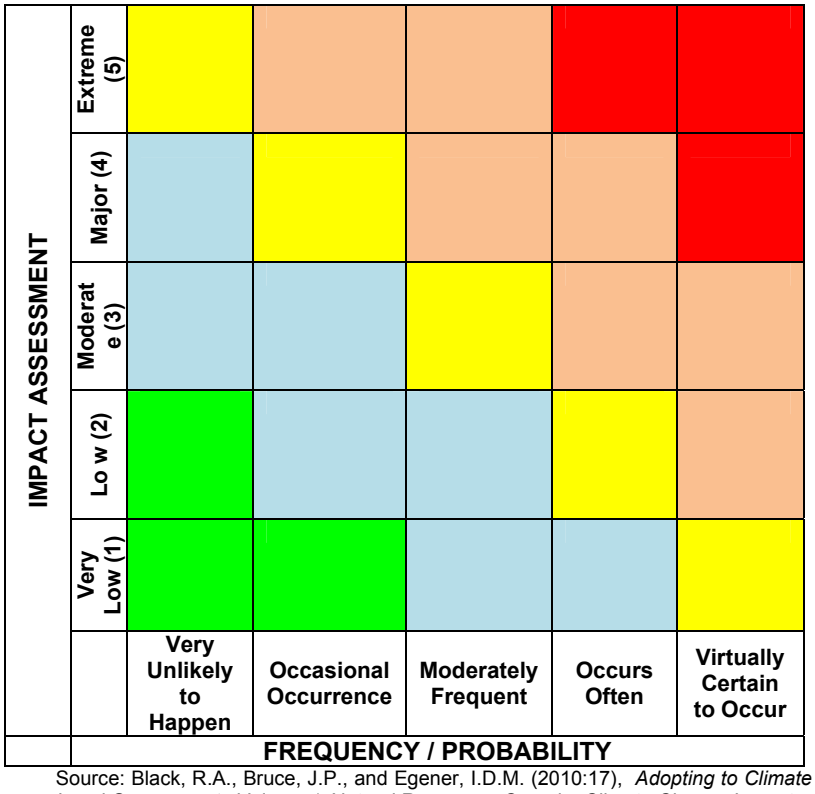
$$Risk\ (R) = Likelihood\ (L) \times Consequence\ (C)$$

Consequence Categories for Assessing Impact Risk for Economic, Natural Resource and Social Success Criteria

Consequence	Profitability and growth	Natural resource sustainability and environment	Supply chain and market	Lifestyle and community	Public safety
Catastrophic (5)	Business would be unprofitable and contract markedly making it unviable. Business would have to be wound up.	Extreme, permanent and widespread loss of environmental amenity and progressive irrecoverable environmental damage	Loss of a key source of supply or market threatening the business	The region would be seen as very unattractive, moribund and unable to support its community	Large numbers of serious injuries or loss of lives
Severe (4)	Business would be unprofitable and contract markedly and would likely become unviable even with significant remedial action	Severe, semi- permanent and widespread loss of environmental amenity and likelihood of irrecoverable environmental damage	Severe disruption of a key source of supply or market having a serious effect on the business	Severe and widespread decline in services and quality of life within the community	Serious injuries or loss of lives occurs routinely
Major (3)	The business would be unprofitable and contract and require significant remedial action to remain viable	Major, semi- permanent loss of environmental amenity and danger of continuing environmental damage	Major disruption of a key source of supply or market having a significant effect on the business	Major and widespread decline in services and quality of life within the community	Isolated instances of serious injuries or loss of lives
Moderate (2)	The business would only be marginally profitable with growth stagnant	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Components of the supply chain and market would require more than normal levels of management attention to protect the business	General appreciable decline in services	Small numbers of injuries
Minor (1)	The business is profitable and growth is achieved but they both fail to meet expectations	Minor instances of environmental damage that could be reversed	Isolated difficulties would arise in the supply chain and market but would be resolved	Isolated but noticeable examples of decline in services	Serious near misses or minor injurie

Source: Queensland Climate Change Centre of Excellence, Department of Environment and Resource Management (2011: 12), Climate Change Risk Management Matrix: A Process for Assessing Impacts, Adaptation, Risk and Vulnerability - Workbook.

Risk Evaluation Matrix



5 **Extreme risk:** Immediate controls required

4 **High Risk:** High priority control measures required

3 **Moderate Risk:** Some controls required to reduce risks to lower levels

2 **Low Risk:** Controls not likely required

1 **Negligible Risk:** Scenarios do not require further consideration

Source: Black, R.A., Bruce, J.P., and Egener, I.D.M. (2010:17), *Adopting to Climate Change – A Risk-based Guide for Local Governments Volume 1*. Natural Resources Canada, Climate Change Impacts and Adaptation Division.